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July 2008

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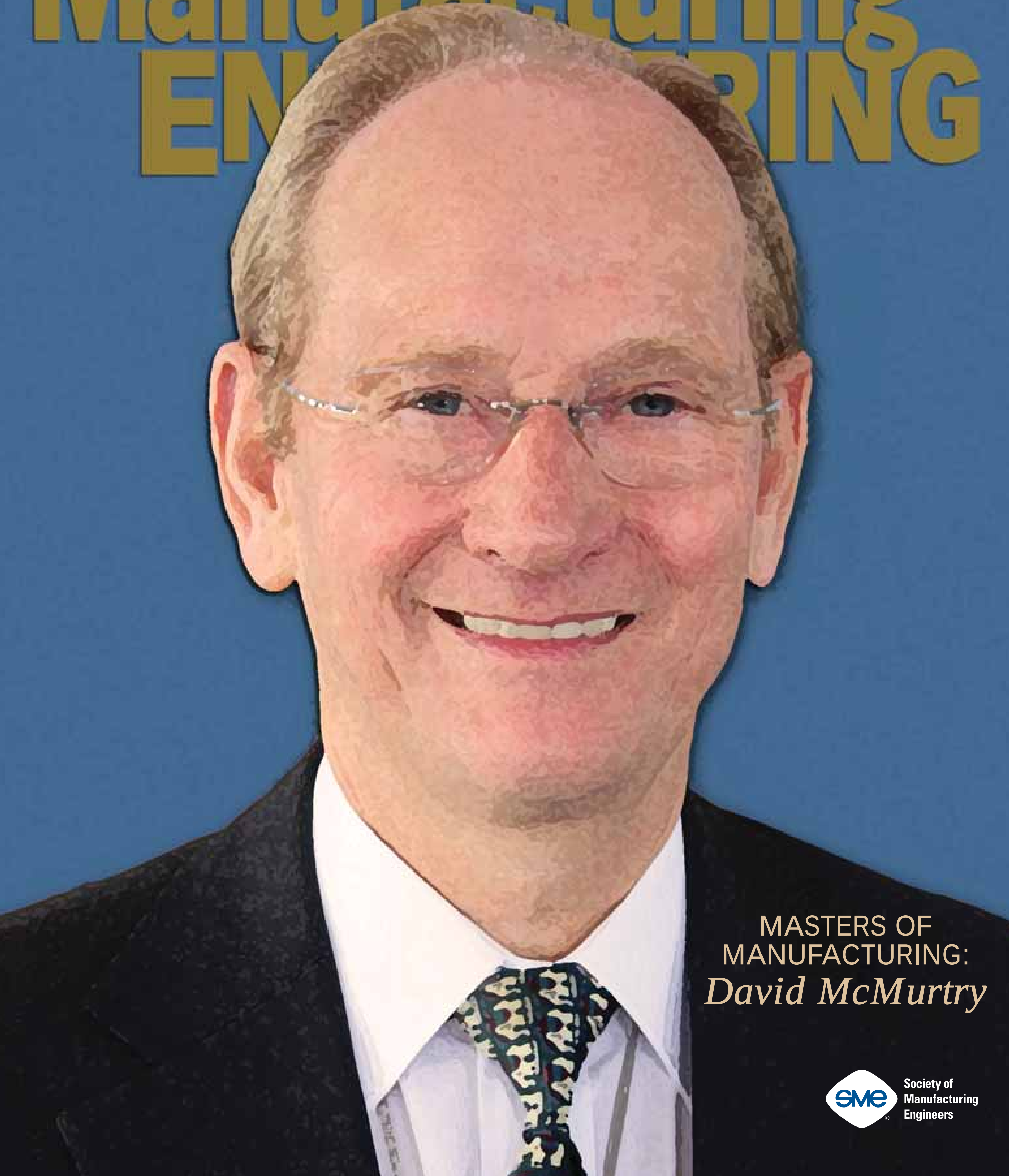


MASTERS OF MANUFACTURING:

David McMurtry

SME Society of Manufacturing Engineers

Who Did That?

You've seen touch probes. They're used in almost every manufacturing facility of any size. Did you ever wonder where they came from?

Well, our Masters of Manufacturing subject for this issue, David McMurtry (*Sir* David, if you're British), developed the touch probe to solve a measurement and inspection problem while he was working for Rolls Royce plc. After that invention came years of struggle to establish a company, defend patents, and win acceptance for this new technology of electronic touch probing.

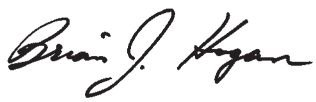
The touch probe is ubiquitous because it's useful. Like the PLC and CNC, it's a component of the manufacturing enterprise that is simply part of the background noise of our lives. McMurtry's innovation has become as casually accepted as cutting fluid or carbide tools, and yet very few manufacturing practitioners realize where it came from.

None of the equipment or technology that we encounter in today's manufacturing world simply emerged from primeval ooze. All of it is the product of the mind and imagination of some individual who worked in manufacturing, encountered a problem, and devised a creative solution to that problem.

Modern manufacturing is a result of that intellectual activity. Manufacturing has been carried to its present level of productivity by individuals who have made careers in manufacturing that are significant not only in their own time, but for posterity. In one form or another, it's safe to predict that David McMurtry's touch probe will be used by manufacturing engineers at least throughout this 21st Century. Persons who imagine manufacturing to be a dead end should consider McMurtry's career, and the careers of the other individuals profiled in our Masters of Manufacturing series. When fashionable athletes and entertainers and politicians have gone into history's dustbin, the devices and techniques introduced to manufacturing by these Masters will be meeting human needs all over the world.

Manufacturing truly matters. It's the specialized field of technology that takes the discoveries of science and the ideas of design engineers, and converts those discoveries and ideas into products and devices that enable people to live better, more prosperous lives. Without manufacturing, genius remains trapped in the laboratory or in a designer's mind. Manufacturing is the bridge, and the enabler, that has allowed the development of our modern world.

We welcome David McMurtry to our Masters of Manufacturing honor roll, where he joins John Parsons (inventor of NC), Richard Morley (the PLC), Eugene Merchant (scientific metalcutting), Joseph Juran (quality in manufacturing), Joseph Engelberger (industrial robotics), and James Bryan (telescoping ball bar and determinism).



Brian J. Hogan, Editor

MASTERS OF MANUFACTURING: David McMurtry

This is the seventh annual installment in an article series we call Masters of Manufacturing. *In these articles, we honor a distinguished figure in manufacturing technology, and by doing so, we hope to remind readers that a career of great achievement in manufacturing is still possible.*

Patrick Waurzyniak
Senior Editor

Inventor of the touch-trigger probe in the early 1970s, Sir David McMurtry began his manufacturing career in 1958 as an apprentice at Bristol Aero Engines Ltd., which later became part of the Aero-Engine Division of Rolls-Royce Ltd. at Bristol, England. While working at Rolls-Royce, McMurtry designed and patented the touch-trigger probe to solve a specific measurement problem for the aircraft engine manufacturer. In 1973, McMurtry and Rolls-Royce colleague John Deer founded Renishaw Electrical Ltd., which later became the metrology developer Renishaw plc (New Mills, Wotton-under-Edge, Gloucestershire, England), based on his ingenious invention with the omnipresent touch-trigger probes now employed on coordinate measurement machines and CNC machine tools worldwide. The company that they founded successfully endured a number of court struggles over McMurtry's original patent with competitors before going on to become one of the premier metrology suppliers in the world.

Recipient of the SME Albert M. Sargent Progress Award in 1986 and elected an SME Fellow in 1988, McMurtry, CBE, RDI, CEng, FIMechE, FREng, held the positions of deputy chief designer and assistant chief of engine design for all Rolls-Royce engines manufactured at Filton, Bristol, England. A native of Dublin, Ireland, Renishaw Chairman and CEO McMurtry, 68, owns some 200 patents in the field of electronic measurement technology, and still has overall responsibility for group technology at the company. In an exclusive interview with *Manufacturing Engineering*, McMurtry recently discussed his life, his work, and his vision for the future of manufacturing.

Manufacturing Engineering: Tell us about your early years in Ireland, how that affected your professional life, and how did you get started?

David McMurtry: Oh my goodness, that's kind of a long one. At school I was a keen aero modeler, and in those days, keen at team racing and modifying the small diesel engines that we had, so I decided that I wanted a career in the aircraft industry. The aircraft industry got sent to the ground, so my parents decided I should be in the insurance industry, which was big at the time. Later, I decided that I didn't want to be there, so I applied to Rolls-Royce, who turned me down, and so I applied to Bristol Aero Engines Ltd., which was where the engines for the Concorde started and which was Rolls' rival in aero engines and military engines, in England at the time. This was in 1958, when I was 18. I was reasonably good at math, physics, and chemistry, the sciences of that time, and they accepted me, although they didn't recognize the Irish qualifications, which are different than from the English ones. They accepted me for a craft-grade apprentice, which is basically a shop-floor apprenticeship—only one day college and four days out on the shop floor—for a start. I accepted the apprentice program because they said if you did well, they'd upgrade you and you could become a full-time student. I had two years literally on the shop floor, which when I look back on it, was amazing because in the apprentice school, they took you through machine tool millers, turners, and grinders, two weeks in each section—and then on engine build. So it was all practical, then one day a week in college. I did well in that and they upgraded me to a full-time student, which meant I was a full-time academic. I found the reason why I did so well was that the craft-grade apprentices, the English guys, were really probably two years behind me in education, because they were in at 16. So it wasn't difficult for me to academically shine, because a lot of this stuff, the math, I'd done before, so it was a good start. I had two years ahead of them basically. Dublin was very good academically in math and physics.

ME: Where did you go to school in Dublin?

McMurtry: It was called Mount Joy School, which I think is now called Mount Temple; my claim to fame is it was the school that the rock group U2 went to!

First 3-D touch-trigger probe and patent by Sir David McMurtry.

ME: What were you working on when you made your discovery of the touch-trigger probe?

McMurtry: The Concorde itself. After I went into the main design office, I was working on the RB199, which was a Tornado aircraft. In '73, I was working on the Concorde engine, and that's when I designed the first trigger probe. In those days, we didn't have CAD/CAM, as you know, and the engine was designed with normal blueprints. A mock-up was built, and the fuel systems, the oil system pipes, were all hand-laid on the actual mock-up. It was made by model makers, then they had to be measured. Some of them were about a quarter-of-an-inch diameter. They had to be taken off and measured on the first early coordinate measuring machines our shop was using.

The large-diameter fuel pipes were fine, but the small-diameter pipes would deflect when we tried to measure them. It was a solid probe on a manual CMM, which you'd push against the pipe to try to get a data point. Of course, you'd move the pipe, and I was called down to find out why. I couldn't understand why they couldn't measure the thing. I got a note back saying, 'They couldn't make it, because they couldn't measure it,' and that puzzled me, so I went down to the shop floor. In those days, it was quite weird because the design office was completely separate from manufacturing, and literally designers designed it, production made it—there was a big void between the two, between production and design. More of a wall then, I'd chuck it over the top, and that was really the way it operated.

I said 'Let's go down and see what the problem is.' They had the first of the LK coordinate measuring machines there. The first LK machines were manual machines, with no probes, and solid styli. They hard-mounted the quill, and you had tapers for measuring holes. Then you'd pull this machine along to a pipe, and as soon as you'd touch it, you'd notice the machine would carry on.

Well, it was pretty obvious that you wanted something that wouldn't deflect the pipe. It would need to latch the readings, latch the counters—the tubes in those days—as you just touched it. Clearly it was requiring a very light switch, and it would have to be a 3-D switch, because you didn't know which direction you were going to hit with it. It was quite clear that you wanted something that could trigger with an extremely light load. I got to work on that problem, and I decided I would try to make one.

I drew a circle and divided it into three with a pair of compasses, as any schoolboy knows. I put six ball bearings on the table at the three radii and embedded them in plastic padding [a molding compound used in model making]. I soldered up the connections between the balls and built up the plastic padding to form a body. Then I made a crucifix and stylus on a micro lathe. Next day I took it into the factory and it worked. The touch-trigger probe was quite a simple construction but because it employed fundamental kinematic location principles it did the job!

ME: How much time did it take for you to make it?

McMurtry: Oh, it took me all weekend—many hours, and nearly a divorce! It was purely to get that problem solved, and I expected it to be a one-off solution.

ME: Is it possible to get somewhere in engineering and manufacturing without taking risks, as you have done?

McMurtry: Well, I actually didn't take much of a risk. In the early days, what actually happened was that when Norman Key, the owner of LK, saw the device on his machine, he wanted to find out where he could buy it. He gave me an order for 10! It became clear that there was money to be made from the sale of probes, and I had to decide then to see how to get it into production. I met John Deer, a colleague at Rolls-Royce, and he seemed very keen on the idea. I was at the time doing quite well in the design office, and I didn't want to leave Rolls. So we decided then that we'd start up a company between us, where I did the design and development at home in the evenings, and he was prepared to get the company off the ground, get things made and assembled. So he was the first to leave Rolls. I didn't actually leave Rolls right away; I originally gave notice in around '74 or '75, was persuaded to stay on to finish the ultra-quiet engine program, for which I was responsible. This was the Rolls-Royce M45 SD-02, an ultra-quiet research engine. They offered me the same salary to work for them two or three days a week. So I finished the program off, and then joined John full-time in 1979 to develop Renishaw. At no time did I need to mortgage the house, to take a real financial risk.

ME: How did you make the initial production of probes in your home?

McMurtry: I had an English lathe, a Myford Super 7, which was converted with a miller attachment that I used to make the bodies and styli.

ME: How did the probe work?

McMurtry: The stylus is mounted on a platform having three hard rods that go out 120° from each other sticking out from a center point. Each of the three rods sits on two rollers. You had to insulate the rods from one another. The wire would make contact with one of the rollers but it was isolated from the others, so the current had to pass through the rod that is sitting on the roller and then go into the next roller that's on the same rod. This completes a simple circuit. As the stylus is deflected, as it makes contact with the surface of the component which is being measured, one or more of those rods is going to start to lift off and the contact patch size between them reduces. That increases the resistance in the circuit. That first probe was simply a switch so when the stylus touched the component, contact was broken and froze the digital reading on the CMM. This was done quite simply with a battery in circuit and a solenoid which took the place of the machine's normal foot switch. Very, very simple and it worked like an absolute charm. It has mechanical repeatability of a couple hundred nm, and electrical repeatability of probably a little bit less than that. In today's probes, we look for a change in resistance and a trigger signal is produced when the circuit reaches a certain resistance value.

ME: I understand you were the youngest chief engineer at Rolls when you left?

McMurtry: My position was deputy chief of engine design and deputy chief designer. Yeah, that's possibly right—I have never bothered to check it. The probe was a very simple device, and that gave it, for the investment, two things that were in our favor; it was simple, and the market wasn't huge at the time, therefore, it didn't take a big investment to satisfy the market at the time. And then when the market grew, we grew with it.

ME: How did you get the patent?

McMurtry: At Rolls, I had a number of patents already. When I saw this had commercial value, I went to the patent office at Rolls and I said, 'I think we should patent this. This has got commercial value.' They agreed, and Rolls-Royce took out the patents, because in those days, they owned it because you agreed when you joined the company to sign over to them anything that you invented while an employee. I went to my boss man and told him what I wanted to do, and he tried to put me off as much as he possibly could. Eventually it was agree that a license would be issued, but the legal department would only license to a limited company, and not to an individual at the time. So we had to form a limited liability company as quickly as we possibly could, but in those days it took six months to register a company in England, and we wanted to get going pretty quickly. However, there was a company that bought registered companies and sold them off, so you could trade quickly. John went to Bristol and bought one of those, and it happened to be called Renishaw Electrical Ltd. We looked at the companies available, and said 'We'll have that one,' and paid £45 for it, so we could trade tomorrow!

With its new Revo Renscan 5 system, Renishaw has improved speed and quality of measurements in a full revolution around the workpiece.

ME: To get this patent, you went through a lot of trouble. It was a difficult time?

McMurtry: It was. It was unconventional, because we were negotiating a license through my boss, who said 'For goodness sake, forget it and go back to doing something useful.' He saw greater value in the aero-engine business.

ME: The patent was attacked by other parties; how did you defend it, and how did that affect your company at the time?

McMurtry: The first encounter we had was that DEA in Italy copied the principle, and the Rolls-Royce attorneys handled that case and eventually came to a settlement with them. This was around 1975. We were just getting going when the DEA case appeared. Because the patent was owned by Rolls, they defended it but settled out of court with DEA. Certainly, we didn't like the settlement. It threatened us so John and I decided we would buy the patent from Rolls, and John got busy with his negotiations. First, we were sole and exclusive licensees of the patent, then we became co-owners. In 1987, we bought it outright. John did a good job in wresting it away from them.

A major case, some years later, was against GTE Valeron, which was a distributor of our products. They obviously decided they'd get into the business themselves. They didn't copy the probe that we were doing, but they copied a design that I had previously patented. I had a number of patents because I realized that the way we had done it was a good way of doing it, but you could have a competitor who could do it differently and could then compete. So I had covered a number of ways of competing with the original patent and they copied one of those. A patent is useless if there's an equally good way of doing it that's different. If there is an equally good way of doing it, then you've got to cover that as well.

The DEA suit was settled out of court, but the Valeron one was a full-blown court case, which also cost us an awful lot of money. It went the whole way. It was extremely expensive, an extremely stressful, time-consuming process that tied us up for three or four weeks in the States for the court hearing, and then, the funding of the appeal, right through. However, there was a successful conclusion and Renishaw received compensation for its efforts.

ME: Did you ever at the time think that 'well, this is going to be the end?'

McMurtry: Oh yeah. I mean, put it this way, I would say being on the stand in a courtroom in the States is a pretty stressful situation, knowing that if you make one mistake, you've lost a lot. I think the stressful thing is if we had lost the case, we might have lost the company. So from that point of view, not making any mistake, was absolutely quite stressful. When you're cross-examined on the stand and somebody's out to get you to make mistakes, it's a pretty hairy situation. But we won outright.

ME: There was another later case, where Renishaw sued Zeiss for infringement?

McMurtry: In the Zeiss case, they copied the original mechanism, but also added a piece to it, an acoustic sensor, to pick up the acoustic wave passing through the mechanism, generated as it touched a component under inspection. We were silent on the means of sensing. The original judge ruled the patent was invalid, but the appeals court overturned it, and we won the case.

ME: How difficult is it to start up a company in the UK today?

McMurtry: Ours was a unique set of circumstances, but people do start their own businesses by leaving big companies, and if you've got the right product that you can patent, it's a great help. There are plenty of successful people who left Rolls-Royce and started their own subcontract companies, and also others in many other industries. It depends obviously what you want to do. The startup costs for Renishaw were very low, because we made everything then in small quantities and grew. Obviously the startup costs can be very high, if you try to get into manufacturing, buying all new machine tools, but in our case, it was very, very low.

ME: Is it possible for young people to have a career in manufacturing today in the US and in the UK?

McMurtry: There are many opportunities for young people today but in the UK, engineering is not generally seen by young people as a 'sexy' subject. Renishaw encourages young people into the industry at craft level by offering apprenticeships and will also sponsor those with good 'A' levels through university in the hope of retaining them once they have graduated. Several who joined us in the late '80s are now Divisional Directors of Renishaw and main Board members. Really, I think the whole thing's changing. If you design the manufacturing process, manufacturing can certainly be done here, but a lot of manufacturing is going to be done in the Far East. In England, now, the future for us is high-value, low-volume products, like dentistry, medical, things like that, there will be opportunities. What is now rapid prototyping will merge into small-batch manufacturing. Complex parts in the future, high-value, low-volume parts, could be made with rapid prototyping here. We're now sintering metals directly, and then you go into high-quality finishes after that. But certainly in England now, we'll be looking at new manufacturing processes, new methods for young engineers to develop, and the volume stuff will tend to be in the Far East. In the US, you still will have the military and the aircraft industry, and there's big opportunities here, as Rolls-Royce is still a big player in the aircraft industry. In the world market, both military and civil, there is certainly an opportunity in big companies. The real change is that the educational institutions are not pushing manufacturing, either here or in the US. In England, a high percentage of the best graduates go into the London financial district. That's where the jobs are; they're high-paying, and the bonuses can be ludicrous.

So you find that the best guys tend to be attracted there, although we've attracted a lot of students from 'OxBridge,' which are Oxford and Cambridge graduates here. We've sponsored engineering students at Oxford and Cambridge, which are the top two universities for engineering students.

ME: Why aren't our educational systems fostering engineering and manufacturing?

McMurtry: Well, certainly engineering tends to be more focused on design and development, roles that would be at the top end. Manufacturing definitely is less emphasized, and certainly very few people are pushing careers in manufacturing. Germany, Japan, and China are the exception, with technical colleges. Manufacturing tends to be migrating to cheaper environments, and interestingly, it's also going to environments that are tax havens, like Switzerland and Ireland. If you can make profits in a tax haven, that's attractive for a manufacturer.

ME: What goals may you still have left unattained?

McMurtry: There's still lots of goals. The company's got many product divisions now, and each one of them is a unique challenge, which keeps your brain really moving, that's for sure. I've had a passion for inventing things right from the very start. When we found out that the first product was successful, and the reasons why it was successful, we continued exploring other opportunities in metrology. So we really are looking now for products that can get a good, strong patent to start, and then we can actually protect it, not only with patents, but also with how we make it, so we do the manufacturing process as well.

ME: I understand you have five full-time patent agents on site; you're still churning out ideas, like your new patented Revo system?

McMurtry: We have multiple patents on the Revo and many of the original ones are mine. As you know, patents run out after 20 years—fewer in some countries—and so we started on this just before the touch-trigger patents ran out. We asked ourselves, 'What would we replace it with? What technology would we replace it with?' Clearly, it had to be a lot faster, and gather a lot more data than a touch-trigger probe off the surface, so you could measure profile as well as size. The touch-trigger principle really only measures size, not form. The first of the new Revo patents covered how we can actually scan extremely fast and get good data on the surface. The 'active head,' which was the name we gave to the technology, uses air-bearings, direct-drive axes, and then controls those axes off a sensing system that actually sensed the tip of the stylus as it was contacting a component, so that you've got the bandwidth and you've got the information direct. With present analog probes, if you moved the stylus tip very fast, the transducers in the head didn't follow. So the technology that we use, that made the active head what it is today, is basically sensing at the tip with the direct-drive servosystems off that. These are actually in the head itself. It has taken us many, many years to perfect the actual technology. It's basically a simple technology, but extremely difficult to perfect, to get the last bits of a micron out of it. The name Revo doesn't stand for anything. We were just trying to think of a name, because we're now actually scanning all of a complete circle, so revolution was the name, one revolution.

ME: What advice would you give someone starting out in engineering or manufacturing today?

McMurtry: For me, successful manufacturing has been the design and development of the product and the manufacturing process as one. It's easy to design something that can't be made. But the secret is to design something that can be made efficiently with your manufacturing process. You can't separate the design from the manufacturing. If you design something and chuck it over the fence, it's more likely to be a heck of a lot less efficient than if you designed the product thinking about the manufacturing process. And today, we attempt to design products to go through the processes that we have actually got in place here. There are rules and restrictions in design that channel people into the manufacturing processes that we've developed.■