CNC MACHINING

volume 2
number 7
fall '98

coverstory

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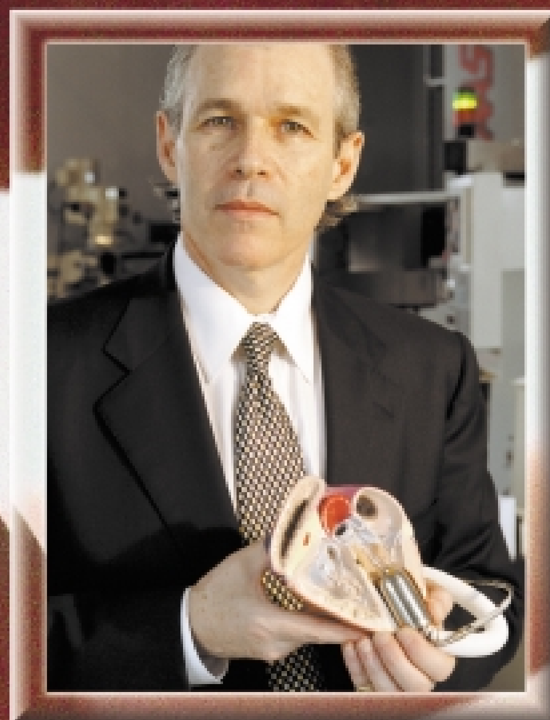

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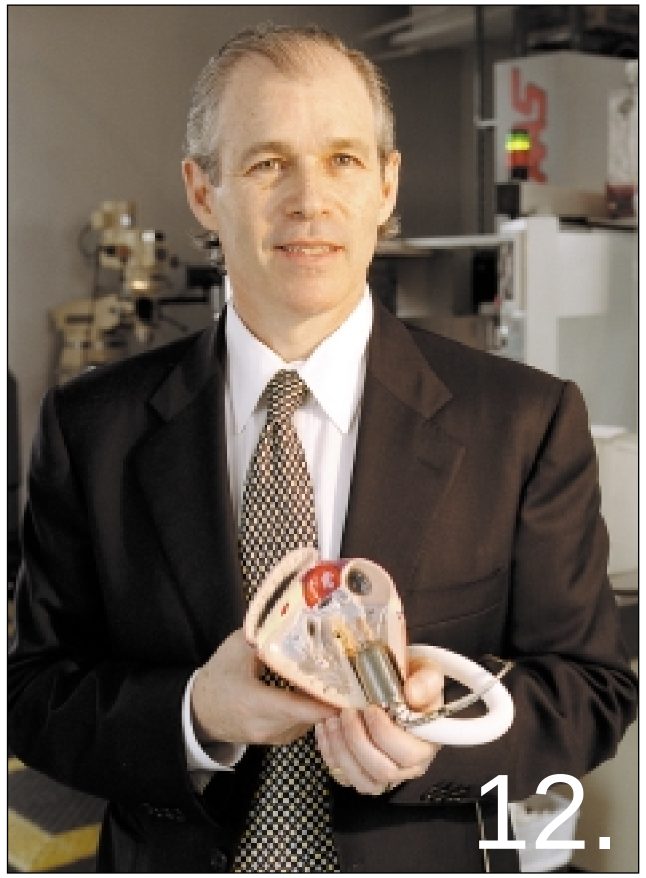

Photo: Scott Rathburn

Dr. Robert Jarvik, a leader in the field of artificial heart research, displays his latest heart pump. The Jarvik 2000 is a miniature axial-flow blood pump that is implanted directly into the left ventricle of the human heart.

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On the Cover

An early stator blade design for the Jarvik 2000 heart pump. Components are five-axis machined out of titanium on Haas VMCs.

Inset: Dr. Robert Jarvik with the Jarvik 2000 heart pump.

Photos: Scott Rathburn

Denis Dupuis General Manager, Haas Automation

A lot's happened in the last ten years

This issue's editorial was going to be the last of my four-part series on managing a business as I see it. But then I realized this September is the 10th anniversary of the introduction of the first Haas CNC machining center. The VF-1 was introduced to the world in 1988 at IMTS in Chicago. Ten years is a long time, yet it seems like yesterday. A lot has happened to Haas Automation since then, and I hope you will bear with me while I reflect a little on the past ten years.

I remember the excitement as we gathered to take photos of the prototype VF-l as it was loaded on the truck and sent down the road to Chicago. I don't think any of us realized the floodgates we were opening. We were just a small group manufacturing CNC indexers and rotary tables in a 20,000-square-foot shop in Sun Valley, California. Sales were less than $5 million a year.

By the end of June 1989, 10 customers had purchased the new machining centers and agreed to be test sites. By the end of 1989, an additional 27 customers had taken delivery of Haas VF-1s. I think we especially owe a debt of gratitude to those first customers, because they helped us improve the product initially. Every new machine shipped incorporated upgrades and refinements resulting from the suggestions and requests of those owners. This program of continuous improvement quickly became a mainstay at Haas, and is still evident today in every product we build.

The early success of the VF-1 led to our customers asking for machines "a little bigger," and then "just a little bigger," until the product line expanded to include the machines you see today – from the compact VF-E to the gigantic VB-l (the 5-axis bridge mill launched at IMTS 98). Our customers asked for a horizontal, so we designed the HS-l series, the HS-2 series and now the HS-3. "What about turning?" some of our customers asked, so we developed the HL series. Thanks for asking!

We not only owe a special "thank-you" to the original Haas owners, but to all the owners of the 17,500 CNC machines, and more than 24,000 rotary products, now in use worldwide. We

make them the number one selling machine tools in the USA.

On this 10th anniversary, kudos must go out to our distributors, who have risen to the occasion each and every year. They have expanded their organizations to meet our customers' expectations in sales, service and applications. And we would be remiss if we didn't also thank all of our suppliers, who have stretched and strained to meet our production schedules as the demand for Haas products skyrocketed.

Last, but certainly not least, I want to thank all of the people at Haas, who have exceeded all of our expectations through the meteoric rise of the company. From the first move to Chatsworth in 1992, through the 1994 earthquake, and on to last year's move to our new 420,000-square-foot facility in Oxnard (now 620,000 square feet), everyone on the Haas team has shared in the triumphs and survived the disasters. They made it all possible.

As I listed the groups above (and probably missed a few), I couldn't help but remember that these groups are made up of individuals who have pushed the envelope, and helped make "Made in America" something to be

Continued expansion at Haas Automation, Inc.

By the time you read this a new 200,000-square-foot addition to the Haas Automation facility in Oxnard, California – affectionately dubbed Haas II – will be complete.

The foundation for the new building was poured in June, and the walls were tilted up in a mere four days during the second week of August. Plans are to have machinery moved in as soon as October.

Haas II will be used to expand existing production lines and increase machine shop capabilities, as well as house one month's supply of finished machine stock to speed shipments to customers.

Already the largest machine tool builder in the United States based on unit production, this expansion will also make Haas Automation the largest machine tool builder based on square footage for a single facility.

Year 2000? Y2K? Are You Ready?

As the new millennium fast approaches, there seems to be much worry about what will happen when all the internal calendars in all the computers in all the world reach that magical number: 00. The year 2000, the dawn of a new age, Armageddon.

Fear not, ye owners of Haas machine tools. Thou shalt not be subjected to the wrath of the Almighty Double Zero. Every Haas machine from the dawn of time (or at least the dawn of Haas Automation) has utilized an internal calendar with four, count 'em four, places to enumerate the year. Unlike those who failed to plan for the future, there'll be no double zero here in the land of Haas. No! It will be the year 2000, with all the appropriate numbers in all the appropriate places.

So, while the rest of the world cowers with fear as their clocks tick toward January 1, 2000, those smart enough to buy a Haas will just keep on making parts.

TRADE SHOW CALENDAR '98-'99

MTA '98	Nov. 17 - 21, 1998 Singapore	The largest machine tool & metalworking show in S. E. Asia.
PRI '98	Dec. 3 - 5, 1998 Indianapolis, IN	Buyers from around the world come to see what's new in hardcore racing products
Orlando '99 APEX	Jan. 19 - 21, 1999 Orlando, FL	The premier manufacturing exposition in Florida during '99.
Greenville, APEX '99	Jan. 26 - 28, 1999 Greenville, NC	New show. Metalworking equipment and accessories.
WESTEC '99	Mar. 22 - 25, 1999 Los Angeles, CA	North America's largest annual metalworking & manufacturing expo.
'99 Cincinnati MTS	Mar. 31 - Apr. 1, 1999 Cincinnati, OH	A premier manufacturing exposition for the Ohio Valley and Tri-State area.
EMO	May 5 -12, 1999 Paris, France	Considered the "World of Machine Tools," this show will be held at the Parc des Expositions.

A virtual gridfull of racecars and trucks are carrying the Haas Automation logo into competition throughout the racing world. From international CART competition to dirt-slinging SCORE and SCRA entries, Haas-sponsored vehicles have gathered a fair share of checkered flags this season.

PacWest Racing Group

CART competition finds the PacWest team of Blundell (#18) and Gugelmin (#17) fighting developmental gremlins as new rules, engines and suspension components tax the team's performance. New aerodynamic devices designed to slow the terminal velocity of the high-performance open-wheeled racers will likely guarantee "Big Mo's" place in the California Speedway record books with the ultimate fast lap of 240.942 mph set during last year's qualifying.

In Indy Lights competition, Didier Andre (#18) continues to add championship points to his credit as he maintains his top-five standings in the PPG-Dayton series.

Hendrick Motorsports

Jeff Gordon (#24) continues to hold court over the four-door doorless Fords, staying on top of the series points standings with consistent top-ten finishes bolstered by meticulous machinery and quick pit stops. Wally Dallenbach, Jr., is slated to finish out the year in car #50 with numerous top ten finishes already on the books. "Texas" Terry Labonte (#5) is keeping his Monte Carlo in the top ten of the points race, showing that Chevy is still a major factor on the Good Ol' Boys circuit.

In NASCAR truck competition, Jack Sprague (#24) is keeping his Chevy pickup at the lead of the points race, and rewarded his new primary sponsor, GMAC Financial Services, with a win at California Speedway. The victory was Sprague's eighth career super speedway win. "Mile Track" Jack hopes to become the first repeat winner of the truck series, having won last year's series and now leading the standings in this year's competition.

photo courtesy of C&C Motorsports

Joe Custer pilots the C&C Motorsports SCORE off-road truck to a first-in-class victory in the Baja 500

C&C Motorsports

Dirt diggers Custer and Cline are putting the pedal down hard and bringing home the gold with first place finishes at a number of racing venues.

Custer's SCORE off-road racing pickup truck scored a first-in-class victory on its first-ever outing in the Baja 500. Not bad for a shakedown cruise! Preparation continues for the Baja 1000 in November.

Cline had the sellout crowds on their feet and cheering at Perris Auto Speedway as he out -dragged the current points leader in SCRA competition and won the prestigious 4th of July race. Witnesses say this was by far the most exciting race of the dirt track season, as Troy "Hotfoot" Cline led 22 laps of the 30-lap main event only to find his #11 sprinter three car lengths behind as he entered the final turn of the final lap. He dove to the inside of the turn and drove home the winner before the largest crowd of the season!

Danze Racing

Sporting fresh paint and running less than a half-second off the class record at Willow Springs Raceway is the Danze Racing Indycar Racing Series entry driven by Alex Danze, general manager of Innovative Metal Designs Incorporated. Formerly driven by John Andretti against his father and two brothers in the 1991 Indianapolis 500 race, this Buick-powered Lola is capable of speeds in excess of 215 mph. Danze's shop runs seven Haas CNCs around the clock, and he hopes to run his Lola to victory in the highly-competitive Indycar Series.

Yearning for Learning

Apprentice Program Plants Seeds of Perfection

Story and Photos Preston Gratiot

Where do novice machinists come from? The industry used to take care of its own, bringing up the kin of family and friends through the school of "hard knocks" and teaching them the trade. Journeyman machinists took young apprentices under their wings and passed on lifetimes of experience over a period of years. Over time, and under a watchful eye, these apprentices mastered the trade and gained the necessary skills to venture out on their own.

However, as technology advanced and other trades became more lucrative, the efficacy of these programs waned. It was no longer appealing to spend years as an apprentice learning a blue-collar trade that was considered less than desirable. During the past few decades, the basic tutelage of entry-level machinists has become the domain of public school "Shop" classes.

Old-world apprentice training paved the road for the development of public school programs designed to introduce the basics of the Industrial Arts. But an hour a day of high school "Metalworking 101," pounding out an ashtray for Dad, bears little resemblance to the typical day put in by the traditional apprentice of old.

To some degree, the public school system took over the task of directing novice workers into the machining trades – until budget cuts started nibbling away at what many considered were super-superfluous classes and programs. Industrial Arts classes were an easy target, and many school districts pulled the plug – quite literally – on their machine shop programs. Thus the pool of students exposed to the metalworking arts began to dry up, resulting in a shortage of qualified machinists entering the work force. That shortage continues today, and is proving disastrous for the manufacturing industry, in general, and the metalworking trade in particular.

There is a new ray of hope, however. A cadre of teachers, small-businessmen, corporate executives and shop managers are joining forces to rebuild school industrial arts programs and set up continuing education programs for on-the-job training. David Goodreau, Chairman of the Board, Small Manufacturers Association of California, is one of those working to increase interest in the metalworking trades and resurrect traditional-style apprenticeship programs.

"It's important that we find solutions," Goodreau says, "because the alternatives aren't very good. We, as a country, have set a path, and that path leads to ruin. You cannot sell quality machines or technological upgrades if you don't have talented people to run them. The bottom has been eroding out of our educational support system for

Please see page 6

Working in an apprentice program means on-the-job experience. While few schools can boast of having the latest in CNC machining centers, working machine shops can provide the real tools.

Continued from page 4

probably the last three decades, and it's been a steady decline for the true industrial arts. We are at a real crossroads: We have reached a point that demands some real strategic thinking if we are going to survive as an economic leader.

"We are trying to establish an organizational body that will provide tangible benefits for the participating companies, educational facilities and the potential work force," Goodreau says about his association with the Small Manufacturer's Institute (SMI). "We've helped develop the Machine Tool Partnership Academy (MTPA), a corporate-supported apprenticeship program, at Van Nuys High School (Van Nuys, CA), and we're going to replicate this program at two other area high schools. "

The MTPA is a cooperative effort between schools, corporate sponsors and local businesses, where students attend Industrial Arts classes during the day and report to an afternoon or evening "job" as a working apprentice. The program gives students the opportunity to learn a trade first hand, and gives businesses the opportunity to train their future work force. It's a win-win situation.

Goodreau says the students have to score relatively high in their mechanical skills to get into the Academy. "You take qualified kids who have the talent, then you connect the world of learning to their interests – and to their future earning potential," he explains. "That's where the winning is. We have some 30 mentor companies for these students, and these kids have got jobs! They've got a future. But the bottom line is this: They have become part of a working family.

"It's not uncommon for high school students to think they have no need for good grades or continued studies in the so-called basics because they have chosen a career in metalworking," says Goodreau. "But given the chance to experience real-world production as an apprentice, they can see how some Readin', 'Ritin' and 'Rithmatic will help when they actually enter the work force."

According to Goodreau, "When a kid gets in with the right company, there's a chance he might stay in school. That's important. The workplace needs highly-educated, agile employees."

This is especially true with the kids in the Van Nuys program. These students are all "at risk" kids who come from relatively impoverished backgrounds. The typical dropout rate for these kids is 50 percent. But the dropout rate for participants in the Academy Program is less than 10 percent.

"What we're really trying to do is encourage this prospective work force and let them know that metalworking isn't a dead-end occupation," Goodreau continues. "It is more likely the starting point for multi-level, professional opportunities."

This year, 30 kids came out of the Academy program, some of them are already apprenticed with 12 college credits under their belts. "If they end up getting into engineering or something like that, most will probably know more than the guys already on the job. This is because most straight engineers have probably never even seen a machine tool, and that is a crime," laments Goodreau. "How can you have somebody designing products that has no idea how the product is made?"

This apprenticeship program is an investment – an investment in the future. "What we've forgotten is how important it is to shape people," says Goodreau. "Nobody is saying these kids are going to end up being machinists. But I'll tell you what, their experiences here will shape their careers – and our future as an economic power in the world."

Haas Automation Supports College Program

"I've been working with Haas for a number of years, and helped get the apprentice program started," says Bill Lavoie, instructor, Los Angeles Valley College (LAVC). "I talked with Gene [Haas] at one of the WESTECs and asked how I could get some Haas equipment at Valley College. It took a few years, but because of the apprenticeship program, the college now has three Haas machines: a VF-3 vertical machining center, an HS-1 horizontal and an HL-2 lathe. I'm planning an open house this Fall so that more local companies can find out about the LAVC / Haas cooperative program.

I've promoted corporate support of Industrial Arts classes for years. But Haas was the first company to step forward and put some real support on the classroom floor. LAVC students are learning how to run CNC machining centers in these classrooms, so they will already know the Haas control, all of the M and G codes, and they have already cut parts – they are off and running."

Insert Ideas Turn Problems to Profits

Story and Photos Preston Gratiot

How do you turn a problem into a profit in a matter of months? Simple: analyze the situation, formulate a solution, find the financing and take a chance.

That's how two coworkers in British Columbia made the jump from employees to employers, and set up their own profitable job shop. Their entrepreneurial escapade started when they realized that most of the shops in their area were seriously behind in their schedules – there was just too much work to go around.

Based on this recognized need for on-time production capabilities in their locale, the two machinists got to work formulating a business plan that would convince one of the local banks to underwrite their own job shop.

In business for only 20 months, Duo CNC Machining Inc., owned by partners Calvin Jacques and John Belton, now has nine employees and runs three CNC machines in the 3,500-square-foot shop in the Delta region of Vancouver, British Columbia.

Working two shifts a day, Duo specializes in machining gears and housings, parts for bicycles, oil field machinery, electronics and aircraft componentry. Short runs, however, mean that the shop counts heavily on Haas controls and machining centers to simplify the setups and save time.

Running Costs

Both owners agree that price was the main factor in their initial choice of Haas machines for the shop. The first VF-3 was set up in November 1996, followed soon after in December by the HL-4 turning center.

Partners Calvin Jacques, left, and John Belton built Duo CNC Machining into a success in just 20 months.

Turning steel on the HL-4 is a daily occurrence in support of the local pulp and paper mills, in addition to the many heavy equipment manufacturers located in the Vancouver area.

Duo CNC Machining builds its customer base by finding new ways to machine problem parts that other companies judge too difficult to tackle.

"The control is fully loaded with standard options that other machine tool builders charge extra money for," says Calvin. "But the Haas machines allow us to keep our costs low, thus allowing us to compete in a very competitive marketplace."

Calvin and John agree that the Haas control can be the difference when it comes to making a short-run part pay off for the company. "When you're dealing in a job shop world, setup time can kill you," reasons Calvin. "We cut a lot of short run parts, so it's not just how fast the machine can make the parts, but how quick you can set the machine up to make them."

Networking for New Work

"We originally opened our doors in this same building, but in a little 500-square-foot shop next door. It was a little crammed-up place," said John. "Mostly, the stuff we made on the mill was the stuff that nobody else wanted to do, ugly stuff. But we didn't have much choice in the beginning, because those are the only jobs you get. At least we stayed busy."

A good 50-percent of Duo's initial work was with Delta Dynamics, a company located right next door that specialized in gearboxes and gears. "Our relationship with them has been a great contributing factor to our success," says Calvin about the neighborly business pact. "I didn't know them prior to coming here, but John used to work with the guys back at Vancouver Gear."

John says Duo still does a lot of gears, but lately they've seen a big growth in the aerospace market. "We weren't doing anything in this market last year, but this year it's about 30-percent of our business."

Problems & Solutions

However, working as a job shop does present the occasional problem part. "It was a job nobody else could master," laughs Calvin. "But we happened upon a simple solution, and it's been fine ever since." The part was an actuator housing for the pulp and paper industry.

"We were trying to cut the stainless steel housings on our HL-4, but the material was centrifugally spun, so all the crud and crap was in the crust on the outside. We spent days on end busting inserts trying to get something that worked. Then, all of a sudden, I found it! Essentially, what I did was take one of the broken inserts and use it to cut the crust away first, then start doing the real machining afterwards with a good cutter." Kind of like eating crab legs!

The job's been fine ever since, explains Calvin. "It worked great! There was nothing fancy about the job – the other guys just couldn't find a way to remove the crust!"

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KB Golf – The Mouse That Roared!

Story Gary Brient

Titleist, Callaway, Dunlop, Cobra, if you don't recognize these brands, you're not a prospective customer of KB Golf. Tucked into a small industrial park in Sunnyvale, California, a 2,200-square-foot machine shop assaults the giants of the industry and mills its way into the hearts of golf aficionados worldwide!

Kevin Burns commenced designing and milling golf putters in 1993. With a four-year background in golf club repair, Kevin had the vision of his own product, his own company, his own profit. After five years of research and development, Kevin Burns decided that he had produced the ultimate golf putter.

In 1996, Kevin traveled to four West Coast PGA tournaments, sneaking into locker rooms and holding lengthy discussions with pro golfers. By placing a few putters into the hands of some top-flight pros, it only took three tournaments to establish his first PGA win: the 1996 Nissan Los Angeles Open. With this success in the record books, January of 1997 saw Mr. Burns hiring a full-time tour representative, Eric Brown, to market his exclusive product. Now the mouse was playing in the lion's den, competing against major companies that were paying tour players to use their putter line.

Word of mouth saved KB Golf the expensive task of buying allegiance amongst the pros. By the end of '97 there was a tour win (The Greater Vancouver Open), as well as four second-place finishes, three third-place finishes, 21 top-ten finishes and two U.S. Ryder Cup appearances. More noteworthy, the Darrell Survey, which surveys professionals to see which clubs they have in their bags on the first tee, found the Burns putter to be the number four putter, preceded only by Titleist, Odyssey and Ping.

In route to fulfilling his dream, Kevin plunked his money down on a used Haas VF-1 vertical machining center in 1993. That machine, number 1083, is now affectionately known as "Bambi" in the shop. Three years later, in 1996, another VF-1 was purchased, and the two machines now produce an expanded production run of one of the highest quality putters ever designed. The addition of two Haas VF-3s, one in '97 and another in '98, completes the contemporary production line.

Photos Courtesy KB Golf

Three of the Kevin Burns Signature Series putters available from KB Golf. Custom lengths, loft and lie are available upon request.

In 1998, the sales and successes of Kevin's milled putters accelerated tremendously. A win at the Bob Hope Chrysler Classic, and five top-ten PGA tour finishes in the first six months, justified a production run of 800 putters per month. By July '98, the production run had increased to 1,500 putters per month. With all orders prepaid by distributors and an asking price of $350 a unit, capital worries have flown south for KB Golf. In fact, another three Haas mills may soon adorn the shop if space can be created.

Using Haas VMCs, the team at KB Golf produces what they consider to be the ultimate golf putter – at a rate of 1,500 per month.

photo: Gary Brient

Constructed of carbon steel and 303 stainless, seven operations are necessary for the production of the eight models of putters produced by KB Golf. The initial cut is one inch wide and .200" deep. A single pass at 15 inches per minute is made with a 3/4-inch-diameter hog mill at a spindle load of 45%. This maximizes the tool's efficiency without jeopardizing the tool itself. Options that KB Golf elected for their Haas mills are a chip auger, rigid tapping, programmable coolant nozzle, tool management alarm and macros, and the engraving package. KB uses the latter (engraving) to carve Kevin Burns' signature into each putter. An artist then lacquers the signature by hand. This attention to detail truly distinguishes the Kevin Burns Signature Series from any of its competitors. Truth of the matter is, there is only one other handmade putter in the marketplace, the remainder are stock castings with none of the balance or feel provided by these custom-designed putters.

According to Kevin, professional golfers like aggressive putting, and the special softness of his putters (there is a copper insert in the putting head) has struck a nerve with many of the playing elite. Kevin has four past Masters champions playing with his putters. Professionals demand a carefully finished product, and the utilization of Haas mills has fulfilled the highest expectations of players and staff alike.

Jerome Sorich, shop superintendent, had this to say about the exclusive use of Haas mills, "I've worked on Mazak, Matsura, Fadal . . . and Haas is as trouble free as any. You don't have to spend a million dollars to have reliable machining; our reliability has been outstanding . . . they (Haas) don't break down!"

Jerome has inherited the research and design program at KB Golf, which relies on a CAD program that is integrated with the older VF-1. All the experimental cuts are performed on the older machine – this is its only role. It should also be noted that all of the jaws that hold parts are custom made. Assisting Jerome in production are John Bunuelos, Blair Phelps, Joe Gutierrez and Pete Dimas.

Obviously, the golf world is on notice – KB Golf is distributing its putters in the United States, Europe, Malaysia, India, Japan, Hong Kong and Singapore. Sixty percent of all production is sold in the good ol' US of A, and the remaining 40 percent is foreign. But more notable is the special market niche Kevin Burns has created with intent. Were this putter a car, it would be a Ferrari, a Porsche. . . were it a liquor, it would be a Chivas Regal, a Jack Daniels . . . the high end, the premier, call it what you want, the Kevin Burns Signature Series of putters is the ultimate market phenomena . . . a special area of demand created by a superior product. What's not to like?

KB Golf Manufacturing
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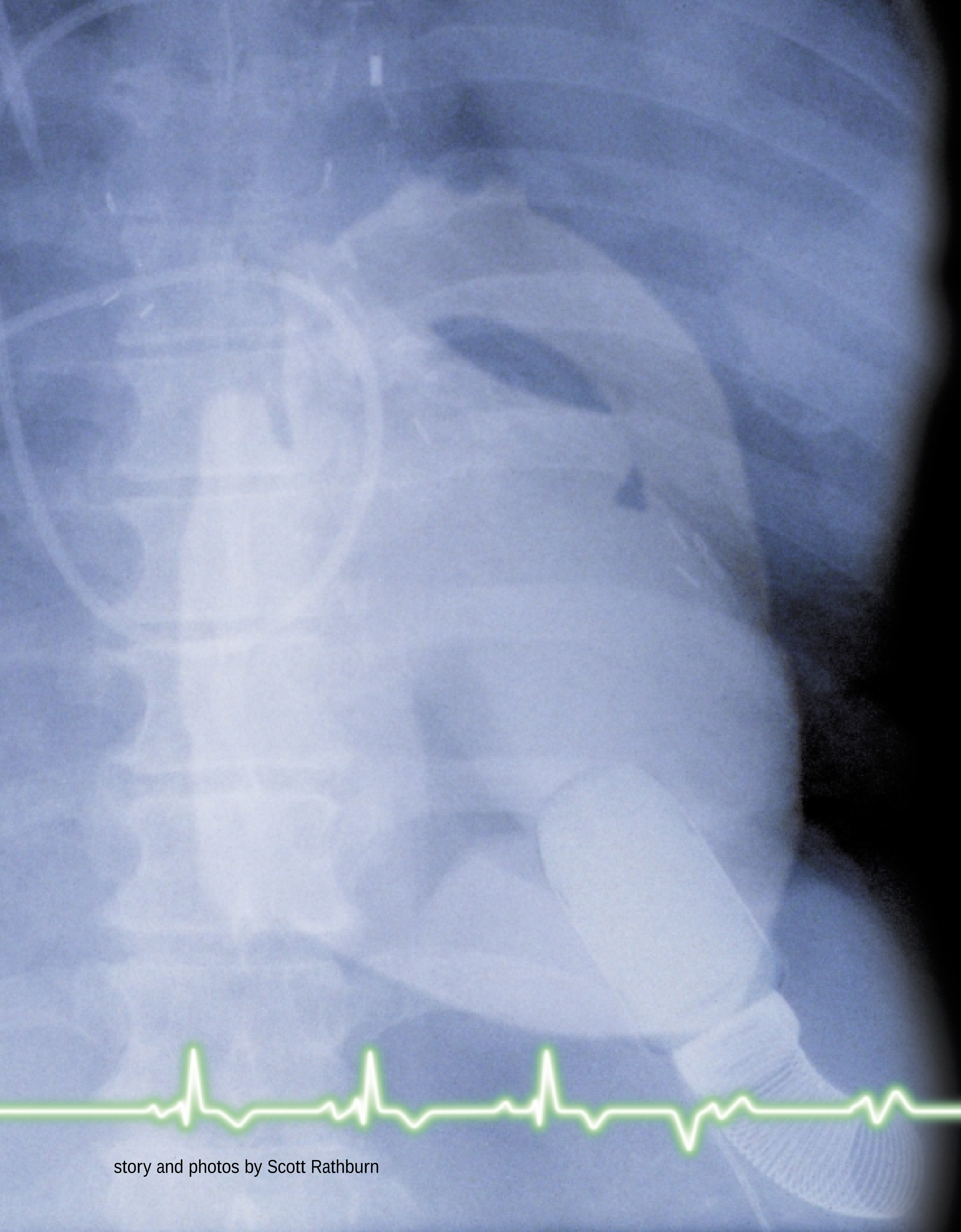


The Heart of the Matter

story and photos by Scott Rathburn

The heart. Oft considered the center of emotion, the embodiment of the soul, the keeper of the spirit, it is seen by many as the source of courage, intuition and affection. It is the symbol of love. In reality, the human heart is a fist-sized mass of muscle connected to the rest of the body by a network of blood vessels more than 60,000 miles long. Running non-stop from birth until death, it will beat more than 2.5 billion times and pump more than 1 million barrels of blood.

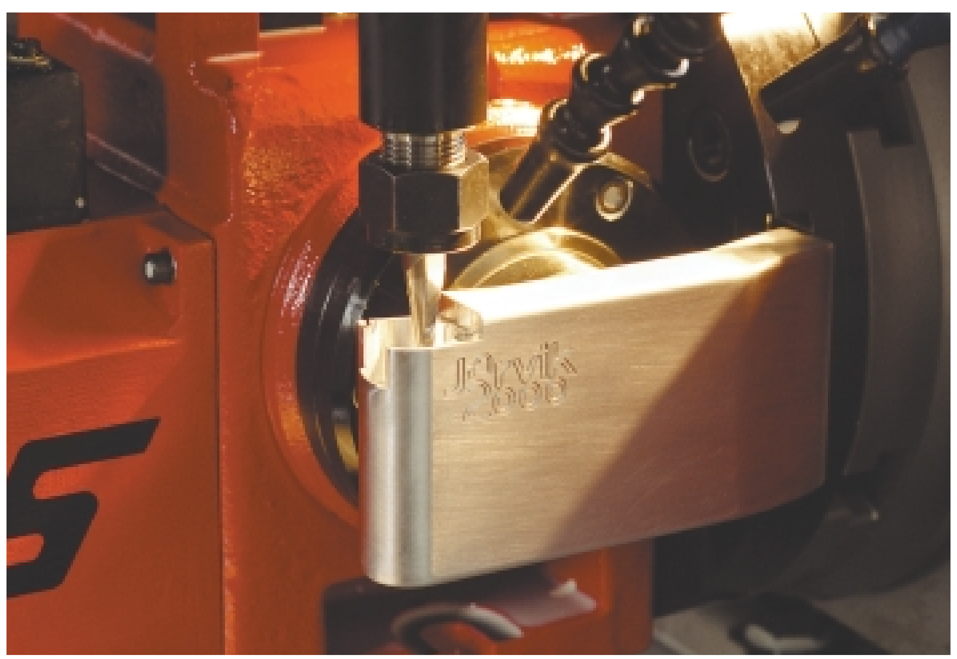
Unless it stops.

HEART DISEASE is the number one killer in the United States, claiming nearly one million lives per year. Since the 1950s, researchers have worked endlessly to develop artificial replacements and assist devices to stem this tide of failing hearts.

One of the preeminent researchers in the field of artificial heart development is Dr. Robert Jarvik, who has been heavily involved since the early 70s. He is probably most well known for his work on the Jarvik 7, the first permanent total artificial heart to be implanted in a human.

On a snowy night in December 1982, a Jarvik 7 total artificial heart was implanted into the chest of a 61-year-old Seattle dentist named Barney Clark. The world looked on as a team of surgeons removed his failing heart – so damaged that it stopped pumping during surgery – and replaced it with a mechanical assemblage of polyurethane and titanium. Connected by a pair of hoses through his abdomen to an external pneumatic pump, the Jarvik 7 kept the elixir of life coursing through Clark's body, allowing him to survive.

Prior to surgery, Clark had literally been on the edge of death. He could not get out of bed and had to stay in a darkened room. Doctors even restricted visits by his wife – the excitement was too much for his failing heart. Medically not a candidate for organ transplant, Clark's only alternatives were the Jarvik 7 . . . or death.



A version of the axial-flow blood pump being built at Jarvik Heart in Manhattan uses external batteries and electronics. The control boxes (above) and other components are machined on a VF-1 with a T5C tilting rotary table.

Following the implantation of the artificial heart, Clark was able to sit up, see his wife and eventually resume some semblance of functionality. Though constrained to the hospital, he was able to get up and around, and at one point was even able to practice putting a few golf balls.

Despite the success of the implant and the valiant efforts of his doctors, Clark eventually succumbed to complications and died. Though he only survived 112 days with his replacement heart, it was 112 days of life he otherwise would not have had.

The Jarvik 7 was the culmination of many years of work by a multitude of people. Chief among them was Dr. Jarvik, who spent more than a decade of his life modifying and perfecting the design to bring it to clinical trial.

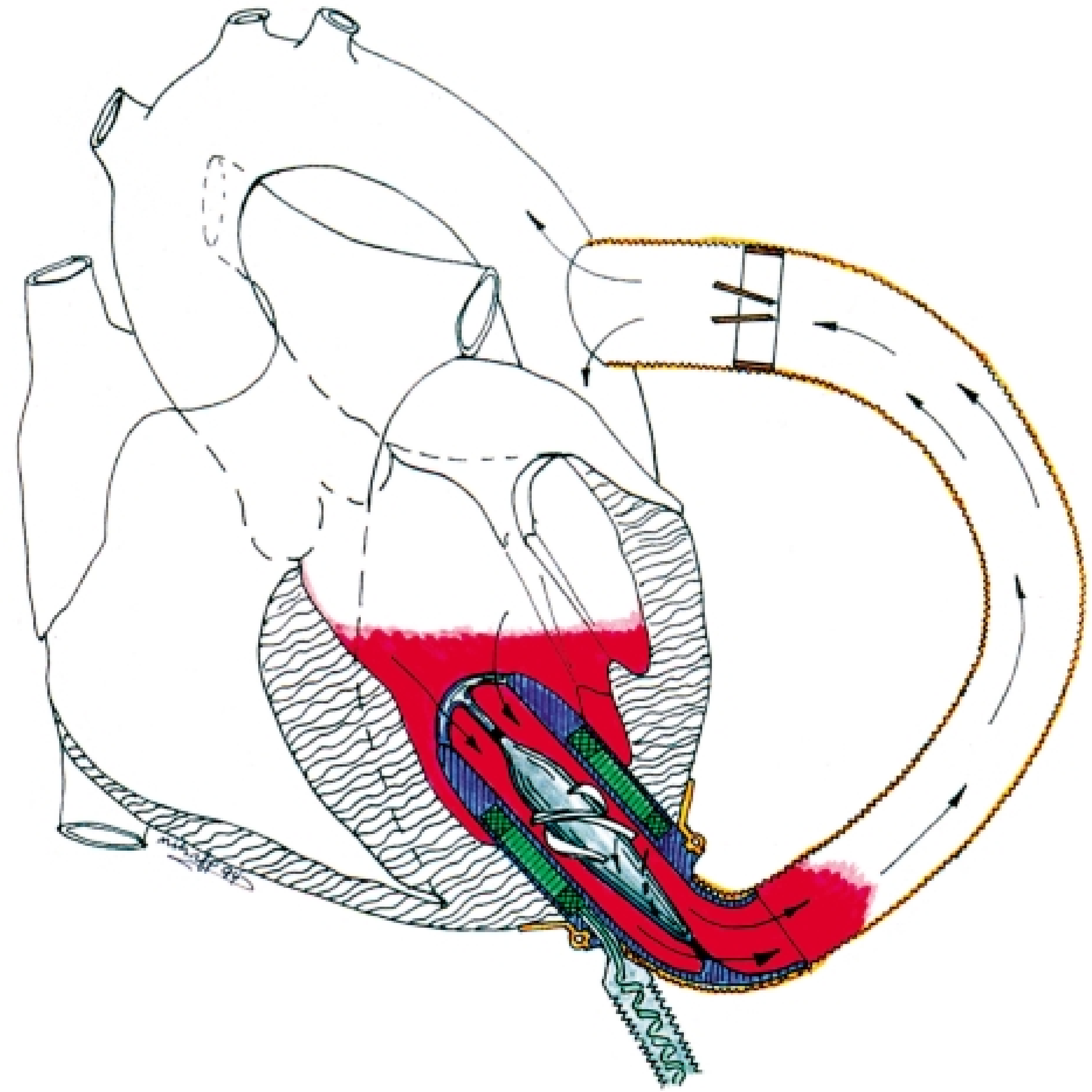
But even before the clinical trials of the Jarvik 7, Dr. Jarvik was looking for a battery-powered portable system. Today, he continues his quest for a reliable, practical and forgettable artificial heart.

"If the artificial heart is ever to achieve its objective," Jarvik stated in a 1981 Scientific American article, "it must be more than a pump. It must also be more than functional, reliable and dependable. It must be forgettable." In other words, "It has to be so good that the patient goes about their daily life and, most of the time, doesn't think about the fact that they've got an artificial heart."

Jarvik's latest effort at a forgettable artificial heart is the Jarvik 2000. Unlike the Jarvik 7, which was a total artificial heart and required removal of the natural heart, the Jarvik 2000 is a left ventricular assist device, or LVAD, which leaves the natural heart intact and acts as a booster pump. About the size of a C-cell battery, the Jarvik 2000 is actually placed inside the left ventricle of the heart, making it an intraventricular device.

"The left side does 80% of the mechanical work, or more," Jarvik explained. "And the number of patients that primarily need left support only, rather than bilateral support, is probably about 75%. The estimates – year after year – keep indicating that about three-fourths of the people will only need a left-sided pump. That's why we're starting with that."

Also, research has shown that it is better to leave the diseased heart in place, rather than remove it and put in a total artificial heart. "There's a lot of evidence now that when



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One of the issues that evolved from the clinical trials of the Jarvik 7 was that, in a number of patients, there would be infections around the outside of the artificial heart. "That was a hard thing to prevent," Jarvik said. "In fact, with many types of heart-assist devices, there's a very high incidence of infection.

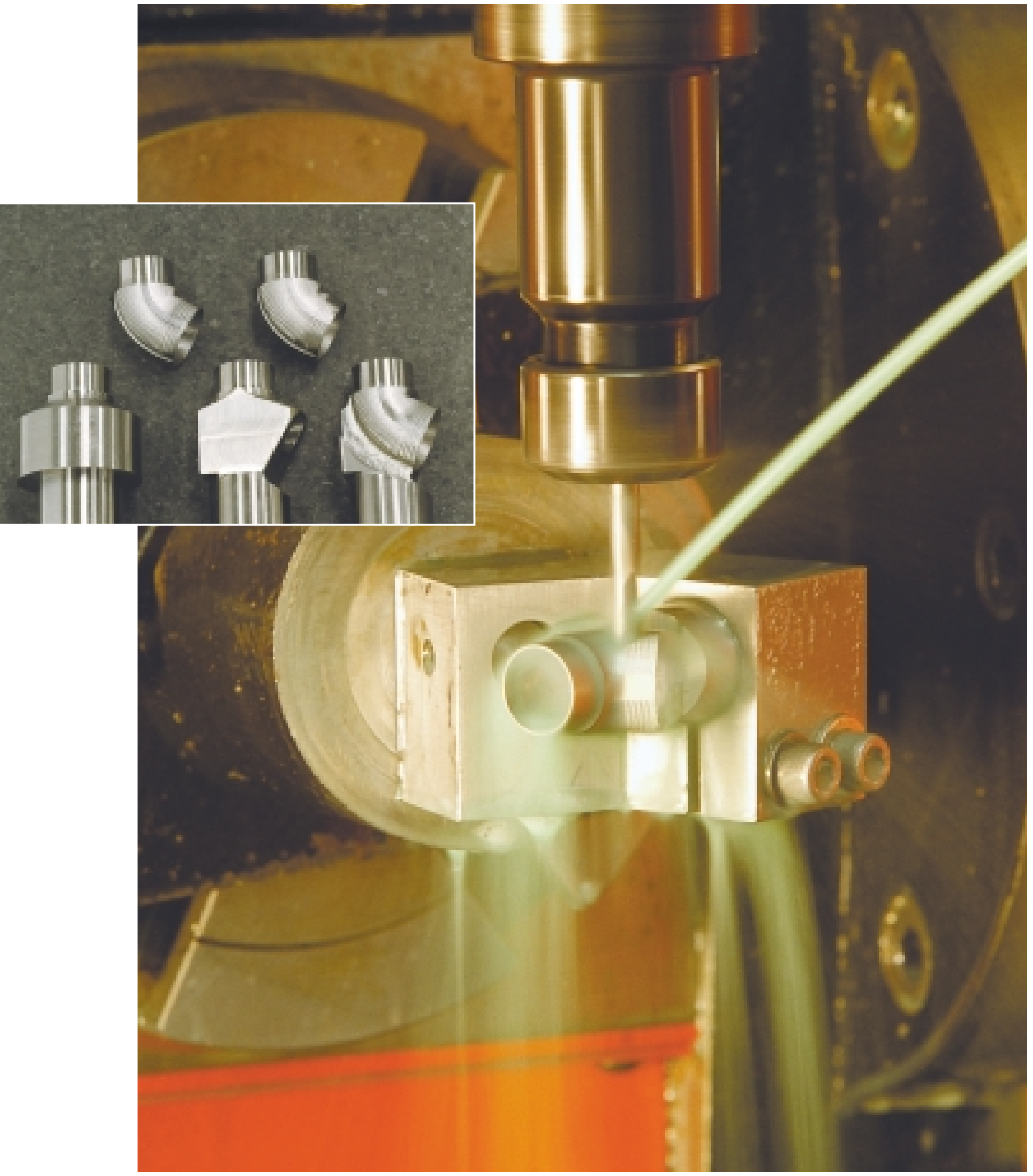
"I invented the intraventricular heart to prevent infection," he continued. "By making an artificial heart that is so small it can actually be implanted inside the natural heart, you have the advantage that the natural heart is there to support and protect it. But also, now the artificial device is surrounded by blood, and blood has antibodies and white cells and all the things that fight infection."

Making a pump that would fit inside the left ventricle required a design that was very small and very efficient. The solution was a small axial-flow pump, where the blood flows through the pump and parallel to the axis of rotation, like in

to pump hydraulic fluid which, in turn, pushed the diaphragm of the artificial heart. "This would give you an electrically-powered, portable, very practical kind of device," Jarvik said.

"It's that miniature rotary pump technology that has evolved and developed into the Jarvik 2000 heart. The difference, of course, is that the Jarvik 2000 heart is a miniature axial-flow pump that pumps blood directly, so we've eliminated all the diaphragms and the valves and the size and complexity of the Jarvik 7."

According to Jarvik, "The key to making a really miniaturized and reliable axial-flow pump is precision machining. The design has to be right, but we also need some fairly elaborate three-dimensional blade shapes, like turbo machinery typically has. We need precision, blood immersed bearings, and high-precision alignment of the pump parts that hold the bearings and rotor in order to get



The outflow elbow and bearing support of the Jarvik 2000 heart pump is the most complex part to machine. With both internal and external contouring, it takes almost six hours to run.

hydrodynamic support on the bearing film for a really reliable device."

From the start, Dr. Jarvik has done his own designs and his own machining. "I got involved in machining pretty heavily when I started out in Utah," he commented. "I would always machine most everything for the prototype models of what I was doing. I have a lot of experience in machining."

Jarvik still does his own design work, but most of the machining falls into the hands of Michael Morrow at Jarvik Heart, Inc., in Manhattan, and Walter Wood at Transicoil Inc. in Norristown, Pennsylvania.

Michael Morrow is the research technician/machinist at Jarvik Heart, a self-contained, development-type machine shop located on the 15th floor of a Manhattan office building. Walter Wood is a manufacturing engineer at Transicoil, a leader in precision motion control, actuation systems, pilot and interface products for more than half a century.

Transicoil's involvement stemmed from their work with fractional horsepower brushless DC motors. "We use miniature electric motors in these types of pumps," explains Jarvik. "At first, Transicoil was building special little DC motors for the earlier model axial-flow pumps. Now they are the prime contractor on the NIH (National Institutes of Health) contract for an innovative ventricular assist system using the intraventricular pump."

The NIH currently funds three major blood pump development programs that use rotary pumps, they are: the Jarvik 2000 at Transicoil; another axial-flow pump from a company called Nimbus; and a centrifugal pump from the Cleveland Clinic. Additional work is also underway in Europe and Japan.

"What we're trying to do is prove the feasibility of this design, and demonstrate its effectiveness in humans," states Jarvik, "and then have it grow from there."

At present, work is underway on several different versions of the Jarvik 2000 axial-flow blood pump. There is the NIH-sponsored work at Transicoil, which is designed for long-term use and features an implanted power supply and redundant electronics systems. There is a version which has external batteries and electronics and brings power into the unit through a skull-mounted pedestal. And there is a plastic molded version under development by US Surgical Corporation for temporary use during surgery as an improvement over the heart-lung machine.

The key to making a reliable axial-flow heart pump is precision machining. From the outset Dr. Jarvik has relied on machine tools from Haas Automation for his research. In the early days he performed much of his machining on a retrofit mill with a Haas 4th-axis rotary unit. Today, he dedicates a pair of Haas VMCs with 4th- and 5th-axis rotary tables to his research: a VF-2 with a TRT-160 tilting rotary table at Transicoil, and a VF-1 with a T5C tilting 5C indexer at Jarvik Heart.

The pump blades and housing of the Jarvik 2000 are machined entirely out of titanium because of that material's bio-compatibility, light weight and strength. It's this last characteristic, however, that makes the components of the titanium heart difficult to machine.

Michael Morrow explains: "Titanium is really a difficult material to cut, and it can break down a tool quickly, just because of the nature of the material. You need a good, rigid spindle, and a good, rigid table. Of course we're not cutting large pieces of titanium," he continued, "but the tolerance we have to hold is within two-tenths (two ten-thousandths of an inch). Your spindle has to be very rigid and run very true; and the table has to have very little backlash, and you have to be able to compensate for the backlash very precisely. The Haas has really handled that very well."

Walter Wood added, "Titanium is such a poor conductor of heat that if you get a little too aggressive with cutting, you'll either burn up the tool or leave a lot of galling on the part. And, some of the tools we use are pretty small in diameter, so we can't push them too hard."

The Jarvik 2000 is a very compact unit – about 1" in diameter by 2.5" long – so the individual components are quite small. The parts are also quite precise and require a lot of complex multi-axis machining.

"We have essentially four parts that we are contouring on the Haas," said Wood. "The central part of the heart pump is simply a contour-bladed impeller such as you'd find in any axial pump. Then we have what we call the inflow cage, which is a three-arched bearing support for the motor.

Alien Heart

story and photos by
scott rathburn

photo courtesy Transicoil Inc.

The human body does not take kindly to having a foreign object placed inside it – even if that object promises continued survival. Angrily the body tries to encapsulate, destroy or expel the offending item. Rarely is the invasion accepted at face value, without protest.

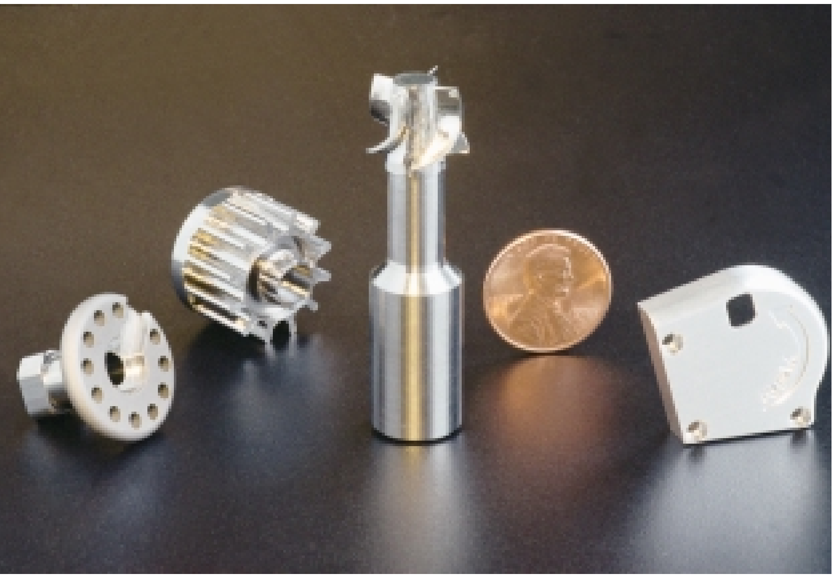
Such is the case with artificial hearts. Early designs attempted to mimic the function of the natural heart, utilizing complex pumping chambers and intricate valves to create the pulsatile flow considered necessary for life. But these designs were cumbersome and inefficient, not at all like the miraculous organ they were designed to replace. The body was offended by the alien apparatus: Blood clots formed, infections raged, and bodily enzymes tried to reduce the intruder to harmless nothingness. The result was often death.

Since the early 1970s, Dr. Robert Jarvik has striven to develop an artificial heart that the human body would accept and embrace. One that would provide the essential life-giving blood flow, but without the death-inducing complications. His latest effort, the Jarvik 2000, may be just what the doctor ordered.

Rather than being a total artificial heart, the Jarvik 2000 is a left ventricular assist device, or LVAD, which supplements the output of the failing natural heart rather than replacing it. "It's really a true booster pump," explained Jarvik. "It doesn't have to do all the work of the natural heart, it just adds to what the natural heart is able to do. The natural heart still regulates the body's needs and participates in regulating the flow of blood. We're using as much function of the patient's natural heart as it can provide, and adding on the additional function to give them exercise capability – to not just keep them alive, but get them back to a mobile lifestyle."

The Jarvik 2000 is a small axial-flow pump about the size of a C-cell battery.

Continued on page 30



Left: Most of the components of the axial-flow heart pump and its control system are very small, requiring precise machining. Below: A finished control unit for the Jarvik 2000 and the corresponding parts.

We have the outflow stator blades, which are similar to the impeller blades. And then the most complex part is an elbow with both internal and external contouring, which is the outflow end of the pump. That's the most complex," Wood emphasized, "it takes us almost six hours to run one altogether."

The majority of the multi-axis work for the Jarvik 2000 is performed at Transicoil, with many of the prototype and support components being machined at Jarvik Heart in Manhattan. Although the heart pump itself is made of titanium, many different materials are utilized for other components. "We run parts out of titanium, we use a lot of aluminum, we use stainless steels, we use brass and we use acrylics," Morrow explained.

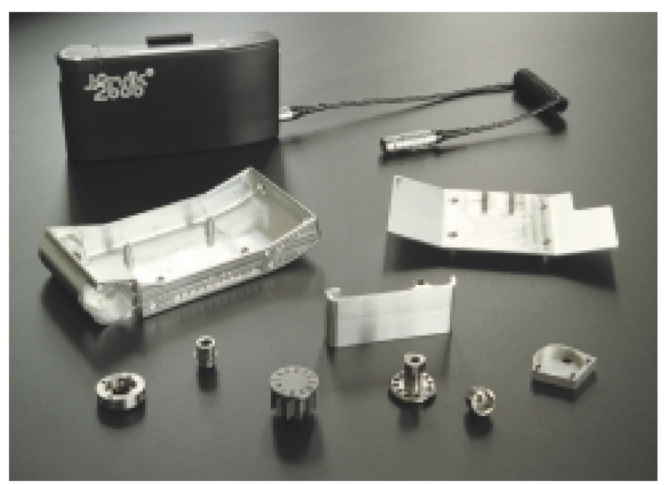
"The first parts we made on the Haas were part of the implant that would go with the artificial heart, and they were made out of titanium. They were very small pieces, about 3/8" in diameter, and we had to hold a tolerance of two-tenths on the mill work. We're making injection molds for some of the plastic pieces that will be implanted with the heart; those are out of stainless. We're also making our own electronic boxes out of 7075 aluminum. We start with a square billet and machine it into a box. Some parts of the boxes – the inside and a lot of the outside – are actually 3-D programming, and we're using Mastercam to program that, and machining it with a ballnose endmill.

"The Haas handles the materials very well. We didn't have any problem holding tolerances on the titanium. And the control has been able to handle the large programs that Mastercam generates. We run our tolerances on the Mastercam very tight, so it generates a longer program, but the Haas control handles it very well," Morrow said.

Transicoil's Wood agreed, "We all like the control here. We find it very well prompted, easy to follow and very friendly, especially since we were already primarily a Fanuc-type shop."

About 99% of the programming for the components of the Jarvik 2000 heart is done offline using a combination of standard and custom software. "We typically use a combination of several different software packages," Jarvik explained. "We use CadKey for the basic CAD layout kinds of things, we use Mastercam as the interface for machining, and we have some custom software that CNC Software, the company that puts out Mastercam, has developed for us especially for machining complex blade shapes."

According to CNC Software's John Summers, who has been working with Dr. Jarvik since 1990, the impeller blades of the Jarvik 2000 posed some interesting mathematical challenges. "There's something peculiar to that part that makes it an unusual machining project," he said. "The leading edge and the trailing edge are very small radius, and



when you're machining it, it's important that the part is not turned at all. The cutter goes around the part to give it a cylindrical leading and trailing edge. Then the rest of the blade is similar, because it doesn't collapse on you – it's always two points across the blade that are parallel to each other. You could let that blade get as long as you wanted, and it would stay the same thickness and still be wrapped around the hub. We made a 4-axis post processor that was uniquely suited to the part, and made it possible for Dr. Jarvik to machine the blades."

"Mastercam has been very good," Jarvik commented, "and it interfaces very well with the Haas machines. We're using these same programs both at Jarvik Heart and at Transicoil."

Although the heart is still in the research stage, human trials are expected to begin this year. "We're doing animal testing now, and we're getting ready for the first human cases," Jarvik said. "We're very confident that, based on the animal data, we can do very well with humans.

"Interestingly," he continued, "in the history of artificial heart devices, the results in patients have always been better than the results in animals. With animals, there are more infection problems. An animal in a laboratory doesn't have the kind of medical care and nursing care and all the technology that exists for the patient. And when these devices are applied in a sophisticated, modern hospital, the results are better. So we always expect to do better in humans than we're able to do in animals. And we're already able to do very, very well with the animals."

It's estimated that 50,000 to 100,000 people each year need an artificial heart or heart-assist device. Even though a small number of devices currently exist and are used as a bridge to transplant, including a variation of the Jarvik 7, they account for only about 2,000 patients per year. "It doesn't have any major impact on public health," Jarvik stated. "It's not until we have a really practical, forgettable permanent device, that it will."

If the human trials of the Jarvik 2000 heart are successful, the impact on public health will be far-reaching and important. Maybe then the tide will turn in the battle against failing hearts.

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New York, NY 10019-6238 • 212-397-3911
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2560 General Armistead Avenue
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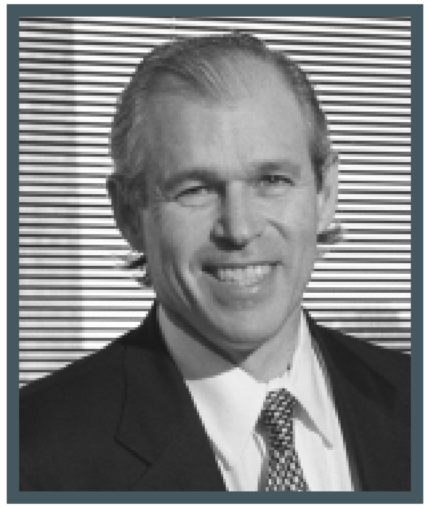
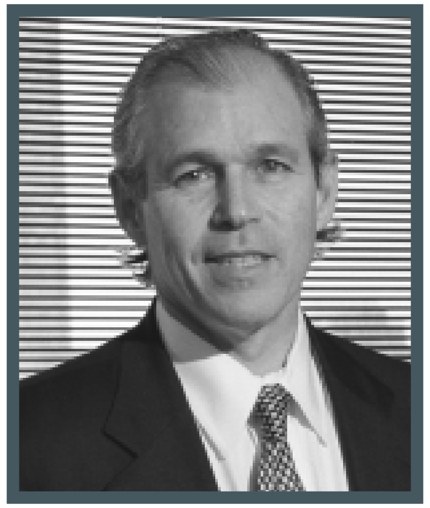
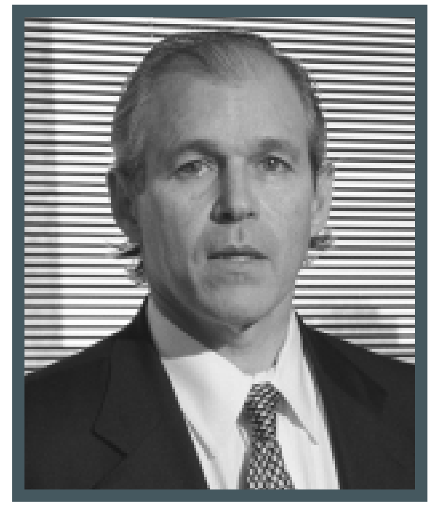


"When I was a student, I was rejected by every medical school I applied to, at first."



"It was rather interesting as a young man to be given the opportunity to design a completely new artificial heart"



"Even though I'm a physician, I've been involved in bio-engineering, mechanical engineering, machining and things of that nature for most of my career."

Q&A

CNC – How did you get into the field of artificial heart research?

Jarvik – I got interested in bio-engineering pretty early. When I was in high school I began working on the development of surgical stapling instruments. Through that I met certain people who had an interest in bio-materials for artificial organs. That led to an opportunity to work on the artificial heart, which was very interesting to me because my father had heart disease. I thought he would need an artificial heart, and I hoped to be able to get something ready for him on time.

CNC – What is your background?

Jarvik – I did a master's in bio-mechanics . . . When I was a student, I was rejected by every medical school I applied to, at first. So I went to medical school in Italy and was working to get into medical school in this country. One of my motivations for starting work in artificial heart research was to have an avenue to get accepted into medical school, something more than the average student was doing.

CNC – Did you get your master's in bio-mechanics before you went to medical school?

Jarvik – I was in medical school in Italy, and then I took off a year to do the master's in bio-mechanics at New York University. Then I decided to move to Utah to work with Dr. Kolff* in artificial organ research and work on the artificial heart project.

That was in 1971. I worked on the program for a year, and applied to medical school as an in-state resident. I was accepted and started medical school all over again, without taking any credit for the work in Italy, which was two years. I worked extensively on artificial heart research – 30 or 40 hours a week – throughout medical school. **(Dr. Willem J. Kolff is the father of the artificial kidney and the heart-lung machine. A pioneer of artificial organs, he led the effort to develop the artificial heart for 25 years.)*

CNC – Was your father still alive at that time, and was that still part of your motivation?

Jarvik – Yes. Actually, he died the year I graduated. But that personal motivation was only part of the reason for working on something with a very broad need. And certainly, after he died of heart disease, I wanted the artificial heart to succeed all the more.

CNC – You started out by working with some of the other doctors who were developing the artificial heart. At what point did you begin working more on your own?

Jarvik – Well, in 1971, when I joined Dr. Kolff's group at Utah, the research was at a point where the longest animal survival with an artificial heart was about a week. It was questioned whether it was feasible at all to have animals – or humans – live any longer than that. It was a completely different era then; a lot less was known. Actually, the emphasis had nothing to do with making a practical device for humans. The emphasis was to try to show that the idea would work at all.

There were serious problems, at that time, with the devices that were being made. They didn't fit adequately anatomically, they didn't pump enough blood for their size, they were ineffective as pumps, they caused damage to other organs, and they had a very bad bio-materials interface problem.

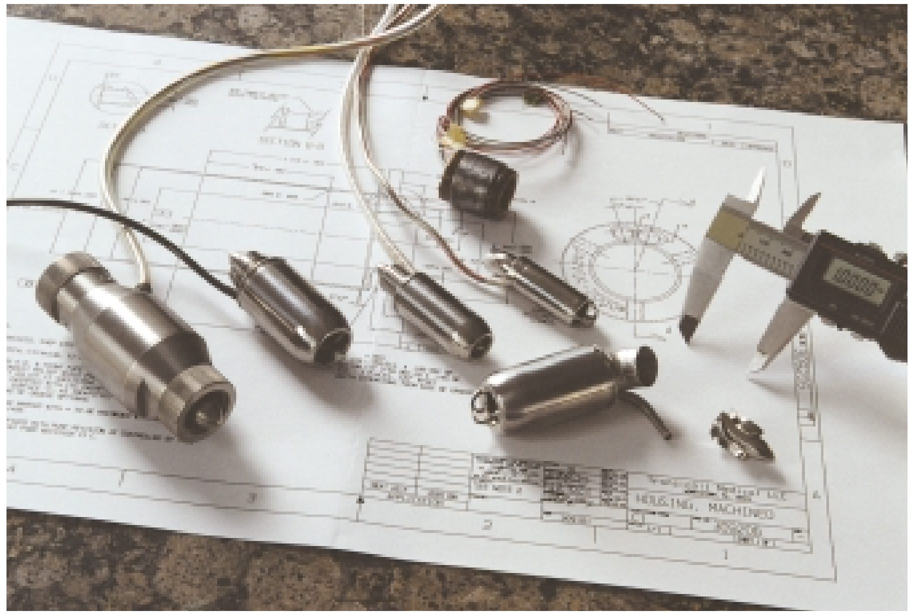
My assignment was to design a new artificial heart that would, hopefully, solve some of those major problems.

Please see page 32

Machine shop over Manhattan

From the street it looks like your everyday Manhattan office building. The lobby contains the usual directory of building occupants, and a couple of elevators provide transport to the upper floors. As with many early skyscrapers, there is no 13th floor – it was considered unlucky.

The no-frills elevator delivers you to the 15th floor, where the doors open to reveal a stark white hallway leading to a glassed-in office, also in white. Entering the office, there is a reception desk and a small waiting area. A large logo announces you have entered Jarvik Heart.



Above: The Jarvik 2000 has undergone several incarnations during its development. The current version is the pump at bottom right. Below left: Michael Morrow, research assistant and machinist at Jarvik Heart, sets up a job on the VF-1 with TRT-160.

All around, large windows flood the room with light, emphasizing the cleanliness. The Manhattan skyline is clearly visible in all directions. Beyond the reception area, counters and work benches topped with black Formica line the left side of the room. On the right, a cage of wire mesh houses medical supplies and electronic components.

At first glance, the room appears to be a medical laboratory, or an electronics assembly facility. In reality, it's both. But what isn't apparent is that Jarvik Heart is also a fully-functional machine shop. Venturing further into the facility reveals an assortment of CNC machines, including a Haas VF-1 vertical machining center. This doesn't seem that unusual . . . until you realize you're 15 stories above the ground.

Just how do you get a Haas VF-1 on the top floor of a Manhattan office building, anyway? Well, according to Tom McGill of Allendale Machinery (Allendale, New Jersey) it takes some careful measuring and a little creative disassembly.

"The elevator was the big problem," McGill said. "It had a load limit of 6,000 pounds and was 60 inches wide. There were also floor load concerns, but Dr. Jarvik resolved those with the building engineers and the building maintenance people. They determined the floor load would not be a problem, but did position the machine over existing column support on the floor below.

"Basically," McGill continued, "we took off the complete enclosure, the X- and Y-axis way covers, and removed all the motors to reduce the weight as much as possible." (A fully-assembled VF-1 weighs in at 7,100 lb, or 1,100 lb over the elevator's load limit.) "And, if I'm

Please see page 32

Just What Is Wye/Delta?

Story
Kurt Zierhut

There's been much mention lately of "Wye/Delta" when talking about spindle motors and spindle drives for machining centers. But the definitions of just what "Wye/Delta" is have been rather murky. Let me clear up the waters. And in the process, I'll show how the "Wye/Delta" function sometimes isn't needed, and how there are better ways to improve performance.

The goal of the spindle motor in any machine tool is to deliver power to the cutter – a pretty straightforward concept. But to understand how this works, it is important to define power, and explain how it relates to torque and motor speed.

Power is defined as work done or energy transferred per unit of time. For machine tools it is measured in horsepower. Torque is defined as a force that produces rotation; it is measured in foot-pounds (ft-lb). Motor speed is defined as . . . well, rotational motor speed, which is measured in revolutions per minute (rpm). All three are closely related through the following equation: power equals torque times speed, or p = ft-lb x rpm.

Following this equation, a machine that is generating torque but not turning provides no power. Similarly, a machine that is turning but generating no torque provides no power. But if a machine could provide its rated horsepower down to a very low speed, the torque would grow to fantastic values. Since any machine inherently has a torque limit, the horsepower available at low rpm is limited. The best way to provide horsepower down to very low speeds is with a gearbox that allows the motor to turn at a higher speed and then reduces that speed with a selected gear.

Just about every machine tool built for the last 50 years has used an "induction" motor to turn the spindle. Although these motors are a very old design, they are still a good choice for spindle motor power because of their simplicity, cost and power for their size.

Induction motors usually are designed to run at a fixed speed and voltage which, for a simple drill press, exactly matches the frequency (60 Hertz) and voltage (240V) available in a shop. The frequency of the voltage applied defines the speed at which the motor will turn. For the typical motor this is 1,800 rpm when 60 Hertz is applied. There is also a simple relationship between voltage and frequency if the motor is to deliver its designed torque. This is typically 230 volts per 1,800 rpm. So, to run a motor at 900 rpm really only requires 115 volts, and to run it at 3,600 rpm requires 460 volts.

The drives used to run induction motors can generate a variable frequency and voltage output, but they cannot raise the voltage above the line voltage going into the drive. The motor can supply its rated torque up to the speed where the voltage required matches the line voltage. This is usually called the motor "base speed." Thus, all of the rated torque of the motor is available below the base speed. This speed range is called the "constant torque" range.

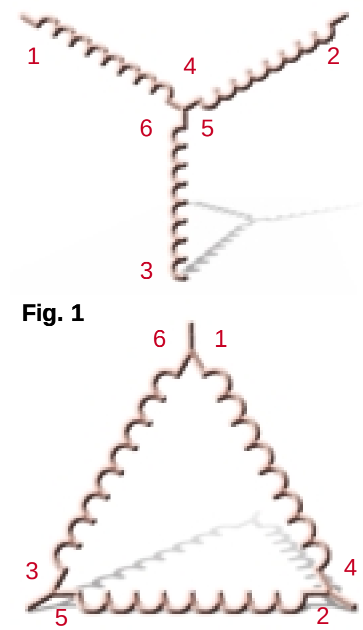


Fig. 1

To run a motor above the base speed, something called "field weakening" must be used. This is where the rpm and frequency increase but the voltage stays limited at the line voltage. In this case, the torque available from the motor goes down as the speed goes above the base speed. Since rpm is increasing while the torque is decreasing, the power, or the product of these two, remains constant. This "constant power" range is usually between the motor base speed and about 2.5 times base speed. Above that speed, torque drops even faster than speed increases and the available power decreases.

All of the above conditions are true because the motor requires a higher and higher voltage as speed increases, and this voltage is above what is available from the system. It is possible to build a motor that requires less voltage; however, such a motor would also require more current (power is the product of voltage and current) and this would increase the cost of the drive electronics. Haas Automation uses this configuration in its high-torque 10K VMCs and 5000 rpm lathes. Most manufacturers do not use this due to its cost.

An alternative is to use a motor that has two different configurations: one for low speed, which is a high-voltage, or Wye, winding; and one for high speed, which is a low-voltage, or Delta, winding. The easiest way to change a motor winding is to go from the standard "Wye" winding, which is usually 230 volts at 2,000 rpm, to a "Delta" winding, which would be 230 volts at 3,460 rpm. The advantage gained from this Wye/Delta change is always a factor of 1.73 because of the way the windings of an induction motor are put together. Thus it can only increase the constant power range by 73%. Figure 1 shows how the three windings of a motor can be rearranged to form Wye or Delta.

If the constant power range is 2.5 times the base speed without winding change, the motor will have constant power from 2,000 to 5,000 rpm. Using a Wye/Delta change will increase the constant power speed by a factor of 1.73 to 8,650 rpm. This is not a huge amount, but it is usually enough improvement in performance to make it worth the effort. A typical transmission, however, has a high-to-low gear ratio of about 4-to-1, providing much more improvement in speed range than a winding change.

A way to get even more performance is to use Wye/Delta switching and a transmission. This combines the increase in constant power range from the transmission with the increase from the winding change to provide more than either of these by themselves. Haas Automation does this in their 10,000 rpm VMCs and their larger lathes. The selection of gear is either done automatically by the control, based on the selected speed, or by an "M" code. Obviously, the best system performance is achieved by using a transmission along with a Wye/Delta switch.

Yet another way to get even more performance than a Wye/Delta switch is to remain in the Delta winding. This reduces the complexity of the wiring to the motor but requires a drive with 73% more current capacity. This is better because the Delta winding reduces the voltage required by a factor of 1.73, allowing the motor to deliver its rated torque to a speed 73% higher. But it also increases the current requirement by a factor of 1.73, which means you are not getting all of the performance possible out of the motor unless the drive can supply an additional 73% of current. Haas does this with their "High-Torque 10K" VMC and their 5,000 rpm lathe.

The method of selecting between Wye and Delta is also an important factor. Many systems use the Wye/Delta selection like a gear change, where the user must pick a gear before even starting the spindle. A more powerful technique called switching "on-the-fly" starts out in the low-speed Wye winding and changes to the high-speed Delta winding when the spindle speed reaches a point where performance would be improved. This method requires a system carefully tuned to the motor and drive characteristics to ensure a quick change and no loss of power during the winding change.

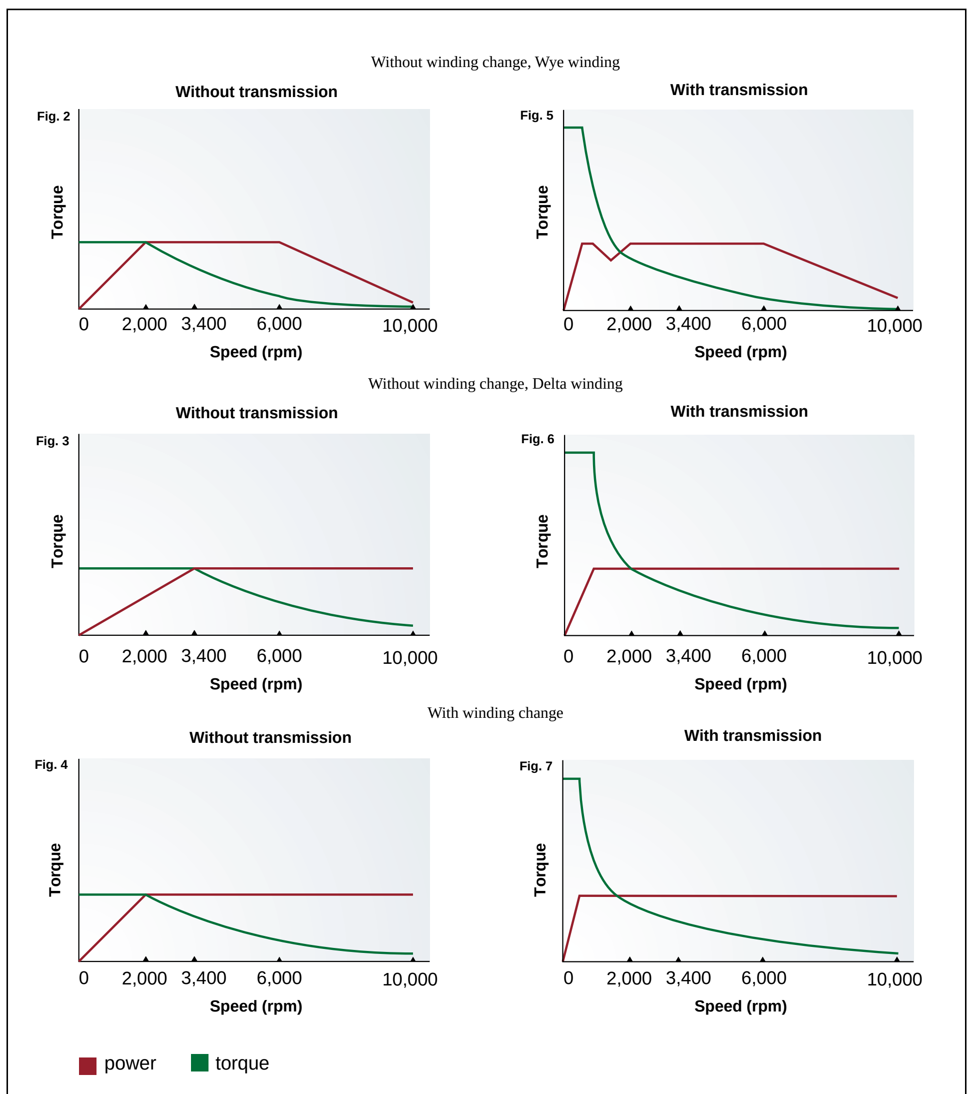
Winding change "on-the-fly" is important mostly for lathes, which constantly make spindle rpm changes and change the rpm while in a cut. The wide "constant power" range provided by the winding change is needed during a constant-surface-speed lathe cut which makes a large diameter change from beginning to end. Haas Automation uses winding change "on-the-fly" in its VMCs and lathes.

Most of the manufacturers using winding change today also use vector drives, another area that needs some explanation. Vector drives are the latest technology available to run induction motors, and can dramatically improve system performance. Vector drives provide optimal motor performance over the widest speed range, and have three major advantages over older "variable frequency" drives. *These are:*

1) *rated torque of the motor is available down to zero speed,*
2) *speed control is very accurate,*
3) *there is no possibility of "stalling" the motor and not knowing it happened.*

Vector drives achieve the above performance by precisely controlling the current running through each of the three "phases" of the motor wiring. This current generates a magnetic field which has a vector direction and magnitude that are modulated precisely to generate the required torque in the motor. Since the vector is controlled according to the rotation of the motor, a device like an encoder is required to determine the rotation. The encoder lets the drive "know" exactly what speed the motor is running, and thus can provide very precise speed control down to zero speed. This same function also allows the vector drive to avoid the problem of a stalled motor by always detecting and responding to the exact motor speed. Haas Automation uses vector drives in almost all of their machines. In addition, because the vector drive is closely matched to the motor, the Haas drive can provide 10 minutes of 150% motor load and 3 minutes of 200%.

Figures 2 through 7 illustrate how transmissions and Wye/Delta switching improve motor performance. Figure 2 shows a normal motor in Wye winding and figure 5 shows that same motor with a transmission. Figure 3 shows a motor in Delta winding and figure 6 shows that same motor with a transmission. Figure 4 shows a motor with winding change and figure 7 shows that same motor with a transmission. It is obvious that the use of winding change in machine tools is advantageous, BUT it is also obvious that a transmission provides far more advantage. The winding change can extend the high-speed performance of a machine, but it cannot possibly make up for the 4-to-1 torque improvement you get with a transmission.



Forging a New Wheel

Catering to the Cream of the Custom Car Crop

Story and Photos
Preston Gratiot

High-tech design, artistic quality and elegant exclusivity: a virtual triad of features that demand respect and get big bucks. Sure, you can get by with cheap imitations that get the job done, but in the rarefied world where cost is no object, there truly is nothing like the best.

In a world filled with BMWs, Corvettes and Porsches, it's no surprise that an elite group of manufacturers prosper simply by catering to the select cravings of this niche group. One such manufacturer is HRE Performance Wheels of Vista, California. HRE produces three-piece wheels with forged centers that are custom-built to their clients' specifications.

Forged in Aluminum

"We only work in forged aluminum, and we have a growing number of styles machined from our two standard forgings," says Philip M. Hillhouse, HRE's head of marketing. "They are precision

Wheel photo courtesy HRE

milled on Haas machining centers, allowing us not only to have a very strong wheel, but a very lightweight wheel as well.

"One of the nice qualities of a three-piece wheel is that any one of our styles can be assembled to fit basically an unlimited number of cars," says Philip. "And we're not just talking bolt patterns here. Proper fitment includes offsets, rim widths, and adaptability that will keep the tire from shredding itself on the fender well or suspension parts while the car is being driven."

Software Solutions to Style

"We found that we could machine wheels that were stronger and more stylish by using forgings over castings," Philip continues. "With designs cut on CNCs using software-controlled programs, these forged, individualized designs command higher prices, yet deliver wheels that not only look good, but are also of the highest technical quality. They're race-quality wheels with market-driven designs.

"For instance, if you look at one of our styles, like the '540,' we have four programs that deal specifically with size, ranging from the 17-inch through the 20-inch diameter. Then we have sub-programs that put in the different bolt patterns," explains Philip. "It all comes out of the same forging, so it's only a question of which program you load into the mill."

The raw forging itself weighs 57 pounds right out of the box. However, when HRE is done with the CNC machining, one of the heavier centers, such as the '545' five-spoke, ends up weighing in at only ten pounds, leaving about 47 pounds of swarf heading back to the recycler.

Why did you buy Haas?

One of the major reasons HRE selected Haas machines was to solve production problems. Unlike the mass-

Cutting the slots and openings – known in the business as windows – in a forged alloy wheel center is a time consuming process that demands precision repeatability. HRE has expanded its line of wheels by capitalizing on the Haas control's ability to easily alter or modify an existing program to provide a visually different part based on the same original wheel design.

market manufacturers that run wheels in five-figure numbers, HRE provides its customers with limited-run, personalized wheels. Designs may be restricted to as few as ten sets for those select few willing to pay the price for personal perfection.

"There were many different machines we could have gone with, but Haas has a good reputation, and frankly, the Haas gives us the flexibility to run various designs through it," says Philip. "The fact that Haas machines are locally manufactured was an additional benefit."

Power to Perform

"As far as horsepower is concerned, the Haas pushes the drills," says Daniel Hinkel, production. "Our lug-hole drill is a step drill. It goes from 0.625" up to almost an inch and a quarter, and the Haas pushes it through pretty good. We had a machine from Korea that didn't perform to our expectations. It would drill about halfway through and then stall the spindle.

"The ample horsepower and torque of the Haas has actually decreased our cycle times, because we can hog out a lot more aluminum, and there's more speed and feed," he continues. "We've got a lot of hogging to do to clean out the windows in the wheel center patterns, so the Haas has really helped us out.

"And frankly, one of the reasons we're staying with Haas is that once you've trained your workers on one, they can operate any Haas. We've got two Haas VMCs now, and we'll probably be adding a third soon. If a worker knows how to work one machine, he'll know how to work all three. And if you have a job go down on one, it can easily be moved to another machine."

Sub Programs

The Haas control has definitely helped HRE when it comes to using sub-programs. "With our old mills," continues Daniel, "there were a lot more steps involved as far as setup programs were concerned. Now I can just throw a sub-program in and flip a wheel over and do the hub bore. On the '545' style, we tap the back side, which used to require loading a separate program. Now we just use a sub-program and machine two centers per setup – one front, one back – combining them both on one program.

"We've also started working a lot of the lug patterns at the same time we cut the windows. Since we put all of our assembly holes and lug patterns on the same program, it saves time by eliminating a lot of extra setup."

Machining wheel centers two-up on the Haas VF-3s, HRE is able to have a single operator run multiple machines for maximum efficiency. Here, a centerpiece for an HRE 540 wheel, the flagship of the HRE line, is removed from the multiple, HRE-designed jig.

Working the Flexibility Factor

"The Haas control gave us more flexibility when trying out new styles," says Doug Chudomelka, production manager. "It's a lot more user-friendly than our old Japanese machine for doing setup changes and program alterations, plus it's real easy to learn. A lot of guys who come in haven't run a Haas before, but they catch right on to the simplicity of the Haas control.

"One of the features we recently have started using more is the engraving function. A lot of countries in Europe now require serial numbers as part of their anti-theft programs. We used to do this by hand, but it is much easier, quicker and more professional looking to use the sub-program to do this step on the Haas."

Short Run Radicals

"Because we can easily reprogram our setups, we can service a growing new customer segment that is highly specialized, yet very noticeable: the 'custom tuner' market. These are what we refer to as our 'Private Label' customers," explains Philip, "the custom outfitters who purchase stock vehicles, then modify them to meet the needs of customers who can afford such special touches. Modifications can include simple bodywork, or involve major redesigns of the suspension and engine for enhanced performance. In a sense, these are custom-fitted, re-badged, brand new cars."

One of the easiest ways to make a car look substantially different from stock is to bolt on custom wheels. And since HRE can provide a design that's unique to a particular 'custom tuner,' that tuner can have a singular design that is not available elsewhere on the market. Since it's just an exercise in modifying the part program for HRE, it's relatively inexpensive to provide these outfitters with a short-run custom wheel of their own dedicated design.

"These are usually based on pretty basic designs," says Philip, "But since they are available in a three-piece format, it gives us the ultimate versatility to provide a perfect fit for any fender well, modified or stock. And because of the added strength found with the forging process, we can be more creative in our designs, while maintaining the structural foundation necessary in a wheel of this type."

Quantifiable benefits

"Cutting our window patterns [the see-through areas between the wheel spokes] is probably our longest cycle," says Daniel. "Our shortest run time is on a flat-style five-spoke wheel, which has a 15-minute cycle time to hog out the windows. When you get into the more complex designs with a mesh of criss-crossing spokes, such as the flagship '540,' you are looking at 45 minutes per wheel to cut all of those openings.

"But as far as having enough horsepower and torque to give us clean cuts at a good feed, the Haas VMCs have been great," says Daniel. "We haven't had any problems at all, especially for as hard as we cut them. I run a spindle load of probably 80-90% almost all day long, and they've held up fine," he continues.

"But as far as having enough horsepower and torque to give us clean cuts at a good feed, the Haas VMCs have been great."

"I've never had a problem with it stalling out or anything like that."

Future plans?

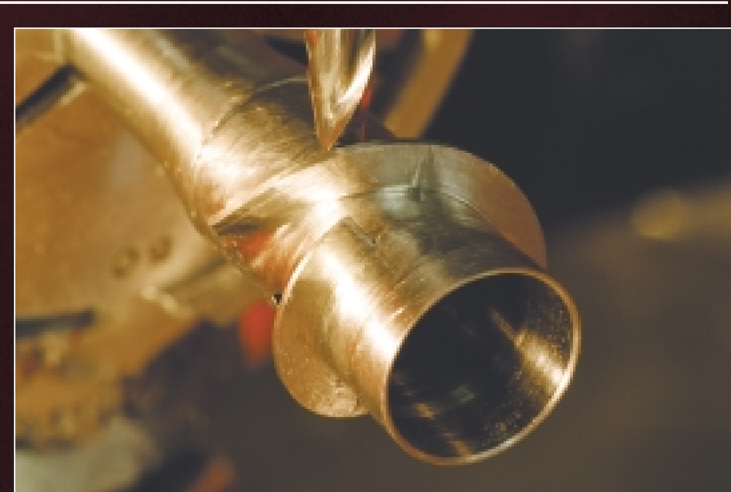
While HRE does build limited quantities of wheels, they refuse to be limited to one vehicle market. "We're going to expand our work into the upscale SUV (Sport Utility Vehicle) market," says Philip. "The same customer who is buying our wheels for their expensive car is also going to buy wheels for his expensive SUV."

But the ability to cut incredible looking designs out of forgings is somewhat time consuming. "It is strictly for a high-end market," says Philip. "But the look you get is unique, and it gives you a niche in the market that no one else has filled. You might say we're creating wheels now that people don't even know they need. Since we're custom, we basically react to the needs of the customer – the specific needs and diameters of the vehicle the customer is driving – and then we go out in the shop and build it."

HRE Performance Wheels
2453 Cades Way, Building A
Vista, CA 92083
760-598-1960

Polished to a mirror-like sheen, this HRE wheel appears to be chrome-plated, a testament to the wheelmaker's art, and a clean-cutting CNC.

alien heart: continued from page 17



Above: Cutting the contour-bladed impeller. Below left: A three-arched inflow bearing support, a machined impeller and an outflow elbow and bearing support.

Machined from titanium, which is biologically inert, it is capable of pumping up to 8 liters of blood per minute at a pressure of more than 100 millimeters of mercury. The pump's impeller rides on a pair of blood-emersed bearings less than a millimeter in diameter, spinning up to 14,000 revolutions per minute. A hydrodynamic film of blood on the bearings acts as a lubricant and prevents wear.

Jarvik has eliminated much of the problem of infection by implanting the pump directly into the left ventricle, where it is completely immersed in blood. He has dealt with the issue of clotting by keeping blood flowing continuously through the pump, and polishing the pump's surfaces to a mirror-like finish so the blood does not collect and coagulate.

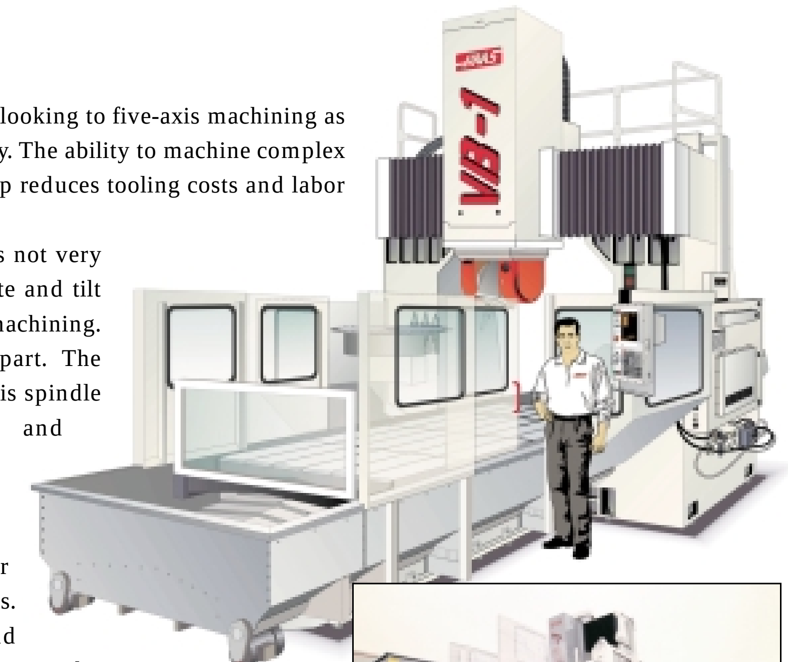
The Jarvik 2000 consists of a three-arched, inflow bearing support called the cage, a contour-bladed impeller, a set of outflow stator blades, and an outflow elbow containing another bearing support. The outflow end of the pump is connected to the aorta via a flexible polyester graft.

Blood flows into the axial-flow pump through the three-arched inflow cage. The impeller, which houses the permanent magnet for the motor, pressurizes the blood and drives it through the pump. Stator blades at the outflow end of the pump convert the rotational flow from the impeller into axial flow. The outflow elbow directs the blood toward the aorta.

Dr. Jarvik emphasizes that, although the pump generally has a constant motor speed, the Jarvik 2000 is not a pulseless system. "It's really important for people to understand that the Jarvik 2000 does have a pressure pulse and a flow pulse," he said, "and that pulse is generated by the beating of the natural heart. When the natural heart pumps, it increases the flow through the pump, and decreases the differential pressure across the pump. When the heart relaxes, the pressure on the inflow side of the pump goes to almost zero, while the pressure on the outflow side of the pump stays at the higher arterial level. So it's actually while the heart is relaxed that the pump has the most differential pressure across it, and its flow goes down. When the heart beats, the differential pressure across the pump is less, and the pump's flow goes up. In other words, at a constant speed, the amount of flow the pump produces is a function of the differential pressure."

Thus, as the heart pulses, so does the Jarvik 2000, maintaining the constant ebb and flow of blood necessary for life. Will the human body accept such a device without question, seeing the value of continued existence? Or will it reject it out of hand as alien and dangerous? With human trials scheduled to begin this year, hopefully the answer is just around the corner.

Bridging the Gap



Many industries today, especially aerospace, are looking to five-axis machining as a means to speed manufacturing and increase accuracy. The ability to machine complex shapes, undercuts and difficult angles in a single setup reduces tooling costs and labor time, resulting in a better cost per part.

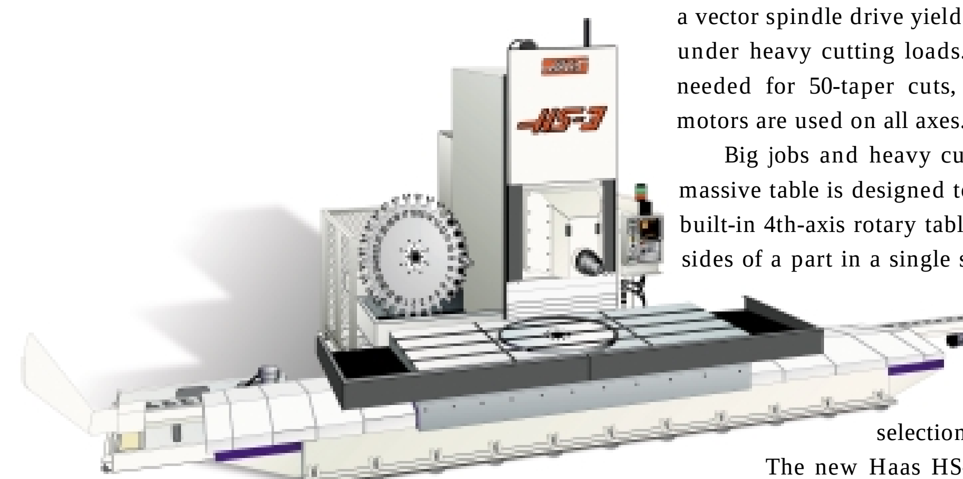
But what do you do when the parts are BIG? It's not very practical – or even possible, for that matter – to rotate and tilt parts that are 10-feet long by 5-feet wide during machining. The answer is to rotate the spindle around the part. The prototype Haas VB-1 vertical bridge mill with five-axis spindle head bridges the gap between large parts and complex machining.

The VB-1 is a profiling bridge mill with travels of 200" x 66" x 40" and full five-axis capabilities. The 126" x 60" table allows machining off the ends of the table, or a large subplate can be mounted for larger workpieces. Travels for the 5-axis head are ±120° on the B axis and ±180° on the C axis. The 30-hp spindle employs an integrated-motor design and features a vector spindle drive. The spindle is water cooled for thermal stability and provides speeds to 15,000 rpm for high-speed milling. Unique ballscrew supports along the X axis prevent whip, allowing faster rapids; and linear scales can be fitted to further enhance accuracy. Designed primarily for the aerospace industry, the five-axis VB-1 vertical bridge mill is designed to meet – and exceed – the demands of shops profiling large, intricate parts.

Heavyweight Boring Mill with Built-In 4th Axis

IN THIS CORNER . . . WEIGHING IN AT 42,000 POUNDS . . . AND SPORTING A 126" X 40" WORK TABLE, A 50-TAPER SPINDLE AND BUILT-IN 4TH AXIS . . . THE SUPER HEAVYWEIGHT CONTENDER FROM HAAS AUTOMATION . . . THE NEW HS-3R HORIZONTAL BORING MILL! LET'S GET READY TOOOOOOOO RRRRRRUMBLE!!!

The new HS-3R is a 50-taper monster offering travels of 150" x 50" x 60" (xyz) – something other T-shaped HMCs can't match. The 30-horsepower, 50-taper spindle provides 450 ft-lb of low-speed cutting torque through an oil-cooled, two-speed gearbox. And a vector spindle drive yields peak performance and precise speed control under heavy cutting loads. To provide the rigidity and holding power needed for 50-taper cuts, large ballscrews and high-thrust brushless motors are used on all axes.



Big jobs and heavy cutting are what the HS-3R is all about, so its massive table is designed to hold large parts and fixtures with ease. The built-in 4th-axis rotary table (37" diameter) allows machining of all four sides of a part in a single setup for greater accuracy, and features a 50" swing radius. The 28-pocket, side-mounted, shuttle-style tool changer moves out of the work envelope for unobstructed machining, while offering ample tool selection for most applications.

The new Haas HS-3R extended-travel horizontal: a large-table, heavy-duty 50-taper champion.

Continued from page 20

It was rather interesting as a young man to be given the opportunity to design a completely new artificial heart. I was presented with a problem and given the opportunity to solve it.

CNC – How old were you at that time?

Jarvik – I was very young, about 25. Within the first 6 or 8 months we broke the world record for survival with one of my first designs. I continued to work on that, and invented some of the things that became incorporated into the Jarvik 7. The key element that made the Jarvik 7 heart work was what was called a multi-layer diaphragm.

Basically, the kinds of bio-materials that existed caused serious blood clots, and they didn't last long enough without breaking. So I invented the multi-layer diaphragm system. Rapidly we went from hearts that would last no more than a couple weeks, to a design that has proven to last more than 10 years of continuous pumping.

CNC – What are your goals for the Jarvik 2000?

Jarvik – At first we will use it just on the left side. Later we'll probably provide a model where two pumps are used, one in the left, one in the right, which will make it a total heart.

CNC – Is the eventual goal to totally replace the heart, or just replace the heart's pumping mechanism and still use the heart as a container for the two mechanical pumps?

Jarvik – Well, let's just talk about the left side only, for now. There are actually three kinds of new applications for heart assist devices. There's the bridge to transplant, there's the permanent use, and there's a new use called bridge to recovery. With certain kinds of heart disease, if you put in an artificial pump that supports the natural heart, but doesn't damage it, after a period of time the natural heart recovers sufficiently to take out the assist device.

One of our objectives in the early work is to delineate the appropriate patients where we can actually give them long-term support – long enough for the natural heart to recover – and then avoid the need to find a donor heart for those people.

CNC – Did you design the pump itself?

Jarvik – Yes.

CNC – You have a degree in bio-mechanics, but how did that translate into the machining and designing aspects?

Jarvik – I got involved in machining pretty heavily when I started out in Utah. Even though I'm a physician, I've been involved in bio-engineering, mechanical engineering, machining and things of that nature for most of my career. I gained my experience the same way most engineers do – through working hands-on, not through a particular degree, necessarily.

CNC – When did development start on the Jarvik 2000?

Jarvik – About 1988 or 1989. Before that, when we developed other miniature axial flow pumps, we used to design the hydraulic blade shape on paper, lay it out, build the three-dimensional scale model, then reduce it with a three-dimensional pantograph to get the titanium blades. That's the way things were done until good computer programs came along. What really enabled us to move into the CNC machining of the blades was the combination of a good 4-axis machine and the special programs that CNC Software wrote for us.

CNC – At what point did you decide to go with the machining center?

Jarvik – When we got NIH funding for the project we went to the Haas machining centers. We got the machine at Transicoil first, and we had that for quite awhile before we got the machine here in New York.

CNC – Do you still do much of the machining itself?

Jarvik – Only a little. I used to do a lot of the machining, programming and running the machine, and I did most of the programming for the contoured parts that are made at Transicoil. But right now, we have people that are more expert at that than I.

Continued from page 20

not mistaken, the end-to-end dimension of the VF-1, where you've got just the cast iron and can't go any smaller, is 58 inches. We only had an inch on either side to spare on the elevator.

"We took the machine apart in our warehouse, then it was brought over by the rigger, who moved it up in the elevator and onto the floor, along with the disassembled parts. Then we did the reassembly and checked out the machine," McGill explained. "We swept the table in the fashion prescribed by Haas, and performed the necessary check-out procedures to make sure it would be running like when it left the factory."

Jarvik Heart took delivery of their VF-1 in April of 1997. Since then it has been hard at work machining parts for the Jarvik 2000 artificial heart.

For Tom McGill and Allendale Machinery, their association with Dr. Jarvik and such a critical industry has been fascinating. Tom McGill explains, "Anybody can make an automotive part. Anybody can make a part for an aircraft, or make a part for the electronics industry. But here you have a Haas machine making a part that is vital for life, and that's impressive."

by Bob Burrows

There has to be a better way

OCTOBER 1998 signifies the 15th anniversary of the introduction of the first programmable 5C collet indexer. It was WESTEC 1983 when Gene Haas decided to offer his new idea for sale to the general public. The idea of building such a product actually began nearly three years earlier in the summer of 1980. Gene then owned a machining job shop called Pro-Turn Engineering in Sun Valley, California. It was basically just him and a couple of machine operators named Tony Cortez and Abel Bugarian – both are still Haas employees – who primarily ran production parts for the aerospace industry. Gene specialized in machining parts that many other shops turned away because of their complexity.

One day Gene noticed Abel running a job that required indexing a part with a manual 5C-collet head. Using the dividing head seemed such a nuisance, because Abel had to let go of the quill handle and use both hands to index the part to the next position. Gene thought to himself, "There has to be a better way," and so began the development of an automatic indexing head.

The first design incorporated a stepper motor as the drivin mechanism, and a manu 5C collet head modified accommodate a worm and ge housing. The mechanical side the design wasn't terribly hard but deciding how to drive th motor and control the motio was another thing. At first, G entertained the idea of u someone else's control systen high costs were a major disadv He decided to call his old schoo Kurt Zierhut – yes, he too stil at Haas – who worked as a computer engineer at Librascope. Between the two of them they came up with the first version of what is still called "the black box." It took nearly three years of engineering in their spare time, including evenings, weekends and vacation time, to bring the first unit to market.

Gene had many friends and acquaintances at other machine shops, so he built a few indexers for them to use. In return he asked only for their feedback. Everyone loved them! They thought they were a great way to increase productivity on a manual machine. They had no idea this was only the beginning.

The first year, Haas sold about 20 units per month. Customers loved the concept, and now were asking for something a little bigger. The next step came in 1985 with the development of an 8-inch rotary table. Gene took an old manual rotary table, pulled off the handle crank, retrofitted a stepper motor and control, and the second product was born. By now sales had grown to about 40 units per month.

Increasing sales eventually taxed the abilities of the company supplying the manual indexers. So in 1986, Gene developed and began manufacturing heads and tables of his own design. By 1988, after only five short years, sales reached more than 100 units per month, and the product line grew to include the 5C indexer; 7-, 9- and 11-inch rotary tables; multi-spindle units and a tilting two-axis table.

Suggestions and feedback from customers not only led to new rotary products, but to the development of a vertical machining center. In 1988 Haas introduced the VF-1, a 20"x16" vertical machining center priced less than $50,000 – an unheard of price for an American-made machine tool.

In 1993, the rotary line underwent a redesign that is still in production today, although improvements are continually made all the time. Today, Haas manufactures more than 24 different