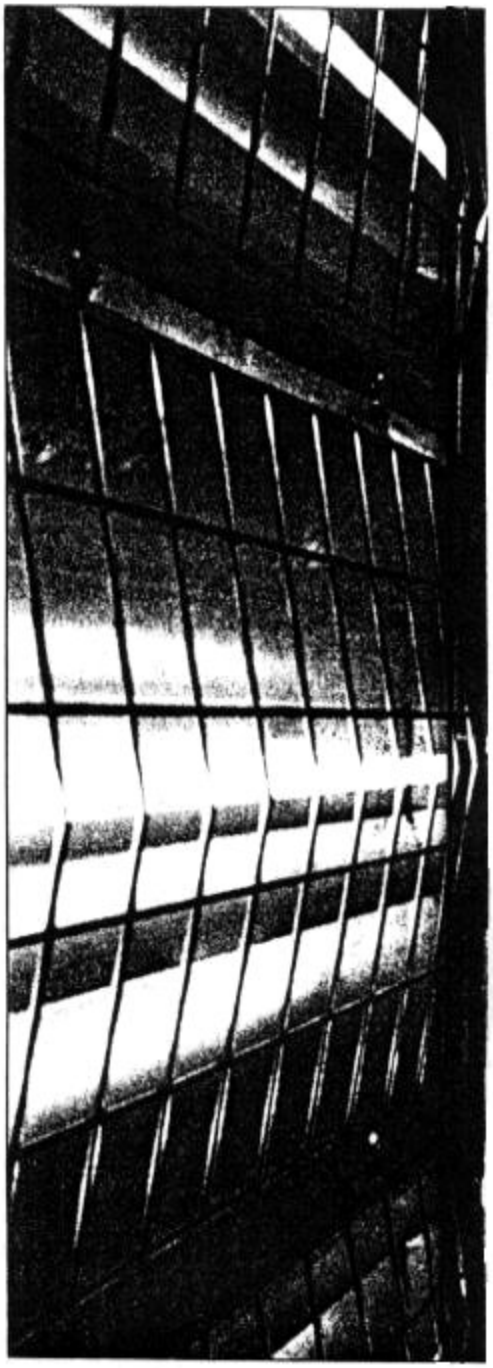
THE NEW AMERICAN BICYCLE

TREK

TECHNOLOGY CENTRAL

With a string of successes in automation and bonded aluminum, and with carbon fiber composites on the immediate horizon, Trek has secured its place among the true innovators. ***By Ted Costantino***



On the west coast, it's the Silicon Valley—California's route 101, which stretches through the San Jose Valley south of San Francisco. In the east, it's Route 128, the high-tech necklace that surrounds the city of Boston. And in the midwest, it's Waterloo, Wisconsin.

At least, that's where technology central is located in the view of many observers inside and outside the Trek Bicycle Corporation. For within the past decade, the sleepy farming community of Waterloo (population 2393) has become home to the most advanced technology the bicycle industry has to offer.

Founded in 1975, Trek quickly became the largest producer of handbuilt, silver-brazed, high-quality framesets in America. By 1980, Trek had already installed its first automatic frame painting system.

In 1983, Trek installed automatic brazing machinery that increased production speed and reduced hand labor by a third, but continued the tradition of close tolerances and fine craftsmanship.

Then in 1985, Trek replaced the automatic brazers with a robot that automatically assembles, aligns, and brazes in a single pass. The machine was and is the only one like it in the world.

Five months later, Trek upped the technology ante with the adhesive-bonded, internally lugged, high-strength aluminum model 2000.

Six months after that, Trek's engineers again stole the spotlight with the introduction of the carbon fiber composite model 2500, a bicycle so advanced that it makes the leading-edge 2000 look almost ordinary in comparison.

Standing in the wings are the model 3000, a seven-tube composite design that carries the 2500's concept a step farther, and the model 8000, the only bonded aluminum mountain bike in mass production, due this fall.

Clearly, there's something going on here. What on earth has been driving Trek? Better to ask not what, but who. And the who is one man: Bevil Hogg.

"I'm an iconoclast," says Hogg unself-consciously, "and so is Trek because of it."

True. The co-founder, vice-president, and general manager of Trek is a singular figure in the world of bicycles, driven by pride, vision, and a belief in science and technology and their inexorable power to cause change.

"Someone once said, 'Love is what makes the world go round,' and somebody else corrected him and said, 'No, it's *change* makes the world go round,'" says Hogg, warming up to one of his favorite subjects. "And it is, it's change and today's technology-driven change that is driving our culture."

This may be an unsteady precipice for a leader in an industry that evolves with the headlong rush of the horseshoe crab. And Hogg is all too aware that he is dealing with a living fossil. "The bicycle industry has rejected evolution, and that is dangerous. Because the only alternatives to evolution are status quo—which is impossi-

ble in a changing world—or revolution.

"I have a vision of an industry that *is* changing, *should* change, *will* change *totally* according to objective scientific principles of new materials technology. I firmly believe that. I would bet my last dollar on it—not because *I* have vision, but because Howard Head had vision, and Hobie Alter had vision, when the Head ski and the Hobie Cat and the Prince tennis racket came along. I'm just reflecting their vision."

Many observers would argue that point. In an industry where true visionaries are in woefully short supply, Hogg's place among the few is secure. With singleminded determination, he has pushed Trek to the top of the technology heap in the American bicycle market.

Hogg's vision took shape at a time when, with the exception of custom frames from small shops, the American-built bicycle was a ghastly collection of carbon steel tubes and poor geometry. Indeed, Trek was born in 1975 out of one businessman's pragmatic assessment that the sporting goods market was heating up and could become a profitable addition to his other business pursuits, and another businessman's dream to create bicycles that offered real value to the consumer. The pragmatist was Richard Burke, president of Trek and of Intrepid Corporation, the Milwaukee-based holding company that now counts Trek as one of its three operating subsidiaries. The visionary was Hogg, who at the time was importing French bicycles and operating a string of bicycle shops from Madison, Wisconsin. Determined to locate a steady supply of high-quality, mid-price framesets, he ended up creating his own.

In a 1981 interview with the *Milwaukee Journal*, Hogg recalled the fledgling company's strategy: "[Trek] was conceived as a high-risk venture. We really didn't see why using good old American ingenuity and technology couldn't lead to success. The technology was available. It just hadn't been applied to bicycles."

The product, Hogg recalled for the *Journal*, was aimed at the adult cyclist "who is exercise oriented, who regards the bicycle as more than a toy, and who, having learned to expect quality in everything from stereos to skis to tennis racquets, has come to expect the same quality in bikes."

Those first bicycles emerged from a 4800 square foot rented facility (which now houses Trek's Matrix wheel rim subsidiary)—rented, says Burke, "just in case the whole thing flopped." And the framesets were unlike any production models seen in the U.S. before. They sported Reynolds 531 tubing, investment cast Nikko Sangyo lugs, and specific geometries for different uses. In its first year of production (1977) Trek turned out about 1000 framesets.

By 1979, it was clear that a flop had been avoided: Trek's factory was bursting at the seams, and the company purchased a few acres of land around the corner. Trek moved into its new 24,000 square foot plant in 1980 and geared up to churn out 25,000 bicycles in 1981. That factory was expanded twice to its present 90,000 square feet, and, with remarkable automation, is now capable of sending more than 100,000 bicycles into the world every 12 months.

It was through specialization of design that Trek caught the eye of the American cyclist. Hogg pushed the concept of "function-specific" bicycles—long wheelbase geometry and handfuls of brazed-on bosses for touring bikes, short wheelbases and rigid framesets for racing. Europeans had designed bikes that way for years, but it took a young company and a new generation of quality-conscious riders to make the concept a production success in the U.S.

And it was through the pursuit of specialization and of high quality that Trek is becoming the only American mass-producer of carbon composite bicycles.

To be sure, the carbon fiber bike was partly born from Hogg's sense of business survival. "As the newly industrialized countries dominate steel production, the developed nations will have to switch to different materials in order to be competitive," he notes.

But also driving him was an irrepressible need to build and sell the most advanced production bicycles in the world. "Different materials [provide] technological and performance superiority," says Hogg flatly. "One is providing a qualitatively better product. That's why I'm sold on composites.

"The bicycle is a *highly* functional item. So when it gets caught up in fashion and esoterica, it does a real disservice to the bike. By fashion, I mean . . . five-part paint jobs and outlining the lugs, and chrome-plating half the lug. This adds cost and offers no value to the consumer. It makes him feel better when he looks at it but not when he rides it. That's the danger. A guy gets on a pair of skis or a boat, and it performs radically differently than that same object ten or 15 years ago. Why? Not because of fashion, but because of tangible scientific advances in those areas. But [he] lays out $1000 for his Italian racing frame and does it ride any different that it would have done 40 years ago? I don't think so."

Hogg began studying alternative materials even as the first steel Trek frames were emerging from the original factory. In late 1983, he assigned frame designer Tim Issac, who has since left the company, the task of drawing up plans for what was to become the 2000 aluminum bicycle. "We had two criteria: stiffness, or rigidity, and weight—ride being something that we could not model, even with finite element analysis," says Hogg. Issac began by tossing conventional ideas out the window. Welding was discarded because it limited the choice of alloys (exotic high-strength aluminums are generally unweldable), and was labor-intensive. Bonding, on the other hand, seemed to offer unlimited potential. Besides, two other large U.S. manufacturers—Klein and Cannondale—were already offering welded framesets, and, says Hogg, "We don't copy. We never have."

There came to be, however, a few restrictions on Trek's design when Gary Klein won a patent on the ride characteristics of his welded aluminum frame. The patent takes effect with frames that are about 25 percent stiffer than conventional chrome-moly steel frames. Issac's initial design threatened to exceed the patent's threshold.

At the same time that Issac was poring over his drawing board, Hogg was picking the brains of Kelly Londry and Leisha Peterson of Pegasus Research Company, in Ann Arbor, Michigan. Pegasus was a fresh, young design and engineering firm that had decided to show the world its stuff by attempting to cop the International Human Powered Vehicle Association's top speed prize. Their Kevlar composite entry, Fusion, was sponsored in part by Trek, courtesy of Hogg.

Hogg was intrigued not only by the technology within the Fusion, but the finite element modeling and analysis that Pegasus was capable of performing. Hogg had them model the 2000 prototype. "We predicted the thing would be way too stiff," says Londry. "Initially, the frame was to be not as stiff as the 770 [then Trek's best racing bike, made of Reynolds 531P tubing], but stiffer than certain other aluminum bikes. But it didn't come out that way.

"We did what you might call a parametric study, or a sensitivity analysis. Between Trek and ourselves, we all came up with some ideas on how to reduce the vertical stiffness. They involved changing the diameters of the tubes, and wall thicknesses and taper rates."

With the changes in place, the design ended up about 20 percent stiffer than Trek's 770, but did not infringe on Klein's territory—by a whisker. "Our 2000 is very, very close," notes Trek's Production Manager Larry Quick. "Yeah, it came out stiffer [than the 770]," says Londry, "but of course it's lighter, too."

The 2000's combination of rigidity and light weight got Trek moving toward Hogg's concept of the perfect bike. Now he could get his engineers working on his true vision—carbon fiber.

"At that time, I was in awe of carbon fiber," says Hogg. "I didn't realize that it is a fact of life for every other sporting goods industry." Even now, Hogg finds himself under carbon's spell. "Carbon fiber offers so much," he says reverently. "It is infinitely variable, it is infinitely moldable, it is infinitely strong, it is infinitely stiff. It's whatever you want to do with it. It is one of the most malleable materials that I know of. Advanced composites . . . are the material of the future."

Hogg wasted no time in pursuit. He hired a composite specialist and engineer from the Wilson Sporting Goods Company, Dr. Bitthal Gujrati. Gujrati, whose background at Wilson included development of their carbon fiber tennis rackets, was charged with the task of creating Trek's carbon fiber framesets. Working on what some would consider an impossibly compressed schedule, Gujrati, Quick and Trek, with input from Pegasus, brought two carbon fiber projects to fruition in 12 months.

Ask Bevil Hogg how he was able to put together the aluminum project in 18 months and the carbon fiber in 12, and he recites a memorandum from memory: "I said, 'Gentlemen, the revolution is upon us. We better get our act in gear or we will be left behind.' By getting our act in gear, I meant get the hell out of steel and into some of the more exotic materials." Ask him how he managed to fund it, and he responds with a bemused smile.

Ask Dick Burke, and he shakes his head in a mild state of disbelief. "If I had been asked to approve the costs associated with the 2000 project, I would have turned it down. I think this is a tremendous accolade for a fellow like Bevil, who had the guts—or foresight, or lunacy—to basically fund a project like that off the operating statement in more or less a skunkworks within Trek. I can be very pleased with the results, and I can say enviously that I wish I had done it, but it took a tremendous amount of courage. I would hate to think of what the downside could have been."

A walk through the Trek factory demonstrates just how deeply Hogg's ethos has permeated the corporation. In every corner, the commitment to technology and quality is evident. Trek's designers, for example, have a computer-aided design (CAD) system at their disposal, which knocks up to two days of labor off each engineering drawing they produce. Using the CAD system instead of the usual drafting tools, notes Hogg, "is like the difference between typing with an electric typewriter and writing with a crayon between your toes."

Back in the shop and just around the corner from the automated paint booths, incoming aluminum forks from Tange are examined. Each fork comes with its own X-ray, and each X-ray is checked by a Trek employee. As a double-check, Trek rescans ten percent of the forks. The company rejects a surprising percentage (Hogg declines to name a figure); they assemble equivalent forks themselves to supply the difference.

In the mind of some observers, there's another side to Trek's continuing—some would say fanatical—quest for quality. It arises from the company's rocky start. Early frames had a reputation for alignment problems, obliging some dealers to laboriously check and correct each frame as it was received. Other dealers who couldn't be troubled simply dropped the line altogether. The company has long since left those growing pains behind by pouring hundreds of thousands of dollars into state of the art brazing and alignment equipment, and designing its own lugs in 1983 to assure precise assembly.

Today, Trek's steel frames travel down an assembly line unlike any other in the bicycle world. Comparable efficiencies—though not comparable equipment—exist only in the Orient, within the factory walls of companies whose output dwarfs that of high-tech, low-volume Trek.

Trek's steel production line has long since evolved from the old-world methods of painstaking hand assembly. Hand brazing of the main triangle was abolished when those first wire-fed brazing machines were installed in 1983. At the time, they were as advanced as any in the

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U.S., capable of churning out precisely made frames day after day with minimal intervention (human brazers touched up the occasional misfire, and double-checked alignment on a now-discarded laser-guided alignment table). Today, that wire-fed line is used to assemble a small number of 18-inch frames.

In the old brazing line's place stands a year-old five-axis robotic system, still gleaming with freshness and innovation. This machine, designed and built to Trek's exclusive specifications, uses electrical induction instead of acetylene to heat each frame joint. It can, in fact, bring a lug to temperature and complete the brazing process in ten seconds.

The keys to this robot's remarkable efficiency lie in Trek's commitment to two additional expensive technologies: investment cast lugs and silver brazing material. Trek's investment castings speed up assembly and ensure tolerances as fine as one-thousandth of an inch—this in a production frame, remember. And using silver brazing rod permits lower brazing temperatures and faster joint wetting.

Both properties make life easier for the robot. Prior to their manipulation, each lug receives a ring of silver brazing rod for each joint. The robot grabs the lugs and pre-cut tubes, presses the parts into place, and applies a microprocessor-controlled amount of heat, created by magnetic induction. The silver melts rapidly, preventing the tensile strength losses that can occur when too much heat is applied for too long. As quickly as the process begins, it is over; the robot swings the completed frame out of the way, releases it, and reaches for the next set of tubes.

At the alignment table, another benefit shows up. The short brazing cycle assures minimal heat distortion, and indeed it is the rare frame that requires post-brazing alignment, according to Hogg. Nor are the old hand-held acetylene torches fired up much these days; the robot doesn't have bad days, and the frames emerge without voids or blobs at the lugs.

If there is a flaw in this masterful perfection, it lies not in the machine itself, but in the financial commitment to a technology that Trek may have superseded. For just down the shop floor from the amazing robot lies Trek's apparent future: the adhesive frame assembly area.

As you watch Trek's people manufacturing aluminum frames, you cannot help but feel that you are witnessing the future of the American bicycle industry—although, ironically, there are more humans involved here than on the steel line. The shop area is quiet and clean—the only factory noises are the hissing of the air-driven assembly tools. The frames go together quickly. There is no separate alignment table in sight—the precision of the assembly jig assures congruence with the blueprint. At the moment, Trek can churn out up to 80 frames every day with only one jig in operation; Larry Quick has recently added a second. It would seem that the future of the aluminum bicycle is secure in Waterloo.

Indeed, as Trek enters its second decade, it could be a model for the modern American manufacturing company. It has created a niche for itself as a supplier of high-quality bicycles that are easily differentiated from their competition. It has advanced the performance of the bicycle by daring to innovate. And it has acquired a reputation for delivering good value per dollar.

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To be sure, there have been signs of distress. Four years ago, Trek embarked on an ambitious plan to increase its market share, setting a goal of 100,000 bicycles a year by 1986. Its pursuit of that goal has made profits inconsistent, and led to manufacturing snafus. The company overbuilt some models that were in low demand, and couldn't obtain components to complete others that dealers clamored for. Dealers received bikes with vouchers for missing parts. Specifications seemingly changed overnight, as new vendors filled in for others that couldn't meet demand.

And it is only recently that Trek's target audience, the mature, upscale sports enthusiast with a taste for fine equipment—the yuppie, in other words—has entered the market in significant numbers. It is entirely possible that despite operating well below capacity, the company has been shipping more high-quality bicycles than the market could absorb. It would be ironic indeed if Trek were to falter just as its target consumers started a buying spree.

Burke, determined to avoid that scenario, has hedged his bets with continued investment in steel production, and has aggressively pursued the goal of bringing a less expensive steel Trek bicycle to the market. Trek currently imports inexpensive steel bicycles from Japan, and hopes that continued manufacturing efficiencies will allow it to move that low-end production to the States. Moreover, Burke points out, "the investment in steel did not preclude management from continuing its leadership position in technological developments. If Bevil Hogg and his group had been shortsighted and said, 'Oh my God, we've got all of this steel production, we can't look at aluminum,' we would have missed a tremendous opportunity."

For his part, Hogg is still mulling over the concept of the perfect bicycle: "It incorporates all the elements—or perfects all the elements—that everyone is trying to achieve," he muses. "Light weight, meaning probably under two pounds for the frame; aerodynamic—true aerodynamic, not pretty-pretty aerodynamic; efficient; and comfortable. The bicycle frame has a long way to go before it gets there. It also has to be affordable."

Hogg seems well aware of the dangers of boutique bicycle building. "It's very easy to sell egotism—our concept of what the perfect bike should be like. Fifteen hundred dollars, sell ten of them." He waves the thought off.

Burke agrees: "I kind of think that Trek is the Porsche of the bicycle business. We are not Lamborghini. Our constituents are more in the mainstream than at the extremes. We feel we have to meet the demands of that constituency. We have to use our technological leadership responsibly and we still have to be in the position of providing the market what it wants rather than what we want to give them. I sincerely believe that."

Whatever the outcome, Trek has clearly left its mark in Waterloo, and on the bicycle business. Whether or not the industry can be dragged "kicking and screaming into the 20th century," as Hogg once hoped, is unclear. But he and his company have set a remarkable example for all who follow. □