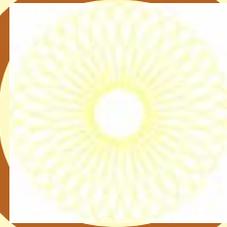# The Dean of Engineering

INTERVIEW BY WILLIAM LIDWELL
PHOTOGRAPHY BY GERRY MANACSA

Caption TK

Dean Kamen holds more than 150 patents on revolutionary inventions

ranging from portable dialysis machines to sophisticated mobility devices to highly efficient and compact Stirling engines.In addition to numerous honorary degrees, Kamen has received such honors as the Lemelson-MIT Prize, Heinz Award, Kilby Award, and the National Medal of Technology. A tireless advocate for science and technology education, Kamen founded FIRST (For Inspiration and Recognition of Science and Technology) to encourage kids to pursue careers as scientists and engineers, as well as to reset societal values so that people aspire to be thinkers and inventors. "Our culture celebrates one thing: sports heroes," he says. "You have teenagers thinking they're going to make millions as NBA stars when that's not realistic for even one percent of them. Becoming a scientist or an engineer is."

Armed with a crack photographer and an iPod recorder running iPodLinux (See MAKE 02, page 135), I met with Kamen at his company in Manchester, New Hampshire, and at his home in Bedford, New Hampshire. His company, DEKA Research and Development Corp. (DEKA from DEan KAmen) is located in a series of renovated mill buildings on the shore of the Merrimack River. The buildings are simple and nondescript on the outside, revealing little about the kind of work that goes on inside. The interior, by contrast, is dot-com office meets Monster Garage. It is a casual environment adorned with tools and technology, testaments to past and present inventions, and a wide variety of exceptional artwork created by Kamen's father, one of the legendary EC comic book artists, Jack Kamen. After a few hours at DEKA, we moved to his home, called West Wind. Built around an 87,000-pound steam engine once owned by Henry Ford, West Wind is as much homage to innovation as it is a living-work space. Designed and built by Kamen in 1997, West Wind features multiple workshops, an extensive library, helicopter hangar, and a sufficient number of interesting gadgets and gizmos to qualify it as a sort of technology museum.

Dressed in his customary cotton work shirt and Levi's, Kamen wasted little time in getting things started: "You know how a slide rule works?" he asked without context or warning. I sheepishly confessed that I didn't. "Slide rules were a bit before my time," I said. Clearly dissatisfied with my response, Kamen sprang from his chair and quickly located a six-foot slide rule lying against a wall in his office. He then proceeded to show me how to use this giant slide rule to perform all manner of calculations, simple and complex, and frequently inserted commentary on the design elements that made the slide rule work. Kamen was never condescending or mean-spirited during what turned out to be a 30-minute unsolicited exposition on slide rules.

Much of the interview went this way. I came in a skeptic of the Segway. I left exploring financing options for the new cross-country model. Can a Stirling engine really save the world? I came in thinking the notion ridiculous. Now I am tinkering with Stirling engine models. One thing is for certain: Kamen's unique mix of world-saving idealism and inventive genius makes for a very addictive confection.

It is said that Edison embraced enlightened trial and error to achieve the majority of his breakthroughs, whereas his contemporary Nikola Tesla worked through everything in his head before getting his hands dirty in the shop. How would you characterize your approach to innovation relative to Edison and Tesla?

Unfortunately, I would put myself closer to the Edison end of the continuum: the tinkerer, the get-your-hands-dirty and keep-screwing-with-it-until-you-make-it-work side. I am much more in awe of people like Galileo, Newton, and Einstein than I am of the tinkerers who

just kept working with the tools and technology of their day until they got something to work. I am just in awe of those people. I wish I was one of them, but it's not in the cards. So I work hard to succeed at the other end of the scale.

This relates to what you call "frog kissing" in your research and development?

Yes. Engineers are taught to think and work in a risk-averse way: let's avoid making mistakes, let's only do what has been documented to work, let's play it safe. Well that's great, but it will never result in significant innovation. So I try to get my team to try things that aren't likely to be success-ful — i.e., to kiss a lot of frogs. The princess went out and took a chance. She kissed a frog. Most of the time when you kiss a frog, you end up with warts. But every once in a while, you kiss a frog and you get a prince or princess. It is okay to get warts. It is okay to fail. You laugh at it, learn from it, and move on. And then, every once in a while, you'll kiss a frog and get an iBOT, or a Segway, or a dialysis machine. And that's a big deal.

I understand that some of your engineers built you a replica of a Chinese south-pointing chariot as a gift. What is the story behind that?

Every year the people at DEKA secretly go off and build a spectacular holiday gift for me. And since I have an incredibly talented team of engineers and designers, and an extraordinary machine shop that can literally make anything, they come up with some truly amazing things.

Well, everyone at DEKA has heard me talk more than once about an ancient Chinese inven-tion called the south-pointing chariot. Imagine you have a two-wheeled chariot drawn by horse. Each wheel of the chariot is connected to a differential, both of which turn a central shaft a variable amount as the chariot turns. A pointer is connected to the central shaft. The gears are configured to turn the central shaft so that the pointer always ends up pointing the same way as if you had gone straight. So you could look at the pointer and pull yourself back on course. It is an incredible piece of technology — literally an ana-log computer, a summing machine. It is a great piece of technology except for one thing: it is

well documented in history that the Chinese had knowledge of lodestone [iron] well before they were building these chariots. They knew that if they took a little piece of lodestone and put it on a cork in a bowl of water, it would always float to the same side of the bowl. Today, we call this a compass. So, they were building these hugely complicated chariots to tell them which way they were going, rather than using something simple and elegant like a compass. So when we evaluate possible approaches to a technical challenge at DEKA, the engineers each have a passion to use their area of expertise to create a solution. I'll look at these solutions and ask, "It's great, but is it a south-pointing chariot?" Meaning: are we reveling in a particular technology that we love, or did we really apply the best available technol-ogy to solve the real problem?

So one year, the gift that they made me was a beautifully crafted, stainless-steel-geared south-pointing chariot. I pulled it around and the pointer always pointed in the same direc-tion. It was a marvel to watch. Then they told me, "Dean, go squeeze that little jack-in-the-box on the pointer." I did, and out popped a doll of Albert Einstein with a compass pinned to his chest. And they said, "Dean, we want you to know that we really do listen to you. And though we love technology, we really do try to separate our love for the technology from the objective of bringing the best solution to the problem." DEKA's goal is not to build monuments to engineering. Our goal is to bring the best available solution to solve important problems. We use the lesson of the south-pointing chariot to help us keep our perspective.

The Segway is a beautiful piece of design and engineering, no doubt. However, it competes with some pretty simple and efficient alternatives, like scooters, bicycles, and walking. Do you ever won-der if, with the Segway, you created a modern-day south-pointing chariot?

I worry about this with every product we make. To me, a south-pointing chariot is any product

Caption TK

that, even when it was first conceived, was not the best solution to the problem. Right now, people use cars for most of their travel for anything beyond a few hundred yards. Most people that we know won't walk one or two miles to get somewhere — they just won't. To walk a couple of miles would take a half-hour to an hour, and we live in an era where time is compressed and so valuable. Over 50% of the car trips in the United States are less than three miles. The average speed within the city limits between any two points within the 20 largest cities of the world is less than 9 mph. Then why does everybody use his or her car to get around? Because walking is less than 2 mph!

So what if you could give people in cities an alternative to walking for distances greater than 100 yards and less than a few miles? People generally don't walk, because even in a congested city, walking is four times slower than taking a cab. But, what if they could get on a Segway and cruise from start to finish at 8 mph? That's the same speed at which a taxi travels. And, it's cost effective, energy efficient, environmentally friendly, and fun. In highly dense urbanized areas where buses and cars do not work well — they have only been used to fill the gap for lack of a good alternative — the Segway shines. I would argue that a car, when used in the city, is in fact a south-pointing chariot. If a better solution comes along in the next 20 years to address the rapidly worsening inner city transportation problem, then the Segway may become a south-pointing chariot. But so far, I have not seen a better solution.

So what about a bicycle? It is cheap, reliable, and inexpensive.

A bicycle cannot mix effectively in a congested pedestrian environment. It can't move at walking speeds with humans, then stop, back up, and spin around. I think bicycles are wonderful. And there are hundreds of millions of them out there. I don't think that they compete with the Segway because while they have many advantages at higher speeds and longer distances, they are poor at low speeds involving lots of stops and tight turns. By contrast, a Segway is designed to use the same infrastructure that pedestrians

use, occupy the same footprint as a pedestrian, be highly flexible, mobile and safe, while increasing the user's transportation efficiency 300-400%. I think that's pretty terrific.

The AutoSyringe, Segway, iBOT, Stirling generator — all of these products addressed nuances of problems that nobody else seemed to recognize. For example, the iBOT enables the wheelchair-bound to interact with people at eye level, traverse stairs and uneven terrain, and be remotely operated so that its owner can navigate it into a vehicle. How do you attain such a deep understanding of the problems you seek to solve?

I try to understand the basic laws of nature. Beyond this, I do very little research as to what the product should be. You would never get the iBOT by doing research on wheelchairs. If you do "product research," the product that you end up with will be similar to what already exists. For example, if you went out to people who make wheelchairs and said, "I want to make the next great improvement," they would typically conduct focus groups with people who use wheelchairs. And these wheelchair users, operating within the context of their existing wheelchairs, might ask for things like a new cup holder. They saw a great cup holder in a minivan, and realized that their wheelchair didn't have one. So they ask for a cup holder, or some other incremental improvement. So, you have to start with basic questions: if this person is now missing this amount of functionality, is there some alternative to a wheelchair that is both dramatically better and not prohibited by the laws of
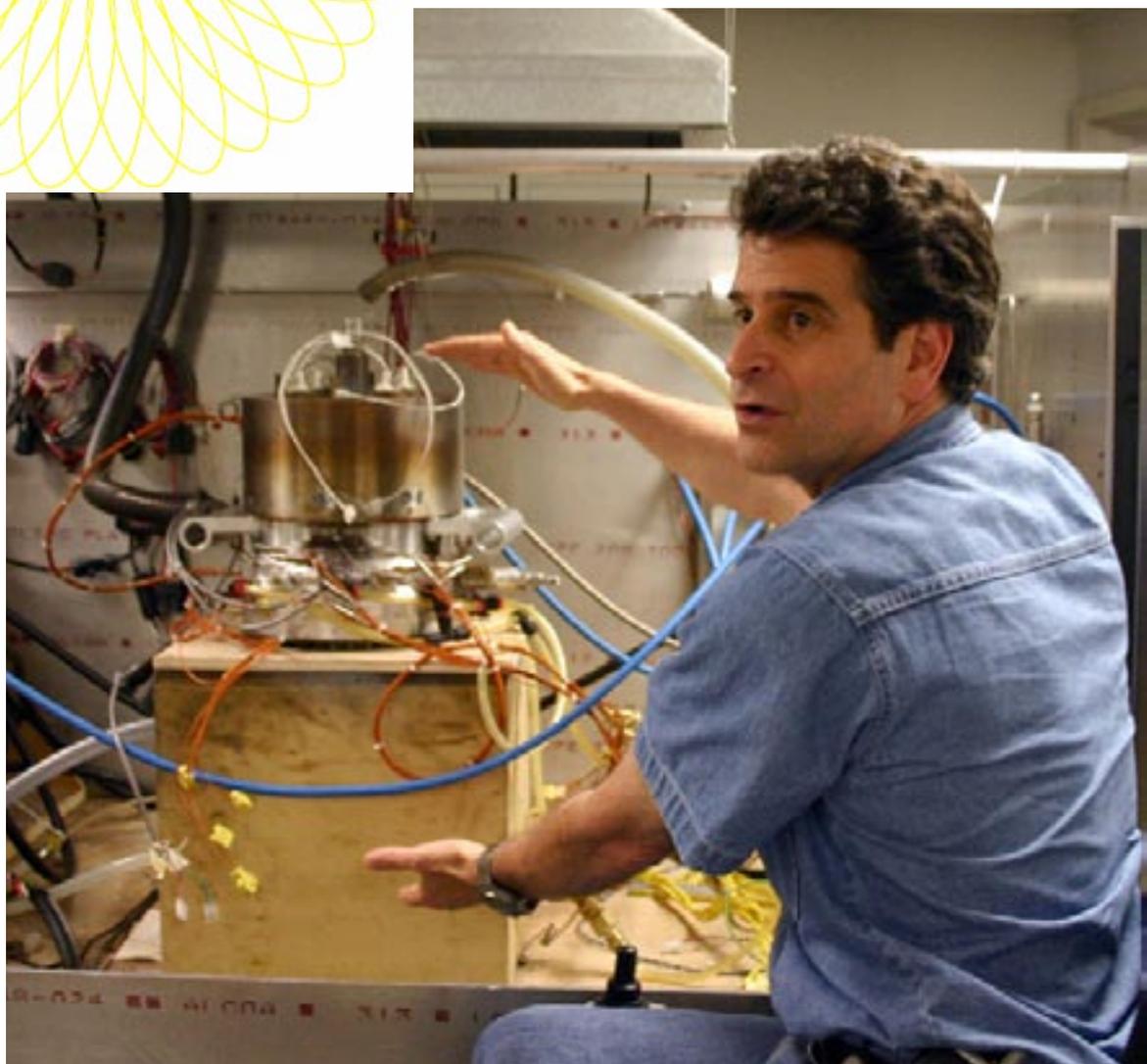
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"If I could ask God for one thing, I would ask for assurance that a problem is solvable given existing technology and tools and resources."

"I try to understand the basic laws of nature. Beyond this, I do very little research as to what a product should be."

physics and the current state of engineering and technology?

Focusing on the problem in this fundamental way allowed us to understand that wheelchair users need to have the same small footprint on the ground as you and I so they can navigate around areas and obstacles as we do. They need to have their eyes and hands at the same level as a standing person, so they can see over counters and get things down from shelves. They need to be able to get water out of a faucet. And so on. In order to achieve any of these things, we looked at how fully functioning humans do it. They do it by being dynamically stable — by constantly adjusting themselves to maintain balance. Balance is a prerequisite condition to living in a world that is architected by people who walk around balancing themselves. So we decided to forget about wheelchairs and focus on the real problem. The real problem isn't locomotion — wheels solve that problem fine. The real problem is that these people lost their ability to move around while also physically elevating themselves within a small footprint, which requires dynamic stability. Solving this problem would dramatically improve their lives.

Rumor has it that you don't sleep much. What keeps you up at night?
Not knowing if a problem is solvable. If I could ask God for one thing, it wouldn't be for a solution to a particular problem — that would make life boring. I would ask for assurance that a problem is solvable given existing technology, tools, and resources. I don't want answers or clues, just assurance that a problem is solvable. If I go to bed frustrated, it isn't because I didn't solve a problem; it's that

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I don't know whether we are chasing some windmill over the horizon or whether we are learning and making real progress. I get emotionally stuck between two conflicting lines of thought: [1] I shouldn't give up at this. Giving up is for people with no courage, no vision, and no conviction. You don't give up on an important problem — ever; and, [2] I have failed and failed and failed. Am I just being stubborn? Stupid? People are tired and frustrated. We don't seem to be making progress. Am I just not quitting because I am in denial?

Then I think back on past projects where we were very close to quitting, but we went just a little further and had a breakthrough. It really gives me a chill to think how close we were to quitting and what would have been lost. And then other times, we'd spend a year or two, spend a million dollars, and fail to solve a problem. I'd think to myself, "I should have quit over a year ago. I knew over a year ago that this wouldn't work. Look at the human misery and anxiety and energy we put into this to just shut it down. We could have shut it down over a year ago."

An unexpected success after you are that close to quitting really makes it hard to quit anything else. It's like trying to disprove the existence of aliens. You can't. So how can you prove to yourself that you can't do something? Especially because once in a while, one that you didn't think you could do, you do! It's that "once-in-a-while" event that distorts your judgment and perspective, so then you really start to second-guess yourself. For example, we are working on a system to bring potable water to 20% of the population of this planet. For sixty years, huge international organizations such as the World Bank and the United Nations have tried and failed at this. Yet, I think a few people here at DEKA can solve it. Part of me thinks, "You're nuts!" But another part of me thinks, "You can do this. The world needs this. Be courageous."

Read more of William Lidwell's interview with Dean Kamen at makezine.com/04/interview.