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Prototyping Takes a Giant (*Smooth*) Leap Forward

Conventional wisdom runs there are two basic paths in prototyping die/mold work. EDM or machining (yes, there are other options, offshoots of EDM, grinding, the magical black art of 3D imaging, etc.). EDM is fine; a tad slow, and the finished part may require an additional operation or two. Overall though, not much new. The same can be said of machining (not much new) — with one significant exception: a new high-speed, very precise VMC that employs constant velocity (CV) instead of brute horsepower and variable speeds/feeds due to the disruptive accel/decel tied to the laborious processing rates of complex programs. CV is a paradigm shift in chip removal theory, a "revolutionary" leap forward

LANDENBERG, PA — The W.L Gore facility is 106,000 sq ft, employs some 500 (the bulk of Gore's Electronic Products Div., EPD) and is a recent consolidation of three plants. This is one of 17 manufacturing plants that make up Gore's "eastern US cluster." Other manufacturing facilities are in the western US, Germany, Scotland, Japan and China.

W.L. Gore & Associates, Inc. (Gore) was founded January 1, 1958 (Newark, DE), by Wilbert L. (Bill) and Genevieve (Vieve) Gore. The company is privately held and lists 8,000 employees in 45 plants and sales facilities worldwide.

Gore technology is found in consumer goods, electronic and electrochemical materials, fibers, geochemical services, cables and cable assemblies, fabrics, filtration, pharmaceutics, medical/healthcare, sealants, venting and many others. Its most univer-

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sally recognized product is Gore-Tex® Fabric.

Reported sales in 2008 were $2 billion.

Prototypes

When asked about his title within Gore, Ed McCracken says, "machinist", and while he *is* that (a *real* machinist, a noble but vanishing breed and not to be confused with "operator" or "technician"), he is much more, traveling frequently to build machinery, set up machines, install entire production lines in Mexico. . . and so on.

"In the 25 years I've been with Gore, I've done just about everything," he says. "But now I'm creating prototypes primarily for EPD — die/mold work — but then I handle anything that comes in from R&D, regardless of division. We're using this new VMC to service customers everywhere, the West Coast, Europe, Asia, China, you name it. Basically, if I can get the part on the machine, we get the prototype to them. Very, very fast turnaround."

McCracken says the parts he machines are usually very small — from the size of a finger to that of a finger tip. Materials: plastics, delron, Teflon, norel, nylon, aluminum and some steel. When he had the time and machines McCracken would mill a prototype, then shoot a couple hundred parts (injection molding) using the just-finished prototype mold, checking that the product coming off the mold is what he wants.

The typical mold shop would likely burn (EDM) these prototypes, a capability Gore has in this facility. "But when I can put the part in the VMC, and the finished prototype meets the specified tolerances (or better), why would I use another technology?" he asks. "I finish these parts right in the Revolution™. I put the part in one time, machine it, and it comes out finished. And when we set up the 4th axis, these prototypes will come off perfect, every time, ready to ship."

A quiet Revolution

Yes, that's a capital "R". Specifically, the VMC McCracken's using is a Revolution CV4020 by GBI Cincinnati, Inc. (Cincinnati, OH). It's a new entry in a VMC market that is already bloated with competitors. However, the Revolution, a lean, limber deceptively quiet machine, stands apart. "I swear," McCracken says, "I actually have to check to confirm the Revolution is running — it's so quiet. Quietest machine on the floor."

McCracken's CV4020 is a 40-taper general purpose/die-mold machine with 15,000 rpm, a 25-hp spindle (8,000, 10,000, 12,000 and 24,000 rpm units are available), a 24-tool magazine and double-arm toolchanger (ATC) delivering a 1.9 sec chip-to-chip tool change. *X* and *Y* axes feature linear guides and *Z* has a box way design.

Axes travels are 39.4" in *X* and 20.5" in *Y* and 19.9" in *Z*. Rapids: *X* and *Y*, 1.417 imp and *Z*, 1.102 imp. Positional accuracy is 0.0003" and repeatability is ±0.00012". The control features a high-speed multiprocessor from MTI (Essex, Ontario, Canada) capable of simultaneous eight-axis, 50,000 blocks/sec processing speed, allowing the Revolution to achieve constant velocity machining, permitting up to a 50 percent reduction in cycle time when milling complex prismatic parts.

On-Demand delivery

"Each Gore facility operates as its own independent business," McCracken says. "We bought the Revolution strictly for R&D, in particular R&D for EPD. And while EPD is paying for the machine, paying for my time, I pretty much run *every* R&D project or hot job on the Revolution."

For example, Gore develops and builds its own equipment, including machinery, and McCracken notes he uses the Revolution to quickly mill parts in those cases as well. "I use it for everything," he says, "but a major reason we purchased the GBI machine was to have the ability to get our product in our customers' hands, *right now*. This is what

today's customers demand. Everybody wants quick turnaround despite greatly compressed lead times. The days of Just-In-Time are over. That's not *fast* enough. Customers now expect On-Demand results. If you can't deliver to their expectations, they'll look elsewhere."

But, aren't there alternative ways to meet customers' On-Demand criteria? McCracken says, Sure. But none he can think of would really work — theoretically, let alone, practically. "We could put a bank of 3- and 4-axis VMCs in here and perhaps have one or two assigned a certain percent of idle time, just waiting for the next hot job," McCracken says, "but that's just bad thinking. Planning *in* idle time. In other words, building waste into a strategy designed to eliminate it. And from a practical point of view that approach wouldn't work. We don't have the space here. We used to do some run off injection molding using prototype molds, but we had to part with molding when we moved in here. EPD is a huge space, but it's a space that's full to the walls.

"A last thought on the idea," McCracken continues. "No matter how many machines we'd put in here to do parts (hot jobs, prototypes) none of the parts coming off those machines would compare to the quality coming off the Revolution — especially the superior surface finishes, hugely important in successfully prototyping die/mold work."

So, then what is it about the Revolution? "The key for us with this machine is processing speed and constant velocity," says McCracken.

The role of CV

According to McCracken, conventional controls have a forward processing capacity of 600 - 3000 blocks/sec. High-end controls may provide 5000 blocks/sec. But a processing capacity to 50,000 blocks/sec for eight simultaneously controlled axes has a significant effect upon machine tool performance and efficiency.

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Because the Revolution's MTI processer can handle the very high volume of data that describes, in detail, the cutting tool path, the tool can maintain a nearly constant speed over the workpiece. This constant velocity along the cutting path eliminates the accel/decel experienced by the cutting tool as a conventional control tries to move through a complex prototype contour.

The Revolution's control has 80 smart data buffers, as compared to 4 to 5 buffers found in conventional controls. Able to run any CAD/CAM brand that can run in a Windows XP environment, the control can handle mid-program restart without difficulty. In fact, such restarts can be handled in four different ways — by line number, block number, percentage of program run, or by having the operator position the cutter over the workpiece and start.

"When we were using a different machine (now retired) to do this work, we'd break a lot of tools," McCracken. "To change a tool and go back in the program to the point where the tool broke meant wading through code to find just the right point. With the Revolution, we don't do that. We go straight in and pick up right where we removed the tool. We save a lot of time, and it's so easy.

"Equally important," McCracken notes, "is that we're using very small endmills, from 0.010" on up. The average endmill is 0.0625". An endmill of 0.125" or 0.250" is a big endmill. Plus, these tiny thin tools are generally long, a good 6 to 10 times their diameter. *Pre*-Revolution, we'd break a lot of these small, thin tools. Now we don't break tools; we change them out when they begin to dull.

A conventional look-ahead system relies on feedback as the machine operates; the Revolution control calculates look-ahead before the machine starts and adjusts cutter movement as the machine runs. Its data-processing capacity enables the control to monitor operations and update tool paths in real time. And 50,000 blocks/sec process-

ing speed is the *minimum* achieved when interpolating eight axes; in a three- or four-axis system, the processing speed is faster.

Production anyone?

"This would be a great production machine, although that's not, of course, why we bought it," McCracken says. "We don't need all the speed, the very high rpms, a tool change in less than 2 sec — in fact, we had to dial the ATC down. We don't need those capabilities in prototype work. What we do need is the constant velocity, the accuracy, repeatability and the designed-in rigidity and stability.

"Now if we were a production house, we could easily retire of a couple of conventional VMCs and replace them with a single Revolution," McCracken continues. "The machine the Revolution replaced was a 6000 rpm, multi-axis VMC, and the Revolution gives us 15,000 rpm. Do we need 15,000 rpm? No, at least not now. Will the Revolution hit 15,000 rpm? We tested it. We ran it up to 15,000 rpm, and it wasn't even working hard. And its impact? With this single purchase, we've slashed prototype times by hours, if not days.

"We recently ran a 0.010" endmill at 12,000 rpm about 0.100" deep in delron, and we made the part without a problem. I was shocked," McCracken says. "With an endmill that small, if you don't have through-the-spindle coolant just right, and if the machine isn't rock stable, and the speed variable not constant, you'll break the tool, snap it right off. At that speed and depth, endmills that small can't survive changes in the tool path. But at constant velocity, they handle complex prismatic work like nothing."

Nothing but the best

"When we set out to find a new VMC, we were told to buy nothing but the best,"

McCracken says. "As hard core (appropriately skeptical?) as I am about manufacturer's claims, two of us took this as a challenging mandate. We looked at just about everyone — VMCs from all corners. We had a list, a kind of 'Best in Class' thing, that were must see candidates. The usual high-end suspects from US, European, Japanese and Asian manufacturers. Some were very impressive — with impressive price tags, as well. It was tough. We really didn't know which direction to go — until we saw it."

Last March McCracken and a team mate attended the official launch of the Revolution CV line at GBI headquarters in Cincinnati. They sat through presentations with current GBI customers, prospects for the Revolution machines and prospective distributors.

They watched a demo of a CV4020 doing the Mercedes test, with the test block at a 45° angle to make it more complicated. The machine was very, very quiet. Someone placed a retention knob on the machine bed to show the CV4020's lack of vibration.

At an appropriate break, McCracken got up and approached Kevin Bevan, President of GBI. McCracken said, "This is a nice event, very nice machine. But I'm not interested in this one. I'm interested in the one you have in the back, the one that's in setup, that's being worked on. That's the one that I want to see."

Bevan led the way, and it was a mess back there, stuff laying around, the kind of thing you'd expect to find if someone were setting up a new machine. They turned the Revolution on, and it began running around, cutting the Mercedes test.

"I was really impressed," McCracken says. "The machine wasn't even leveled up. You could feel it; the machine would shift a little bit, because it wasn't level. It was flawless. It ran the test, and it was so smooth, and that's what basically sold me on the Revolution. If it could run like that and still be in setup, what could it potentially do on our prototypes? And to think I almost went with a major Japanese builder whose product was twice as expensive and had only half the technology — and nothing like con-

stant velocity. The mistakes we're somehow saved from making."

Service "driven"

"The only problem we've had was the Widows side of the control had some trouble communicating with the machining side, resulting in a switching back and forth," McCracken says. "Some GBI guys came out here, and we went down a couple of different avenues without finding exactly what the problem was. And although we were still having trouble, we never had any downtime. The communications problem had no effect on the Revolution's uptime. So, after a time of tinkering on our own, I called Bevan again, and he said, 'We're fixing that issue, *right now. Today.*'

"And he had a guy drive out here 10 hours with a new control, and of course he fixed the problem. It wasn't the control at all. It was a $10.00 switch. In hindsight, we could have fixed this over the phone. Bevan and GBI were absolutely determined to make the machine right. And it was a box in the back of the machine that was switching back and forth. Now the machine is flawless. I can't express the extent to which GBI bent over backwards, coming to our facility numerous times. And then dispatching next day service. No one gets that type of service any more. Frankly, no one *provides* it. When it comes to standing behind their machine, the guys at GBI are simply *possessed* with making things right.

"Further, GBI always asks if there is anything they can do to make this an easier or better machine to run. Personally, I can't think of a thing. GBI's really good about staying on top of their products. They really believe they have made the best machine out there, and I agree. *But they really mean it.* They're always asking how they can make the product better for the customer."

End

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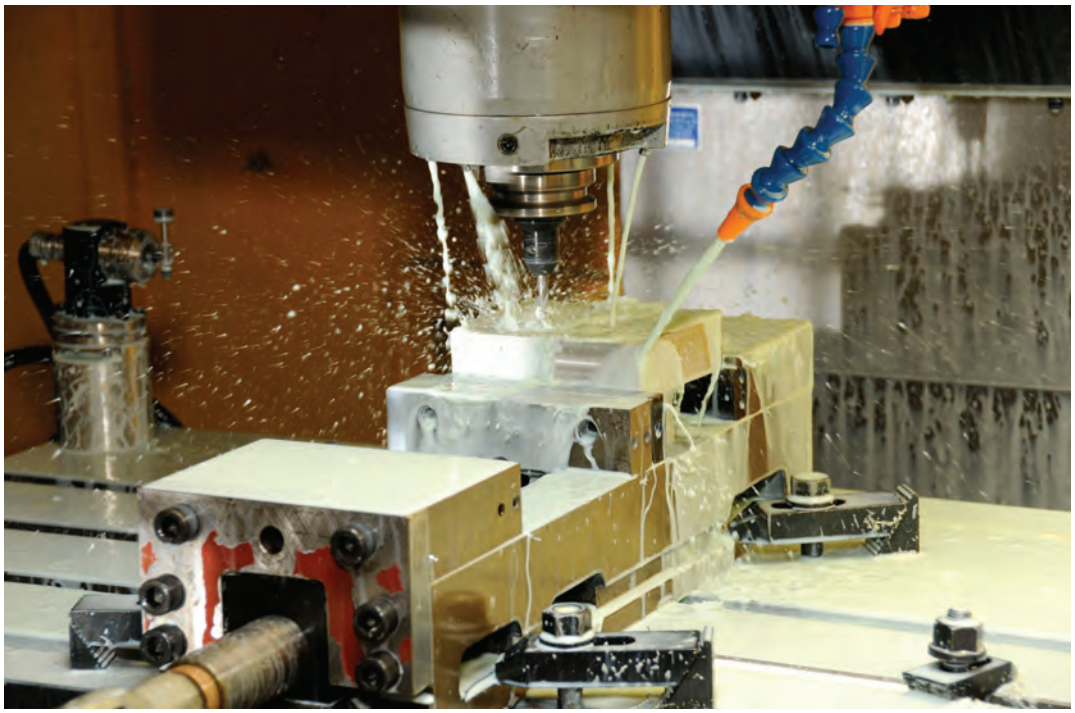

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McCracken at the controls!

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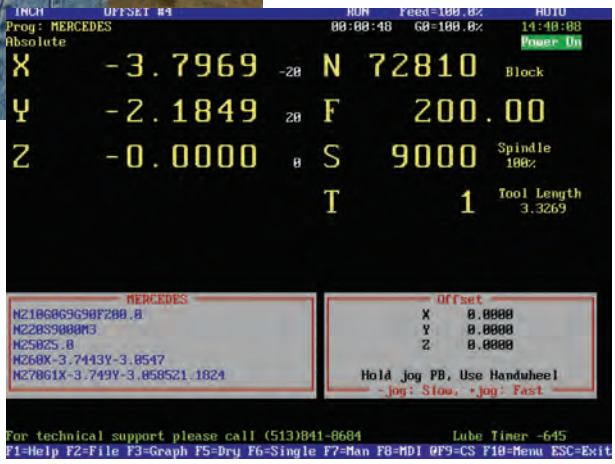

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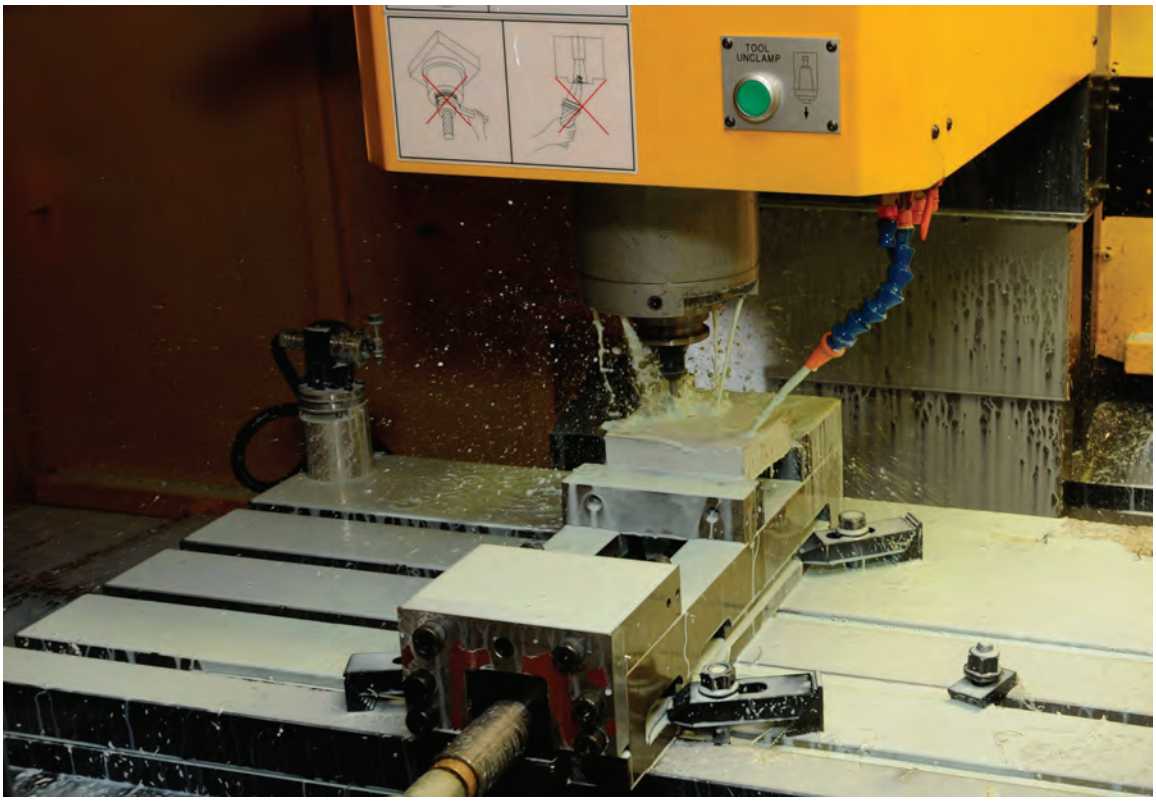
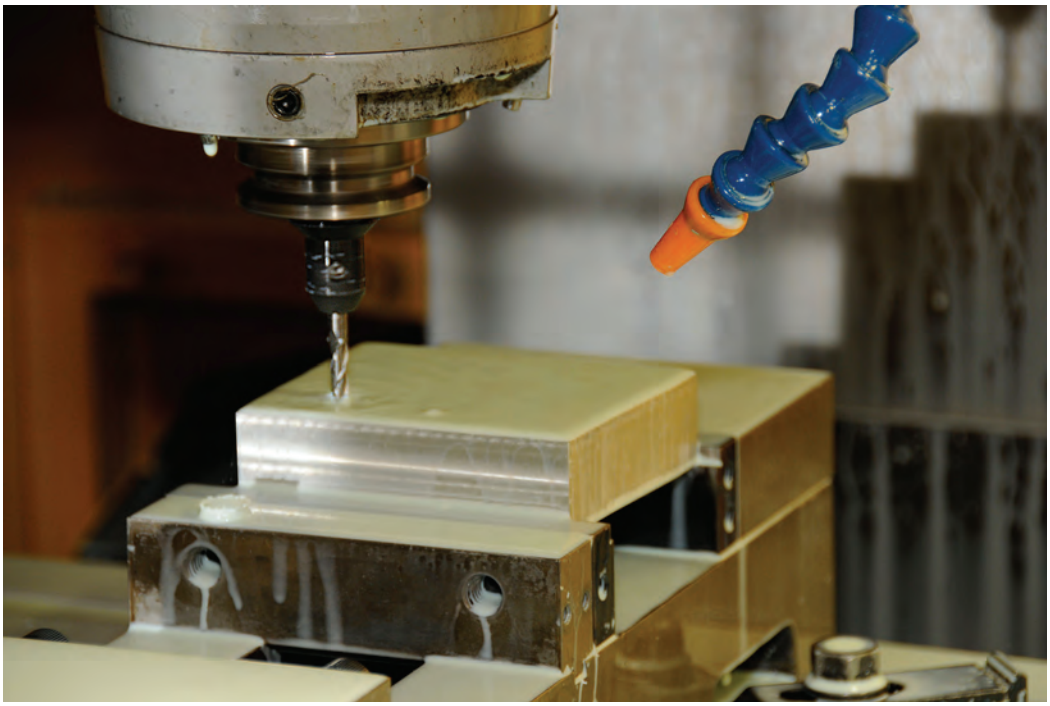


McCracken: "At these high speeds and depths, very small endmills can't survive changes in the tool path. But at constant velocity, they handle complex prismatic work like nothing."



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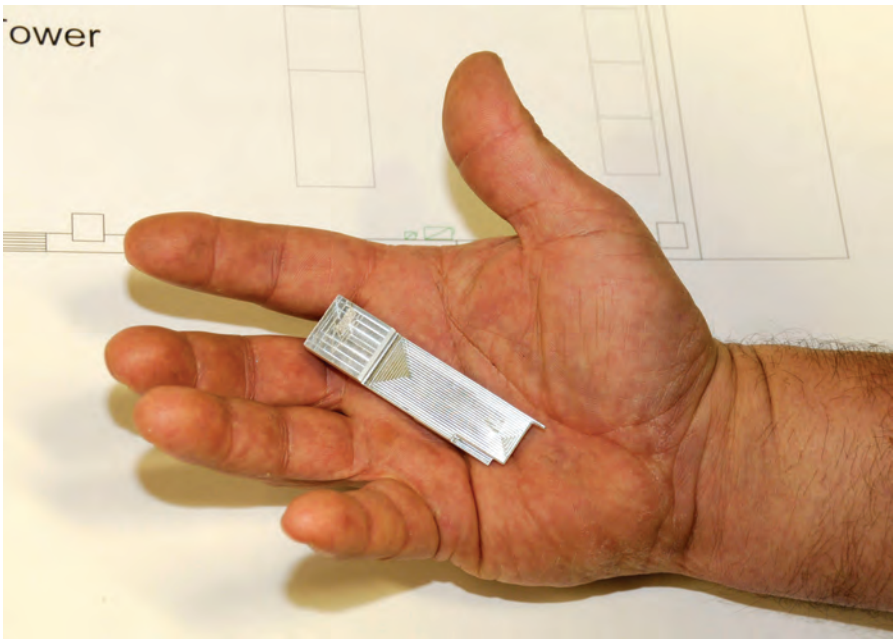

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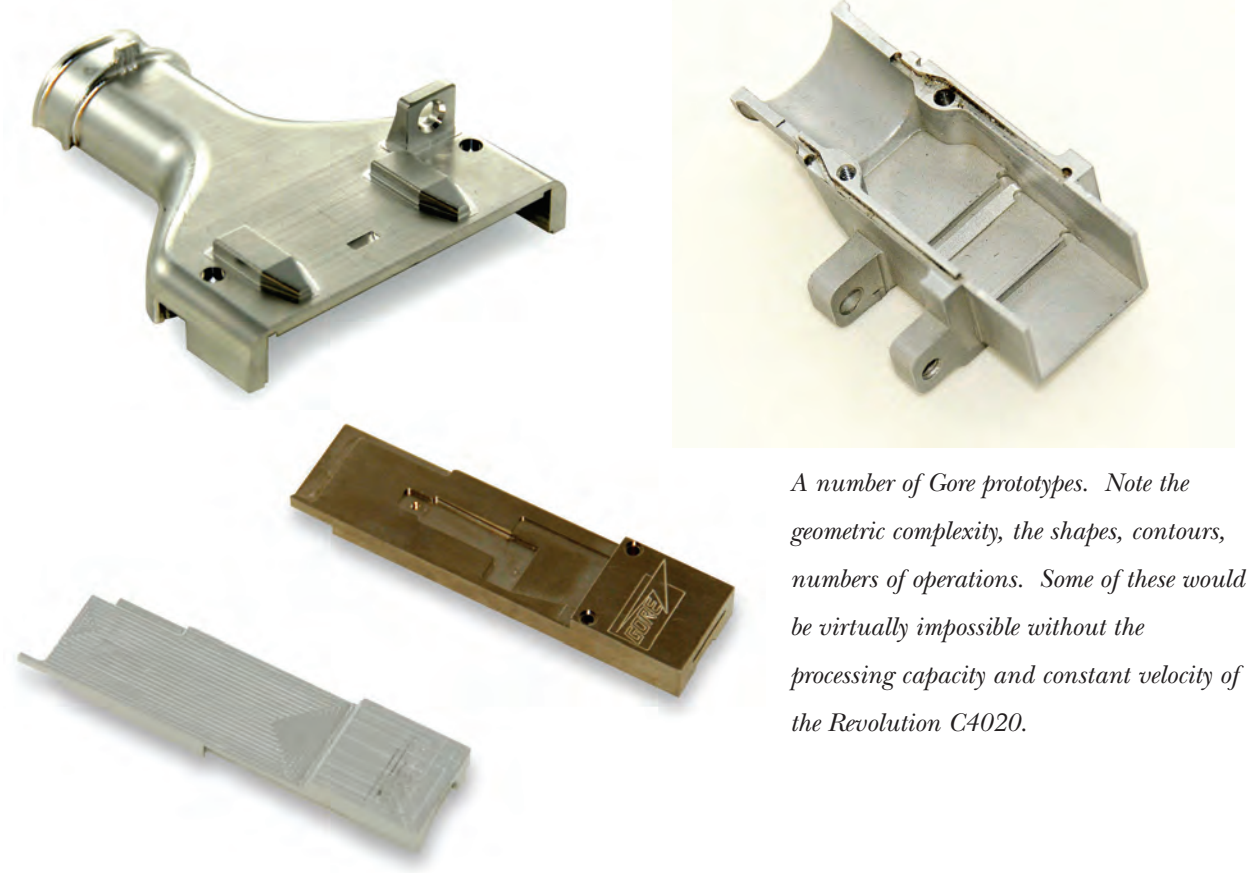

A number of Gore prototypes. Note the geometric complexity, the shapes, contours, numbers of operations. Some of these would be virtually impossible without the processing capacity and constant velocity of the Revolution C4020.