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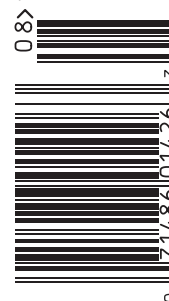
INSIDE THE ALL-AMERICAN ZERO FACTORY



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INSIDE ZERO MOTORCYCLES

Building the shocking sound of silence

For most of us, dreaming up, prototyping and actually producing one viable, marketable invention in a lifetime would provide a lifetime of satisfaction. But Zero Motorcycles founder and aeronautical engineer Neal Saiki isn't like "most of us." Saiki has been described as a "serial inventor," with time at NASA and 10 years at Santa Cruz bicycles. In addition to those day jobs, Saiki has had forays into human-powered flight, full-suspension mountain bikes, battery technology and most recently electric-assist cargo bicycles (www.ntsworks.com). And, of course, there was the electric-powered Electriccross mountain bike/motorcycle hybrid that grew into Zero Motorcycles.

In 2009, the first year of significant production, Zero made a line of dirt bikes, including the X and a performance-oriented MX. Even though the X and MX could be street-registered, Zero also produced the street S model in 2009. The S began shipping in volume in 2010, and sales of street

models persuaded the company to go all street for 2013, though there is still a dual-sport model based on the street chassis.

As amazing as it sounds, until 2010, Zero didn't have a single decision-maker with a motorcycle background on staff. In 2010, Zero brought in Abe Askenazi. Askenazi is a life-long motorcyclist, and his love of two-wheeled transport motivated his degrees in mechanical engineering and a master's thesis on single-track vehicle dynamics. He started at innovative Buell Motorcycles right after college and rose rapidly in the engineering side of the company during his 15 years there. In under a year, Askenazi transformed the performance, production and quality of the Zero lineup. In the electric motorcycle universe, eight years is an eternity. Compared to a modern Zero, the Electriccross is from a distant galaxy, and Askenazi's impact on that transformation is undeniable. It is no surprise that he was named chief technical officer in 2011, and he con-

tinues to drive development. He works for CEO Richard Walker and COO Karl Wharton, but they are in charge of building a business while Abe Askenazi builds motorcycles.

After Abe came on board, more motorcycle enthusiasts were hired, including marketing director Scot Harden (one of America's most accomplished off-road riders) and industrial designer Matt Bentley. Since the new direction toward serious motorcycles, the company has had to move to larger buildings three times, and current production is limited by supply to 14 bikes a day. According to Harden, the demand is there for every bike the company builds, and production is capable of 30 bikes a day. All of Zero's bikes are assembled in America.

We recently paid a visit to the Zero factory just outside the seaside town of Santa Cruz in Northern California where we had the chance to sit down with Abe to get an inside look at how the American-made Zeros are assembled.

ZERO



The powerful air-cooled motor is one of the first parts of the Zero installed in the frame as the bike starts on the production line.



The electric motor used in the Zero is hugely powerful. The horsepower numbers don't sound huge, but with over 100 foot-pounds of torque, the acceleration of a Zero from 35 to 85 mph is breathtaking. Remember, these bikes go from a stop to just over 100 mph with no transmission—just direct belt drive.



With a BA and MA degrees in engineering and 15 years of experience in motorcycle manufacturing, Abe Askenazi put Zero Motorcycles on the map. He streamlined production and suppliers, modernized and refined the design, and pushed forward all aspects of electric motorcycle performance.



The supply room has three aisles packed to the ceiling like this. Despite what looks like a rich parts supply, keeping parts in stock is what limits the production.



ZERO TO HERO

EBA: *How does a guy from the heartland end up making motorcycles on the West Coast?*

Abe: My first job out of college was with Eric Buell at Buell Motorcycles. I started as an analysis engineer, and it was a great company to be with. When Harley-Davidson shut Buell down, I transitioned over to Harley, but it wasn't a great fit. I was contacted by Zero Motorcycles, and they needed somebody with motorcycle experience to drive the development of the models and platforms. I've been here a bit over four years, and my focus has been making sure that we build products that are relevant in the motorcycle industry and to introduce the industry to this wonderful thing that is the electric powertrain.

EBA: *What kind of critiques do you have for the early Zeros?*

Abe: Before I joined the company, there was no one with motorcycle-industry experience. There is a lot of high tech in this area, but there are also a lot of bicycle companies here. So there were people from the bicycle industry and people from high tech, and they created a very interesting product, but it was very bicycle-like. It was not a true motorcycle. After I came on board, the company hired more motorcycle people. The first task was to create a true motorcycle with the electric powertrain.

EBA: *How far do you think the Zero has come in your four years?*

Abe: It is amazing. There are two measures of electric performance: range and power. The best range we had back then was 40 miles in the city, and now we are up to 170 miles in the city. That is huge in terms of how relevant the Zero is for the consumer. At 40 miles it was a niche product. Now it will work for most people who commute. It is not a touring bike. We have a long way to go before we are a factor in touring. But for everyday use and weekend sport riding, the Zero is relevant.

In terms of brakes, real suspension and even the fit of the motorcycle, we have come a long way. From a bicycle pretending to be a motorcycle to a real motorcycle. That has been a great journey. From a power standpoint, we have gone from 27 to 67 horsepower. We were also at 40 foot-pounds of torque, and now we are at 106 foot-pounds, and from 35 or 40 mph to 102 mph.

EBA: *What is the most significant increase in performance?*

Abe: It depends on your outlook of what is important. From a powertrain standpoint, whether you are talking off-the-line torque or horsepower at speed, if you ride a 2010 or even a 2012 model Zero, and then ride the 2014, especially the SR; the difference is night and day. We have made significant improvements in so many areas that it is hard for me to tell you what the most significant change is. Prior to my joining the company, there was no industrial design function. Before that, people were doing their best with what they knew, but the bikes looked a little odd and a bit unfinished. Since we brought Matt Bentley in, the motorcycles are much more appealing than they used to be.

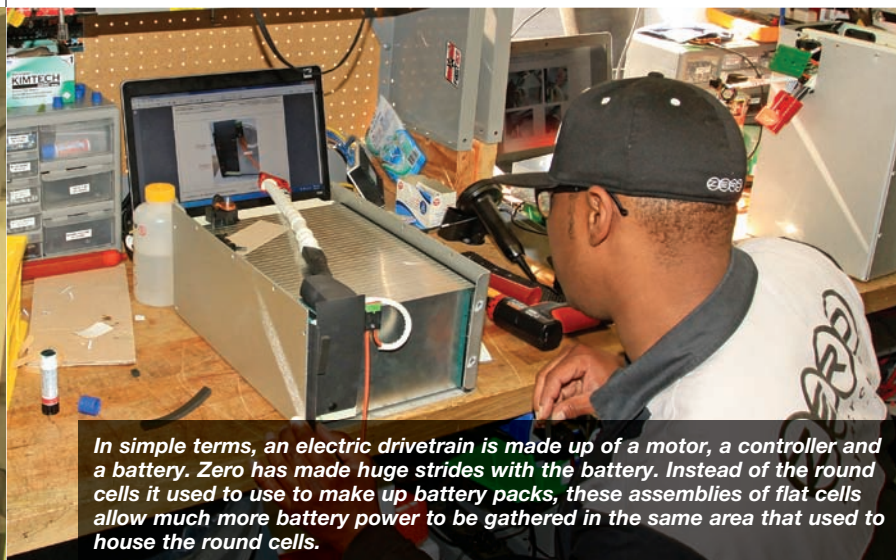
ZERO

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If you look closely, you can see that the dyno at Zero rolls both wheels at the same time. We were told it takes no small amount of skill to balance on it. The dyno measures and ensures proper engine and chassis performance. It replaces the physical test ride that all the bikes used to get. It saves a great deal of time when weather conditions are not perfect. There is no need to clean the bike after a ride on wet streets, but the operator can evaluate all of the machine's systems.

Carts of assembled batteries await installation. These batteries are basically built into the Zero. They are removable, like an engine in a gasoline-powered bike is, but they are not quick-change.



In simple terms, an electric drivetrain is made up of a motor, a controller and a battery. Zero has made huge strides with the battery. Instead of the round cells it used to use to make up battery packs, these assemblies of flat cells allow much more battery power to be gathered in the same area that used to house the round cells.



Before Matt Bentley came on board at Zero, there was nobody taking care of industrial design. As a result, the bikes looked like a collection of parts. Matt is a one-man department so far. He has done an amazing job unifying the look, fit and finish of the Zero motorcycle.



EBA: What will it take to bring Zero Motorcycles farther into the mainstream?

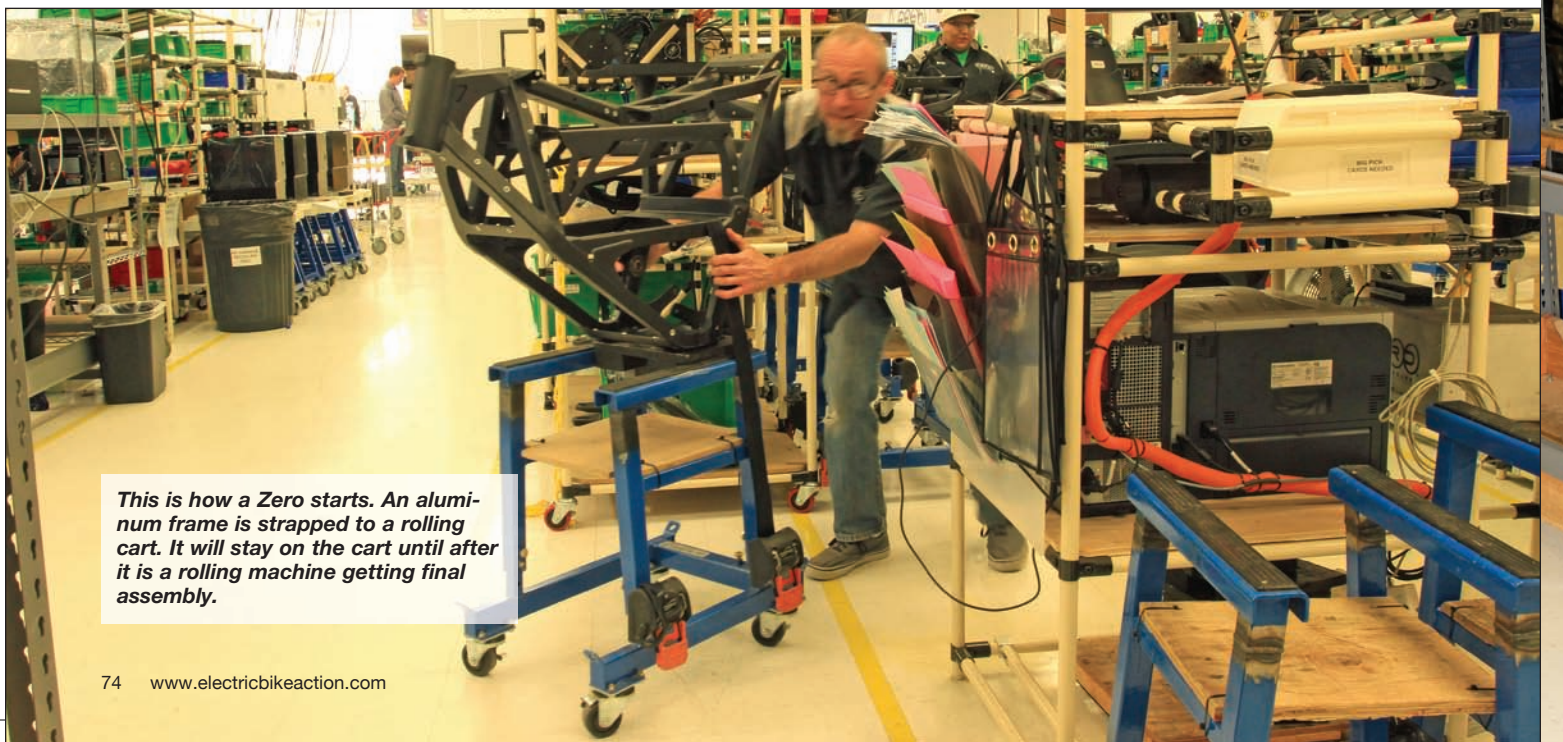
Abe: Highway range is our next big thing. We need to increase the range to the point that it is no longer a concern. Since most people don't really ride more than 175 miles in a day, right now I think the range is spot-on. Even for fleet applications like police, the range is perfect. For people who commute long distances on the highway at 70 mph, the range is half of our city range. Electric is the opposite of internal combustion engines. Gas engines are more efficient at high rpm, and electric motors are most efficient at low rpm. Our bikes are highly efficient in the city, but at higher rpm, the efficiency of the powertrain drops quite a bit, and then there is the aerodynamic drag you are fighting at speed. So while our current 85 miles of highway range is enough for a lot of people, we know it won't satisfy everyone. Our next frontier is making highway range beyond concern.

From a chassis standpoint, it will be more of an evolution. We will evolve to better suspension and better brakes. I don't think we will be making leaps in those areas. We have a pretty solid product now that we will continue to work on. We have reached a place where the power is quite good, and especially on the SR. We will continue to evolve the powertrain, but in the market segment we operate in, there is no need for further leaps in power or acceleration. We will continue to work and look for that next battery chemistry that will provide our next leap.

EBA: What about a transmission or a Constant Variable Transmission to maximize the power?

Abe: A transmission loses efficiency. Any time you transfer power there is a loss. One of the things that make our bikes special is how easy they are to live with, how pure they are and the simplicity of the ride. A lot of the hobbies and pastimes you enjoy tend to complicate your life. A Zero is one of those special things that simplifies your life. You no longer go to gas stations; there is no engine noise or emissions to get in the way of the purity of the ride experience. You don't have a clutch or shifting. What sells our product more than anything else is the experience. It isn't green credentials or anything you think about. It is the purity of how fun it is to get on something that is more like flying than riding a motorcycle. You feel connected to the road, to the environment in ways that are not possible with internal combustion. Plus, you just get on it and go. No need for the engine to warm up, no oil changes, no air filter to clean. Those things you used to have to worry about just go away. Without exception, riders who add a Zero to a stable of bikes—whether they already own one or a fleet—choose to ride the Zero 9 times out of 10 for their day-to-day riding. The other bikes end up parked, because with the Zero you just get on and go. The direct drive that we have is one of the points that people really like, so we have no plans, motivation or market demand for a transmission.

ZERO



This is how a Zero starts. An aluminum frame is strapped to a rolling cart. It will stay on the cart until after it is a rolling machine getting final assembly.

Zero's marketing director, Scot Harden, claims that this line of motorcycles waiting to be crated sets Zero apart from other makers of electric motorcycles. Zero has a steady supply of bikes and spare parts rolling off the production line.



EBA: Do you see battery technology on the horizon that will change things for the better?

Abe: Every year there are mounds of money invested in battery technology by battery and automotive companies. Every major university has a program for battery research hoping to see advancement in this technology. As soon as new battery technology is made available to us, we will make it available to the public, so you will continue to see battery advancements, if not every year then every couple of years.

EBA: What is the most impressive part of riding a Zero? People always ask whether it is weird to ride without the engine noise.

Abe: It is absolutely a magic-carpet ride. We have this great road nearby called Highway 17. It twists around through great scenery. There is nothing that gets in the way of the experience. That is just really special. We had a journalist a couple of years ago, and he got off the bike and claimed, "I have never felt and heard the tires perform like I just did on that bike." He was blown away by the fact that not only could he feel the road more than he normally could, but he could actually hear what the tires were doing as he was pushing the limits of traction. You can focus on the experience in ways that used to be impossible.

EBA: Of the approaching technologies that look promising, what is the most exciting for you and Zero?

Abe: There are a lot of very exciting new technologies on the motor controller side. In the near term, there are a plethora of ideas for battery chemistries that could improve the energy density in a dramatic way. Today you have internal combustion motorcycles, and it weighs what it weighs, and there is really nothing other than substituting lighter materials that can dramatically reduce the overall weight or the layout of the motorcycle. There just isn't room in an internal combustion-engine design. As battery-energy density goes up, the size of the battery can be reduced. Once we get to the range we want, the battery can continue to get smaller. Ten years from now we will likely lose 100 pounds of battery, so the bike will be 100 pounds lighter and all the real estate currently used by the batteries will free up. Maybe it will just become cargo capacity, but electric drive opens up the creative and performance possibilities in a way that internal combustion motorcycles won't allow.

EBA: Why did Zero start with a motorcycle as an electric vehicle?

Abe: As more and more of the population lives in cities, there is only so much room for cars. The narrow profile of a motorcycle makes more and more sense in a congested environment. As electricity is refined as the revolutionary next step in vehicle propulsion, what better vehicle is there to apply it to than a motorcycle—a more advanced individual transportation vehicle than a car. As personal mobility changes and becomes more and more individualized, the motorcycle will already be going in that direction, and with the electric powertrain, it will be even more so. ■

All parts and sub-assemblies, like these completed wheels, sit on carts ready to go at the proper point on the production line. One guy mounts tires all day long. He is impressively quick and efficient.

