



THE HENRY FORD

COLLECTING INNOVATION TODAY

TRANSCRIPT OF A VIDEO ORAL HISTORY

INTERVIEW WITH

DEAN KAMEN

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BARRY HURD:

03:10:00;13

Dean, this is a house unlike most people have. It is part house, part museum, part lab. Tell us how it works for you and your lifestyle and your work.

DEAN KAMEN:

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Well, people have described this place as a cross between Willy Wonka's Chocolate Factory and a technology museum, both of those are right, but there's more to it than that. Besides having these beautiful, old machines that tell you an awful lot about people, it really doesn't tell you much about the technology since it's old. Well, I already knew that. When you look at old technology, you do learn a lot about the people of the time. You look at what they thought were important problems to solve. You can see where they put their passion and their energy.

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They're not only working machines, they're beautiful. The way in which they're beautiful shows where people put their energy. So, it's true that, in part, this place is a technology museum. It's true; it's a little Willy Wonka-ish,

but its got a really nice, well-equipped modern machine shop.

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Its got a nice, well-equipped electronic shop. Its got a great library. It's also a place where it's nice to be alone in the quiet to think and to work; because when I go off to my office, I got 300 astounding, brilliant, frenetically working people. When I'm there, I spend more time just trying to keep up with what they're doing. It's not a place where I can do my thinking. So, I like Westwind.

BARRY HURD:

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Okay. You mentioned before some of these things remind you of some of the people who've passed. Are there some of those people who are inspirations to you, either it could be parents, it could be other inventors? Tell us a little bit about people that might have molded you a little and what you believe.

DEAN KAMEN:

03:11:52;28

Well, I think like most people, I was probably more molded by my parents than by people that might have lived 100 or

200 or 300 or 2,000 years ago, but they all have an impact. One of my heroes is Archimedes, who lived 287 B.C.—212 B.C., or 2,200 years ago. But my parents certainly had a huge impact on me.

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My father was an artist. For a long time, when people asked if my father had a particular impact on my career choices, I'd always say, "No. We couldn't be more different. My father is an artist." Literally, he illustrated comics and then fine art. I said, "He's not into sophisticated mathematics. In fact, he couldn't balance a checkbook. That's my mother's job."

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I said, "He's not a business person. He's not a technology person. He's not a mathematical person." I really had very little in common with my father. As an adult, by the way, when I made that statements I believed it and don't think I'm misleading anybody, I was interviewed by somebody once who was an industrial psychologist from a major university.

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She said to me, "You don't really believe that, do you?" I said, "Well, you asked me the question." We were just starting an interview. She said, "Well, tell me about the impact of your father." I gave that answer. She said, "You do believe that." I said, "Yes. You don't?" I had met her for two minutes. She's never met my father. She said, "I did a little research. Your father was self-employed. From what I can tell, he worked seven days a week because he had passion for what he did. He spent his life being creative. It just so happens that his palette was paint and ink and pencil and paper. You are self-employed. My data shows me you've never had a job."

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I said, "You're right, I never did." "And you spend seven days a week working, according to what people tell me," she said. I said, "Yes, that's true." "And you create things. Your palette is mathematics or your palette is machines. But you are as similar to your father as anybody could be to one's father," she said.

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It astounded me in two ways. One, it seemed she's obviously right in some sense. The other was "how can I have not realized that for my entire life?" So, now when I am asked who has a large impact, I would say unwittingly and maybe unknowingly to me in that regard, it was my father. I always thought my father was a huge influence on me in the ways you learn from your parents, or at least I did, right from wrong, and ethics and hard work and how to be fair to people. I didn't realize that being a self-employed person who tries to create things and see whether the world will accept them or not makes my father and myself much closer than I thought.

BARRY HURD:

03:15:06;23

Do you remember when you were maybe a teenager or before, when you heard the calling of, "Let's put some pistons and gears together and reinvent the world?" Do you remember that? Can you tell us about that?

DEAN KAMEN:

03:15:19;24

Well, I would hate to disappoint anybody. I think it would

be more folklore than fact to say that there was one day or any moment at which I decided, "I'm going to be an, quote, 'inventor.'" In fact, to this day, I think about the fact that I'm a hard working guy looking at a bunch of problems, using technology as my tools and every once in a while, some of the output of what I and all of my smart people do ends up being a product that people need.

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It ends up, in some cases, being called an invention. But folklore aside, I never got up in the morning and said, "I'm gonna be an inventor." I've never to this day gone to work and said, "Oh, 9:00, review this, 10:00, check on that, 10:30, have brilliant idea." I have never thought that being an inventor can be an occupation. Having an invention is a rare consequence that every once in a while happens after lots and lots of work on some specific problem that you've been trying to solve.

BARRY HURD:

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But when you were a teenager, you invented something for a planetarium?

BARRY HURD:

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What made you think of that?

DEAN KAMEN:

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Again, folklore could easily say in my early days when I started building these audio-visual systems like for the Museum of Natural History in New York, I got up in the morning and said, "I'm going to invent that." The truth be told, I'd gotten to the age, the magic age when you're just about old enough to drive a car.

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But I didn't have enough money to buy a car. All my friends were out getting summer jobs, cutting lawns or painting houses, to try to make enough money to buy their car. I figured I'd do the same thing. I went to some business, a manufacturing place in town, walked in the front door in the beginning of the summer and realized I can't just take a job. Maybe it was the impact of my father.

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I don't want to go to a place and give up a whole day to do

something that I wouldn't have done unless someone was paying me money. I have to do things I want to do. I started thinking, "What can I do that I want to do, but also get enough money to get a car?" I remember a guy telling me he had started a business.

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He was older than I was, but not a lot older. He was a creative guy and he was doing slideshows. They were getting bigger and bigger and more multi-screen slideshows. His problem was as they got bigger and more complex, projecting them and synchronizing and organizing the images from essentially slide projectors was becoming problematic.

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He was using relays, electrical relays, and little mechanical devices to synchronize these things. With all these relays and mechanical devices and slide projectors, it was just a nightmare for him. The limit imposed by the technology available was crimping his artistic style. So, I called him and said, "You know, electronics ought to be able to

replace all those relays." I wasn't as sophisticated with electronics.

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I wasn't doing very complex amplifiers, but just a transistor as a switch. Use the transistor to do this instead of that, instead of a big, mechanical relay I thought I could do. I said, "We could synchronize what you're doing with music. We could do that electronically. We could make the things happen without mechanical relays. We can do that electronically. I could build you a box to do this," which I thought would be a fun, challenging job.

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If I did it, it would have to be worth a lot to this guy. Although I wasn't much of a businessman, I knew that these big relays, besides being power hungry and unreliable, were expensive. He needed dozens of them. Even back then, you could go to Radio Shack and buy a dozen transistors for a couple of bucks. So, instead of getting a job like all my friends, I went into my parents' basement and I just worked around the clock trying to

build electronic systems to control these audio-visual pieces of hardware this guy was using.

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The summer was nearly over. I had spent about all the money I had, which was almost 200 bucks. I was pretty much tapped out at Radio Shack and elsewhere. I thought I was close, but the machine wasn't exactly working. All of my friends had made a little money. All I had done was spend a little money.

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I was very tired having worked a very long summer. It wasn't looking good. I finally got this thing put together. I took it to show him. It worked perfectly. He was incredibly enthusiastic. We took it to the Museum of Natural History and put it into the great hall there where they do their stuff. The guy that runs the museum said, "Yes, I'll buy this."

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He asked me how much it would be. I hadn't thought about that part, but the one thing I knew was a brand-new

Mustang, a 1960-something, I don't remember the year now, but a brand-new car, their base price was \$1,995. It was under \$2,000. So, I said, \$2,000. In retrospect, it might still have been a brilliant number.

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My guess is they would've paid a multiple of that, but I remember distinctly saying, "\$2,000," then realizing I should've said more because he's gonna want to negotiate. No, no. He just looked right and he said, "It's a deal, except for one thing." So, here it comes. I got to kill somebody. He said, "Except for one thing. I need three more, because we work in concert with the Chicago Museum of Science and Industry and the Baltimore Planetarium." I'm thinking okay, so he wants four of them for \$2,000.

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Well, it was a lot work to do it, but they cost a couple of hundred dollars apiece. If I have to build four, I'll still have made \$1,000. I'm thinking what to say. He says, "I need four of them. You can't raise the price on the other

three." I'm thinking, "Did I just walk in here and I have now been offered essentially \$8,000," which was probably more than my mother earned as a teacher in that year?

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I looked at him and said, "Okay." I tried to stay calm. I tried to not glow red. We shook hands and I left. I went home. I couldn't sleep. I went out and I bought all the parts. I went around the clock for a couple days and I built four of these boxes. Then I realized I can't run back and give it to them now because he'll think it was too easy. I had one more week before the end of the summer.

DEAN KAMEN:

03:22:58;00

I built them up. I was about to run back with them and realized again, now in hindsight stupidly, I realized, "Oh, if I show up in just three days with these other units, he'll think he was taken." I had one more week of the summer. So, I figured I'll just sit on them. I bit my tongue and I waited a week. I went back into the city, into New York, delivered all the units, got paid, had all this money and immediately took it to just buy equipment, more.

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I used to have a volt meter and a little oscilloscope and a little table with some stuff. Suddenly I had all this money. So, I converted my parents' basement into a little shop. I bought the best electronics I could get. Then I bought a little lathe and a little milling machine. I set up this little shop under their house. For the next few years, I was just building variations of that equipment, because once it got used, people could see it. They'd want it and because of word of mouth, I'd sell more of it.

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I was making enough money that I just kept buying more equipment. Then my older brother, who's a brilliant guy, an MD PhD student at the time, he's a pediatric hematologist and oncologist, he was working on nothing short of trying to cure leukemia in babies.

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He'd come home on the weekends from med school and from his PhD program where he was developing these new drug therapies, and said, "Dean, these babies, they're

preemies. They weigh two and three pounds. I use these ridiculous pieces of hardware that are meant to put fluids into full-size adults. I need tiny, tiny, tiny drug delivery systems to treat these babies." So, I'd get down in the basement and I'd try to make something' that he could use. I spent months of nights and weekends. I'd use the money I was making from my audio-visual business to buy stuff and make stuff for his medical needs.

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I built them and he started using them. They started working. He started lending them to his professors. It's good for a med student to be able to say, "Look at this." Frankly, I can only make a few a week and that was all they needed. These were very, very special, and thank goodness, rare conditions, fortunately, little babies with cancer are rare.

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So, it wasn't that I didn't do this to be a big business. We didn't intend it to be a big business. I was helping my brother and supplying something they needed for these

really sick kids. Some time after that, my brother, he had been at Harvard for awhile as a guest resident and a student. Then he's down at Yale as a professor in their medical school. He goes off to Yale.

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One of the doctors there said to him, "That's such a tiny little thing. I realize it's so tiny that you can put it into these isolates. You can put it with these babies for these rare diseases, but that thing is so small, you could put it in your pocket if you're a full-size adult and walk around getting a drug instead of lying in bed. I've got patients that need drugs around the clock for a long time, maybe for the rest of their lives. They're called diabetics."

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My brother calls me and said this doctor wants to see me, and talked about this. There I am sitting and thinking, "Yesterday, this technology was being used for about the most rare condition you could imagine and today I'm hearing that if I could modify it, make a slightly different version of the hardware and a very different version of the

control system, I might be able to make something that probably could help about the most common chronic-need population in terms of drug delivery."

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So of course, I run home and start making what later became, it took me a couple of years, but later became the first AutoSyringe insulin pump. Unlike our other stuff, that was a very, very large market. We eventually sold the entire business and manufacturing of that to one of the major medical products and pharmaceutical giants in the world.

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Then I said, "You know, it was a lot of time and a lot of work to build up a whole company, to do the marketing, to do the selling, to do all you have to do. I'm glad we sold it." Now, I saw it was like when I was in the basement. I got that first \$8,000. Just buy all sorts of neat stuff so you can do more. Well, now I had made a lot more money than that. I could buy an old mill and fill it up with the world's best prototyping equipment and hire the best

technology people in the world and say, "Let's focus on doing the really important front-end stuff that we can get better and better at.

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Let's figure out how to take the problems that the medical community can articulate and figure out better ways than they're currently doing, better technologies that they're currently using to solve those problems. But instead of building a whole company as we had done with the pumps, we'll just go back to these big companies that are already capable with global reach to get to the markets and the global manufacturing.

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So, let's just build a new company, but we will focus on the front end of innovation, the front end of showing them what's possible. Then we'll work with them to turn our ideas and technologies into products, and let them go build them for the world. That's what big companies are good at. That's how they got big. I'll go back and focus on the next new problem and we'll stay small and focused. We'll

design products for people." We have been doing that for 30 years.

BARRY HURD:

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It's an amazing story, but there's one thing that you didn't touch on. How did you learn how to do all this stuff? You said you went in the basement. I already got that part, and you walked down the stairs, but then you just intuitively knew? Did you read books? Your dad was an artist. He wasn't showing you.

DEAN KAMEN:

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No.

BARRY HURD:

03:28:41;26

Your mom did the checkbook.

DEAN KAMEN:

03:28:43;04

That's a very good question, actually, because, again, not to debunk folklore, I don't think I did know how to do it. That's why I found 50 ways that didn't work, and sometimes 100 ways that didn't work. Maybe it would sound arrogant if I said, "Oh, I just went down to the basement and did it."

03:29:02;00

I don't think I ever walked down those stairs saying, "I know how to do this. I'll just do that, here's the beginning, here's the end. I'll draw a straight line between them." I think history books always explain it that way. In fact, as you point that out, I can tell you I was very disappointed as I finally grew up and realized that all books have to be efficient.

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They tell you a problem. They tell you the answer. Maybe I never thought about it, but in my early days, I must have believed that Isaac Newton got up one morning. Even though it's 400 years later, we still know, Newton's second law "F equals MA." Wow, 400 years later, this brilliant, elegant simple equation, Newton's Law, but I don't think he got up one morning and said, "F equals MB, oh, no. F equals M no. F equals MD, no. F equals MA. Yeah, I like that one. F equals MA, I want to be famous." I don't think it happened that way.

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Then you go back and you don't read the physics textbook which has every subject known to man in it, so they devote one paragraph to Newton's Law which ends with, "and therefore, F equals MA ." You think, "wow, he must have been a genius, one paragraph." Now, I've come to realize, wow, he probably was a genius, undoubtedly, one of the great geniuses of all time.

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I'm certainly not. Then you read his book *Principia*, and you realize it isn't a paragraph. It took him ten or 15 years to do most of the great things he did. You're thinking, "Oh. So, one of the great geniuses of all time spent ten or 15 years obsessed with a problem that finally, in the end, could be reduced to this brilliantly elegant, simple statement: F equals MA . It works where the M , the mass you're accelerating is a galaxy being pulled by another galaxy, is an electron. It works as a scale from the sub-microscopic to the galactic."

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Yet, it's this brilliantly, elegant, simple statement. As I

said, I've now come to believe it wasn't only something even that great genius thought of in one minute or one hour. He was obsessed with it through most of his life. When I walk down to the basement to solve the problem, it's not like, "I'll go down and solve the problem."

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You go and you tinker. Well, its got to be this. Its got to be small. I need some energy source. Should I use a battery? Should I use a spring? Should I make it mechanical? Should I make it electrical? Let me put a syringe on there. Let me use a pneumatic cylinder. Let me put the drugs in something besides a syringe. So, you play with it and you play with it and this thing starts to look pretty good. That one looks really stupid. This electronics might work. That electronics, forget about it. Slowly, different pieces spread around over months.

BARRY HURD:

04:00:54;04

So you're saying you really didn't know how to do this, but it was kind of like you were trying to solve a puzzle? Tell me about that.

DEAN KAMEN:

04:00:59;11

Yeah, I think the puzzle analogy is a very, very good analogy. You don't go to a textbook, read a textbook and then when you're done pull all the puzzle parts out because you read a textbook. You know how to take this piece, put it in the corner, put the next one, the next one, the next one, next one. Then you're done by taking the last piece, picking it up and putting it there. Nobody would believe you could read the textbook on how to solve a puzzle and then go take the thousand pieces and do that. That's a very good analogy. You're sitting there with all these issues and all these constraints and you're trying to figure out how to, let's say in the case of a little drug delivery system, be this small.

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Its got to hold this amount of drug. Its got to deliver this accurately. It can't be connected to the power station outside the isolate. You need certain controls. So you know these are the goals. You know these are the constraints. Should it be electrical? Should it be

mechanical? Should it be electronic? Pneumatic?
Hydraulic?

04:02:06;09

Are you gonna program it with a mechanical system?
Should it be preprogrammed? When I first started, there weren't microprocessors. So it's not like you went down and started to do something that you later finished, you went from A to B. It's more like you went down and over a period of days or weeks or months you ended up literally with a spaghetti ball. You don't know where the beginning and end of any of that stuff is.

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You just don't know where it starts. You don't know where it ends. But in the end, you were here, you were there. When history writes it, they want to devote a paragraph to it. They don't want to spend the same four months around the clock you did. So they say you started here. They show that you finished there. The stuff in the middle doesn't matter.

BARRY HURD:

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Okay, this may be a tricky question.

DEAN KAMEN:

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Right.

BARRY HURD:

04:03:08;08

Can you take us inside how you're feeling and thinking when you're actually there doing that puzzle, when you're innovating, when you're inventing, when you're discovering? Is there something driving you? Are you hearing a voice? Is it just like being hungry? What's that feeling inside Dean Kamen when he's working like that?

DEAN KAMEN:

04:03:27;15

That's another very good question. I think when I'm working at a problem, you've got this problem as opposed to the things you sort of know how to do, it's a task, it might even be a fun task, skiing down the side of the hill. That's a task, but it's a fun task. You know how to do it.

04:03:42;02

I think when you're really looking at the problem and you don't yet know how to do it, you really have two moods and you go between them almost instantly. The two

moods are frustration and fear versus exhilaration, because you keep trying and it's not working and you're afraid you won't get it. Then you get more frustrated. Then you think you got it and you're just exhilarated.

04:04:08;11

Then, "That won't work, you idiot, and you thought of that three days ago. Don't you remember that one?" So you go around and you're constantly banging between the fear of failure, the frustration that it's not getting anywhere, you're wasting more time, and then, but what if in the next minute it'll come to you?

04:04:28;09

Since it's never linear it's not like I did a little and a little and a little and I got; never does the new thing happen by the sum of a bunch of little things. That's why you can't learn how to do it. The new thing happens because this isn't working, this isn't working. I put them together. "Wait a minute! Why don't we just do this?" That might work. The trouble is, "Wait a minute! I might do this." Ninety-nine times that won't work either.

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But finally when, "Wait a minute! This might work," and it does, then a week later you're working on all the details that'll take you the next two years to deliver, somebody says, "What made you think of that?" You don't know. It was only a week ago. You still don't know. You think, "Well, that day I was thinking about these other three ideas and they were pretty dumb. They were unrelated to that. They're really dumb. And suddenly..." Well, what do you mean suddenly? You don't know what you mean suddenly.

04:05:16;28

It's just you went from frustration to exhilaration because you said, "That might work and nobody's ever done it that way before. I've never seen anything like that. But why isn't that way better? What if that'll really work?" Then you spend a lot of time and a lot of effort. Again, the folklore is it's easy.

04:05:35;22

But typically it's a lot of time and a lot of effort once

you've had the good idea. You remember all the time and the effort that you put into it, but the instant before the good idea to the instant after the good idea is a blank space filled with exhilaration that you don't know how you crossed that chasm.

BARRY HURD:

04:05:55;05

Have you ever thought about this, if not for your brother's need for the leukemia babies at that time, might your talents be gone on; you'd be building cars or something you'd probably do that, but even so you see what I am saying?

DEAN KAMEN:

04:06:05;11

Oh yeah.

BARRY HURD:

04:06:05;14

...something else. Or, have you just not thought about that?

DEAN KAMEN:

04:06:08;19

Well, I think even more generically than, "Did I ever wonder that if Bart, my brother, didn't need the pump would I have done something else? Would it have been

better, worse?" I once heard somebody say, and I think it was in one of the scriptures, "Man makes plans and God laughs."

04:06:32;05

I think the idea that anybody goes back in their life and explains what their plan was and how they got here is either kidding you or kidding themselves. People need to seize opportunities and many people don't. People need to work hard and stay focused to succeed, and many people won't.

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So there are attributes that these people that are successful have. Typically it's that they work hard and they stay focused and they know how to deal with failure and they know how to keep themselves going when most people would get tired or distracted. So, yes, I think people can plan and people have certain traits that will make them successful.

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But when they look back and, again, make that nice, neat

line between A and B, and you say, "Well, what if you didn't meet this person," or, "What if that didn't happen," I think it is highly unlikely, in my mind, that most people, as adults, end up doing things that weren't substantially impacted by chance, happenstance, the intersection of an interesting opportunity and the fact that they were open and accessible at that moment.

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It can't be that all young adults happen to fall in love and get married to the one and only person that's perfect for them. But it always happens just about the time they're ready to move out of their parents' house and go to school or work or something. I mean, I'm not a fatalist.

04:07:59;00

I would not pretend to you that I had a plan to start a medical products company and then later do other things and later do other things. What I would tell you is that I try to stay focused on a couple a simple facts. Life is short. Don't waste any of it. Work hard every day. Be open to new ideas. Sometimes, if that new idea, whether

it's a need for something or the new idea is a way to solve a problem that you heard of yesterday or a week ago or a year ago, but being willing to work hard and stay focused on only doing things that matter.

04:08:42;28

Because life really is short is the reason that I think I do most of what I do. You know, people say to me, "What does building water machines or Stirling engines have to do with building drug delivery systems? What does any of that have to do with running your first program for kids? They couldn't be more different." Really? They couldn't be more the same to me. "How are they the same?" They're all important.

04:09:08;21

They all have the potential to give people better lives, whether this person needs a drug delivered or that person in the village needs water for her kids or this kid in some city in the United States really believes he or she's gonna grow up and be a success because they can bounce a ball. At the end of the day, I go to bed tired because I worked

hard.

04:09:36;29

But if I think I'm going to bed good tired because the stuff I worked on all mattered, I'm happy tired. If I go to bed thinking I wasted time, I did something stupid, it didn't matter even if it worked, I'd still go to bed tired because I'm an intense guy. But I'd go to bed frustrated tired, because I don't get that time back.

04:09:59;00

So my decisions as what I do are pretty much driven by not will it work or not. I typically don't know if it'll work, because if you knew it would work, why waste your time? Somebody will do this. If you knew it would work, it's boring. If you knew it would work, it couldn't be a big deal. So I make decisions, not based on, "I know it can work." I make my decision based on, "If it could work, would it be a really big deal? Is it worth taking this much time and effort and energy and risk trying to do that because if we succeed it'll really be a big deal?"

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If it looks like it would really be a big deal, and we might have enough smart people around and enough technology around and we can access a shot at this, we try it. Sometimes we succeed. That just gives us more energy and more resources to try another one. If we fail, we tried.

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If I were given the choice of failing at trying to do something really big or succeeding at something that's no big deal, I'd much rather go down in a ball of flames than die the warm death of mediocrity. I just can't see it. I mean, we're all gonna end up in the same place. So while you've got the energy, try to do the big stuff.

BARRY HURD:

04:11:56;20

Let's just talk about innovation in general. That's sort of one of the themes that we're exploring here. When you think of innovation, what do you think of? What's your sort of definition or your take on that?

DEAN KAMEN:

04:12:07;04

Well, the first thing I'd tell you is having thought about it a

lot and been asked about innovation a lot, I've realized that most people don't make a huge distinction between two very important things: invention and innovation. In many ways they couldn't be more different.

04:12:27;08

When I started inventing things, by the definition of a patent office, first patent I got was three million something. The most recent patent I got started with a seven, seven million something. In my relatively brief lifetime, I don't think there have been four million innovations. Inventions, by the way, or patents, are only a small subset of what inventions are.

04:12:54;02

If there were three million of those patents out before I started and then there's now seven million, not only have there not been four million innovations, but it's hard to believe that there has been more invention in this short period than there was in all of history. So what I would tell you is an invention is a new, unique, different way to address a problem, either with a thing or a method or a

process. A new way to do something is an invention.

04:13:28;03

An innovation is something that is so important to people that they are willing to give up the way they used to do something to do it in a new, different way. An innovation changes the way people live or think or work or understand the world they live in. An innovation is very, very hard, even if the invention might have been great, because the one thing people don't like to do is change.

04:13:58;28

Even when the situation's bad, most people are very reluctant to change. They're very reluctant to give up what they know. If you ask me about innovation, it's rare. You know? Fire, the wheel, movable type, the TV clicker. In modern times invention is all around us and innovation is getting rarer. The frustration to me is that invention is happening at a more accelerated pace, like, Moore's Law that tells you processors are doubling every 18 months.

04:14:39;20

Technology is moving faster and faster and faster and

faster, but people are becoming more and more conservative. They're becoming more and more leery of technology. They're becoming more and more concerned about the potentially unintended consequences of what's around them. Frankly, we're all just getting older, and older people, like older cultures, are reluctant to change.

04:15:11;01

So when you ask me about, what do I think of innovation, that's very different than what I think about invention. Innovation is once you got the invention, what do you do so that society will collectively embrace it and be willing to give up what they used to do to do something differently? If you can have both a good invention and be persuasive enough, where that invention is just so powerful in what it offers that people are willing to do this huge thing called change, that change, in retrospect, becomes known as innovation.

BARRY HURD:

04:15:48;26

So it's almost a loop back. Yeah. I'm not sure whether to call them innovation or inventions as you defined it.

Starting with this iBOT, tell us what that was and how that came to be. Was that somebody came to you and needed or that? Or was that just a...

DEAN KAMEN:

04:16:03;06

No. The iBOT actually was one of the projects that was internally generated by us, the folks at DEKA. I happened to see a guy struggling to get up a curb one time to go into a very modern environment that we all take for granted, a shopping mall. It's pretty much one level. It ought to be no problem for somebody in a wheelchair.

04:16:26;15

But getting up the curb to get in was a problem. I watched him inside. It was a problem that he couldn't reach high things. I happened to see him again at the end of my visit to the mall, where I was stopping in for a good well-balanced dinner of an ice cream cone at the food court. There was this guy at the same counter, but it was a counter height ice cream stand.

04:16:50;16

This guy couldn't go through the interaction and the

transaction. I left there thinking, "I can jump in my helicopter, as a result of its technology, and do pirouettes off the roof of my building and fly home in a couple of minutes and land on a little car." That's what the 21st Century makes relatively easy and safe. Yet a guy that can't walk, can't access in a meaningful way a shopping mall, he can't buy an ice cream cone, it seemed absurd to me. I went home that night thinking, "With all the technology from gyro stabilized autopilots to the kinds of stuff we put in modern transportation devices, how can it be there's nothing out there that can help this guy who's pushing himself around? His eyeballs are at 37 inches. How could it be that there's nothing better than that?" I decided we'd work on it.

BARRY HURD:

04:17:55;17

How long did it take before you had one that actually raised a guy up to get his ice cream?

DEAN KAMEN:

04:18:01;26

That project was one of those, "Wow, looks easy but is hard" projects. There are some projects that look hard

and when you actually do them, wasn't so bad. This wasn't one of those. Understanding human balance, figuring out how to emulate human balance was really hard.

04:18:22;10

Then you think back and you say, "Every mother I know, every mother I know remembers two things about their kids: their first steps and their first words." Being able to stand up and balance, being dynamically stabilized is uniquely human, and extremely hard to do. It takes you a couple years to do it as a kid.

04:18:46;09

Using the technology that was available when we started that project, the processing capability, the quality of the gyros, it was way harder than we thought to build a reliable control system to keep somebody balanced.

BARRY HURD:

04:19:03;28

Now when you're starting that motivation, the story you told us about the guy trying to get the ice cream, were you also thinking, "This could be a commercial success"? At

what point is the goal of, you know, return on investment, as we say, drive the process?

DEAN KAMEN:

04:19:21;03

Well, that's a very fair question, but I don't think anybody's ever accused me of being a really good businessman. I can't think ever of starting a project by working backwards from, "Here's a really big business opportunity and if I can do this I'll make a lot of money."

04:19:38;29

I don't think I've ever started a project. That is not to say I'm not a capitalist. Profit is not a four-letter word. In fact, I would go further and say I'm a dyed in the wool capitalist and I think profit is essential. It's the stuff that gives you the freedom to do the stuff we do. It assures your independence. It's a way of using the Darwinian process of business to weed out the bad and reward the good.

04:20:07;23

I am a big believer in profit and capitalism, but I have never started a project by first starting with, "Here's how I

can make a profit." We look at a problem. We spend a lot of time figuring out, "Can we solve this problem? Is there any technology or any new approach or any different way to look at this problem and come to a better solution than what's out there?"

04:20:32;25

If, and only if, we actually get to, "Yes, we think we have one," then we look at it and say, "Okay, how can we do this project in such a way that it doesn't end up as a science fair project somewhere?" It has to end up fitting into a sustainable model by which you can do this, you can make it available on such a basis that after people have paid the actual cost of making it available, there is enough money left over that you can continue to do it and redo it and make a profit and supply more of them.

04:21:06;26

But to me, that's a separate process. Sadly, I guess people can differ on this point, I think a lot of people in modern business environments do what I think you were suggesting, which is they deal with the two questions

separately. "Is there a better solution to this problem?" and then, "How can I make money delivering it?"

04:21:33;11

I think people can go to a business school and learn how to make more money doing something and then figure out, "Is it even solving a problem?" If you walk through the average shopping mall today and maybe, again, you and I could differ on this, I can't help but walk through these places full of commercial junk and be somewhat depressed by some of it. You walk by some of these windows and it's beautiful boxes, brightly-colored, with some plastic toy or something in it.

04:22:11;04

You look at it and I can't help but say, "Some really creative artist made that box look so attractive it caught my eye. Some really good tool maker worked to make the thing inside that box. Some substantial company put enough resources into making the tooling to make, obviously millions of these things, because you can buy the whole thing for \$9.99, and there it sits. Somebody

made it, moved it, and put it in this store." I look at it and say, "Why? What about this thing makes the world a better place? What problem is this thing solving?"

04:22:53;02

I look at a lot of the stuff that I see commercially available and think, "What really smart, passionate, focused person would waste his or her time getting to this result?" I sometimes feel like, "Who am I to be judgmental about that?" But I can't help it. I feel that way when I see so much junk in the world, as opposed to the fact that there's so much need in the world. You could make lots of people really happy and healthy if you focused on solving the right problems.

BARRY HURD:

04:23:41;16

Let's talk a little bit about DEKA. We know where the name comes from. When you go down there, is your role different? Or can you tinker and innovate?

DEAN KAMEN:

04:23:48;12

No.

BARRY HURD:

04:23:49;04

You got all these people. Tell me a little bit about what you do and how you corral them down there and keep them working.

DEAN KAMEN:

04:23:55;16

Well, I'll debunk myth number 27. I don't manage DEKA. In fact, I don't let anybody else manage DEKA. In fact, the few times people at DEKA have moved in the direction of becoming what looks to most companies like management, we've redirected them, well, recommended that they find a place that wants good managers.

04:24:19;22

You can manage a schedule. You can manage a budget. You can manage resources. There are a lot of things you have to manage. I'm not naive enough to think everybody's gonna show up and know what to do and how to do it, but you can't manage people.

04:24:37;16

You can lead people. You can make sure that we share the same vision and we're trying to go to the same destination. But if you have to tell a person how to do

something, you've probably failed either in selecting the wrong person, or you've failed in not giving them enough insight about what the goal is, or you've failed in not giving them enough tools to accomplish that goal.

04:25:04;16

If you've got the right people and they are properly motivated and understand the goal you don't manage people. I think most big organizations spend a lot of time trying to do that, which is why a lot of people are frustrated. They don't want to be managed. It's also why I think a lot of good things don't get done, because the people that should be doing things are instead managing other people that probably can't do them as well.

04:25:36;18

So I work hard at preventing systems from replacing judgment. People always ask whether we have a policy on this or a policy on that. Again, I look at big organizations. They seem to have policies about everything. It's to prevent anybody from ever either having to take responsibility for a decision or somebody from feeling like

they weren't being treated equally. I don't think you should treat people equally. People aren't equal. People don't want to be treated equally deep down.

04:26:16;20

Everybody's different and wants to be treated as an individual. I think you need to treat everybody fairly. But if somebody's got enormous seniority and a lot of judgment and a lot of experience, and that person comes and says, "I want to do this or this or this," I think it's perfectly reasonable that your response is wholly different than if a young kid with very little experience and not very much judgment comes in with exactly the same question or expectation.

04:26:43;06

So I don't think we should candy-coat the idea that people are different. They're individuals. They ought to be treated that way. At DEKA, in fact, I look for the people that are individuals, that don't fit a mold. I don't care if somebody's an A+ student, the unique one that was the valedictorian, and whether they got there because they're

just fundamentally brilliant, or, "Man, this person really, really worked hard."

04:27:13;00

I don't care. That's an A+, that's an unusual person. I'll take that A+. I'll take the kids that dropped out of school. They're equally unique and equally valuable to me. They come up with equally unique ways to look at things. The people I don't have are all the people that sat through class and got a B and then went about doing whatever else they want to do with their life, because their grades and their job, it's just a career. It's just a job. It's just a course. I don't have any of those people.

04:27:43;00

I have very passionate people that are very different from each other. Most of them are quirky. Most of them have some unique, very, very valuable insight, and skill. Most of them have some unique failing that would make it difficult for them to succeed in an environment which most companies and cultures have which wants to make sure everybody fits in that place in the middle and acts like

everybody else.

04:28:14;27

So you walk around the halls of DEKA and you'll find some pretty quirky people who do things in some pretty unusual ways that might not be well accepted in some other organization, but it's why DEKA comes to uniquely different solutions to problems that other people have worked on for many years.

BARRY HURD:

04:28:38;28

How do you find these people? Do you put "quirky" in the newspaper?

DEAN KAMEN:

04:28:42;10

Well, actually, in the early days of DEKA, it was hard to find people that would fit in an environment where we expect people to be self-motivated, where they're not gonna have somebody giving them direction and patting them on the head and telling, "This is good," and telling, "This is bad."

04:28:59;28

A lot of people say, "I want to be an entrepreneur. I want

to be an individual." Most kids grew up and very quickly learned to expect support from Mom and Dad, to get a gold star from a teacher, to get a little ribbon from the scout leader. Most people need constant reinforcement of one kind or another. Most people like to be led. Most people like to be bounded.

04:29:27;29

That's fine. But if you really, really want people that are self-confident that know that you gotta have a thick skin at DEKA because people are gonna take shots at your ideas, not at you, but at your ideas, you end up with a very, I think, healthy, but significant, tension in the environment. In the early days of DEKA as we collected people like that, I'm not even sure I was doing it knowingly, it's just that's the kind of person that I attract and the company started to grow.

04:30:10;23

When you have a few people like that, you can be a referee. As you start getting a few more people, it gets a little harder. But to your question, how do I find them, the

good news is, once DEKA got a little bit bigger than when I was trying to be directly involved in every project, it also started developing a reputation among the schools, among places. Right now, I'm happy to tell you, I don't think we really work hard at finding the unusual quirky people, because they all work hard at finding DEKA.

04:30:41;28

We bring people in for what's now become famously known as a whiteboard session. They all come in. It really doesn't matter whether his or her resume says Ph.D. from MIT or Cal Tech or Stanford or, "I worked on my uncle's farm." It doesn't matter. They come in. We listen to what they believe their unique skill sets are. We talk to them about what we think our needs are. We put them at a whiteboard and start asking them questions. Most of the time, the questions don't even have answers.

BARRY HURD:

05:00:38;23

I'd like you to say that thing again, until just recently you actually were the human resource department or whatever.

DEAN KAMEN:

05:00:45;03

Well, until relatively recently, I certainly tried to be involved in all the whiteboard sessions. Again, in a whiteboard session, we're not determining does this person have the education or the skill sets to do a particular job? Because I believe, especially these days in technology, skill sets are valuable for about six months, and then they're not.

05:01:09;12

If you need to be educated about a particular task, you'll get educated about it. We're big believers in keeping people in getting education. So, the whiteboard session, the questions aren't ones that have an answer. They're not ones for which we're determining a skill set. We'll ask questions of people to see how do they go about solving a problem?

05:01:34;28

Then when somebody in the room suggests a different alternative, are they receptive? Are they belligerent? If we think they're wrong, are they defensive or will they

passionately stick to their opinion? If they passionately stick to it, they can convince us there's some merit to it or does one side or the other appropriately, after all has been said, agree that we've learned a little and move on?

05:02:02;13

You can learn a lot in an open-ended discussion about problems to which nobody knows the answer. We do a lot of that. I have tried to be in pretty much every whiteboard session. But now with over 300 people, it's getting hard and it worries me.

BARRY HURD:

05:02:24;20

Do you walk up and down the hall and say, "Who's that? Does he work here?"

DEAN KAMEN:

05:02:28;17

I do and that really worries me. The good news is, just as I said, I don't have to go looking for the quirky, unusual people. They find us. I think the good news is while I can't be involved in a lot of what goes on there personally, I think the culture that's now been around there for more than 25 years is very palpably different than the culture in

a lot of organizations, whether they be companies or schools.

05:02:58;00

The culture really does respect, foster, and almost mandate that people will be self-motivated. They will set their own high standards, they will be their own task master. Most of the people that are there who literally see it as their hobby, and they expect everybody else around them to support them with the same kinda passion you support your friends with when you're doing some hobby activity. If somebody happens to slip through the net and becomes part of the organization, and treats it like a job, and they go home, I think the peer pressure ends up very quickly leading to a condition where that person will decide they want to move on.

BARRY HURD:

05:03:45;18

Now let me say, was the iBOT a DEKA product?

DEAN KAMEN:

05:03:48;07

Yes.

BARRY HURD:

05:03:48;16

Okay. You probably talked about this a million times, and we gotta ask you. The Segway, was that an offshoot of the iBOT?

DEAN KAMEN:

05:03:55;09

Yeah.

BARRY HURD:

05:03:55;09

It was the most promoted big idea. I don't even have to ask you. Just take us through that a little bit.

DEAN KAMEN:

05:04:02;14

There's nothing to take you through. We spent many, many years understanding human balance for the sole purpose of making an iBOT to help the disabled community. We were nearly done with what we thought was the tough work. We can make human balance do this.

05:04:21;19

The hard part of the iBOT, besides the fact that doing all the controls work was done first, the hard part was not just balancing on level ground, but when it gets to the stairs, it has to stay balancing while, what we call clusters, it literally switches its balance from one set of wheels to

the other, as it walks up and down the stairs, still balancing all the while. If you take the cluster off that thing, and you take the seat off it, and just put the platform down low and stand on it, using essentially the same balancing and control algorithms, wow, an able-bodied person could do this. It's fun. It was almost like the weekend fun abuse of this really difficult problem solving process for the iBOT. But it was one of the few things that we made that was actually fun.

05:05:13;12

I am very proud of our dialysis machines that we made a home unit that could sit by your bed and allow you to have the dignity and the quality of life of somebody that can plug themselves in without being in a center somewhere and do it every day instead of every other day, because you can do it cost effectively. You can do it at home, and you can feel good. I'm very proud of that.

05:05:33;25

I would never say to you, "Wow, I can't wait till you have end-stage renal failure, so you can try out my new stuff!"

I'm very proud of what we did on stents, but I wouldn't recommend that you eat a lot of fatty hamburgers every day. I'm very proud of all the medical products we make. But frankly, I don't want anybody to ever use any of them. The iBOT is a liberating device for somebody who can't walk and everybody that's ever gotten on one will get emotional about it when they get up to eye level with you, even long before they try a flight a stairs.

05:06:07;11

That's why we work on them. But I would never suggest, "Boy, I hope that M.S. sets in. Or I hope you get hit by a truck in the morn." I don't want people to need iBOTs. But you put a Segway out there, somebody stands on it, and inevitably, they have three seconds of terror in their eyes.

05:06:26;04

They're on this thing, all intuition says, "This can't work. There's a point on the ground. I'm gonna plant my face." They feel it taking over and they feel it taking control of their balance. They have terror in their eyes. Then about

five seconds later, they're just wearing a Segway smile, because, "Oh, this works." While standing up, as we spoke before, is a very difficult, unique, human function, it turns out, as difficult as it was to learn to do as a kid, it's an entirely transferable skill.

05:07:00;13

You get on a Segway, and I think the reason people smile is because they got to watch themselves learn to take their own first step. There they are, doing this. It's liberating, and it's fun. So, the Segway was one of the rare, few, fun projects we worked on. It was a result of a medical product.

05:07:22;08

But then I said, "You know, if this thing could be used by pedestrians in crowded cities, in a world that's gonna have," and remember, we did this seven years ago, I was saying to people, "I know oil costs ten bucks a barrel now. I'm telling you, it'll be 30 bucks a barrel in our lifetime." We were making that before Al Gore won the Nobel Prize for pointing out the obvious. We did that before a lot of

the world gave a damn about carbon footprint, and the polar caps, and geopolitical stability, and a world where there are six billion people, each needing a little bit more energy. If we get a few billion of them out of poverty, they're all gonna want to drive around, even though they live in cities.

05:08:06;07

I thought, "What if we make a piece of technology that makes a truly competitive, attractive alternative for going short distances in densely populated pedestrian areas?", because a car is a great device. People can complain about them all you want, but 60 miles an hour on the highway, keeping you and your whole family warm in the winter and cool in the summer, and pulling a boat. Sixty miles an hour, doing all that safely, cost of it, that's amazing. But what the hell is that big machine doing in the middle of the city, creeping along, bumper to bumper? Now you're sitting in this thing, in a device made to go 60 miles an hour, doing it on only a couple a gallons an hour while it did it. Now you're sitting burning the same couple

of gallons an hour, moving at four miles an hour, sucking up the exhaust of some guy sitting in front of you.

05:08:57;13

It's you and your 22-foot, 3,000-pound machine, isolating pedestrians in this otherwise marketplace, which is what cities were supposed to be. So, I thought, "Let's put the Segway out there and see if we can change the way people, who value their time and value the environment, will apply technology where it makes sense." You want to cross the country, you get in a 747. You can take you and your whole neighborhood across North America in five hours. It's astounding.

05:09:31;01

But when you land at the other end, you leave the plane at the airport. If you decided, "No, I want to just take it home. It's only another three miles," I don't think you would be smart to call Boeing and say, "You know, you got to redesign this thing. It doesn't work. Those wings, they're clipping the trees, and those engines are bothering my neighbors," you'd say.

05:09:47;26

This machine was designed to go 600 miles an hour. It does it very well. I'll leave it at the airport. I'll get into this other machine. It goes a tenth of that speed. It goes 60 miles an hour. But I'll spend a half an hour in it. I'll go 30 miles away from that airport, and I'll get to where I want to go, the city.

05:10:07;22

Then I'll leave it there, in a parking lot. The plane at the airport. The car in the park. The last mile, I'll do that when it's six miles an hour. It's three times walking speed, faster than the average car could go if you take it into the city and doing it on one one-hundredth of the fuel, one one-hundredth of the environmental impact. What's wrong with this picture? So, I thought it would be a fun way to introduce a technology to the pedestrian. You know?

05:10:37;27

The ancient Greeks built cities, because they wanted the people close. Go to an old city, go to Greece, and you get

from the Parthenon to the Theater of Dionysus by slapping on your sandals like Euclid did, and you puddle along at two miles an hour. It worked.

05:10:57;00

Today, you want to go from the Carnegie Deli, the center of the known universe, to the Empire State Building a mile away. You go from 55th Street to 34th Street. You slap on your sneakers and you walk at two miles an hour. I don't think you can tolerate the fact that in 2,000 years we did a little better, airplanes are a little better than Conestoga wagons, and cars are a little better too. Why is it that there is technology for transportation, airplanes, high speed trains, submarines, space ships, but the pedestrian, between the Greek with the sandals and you hasn't changed in 2,000 years? Most of the people spend most of their time moving from one place to another by walking. For the first time in human history, in our generation, most of the people alive today live in cities.

05:11:52;01

A hundred years ago, when Henry Ford built his cars,

almost everybody in America lived on a farm or in a small town. They needed to move their stuff from one place to another. A car, which was twice as fast as a horse and buggy, which the Model-T is, was a pretty big improvement. Twice as fast, doesn't need to eat hay. It was good, big improvement, changed the world.

05:12:19;04

But most people don't live on farms. Now a couple of billion people live in cities. What the hell is a car doing in the middle of a city? Of what good is a car? I mean a city needs a car like a fish needs a bicycle. So, to me, especially as we start to get more concerned about the environment, and energy, and cost, and congestion, and pollution, and healthcare, let's supply technology to the pedestrian.

05:12:50;03

Back to your original question as an example. The Segway is a pretty good invention. It's pretty cool, it's fun. It's not an innovation unless lots of people start using it to change the way we live and work. I don't know whether

the Segway will ever become an innovation.

05:13:10;06

Ten years after the Wright Brothers flew in 1903, I wouldn't have said airplanes were an innovation. They weren't giving out frequent flyer miles in 1913. Nobody would use these crazy contraptions. They were dangerous. How long will it take, if ever, before people start using small, personalized efficient means to move around cities? I don't know.

BARRY HURD:

05:13:41;19

Now, you said that one of the reasons people don't change is because we're getting old?

DEAN KAMEN:

05:13:45;09

Yep.

BARRY HURD:

05:13:45;28

But suppose we had a group of young people here, junior high and high school. They wanted to learn how to be inventors, innovators, and discoverers. What would be your advice as somebody who's sort of been through that? What would you tell them?

DEAN KAMEN:

05:13:59;29

I would tell all kids what I, in fact, do tell all kids at every one of our competitions. The only person that will have a dramatic impact on your life and your happiness is you. Not your parents, not your teachers, and later on, not the company you work at. You're either gonna focus on figuring out something that's important to you, and work hard enough at it, and get good enough at it, that you can make a living doing it or you won't.

05:14:37;21

If you don't, if you don't learn much of anything at all, you'll spend your life dumb, which, to me, doesn't sound like an attractive alternative. Or, if you have other people tell you what to do, what they expect of you, and you do it, you'll waste a lot of your time doing something that you don't find interesting or exciting. Maybe somebody else would, but you don't.

05:15:00;02

You will be using up this very precious thing you have, this very short stint you have here. I tell all kids, the best tool

you have to ensure that you will be a happy, successful person is that muscle hanging between your ears. Do the best you can to figure out what will make you a happy person, and develop the skill sets and the capabilities to live out that plan. In the modern world, no matter what you want to do, some of the skill sets you're gonna need to acquire to accomplish that goal are gonna inevitably be technology.

05:15:48;24

I don't mean become an engineer or a geek. I don't mean playing with a computer or electronics, but having analytic skills, being able to state a problem, think about it, understand the potential alternatives, even being able to connect cause and effect. There are a lot a kids out there today that literally do not get it, and it's not their fault.

05:16:14;01

We have a culture that is so full of noise and nonsense, that a lot a kids are being so distracted that they literally cannot tell fact from nonsense. I mean, we can all talk about the Internet as this incredible tool that makes

available incredible amounts of information and knowledge. Then you realize that in most of the rest of the world, kids use the Internet for that. In the United States, I'll give you a particular single example. Six or seven years ago, we had the Rover land on Mars.

05:16:53;10

Think of the human achievement, for a couple of decades of dedicated work by a bunch of techno-geeks, and this was techno-geeks, but that's not my point. It's a bunch of people in a little group called NASA. They figured out how to take this little gizmo, put her on top of a 20-story building full of an explosive, like liquid oxygen and hydrogen, and they blasted this thing off.

05:17:21;21

It really blasted off. It left the Earth's atmosphere at 20,000 miles an hour. Then it went hurling through space for a few months. Then it gets captured by the gravitational field of a planet called Mars. Then this little thing gets sucked in, but just as it's gonna hit this other planet billions of miles away, it deploys some airbags. You

couldn't have exactly tested this first, by the way. It lands on Mars. It climbs out. It still works after this little trip.

05:17:58;04

This little gizmo starts sending real images of its environment back to Earth. Fifty years ago, this would've been unthinkable. A hundred years ago, Jules Verne and H.G. Wells were considered wacky, crazy people. This thing is really doing this. It's the result of extraordinary effort and brilliant execution by thousands, and thousands of people.

05:18:25;29

Whether you care about what's really on Mars or you just care about this incredible human achievement, it's astounding. Everything had to work, and it did. Here's what I find most astounding. This is why I have my little FIRST program. In every country in the world, on the day that thing started sending back images, every country in the world, the most visited website was the NASA website, to see this. It was our achievement, right?

05:18:56;24

In the United States, it wasn't the busiest website. We're the only country where it wasn't, because on the same weekend that that happened, some young girl named Britney Spears decided to take some clown, and go to Las Vegas, and marry him. The event in the weekend of that landing that involved Britney Spears was the most important website in the United States.

05:19:31;00

That to me is more than troubling. In a free culture, you get what you celebrate. This country has reduced achievement to bounce, bounce, bounce, and throw for \$20 million a season, or keeping track of the inane people that are inconsequential to the world as it was, is, or will be. But we have a culture from which essentially all role models that kids have access to in a media driven age come from two places, the NBA and Hollywood. Our quality of life, our standard of living, and our ability to move forward will not be materially impacted by either of those two. In fact, I'd argue, they are materially, and in some cases, substantially undermined by those two.

05:20:29;26

I tell kids, "If you, which you can, waste your time from seven to 17, in a world where if it's not fun, don't do it, in a world where you need instant gratification, in a world where literally 'fun' is your goal, you can probably get away with that." We're such a rich country that you can get away with that, and our culture will tolerate that.

05:20:55;06

In fact, it'll blame all sorts of other people for the fact that you did that. I'm here to tell you, let them blame the other people or not. Let the teachers blame the parents or let the parents blame the schools. Let the schools blame the politicians. But in the end, you're gonna be 17 years old and as dumb as a rock. The only one that's gonna pay the consequences of that is you.

05:21:17;14

So, why don't you figure out something important to do with your life, and do it? Remember that these other things are pastimes. It's okay to have a national pastime and baseball is a wonderful one, but it shouldn't be an

obsession.

05:21:33;12

Until you can separate that which is important from that which is amusing, you can't get anywhere. The American culture has put amusing on top of everything. Most of what they now consider amusing is dumb. To an intelligent person, it's not even amusing. If you doubt that, I'd ask you to just flip through the 500 channels. I'd ask you to go to a newsstand, and tell me what about you don't find dumb.

BARRY HURD:

05:22:05;20

Pretty scary.

DEAN KAMEN:

05:22:06;23

It's pretty scary to me.

BARRY HURD:

05:22:08;06

Let me ask you this, with that said, America, which has always been sort of considered a great land because of freedom for inventors and innovators, do you think we still have an edge in that? Is America still a land of innovation or invention or discovery?

DEAN KAMEN:

05:22:24;05

I'll give you two answers to that.

BARRY HURD:

05:22:26;06

We'll take them both.

DEAN KAMEN:

05:22:32;21

Well, I personally think the reason that this country has led the world in innovation, literally since this country started is that it's probably why we started as a country. It was a new concept, it was an innovation. That's what started us. I think the reason we've led the world is in part because of our culture. So, as the optimist, I would say to you the answer to the question, are we still leading the world and will we lead it in the ways that most people measure? The same things that concern me about the culture may be the reason, as I said, as an optimist, we're saved.

05:23:17;16

Most cultures around the world, kids are more disciplined. They are more focused. You tell them to go to school for this many hours a day, and they go all year, and they do

it. So, they're probably better educated. There's a lot about most cultures where organizationally and structurally its quote, "better".

05:23:44;01

But when it comes to innovation, the last thing you want is everybody to do it the way they've been told to do it. I mean, just look at our movies, they're all the same. It doesn't matter what the movie is. There's always the big institutional, whatever it is and then there's always the individualist, the vigilante, the underdog.

05:24:07;24

Everybody roots for the underdog, the guy that wants to do it differently or the woman that wants to do it. In the end, whether they win or they lose, they're the one that we root for in our culture. That's not the way it is in most cultures. Most cultures stamp out that kind of activity.

05:24:23;08

They're very efficient, they're just not very effective. So, some of the chaos and some of the outlier defiant mentality that you of course still see in this country, I

think is our greatest strength. Why was it this country that brought us the telegraph? They understood electricity and magnetism in the 1850's and '60's. Faraday and those guys were great scientists. Why in America do we make that hard? Then we made it tough. Then why were the Wright Brothers here? Why were Wilbur and Orville doing that?

05:25:05;10

Why do we have Google? I do believe that in large part, it is more our culture than our educational system, or, a lot of what's in America, there's a piece of our culture that roots for the underdog, that tolerates the bizarre, almost celebrates it. As I said, in a free culture, you get what you celebrate and we do a lot of that.

05:25:37;11

But back to the flip side of that. My concern is we now have all of those attributes of a culture that'll tolerate. But they're not tolerating that weird guy or that weird woman that will work seven days a week, obsessed with flying or building a rocket. We now use that same metric and what

we want is people that are extreme at sports in which the goal is literally to knock somebody unconscious. It's now, I understand, the fastest growing sport out there. We put on the pedestal the people that are the most unusual in terms of bounce, bounce, bounce, and throw.

05:26:26;11

Our culture has drifted so far that we may, in fact, excel over the rest of the world, but we're going to excel at the things that don't matter. We'll have the best teams at the Super Bowl. We interestingly call it the Super Bowl, but all the teams that play in it are from this country.

05:26:46;11

The other six billion people on this planet that have kids are worrying about the super conductor. Who's gonna build the room temperature super conductor that'll eliminate energy transmission needs and whoever does it is gonna have way more leverage in this world than the guy that won the Super Bowl, with eleven 300-pound guys jumping on each other like a bunch of kids. Enough is enough. I am not convinced that the unique capability of

this country to embrace the weird and the different, that has brought us every great innovation that the world aspires to be like, will continue unless our kids are somehow at least made aware that not all passion and effort should be looked at equally.

05:27:45;06

They've gotta focus their passion and their effort. It does matter what they're trying to be good at, and the tool sets they use to get good at it. Unfortunately, I don't think you can blame the kids. You also can't blame the teachers, you can't. Our culture's gone awry.

05:28:02;04

You can't expect a teacher, a math teacher, to fix it when there isn't a kid in that classroom that really gives a damn about that subject. You can't. A culture is a very complex thing. I think one of the results of the wealth that this country has created, unprecedented wealth in the world, was that we could have the last generation or two grow up without having to create any more of their own, without having to work hard. In some weird way, that was an

aspiration of our parents, the greatest generation. My father was born and by the time he was a young kid, it was the Great Depression.

05:28:49;10

By the time he was a teenager, the years we all remember, he was sitting in the Philippines, getting jungle rot, wondering what's he doing there for three years. That generation came back, and I think decided, "We're gonna make the world a better place," and they did.

05:29:07;21

Huge leaps in the capabilities of medicine, and everything else around us: communications, computers, and the Internet. But the kids that grow up assuming it's a birth right, assuming they're entitled to it. You can't blame them for feeling that way. Our culture tells them that. The ads they see don't show hard working innovators failing, and getting up, and trying again, and failing. Fact, the ads they see aren't even implicit in the noise they've given them. I mean, the ads, "Life is short, play hard." How about, "Life is short, work hard?"

05:29:54;22

The jingles come on television. "You deserve a break today." These are ads to 12-year old kids. Your mother ever walked into your room when you were studying and say, "You deserve a break today?" I think our culture is not gonna produce innovators if we lose respect for how difficult it is, and the willingness to work at it, and fail at it, and fail at it, and fail at it, and keep working at it.

05:30:27;24

The same culture that I think created one after another of the great achievements of the world should be protecting whatever that magic sauce is. So, that kids grow up knowing if they'll work hard, if they're prepared, and if they have the tool sets they can change the world and make it better. But you don't see a lot of that message going out to kids. So, I'm worried.

BARRY HURD:

06:00:46;01

Okay, we talked about the culture. We're a little bit skeptical about what's going to happen, but you've done a lot of things. A lot of your history is written. There's still a

lot to be written. What are the things you're most proud of, that you've done?

DEAN KAMEN:

06:01:02;01

I have been asked, "What do you think the best accomplishment or the best project is?" My answer is always the same. I don't know, because it didn't happen yet, because if I look at what we do over our life, every time you have a success, if it was a success, you're a little smarter. You have a little more resources.

06:01:29;23

These days, I have more people. Technology's moved on. There's a bigger field from which to pluck new potential solutions. So, every year, you take on a bigger problem.

06:01:46;24

I think the definition of young is you get up every morning, looking at how much you're gonna go and grow. The definition of old is every day you get up and ask how much have you been able to preserve, or prevent from deteriorating. I never want to get old. I get up every day thinking about what's the next big thing we're gonna do. I

guess my only answer is it hasn't happened yet.

BARRY HURD:

06:02:15;07

So, there's not one thing you'd look back on, even as a teenager, and say, "Boy, I really am happy I did that"? Nothing like that?

DEAN KAMEN:

06:02:21;19

Oh, there's lots of things I'm happy I did. But your question was, "What's the best?"

BARRY HURD:

06:02:26;28

No.

DEAN KAMEN:

06:02:27;07

...and...

BARRY HURD:

06:02:27;19

What are you most proud of?

DEAN KAMEN:

06:02:29;01

Well, the one I'm most proud of I would tell you [about it] if I didn't think, as I get up in the morning, if tomorrow morning I don't get up thinking, "I might accomplish something today, or this week, or this month, or this year, that would make me more proud than anything I did in the

past," I wouldn't get out of bed.

BARRY HURD:

06:02:47;09

Okay, good answer. Now, let me see how you handle this one. This is an interview that's gonna hopefully be preserved for thousands of years. When people look back on your career, the parts you've done and the parts still unwritten, what would you like them to think about you? The way we look back on people who've done things. Have you ever thought about that?

DEAN KAMEN:

06:03:05;20

Yeah, I do, actually.

BARRY HURD:

06:03:06;26

What would you say?

DEAN KAMEN:

06:03:11;19

I guess I'd say that I'd want people to think that in the end I put back more than I took out, because if everybody in this world wants to take out, even just a little, 6.3 billion people, each taking out a little, they'll eat themselves alive. There'll be nothing left.

06:03:33;29

But if everybody just said, wherever you are in the world, I know four billion people all living on less than two bucks a day. We have to fix that. If everybody on this planet said, "I'm just gonna leave it a little better than I found it. I'll just put back a little more than I took out."

06:03:55;04

Six billion people putting back a little bit each, you would have just an incredibly exciting future. In my case, I am not known. Look around: helicopters and airplanes. So, if you want to live and be true to it, then I have no reason to be disingenuous. I just have to add, I want to put back more than I take out.

06:04:24;12

I plan to take out a lot. It means you get up every morning. You gotta do more than the people that are living on two bucks a day. You spend your time making longer systems, or making electricity for the developing world, or building an institution like FIRST that you hope can at least get some kids to think about the world as it should be.

06:04:48;14 I spend a lot of my time trying to do things that I hope will have enough leverage that they can materially impact a generation of kids or populations around the world that need basic things like water and power. That way, if I'm flying in my little helicopter, I can feel a little less guilty, and a little less jaded.

BARRY HURD:

06:05:13;06 Okay, good answer. Let's climb up the stairs.

DEAN KAMEN:

00:04:36:00 Let's climb.

SLATE:

00:04:38:00 The remainder of this interview will be without time code.

BARRY HURD:

00:04:41:00 Alright, go ahead.

DEAN KAMEN:

00:04:43:00 Well, so, now I'm sitting in...

BARRY HURD:

00:04:45:00 Right.

DEAN KAMEN:

00:04:45:00

...a wheelchair.

BARRY HURD:

00:04:45:00

Now just tell us what you're sitting in.

DEAN KAMEN:

00:04:48:00

Actually...

DEAN KAMEN:

00:04:50:00

I'll bring it all the way down.

BARRY HURD:

00:04:51:00

Okay.

DEAN KAMEN:

00:04:52:00

I am now sitting in a wheelchair, not very dissimilar to that wheelchair, which is, well over 100 years old. The difference is that is more aesthetic looking, lighter, and cheaper. If you happen to want to go up and down the stairs, or look people in the eye that one's not gonna do it.

00:05:14:00

Now, I'm lifting myself up to eye level. Now, I'm gonna put all the weight over the rear wheels, and let the balancing system...whoops. Okay, hold on. What I'm gonna do is different code uses different symbols.

00:05:32:00

I'm now gonna put all the weight over the rear wheels and stand up. Then I'm going to actually come up a little more. In real life, I'm a vertically challenged five foot six. I am now just about six feet tall. I can go buzzing around town looking eye to eye at my peers and my friends. I can pretty much go where anybody else goes. Now what I'm gonna do is I'll sit down.

00:06:05:00

You're watching the cluster come around, to sit me down. I can even lower the seat a little bit, here. Since you asked, I'll climb a flight of stairs. I'll go back to this keyboard.

00:06:23:00

I'll put in a code that shows me an icon of a set of stairs. I'll put the weight back on the rear wheel. Since the wheel can't rotate, the cluster instead will rotate. As you see, it rotates one cluster over the other. If I put my weight back, it just comes over the top. Now you're watching an almost full grown man go up and down a flight of stairs.

What I'm gonna do now is come down this way. Then when I get near the bottom, as you saw, I just drive off, the cluster compensating for that change in altitude. Then pop it back into the mode where it was standing up and drive away.

BARRY HURD:

00:07:31:00

Pretty impressive.

DEAN KAMEN:

...on because you had cut them off with a torch.

BARRY HURD:

That was Henry Ford.

DEAN KAMEN:

He cut them off.

DEAN KAMEN:

...with a torch.

BARRY HURD:

Morton, he was the fellow who extracted...

DEAN KAMEN:

Oh, I need to know all of that. I need that story.

BARRY HURD:

I'll get it to you.

DEAN KAMEN:

Okay. We made the flywheels. Everything else that's bright metal that wasn't saved, I re-made with machine. The only thing that we actually made cast iron and tried to match the physical kind of structure, thickness, cross-section of the webbing were the flywheels, because, of course, it had those wooden paddlewheels when it was a steam.

It took me a long time to find a foundry that would make castings of both the spokes and the six segments of the rim for us that would end up looking like they were the same kind of casting as the engine was. We made the two flywheels. I re-made, as I said, all the shafting. This is all stainless steel. Every bolt is stainless steel. Every axle is stainless steel. Now, all the bronze, every rotating

component is sitting in a bronze bearing, except these, where we cheated and put ball bearings on them because these flywheels weigh almost 8,000...

BARRY HURD:

You're allowed to...

DEAN KAMEN:

...pounds apiece.

BARRY HURD:

...cheat a little.

DEAN KAMEN:

We cheated a little, but almost, well not almost, all the rest of the bearings we re-made out of bronze. We took the steam chests apart. We re-ducted everything in those steam chests so that, as you can see, there's still an opening. This weekend, we took that plate off. We're coming straight down with an eight-foot long tube.

I can show it to you downstairs, stainless steel, that goes to a room below this engine the size of the engine. In the room down there, there will be two gigantic displacers that

are used in the Stirling cycle to run the air from a hot end to a cold end, and back. They go back to the hot end, because they're gonna be phased with these pistons, as they go back to the hot end, they will push each of these pistons up through its four-foot stroke.

Those pistons are, you'll like this, 22 inches in diameter, with a four-foot stroke. So, if we can generate about one and a half psi of pressure as we go from the cold end to the hot end in the room below, that four-inch duct over here, with a one and a half psi differential pressure feeding the base of that cylinder. We'll put 1,500 pounds of thrust into each cylinder.

It'll run this wheel at about six rpm, based on what we've calculated the drag to be. Six rpm for these things is trucking right along. So, we've run them on air. I have two big air compressors downstairs. We've made it run. It run beautifully. It breathes at you, because we took, as I said, we took a lot of the plates out of the steam chests

on the front. But we have to vent the other half of each working cycle.

So at six rpm, it's about once every ten seconds, which is kind of like a human breathing rate. This thing just breathes at you. It does a beautiful job. We're excited to have it running. I'm determined that it will be running very soon. So that's what we've done so far with this beautiful piece of memorabilia.

BARRY HURD:

Okay, great. Do you want to go downstairs?

DEAN KAMEN:

Yeah, now we're gonna go downstairs and show all of these guys a Stirling cycle engine. So that we don't have to re-do it in context, because they already know the story. But the goal of that Stirling is that it has many potential applications, particularly these days. Even in the very developed world, where people care about energy efficiency and backup power, but we have spent many

years trying to build that Stirling cycle engine for a very unique application, for which standard engine technology simply isn't gonna work.

The proof it's not gonna work is if it was gonna work, it would be there. But here's some data for you, right now, as you're standing here, of the 6.3 billion people alive today, about 1.6 billion, more or less, 20 percent of all the people ever born, have never used electricity.

They're not gonna wake up tomorrow morning and say, "Oh, look. They put in a central power station, and transmission lines, and switch gear to my little place in this village. They've suddenly delivered regulated power." That is not gonna happen. So, we said, "Why don't we build generators? Not the little generators people use for backup in their home, but let's build small boxes that you can put in places all over the world where people don't have access to electricity, to give them enough that every home has a light bulb at night.

"Every home can charge a computer and can get to knowledge, get to the internet. There can be a refrigerator or two in the village, to keep vaccines and medicines." A small amount of power, that first 50 watts per person, is huge. Well, you can't do it by just taking a standard generator that you could go and buy at some distributor in the U.S. and put it in these places because they need particular fuels, gasoline.

Or they need lots of maintenance. Or they sit there and they make noise. They weren't intended to run 24 hours a day, seven days a week. They just don't do that. The kinds of stuff that's made to run 24 hours a day, seven days a week, Con Edison owns it. It's as big as a city block. It has hundreds of people that are there all day and night maintaining it and running the grid.

It makes megawatts, hundreds of megawatts, gigawatts. You need a couple of kilowatts. You need to be able to

plop it into a place. You need to be able to find fuel for it. It needs to be omnivorous about what fuel it takes in. It needs to be able to simply and reliably run, and run, and run, more like your refrigerator compressor that just runs from the day you bought it for 20 years, till you remodel the kitchen.

Then you put it downstairs and let it run another 20 years. It needs to be more like that kind of reliability than the engine in your car, even though those are great engines. You don't let them idle when you go away for the weekend. You wouldn't let them idle for 20 minutes when you go shopping. So, we essentially built a refrigerator and compressor, running backwards.

Instead of saying, "I'm gonna put electricity into this compressor, and it'll make this end cold, and blow the heat out this end through its heat exchanger, which is hot," we said, "Take that same unit, and instead of saying, 'Put the electricity in; it makes this hot and makes that cold,' how

about instead externally keep this thing hot by some means? Any source of fuel?"

Keep this cold. Let's say, run cold water around it and then the electricity comes out. So, the motor that used to take power in now becomes the generator that puts power out and by running a Stirling cycle refrigeration compressor backwards, it's an electric generator. We built some.

We put two in two separate villages in Bangladesh, each about 75 kilometers from the capital of Bangladesh. For 24 weeks, each of those little systems ran flawlessly in these villages, and supplied electricity. They were small villages; 20, 30 family villages. For 24 weeks, the only fuel that went into these boxes was the methane coming off cow dung.

By the way, if you let the methane just come off the cow dung and just go into the atmosphere, methane gas is 21

times as bad for the environment as CO₂ and CH₄, methane, goes off, does its evil deed as a very bad greenhouse gas. Then the CH₄ eventually decomposes to CO₂ and water. So, it's 21 times as bad for the environment as CO₂. Then it becomes CO₂ anyway, with no benefit to anybody, except along the way it spreads disease. It stinks.

You say, "Huh. What if I put my little box in the village? What if the methane is immediately collected? Our engine could run on it just fine, because all it needs is a source of heat." It could even run on it if it's full of carbon monoxide, which it is, and moisture.

We do all of that. It runs fine. Then it literally gives you electricity, usable heat, and then it ends up at the same by product, CO₂, is it? So, we built a couple of these boxes. We put a couple in Bangladesh. We also tied, as an example, long before we went there, we tied one in to show how they might look as a backup generator in a

home, for instance, in the United States. We also put a very smart interface on it, so you can see how to control it from anywhere. We're now gonna go downstairs and show a couple of engine freaks how it works. Okay?

FEMALE VOICE:

Great.

DEAN KAMEN:

Let's go. We can go this way. That's okay.

DEAN KAMEN:

By the way, so you saw that plate that we took off on the engine?

DEAN KAMEN:

We re-made a bronze one that looks just like it. But as we go from the old, old engine to the new engine, which you'll see below, we transitioned to stainless steel. This weekend, we made all these parts for the stainless. These go down. You'll see they go into these four-foot diameter pistons, with a two-foot stroke, that are going to just be sloshing the working fluid.

Because we're gonna use atmosphere, obviously, and with atmospheric air being sloshed up and back, downstairs between the two displacers, we're expecting to get with a couple of hundred degrees F change in temperature. About one and a half psi change in pressure. That one and a half psi ducted up to the base of those two pistons will give us 1,500 pounds thrust.

BARRY HURD:

Very cool.

DEAN KAMEN:

So, anyway this is the shop, but we're gonna go down one level. We'll fire up the engine. We'll come back into this room. The engine is right below us, behind that wall. We're gonna go down there. We'll turn it on, and we'll come back in here. You will not be able to hear it. So, it normally doesn't look like this.

FEMALE VOICE:

At some point you have to do an actual sit-down...

DEAN KAMEN:

Oh, I see. Okay.

DEAN KAMEN:

Right. So, let's go down.

DEAN KAMEN:

So, now here's the really big vision. We didn't talk about this with you guys because people already think I'm nuts with big ideas. It's a big enough idea to get people to transition to a better engine here, but as I said, we really started building these engines because we could become a supplier of electricity.

I mean, you'd be, by far, the largest utility company in the world if you just started making enough of these to be prime power for the 20 percent of humanity that you take for granted what they've never seen. So for those same people, we built these water machines. This thing takes less than a kilowatt. It's a vapor compression distiller. It's made to sit in a village. We had the other ones also in this stuff that's made to sit in the village, but I didn't bring those back. This, we took the same engine you saw. As you remember, it looks like a refrigerator compressor. It

looks like an air conditioning unit.

Well, I'm not so jaded as to think this represents the typical, ordinary American house. Trust me. It doesn't. If you saw my cooling, heating, domestic water systems, they're out of scale. It wouldn't be realistic. So, what I did after we started this project, is I said, "Well, a typical American house would have a little water heater.

And it's on Lally column eight, feet on centers. It has six or seven rooms that would each want enough light that if you needed minimum, basic power, you could give it to them. I didn't want to put the generator and tie it to the house and have to run all over the house to prove it's there.

So, I put 500 watts in here, just to represent ten different rooms of loads. I put a little off the shelf inverter to point out that we don't even have to be that developed. We now have our own inverters here. I took a couple of simple

lead acid batteries to act as the backup system.

Then, through our other little company that I was telling you about, Teletrol, which builds system monitoring equipment like, for instance, right now, from the building you were in at Manchester, our little Teletrol company controls the Sydney Opera House in Australia. Over the internet, we control something now like 8,800 buildings. So, we have a few engineers. They have screens that talk about different buildings. They do energy management. We've been doing this for longer than anybody, long before it was a common discussion to worry about CO₂ or energy management. It was typically for large commercial buildings, not homes. But again, to demonstrate that stuff, and to demonstrate this stuff, we figured, "Why not?"

So, here, for instance, we made a screen for this house. So, you came in the entry level. You came in the front door. If we go to the front door, that's where you came in.

I'm standing on the engine. It's gonna tell you things about the temperature and whether valves are open or closed, whether we've got fans running or not, whether we're heating or cooling.

It's just a system, in this case, just to look at the house. We'll go back to home. I think somebody's outside playing with this. So, now instead of looking at the different floors, I'll go to power. It's looking at the wind turbine since they're now out there, they're come offline. But oh look, I have something called APU. So, I'll push the APU, and what do you know? It looks a lot like this box.

A lot like this hot water heater and a little heat exchanger here. That's a tiny little heat exchanger, which is right here, with a little pump that's off. So, the water going out of these lines, which is none right now, is at the same temperature as the water coming back. The water in this tank is at 70 degrees.

Everything else is off. It's just telling you the state of the system. Now, if I were to turn this Stirling engine on, for instance, because the house lost main power from the utility company, you'd want to light the house up. You'd like to make use of all that waste heat from the gas line that was ordinarily feeding the hot water heater anyway, which had a gas line.

I'm just gonna take that hot water heater's gas line and instead of directly heating the water, which is nearly a hundred percent efficient. It's just using gas. What if I run it first through here, turn 20 percent of the energy in that gas into electricity to do all of this, make a kilowatt or two, but then take all of its waste heat, and run it into the same tank?

Now, I'm virtually a hundred percent efficient. The reason I make that point is the power company will tell you they're nearly 40 percent efficient at turning the fuel they burn into electricity, and it's true. With the large-scale

system, they are nearly 40 percent efficient at the plant. So, when they proudly tell you they've got a 500 megawatt plant, and it's twice as efficient as I am at making electricity, they are telling you the truth. I'm 20 percent efficient. They're 40 percent efficient. Here's the rub. If they got a 500 megawatt plant that's 40 percent efficient, they could be telling you, "I'm taking 600 megawatts at that very same plant and using it to kill a fish and destroy the rest of the environment."

Forty percent I turned into electricity. The 600 megawatts, I don't know what to do with. They're also not telling you that the 40 percent became about 30 percent because they lose about 25 percent of the 40 percent getting it to my house. So, now they call them even; give them a break. They're 30 percent efficient.

Now, I tell you I'm a little over 100 percent efficient if I happen to need hot water, because I'm gonna burn the same gas that was coming to my hot water tank anyway

because nobody in their right mind would use electricity to heat their water. Electricity is too expensive a form of energy. So, even though every house has electricity, you burn your heating oil, or your propane, or natural gas to run your dryer, your washer, your showers, and your heat because the energy in that gas is used more efficiently. When you're making heat out of it, you're making heat out of about 90 percent of it. Not a hundred.

Because you have to let about ten percent of the energy that comes into your hot water heater or your furnace go out as part of your flue gas, your flue losses, and your combustion products. That's because they run pretty crummy little heaters. They're okay. It's like a kitchen stove.

We spent a lot of time making really, really, really good combustors. So, we burn that same fuel that you got from the gas company a little bit better than an ordinary hot water heater. So, if they're throwing away ten percent of

their energy, but we're only throwing away five, then actually we're not 20 percent efficient. We're not even 80. I'll say we're 105 percent efficient because your gas came in. I made 20 percent of it into electricity. The rest of it I made into exactly the amount of heat you would have gotten, except I gave up a little bit less. The 20 percent that I turned into electricity was from a pretty low-cost form of fuel. As long as I'm making enough electricity to take care of the bare minimum loads, I turn the power outage, the ice storm, the hurricane from a catastrophe into an inconvenience.

I'm not gonna make enough electricity to run the whole house. But if you have a little bit of light, if you can run those pump motors on your well, and those so you have water, and you can run the pump motors, if you can run your security system, if you can run your communication system, you've turned the power outage from a catastrophe to an inconvenience.

So, now I could just hit start, and turn it on. I'll show you guys that, in fact, not only can I do it, but so could a utility company. So could you; so could anybody. But because DEKA is full of techno geeks, before I hit start, I'm gonna turn on this little thing. Oh, look. For you engineering types, why don't I look at all the state variables in this system that are being monitored by the computers inside this little box?

Well, that doesn't give me enough of them. I really also want to know how much power I'm making, what's going on, I want to know lots of stuff in real time. By the way, I can get all of that right now, over the internet, through this box, anywhere in the world. So, if you put a thousand of these boxes in Bangladesh, you could be supplying power to people. Instantly know where they're getting it, how much, the state of the machine, and how is it running? What's it doing?

Now, if I were to hit start, a bunch of things will happen

with these cameras on, you'll probably hear a noise. But if things go well, what you're gonna see, and I'll have to say it now because it'll happen so fast I can't be able to do it in real time, is the machine is gonna do its own diagnostic of its situation.

What's the air temperature? What's the water temperature? What's the head temperature? What's fuel doing? Is it lighting? It'll go from stopped to like a warm-up mode. You'll watch the engine speed immediately turn on and go up to some speed, like, immediately. You'll watch the blower speeds come on.

You'll watch the fuel command start to come up. Like, right now we're looking at our exhaust oxygen. It's 21.9 percent. That's good, because we're sitting here breathing. That's atmosphere. You'll watch that number come down. But all the combustors are making sure that we don't make a lot of pollutants.

So, it won't let them go down too deeply. It'll control everything from speed, to torque, to fuel, to air, all the mixtures, all automatically. You'll be able to watch everything. Now, we charged this crank case up to about 800 psi at least a couple of years ago. We have never recharged it.

DEAN KAMEN:

The people that say, "You can't control helium," and really, it'll be at about 800 again once it gets up to temperature. We'll look at all these temperatures, like, these things are off. It's telling my coolant it is 23 degrees. Don't ask me why we give half the temperature as Fahrenheit, because grandma was up at the thermostat, and we give other half of our temperatures Centigrade. It's a long story.

But anyway, we'll look at all these things change over time. When the head temperature, which is that big head that you saw in my office an hour ago, that temperature's gonna go from room temperature, head temperature 28 degrees C. It's gonna go from that to around 600 degrees.

Actually it'll get around 800. But it will go up to there. As it just ticks over there, you'll hear this thing go from being a motor to a generator. If you think it gets up there fast, it's gonna get sucked down by nearly 300 degrees in about six or seven seconds, because once it starts pushing that high pressure helium, it just sucks the heat out of the head. As it sucks it down, the power out, but we'll go from about minus 200 watts, because we've been running the motor. Now, it's minus six watts, because I'm running controls and lights and a couple, but it'll go from that.

Then every ten degrees it comes up gives me about an extra hundred watts as well, you'll watch it climb. In any event, I'll hit the start as if we just lost power and even though it'll take a couple of minutes before actually making power, instantly upon hitting start, those lights will come on.

All the stuff will go. This thing will go through its

computer-controlled start cycle, all off of this battery, which has enough capacity to make one kilowatt for about 15 minutes. But three or four minutes into this whole process, once this thing is making power, besides taking over and running all the loads, it will recharge the battery.

DEAN KAMEN:

If you had a tiny...

DEAN KAMEN:

Oh, okay.

BARRY HURD:

The battery is doing good.

DEAN KAMEN:

So, does everybody know what's gonna happen? I'm gonna hit this button.

QUESTION:

So these lights are gonna come on, but and that power is going to be coming from the battery.

DEAN KAMEN:

From the batteries. Now, also, this is one of our older, older engines. This has nine, I think at least nine rolling

element bearings in it, ball bearings, needle bearings. There's some, so this one has a little of that sewing machine to it and a brrrr. And it's also, you're in a room that's tin and concrete. This is not exactly a quiet system.

QUESTION:

Is it a four-cylinder system or one?

DEAN KAMEN:

No. This is one of the older ones. The newer ones are dramatically, dramatically quieter than this. So are we ready? Do we need a drum roll? Are we ready? We are ready. So, as I hit "start," it started.

Now, you heard the fans come on. You're gonna hear it "click, click, click." Sometimes it'll catch; sometimes it won't. But it knows; it's gonna catch. See? Burner slate; it's lighting the burner. It's already determined it's going to be a cold start.

It just tried to go; the fans are up at 5500 rpm. Fuel is six percent. Head temperature is already 100, 250. The

flame is stabilized, 300. It's in warm-up mode. Almost 400 degrees, that's C. That's degrees C.

QUESTION:

Wow. That is unbelievable.

DEAN KAMEN:

We're in warm-up mode. We're at 480. We're still, the stands are coming up. The engine is still at zero rpm. I'm at nearly 600 degrees. I'm making minus-30 watts because I'm running fans. I'm now at nearly 700 degrees C, 710. Now, if you think it got up there fast, watch at 740, just as it hits 800, it's startin' to warm up. Now I'm a minus-80 watts; 780. Now it's gonna get to 800. Ready? It just turned on. Now watch: 822, 674.

QUESTION:

Jesus.

DEAN KAMEN:

604, it'll go about 530/540 degrees. So it's gone to 100 percent fuel, full fuel. It's trying to catch up. It's making 18 watts. I'm making it positive watts and the temperature's starting to come back. I'm still at 100

percent fuel. I'm at 526. I'm making 68 watts. Every degree, as I said, ten watts. Look at this.

Now I'm still at 100 percent fuel. I'm trying to bring my head temperature back up. I'm making 140 watts. It's still trying to come back. It's still; I'm at 500 s; I'm making almost 200 watts net electrical out. I got 500 watts of load. I gotta charge the battery.

I'm up; I'm still under 600. You saw, it would run all day at 800. Six-o; I'm now making a quarter of a kilowatt every time it comes up. Just, I'm still at 100 percent power. By the way, my exhaust is still 6.7 percent oxygen. We're not making all the pollution products you make. I'm, in fact, we're not only not making pollution products. Look, I'm now at only 660; I'm making over 300 watts, but we're down, deep in the bowels of a house.

We're breathing. We're talking. I'm standing next to an engine that has no muffler on it, no exhaust system on it,

and we're talking. If we go around the corner and go out of this room and close that door, you can't hear it inside your house. You can breathe. You can run any fuel.

This is just tied into the gas line that everybody has going into their house. And, oh, by the way, we got a, let me just close this a second. Come on out; come on. So this dial that was off is now on. Water is coming out of here now at 76 degrees, coming back at 74.

This one's open. It's now going in here at 73. So I am extracting all the waste heat from this burner and it's coming out at 76; runs through this heat exchanger. And is coming back at 73. So the gas I'm burning, 100 percent of that energy is heating the hot water for this house. Let me open that again. All right, so now we're up to 844; we're making well over half a kilowatt.

This engine's made well over half a kilowatt for a few thousand hours. We're now up to way over eight percent

exhaust oxygen. We're meeting all the standards for an indoor heater. In fact, look, my fuel is now coming down, 84 percent; because it only needs 500 watts plus charging.

It's now making almost three-quarters of a kilowatt. So it's just modulating down. It's down to 58 percent. And it'll sit; now, if I plugged in another few-hundred-watt load and I'll put a bigger load on it, it might start coming back up.

But the battery's enough to be watching over that. And now, if I take the loads away, I'm down-- I'm up at 900 degrees. I'm making almost a kilowatt. I'm burning 47 percent fuel now. I brought it what it's set for. And it'll sit there and modulate and control itself like that all day.

I'll bet you could just roll a unit into somebody's house and do that, right? And you could take this set of screens right now, we can go to any computer in this house and do this. You can go to any computer on your desk in South

Carolina and do this.

You can go to any desk you want and hit "stop." It will shut down. It will turn off. It'll go through a complete shut, in fact, have we seen and heard enough of this? So watch what happens. I will come along here, by the way. You're now, as you see, we're down. I'll hit "stop."

Instantly, those go off. But the engine, which took a couple of minutes to get up to temperature, why waste all that energy? It had that thermal mask. So it's now recharging the battery. The fuel is slowly coming down. My blowers are still running at pretty high speed.

My engine is, doesn't want to thermally shock it. So the fuel is just starting to come down. My engine's still making well over three-quarters of a kilowatt. And the fuel will slowly back itself off. The head temperature will slowly come down.

And just as I pass through that point where I go to zero power output, after I have sucked out all the energy, even as it goes down to 600 degrees, 500 degrees, 400 degrees, just as everything wraps all the way down, what you're gonna find is, see, now the power's coming down; now I'm at 18 percent fuel. It's still making power; I'm gonna recover all the heat that I put into the system in the first place. And then it'll shut itself down and it'll be waiting for the next time.

DEAN KAMEN:

See, this is about as theoretical as a jet engine. And all these people around the world that tell you, "I got a Stirling engine," okay, do that. Just do that.

DEAN KAMEN:

And it's a refrigerator compressor. Now, the problem is, as I said to you, it looks like stampings. It looks like the, every single part of this was hand made. And there's like one of them.

QUESTION:

So actually, you don't even need to actually rent this thing

down here.

MALE VOICE #2:

Yeah. I mean, that's just a pure safety precaution.

DEAN KAMEN:

See. We're now down to...

DEAN KAMEN:

See, it's in cool-down mode. We're removing heat. I'm still making almost half a kilowatt. Which is plenty to put back into the battery, everything it took out just to heat it up.

QUESTION:

And using no fuel.

DEAN KAMEN:

And I'm using zero fuel. And the fuel's, fuel command is zero. My exhaust oxygen's back up. And, by the way, we're at 801 now that we've heated up the engine?

QUESTION:

Yeah.

DEAN KAMEN:

We charged this thing to about 800 like three or four years

ago. We have not changed the charge and this thing since we installed it.

QUESTION:

How many?

DEAN KAMEN:

It had those six-inch pipes that were coming down. They come through these holes right here, one for each cylinder. And one, each one of these stainless steel cylinders that we made will soon be sitting under them. Each one will have a gigantic piston in it that sloshes the air from one to the other. One being hot; one being cold.

And when the air is in the hot end and is high pressure, it's going to be driving those giant pistons in that engine up. And then, when it sloshes back, just as those pistons get to the top, 90 degrees out of phase, it's going to cool the air. It will compress. It will go to a much lower pressure. And it will suck those pistons down.

So the engine upstairs will be sitting there with those

pistons just running, doing six rpm, making zero noise. And then you'll come down under that 150-year-old engine of cast iron, and this will be a completely outfitted room, full of all sorts of digital displays of what's going on.

All this will be polished stainless steel, very modern-looking servo-controlled stuff, sloshing air up and back, proving the second law of thermodynamics really does work. And that engine up there will be just physical proof of it. And it will be the coolest thing you've ever seen.