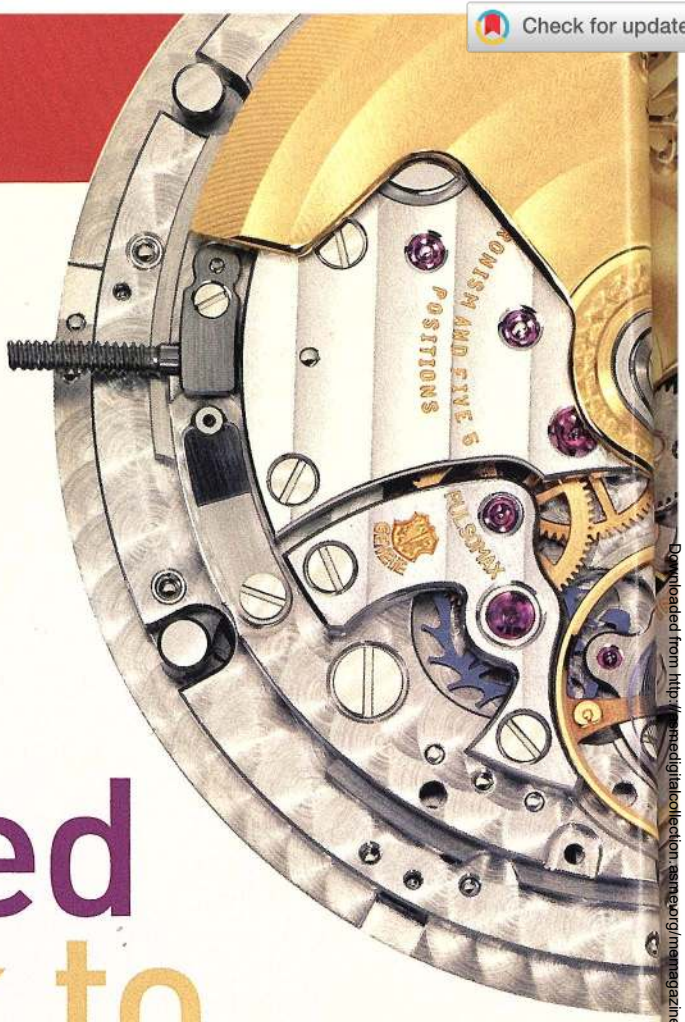


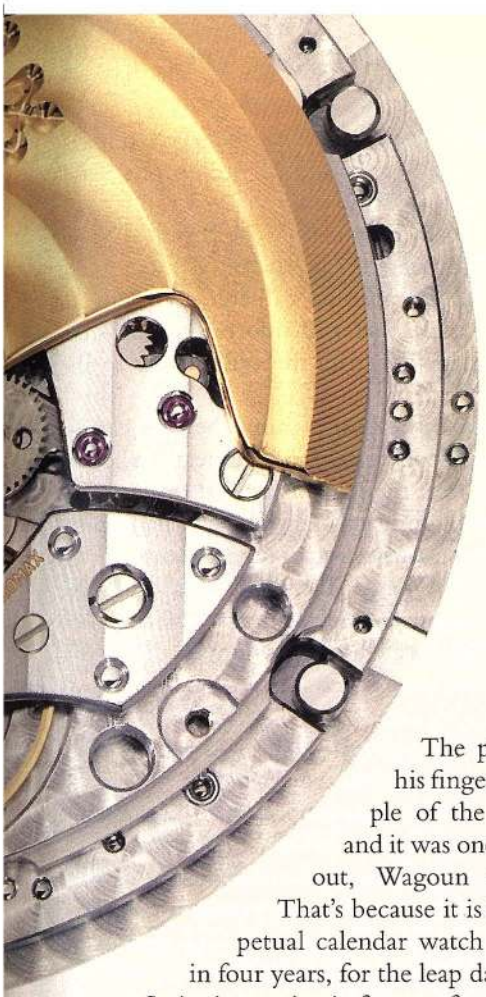
+ traced back to the watch

Micromanufacturing is a significant presence in Swiss industry, and the technology stems from luxury timekeeping. By Harry Hutchinson, Executive Editor

At the Patek Philippe watch factory not far from Geneva, Stephan Wagoun turned to a tour group and displayed a tiny speck resting on his fingertip. An observer squinted his eyes and, taking a closer look, saw something that may have been a tiny metal paisley—the teardrop shape you used to see on neckties.

Wagoun, a graduate of the Ecole d'Horlogerie de Genève, the Geneva Watchmaking School, is a *mécanicien-régleur CNC* at Patek Philippe. That translates to machinist and adjuster of CNC machinery. It's his job to figure out how to machine the tiny parts that make so many of the complications—those mechanisms that keep track of day, date, and what-not—that add the prestige to luxury watches.

PATEK PHILIPPE



Swiss-made micro: Demand for parts that make possible the complications in luxury watches, like these from Patek Philippe, has fostered a high level of precision machining in Switzerland.

The piece of metal on his fingertip was an example of the parts he makes, and it was one that never wears out, Wagoun told the group. That's because it is the part in a perpetual calendar watch that moves once in four years, for the leap day.

Swiss ingenuity is famous for clever inventions that include Swiss Army knives, Emmenthaler cheese, confidential bank accounts, complicated timepieces, and a variety of chocolate virtually unknown elsewhere.

The Swiss point out that they have built a prosperous country against the odds. Their only natural resources, they say, are hydroelectricity and brain power.

At least, that's how Switzerland Trade and Investment Promotion presents the case. Formerly called Location Switzerland, it is a national agency created to stimulate foreign investment in the country.

And that's one reason why there was a tour group inside the Patek Philippe plant. It isn't often that the company opens its doors to tours, except at its timepiece museum in Geneva. This tour was arranged by special request of representatives of the Canton of Geneva's economic development agency.

Switzerland Trade and Investment Promotion, in collaboration with the promotional bureaus of Geneva and other cantons, arranged a tour through several of the country's micromachining businesses and laboratories this fall. Patek Philippe was emblematic of the story that the promoters had to tell.

The requirements of watchmaking—particularly of the luxury mechanical watches that Patek Philippe, Rolex, and other legendary Swiss brands are famous for—have fostered a tradition of precision machining. As important as watches are to the Swiss, though, the country is not able to support itself on time alone. Of course, there are chocolates, banking, and tourism, but precision manufacturing is a selling point and it serves other industries in Switzerland, including the manufacture of medical devices.

According to a study, *Swiss Medical Technology Survey 2008*, published this fall, the country has about 700 medical technology companies, whose combined sales are approximately 20 billion Swiss francs, or about $17 billion. About 45 percent of sales are from medical devices.

A PITCH FOR LOCATION

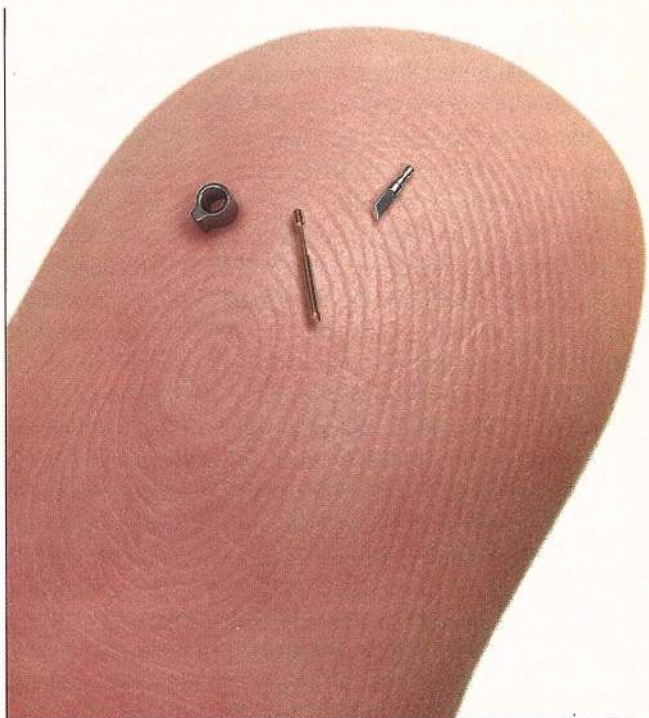
Switzerland styles itself as a prime location for the European headquarters of American and Asian companies. Besides its central location, the country has a gentler tax bite than its neighbors in the European Union. At the same time, it has a comfortable relationship with the EU to make it easy for people and goods to cross borders.

We have all this, the organizers of the tour were saying, and precision machining, too.

In the Geneva suburb of Meyrin, GF AgieCharmilles is a manufacturer of precision electrical discharge and milling machinery. For many of its machines, the company lists a roughness tolerance within 50 nanometers. It has EDM machines that use wire as small as 20 micrometers in diameter.

The company says it supplies industries from aerospace to semiconductors. In connection with its micromachining capabilities it specifically cites "the areas of medicine and watch industry, where components now need to be miniaturized."

According to Ivano Beltrami, AgieCharmilles's head of research in micro and nano technologies for electrical discharge machinery, the company has made progress in accuracy in the past 10 years. Form tolerances over the



▲ Turned in miniature: Polydec specializes in machining parts with features that are challenging to see without a bit of magnification.

POLYDEC SA

contour of a workpiece, for instance, have been reduced to 1.5 micrometers today, from about 3 μm.

The current ability to machine at small scales and to maintain tolerances has made thermal deformation of materials an increasing concern, Beltrami said. When the company designs a micromachining tool, he said, "We need to give it the smallest amount of energy we can so as not to deform the surface."

According to Beltrami, "This refers to the last trim cuts of a wire EDM or to the last cycles of a die-sinking EDM machine. It is not only important for the final precision of small workpieces, but also for guaranteeing the surface quality."

Sometime this year, AgieCharmilles will introduce a die-sinking machine called Form 1000. Mechanically based on its current Vertex 1 wire EDM machine, its positioning precision is expected to permit very fine, deep cuts. The machine in development has managed to make a hole 200 micrometers wide and 14 millimeters deep. That is an aspect ratio of 75.

Also based near Geneva, Endosense SA is part of Switzerland's medical manufacturing sector. The company has developed a cardiac ablation catheter, currently in European clinical trials, that will inform the physician of the force being applied from the catheter tip to the organ tissue.

A cardiac ablation catheter is a thin tube that can be inserted through a blood vessel into the heart, where it is used to find and treat the section of heart tissue that is causing abnormal rhythm. It is less invasive than open-heart surgery and is an alternative to drug treatment.

Endosense's device, dubbed TactiCath, was originally conceived by the company's chief technology officer, Giovanni Leo. TactiCath has a sensor at its tip with a sensitivi-

Laboratories of Micro Manufacturing

A tour of Swiss precision manufacturing included visits to institutions engaged in research and development of micromachining. The technology they are developing into new fields is grounded in the watch business.

EPFL, the Federal Institute of Technology in Lausanne, hosts the Center of Micronanotechnology, which coordinates its activities with two other institutions, the Swiss Center for Electronics and Microtechnology and the University of Neuchâtel, which operates the Institute of Microtechnology.

Among its functions, EPFL's center, known as CMI, offers access to a cleanroom, which is used by more than a dozen companies for R&D.

A number of start-up companies have been launched based on technology developed at the center. Sensimed is an EPFL spinoff company founded in 2003. It is trying to commercialize a system for continuous monitoring of intraocular pressure in patients at high risk for glaucoma. A MEMS sensor is embedded in a soft contact lens, which the patient wears. The sensors monitor the deformation of the cornea as a result of pressure in the eye.

The information is transmitted to a receiver in a pair of glasses that the patient also wears and is transmitted in turn to a pocket-size reader, which collects the data and can send it to a central database. There is also an eye patch to be worn in place of the glasses if overnight monitoring is deemed necessary.

Lemoptix (originally Scanlight Imaging) is also an EPFL spinoff based on microtechnology. The company develops micromirrors and microprojectors, and subcontracts its research and development expertise to other companies.

One of its ideas is to use micromirrors in miniaturized video projectors that could be built into cell phones. The company has a black-and-white prototype and expects to have a working color version later this year.

The Swiss Center for Electronics and Microtechnology, based in Neuchâtel, is a private, not-for-profit company that partners with companies to develop products in a number of emerging technologies, including micro-optics, bioengineering, and nanotechnology. A collaboration agreement, for example, was announced last May between CSEM and Ciba Inc. A press release said they will work together to explore "organic opto-electronic, micro-, nano-, and thin-film technology" to develop new products based on printing and microtechnologies.

According to its CEO, Thomas Hinderling, CSEM has also contributed to about two dozen start-ups in the past 10 years representing more than $100 million in sales. The companies together have attracted about 190 million Swiss francs, or more than $160 million.

It is all technology based on the watch, Hinderling said.

The organization was formed in the 1980s, when the Swiss government became concerned that the country's industry was losing ground in new technologies to neighboring countries. CSEM was formed by the merger of three earlier organizations: the Electronic Watchmaking Center, the Swiss Foundation for Research in Microtechnology, and the Swiss Laboratory of Watchmaking Research.

The University of Neuchâtel operates the Institute of Microtechnology under the Faculty of Science. One of IMT's research activities is the Pattern Recognition Laboratory, which is engaged in advanced machine vision, including applications for microsystems.

The IMT also includes the Photovoltaics Laboratory, or PV-Lab, founded in 1984 by Arvind Shah, who is now an honorary professor. It is currently led by Christophe Ballif. The lab has researched processes for the preparation of thin-film silicon and very high-frequency plasma deposition.

Other research programs include the Electronics and Signal Processing Laboratory, or ESPLAB, which is concerned with the realization of the signal processing electronics in microsystems; and the Applied Optics Group, which deals with nanophotonics and micro-optics, and Comlab, a joint project of the IMT and CSEM devoted to micro- and nanotechnology.

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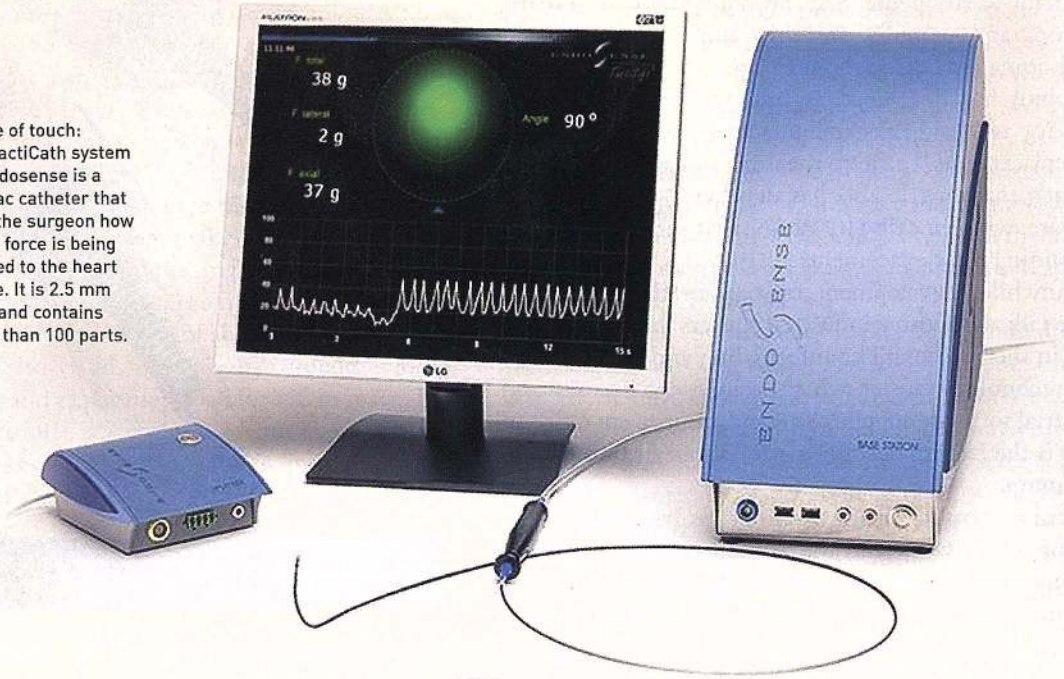
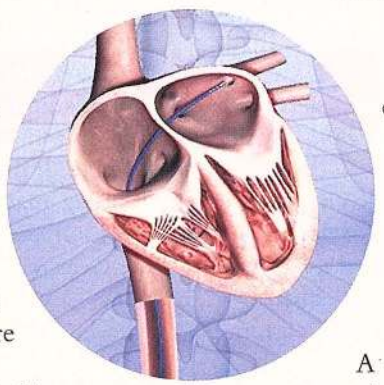


Sense of touch: The TactiCath system by Endosense is a cardiac catheter that tells the surgeon how much force is being applied to the heart tissue. It is 2.5 mm wide and contains more than 100 parts.

ENDOSENSE SA

ty of less than one gram. Force information is displayed on a computer screen.

As Endosense's CEO, Eric le Royer, explained it, knowledge of the force applied can help a surgeon because too little force may result in incomplete treatment and too much may ablate more tissue than needed, or may even interfere with nearby organs.



The catheter contains three fibers bonded in a deformable body and calculates force from the change in light waves. The entire device is 2.5 mm wide and contains more than 100 components.

Polydec SA in the city of Biel makes turned micro parts. The company's owner, Claude Konrad, who is also president, gave the tour group an example of what the company makes. Konrad held up a piece of metal that resembled the barrel of a sink faucet. There was a hole drilled up through the center, another through the side, and a few cuts to make the points at the end. Not very impressive, he said, until you realize it is a 50-to-1 scale enlargement.

He handed out samples of the actual part in small plastic bags so people could handle them. The largest dimension was just over a millimeter. Viewed later under a microscope, each of the parts indeed had all the features of the enlarged version. They are probes to be arranged in an array that will test the conductivity of computer chips.

The company makes many tiny things—micro axles for automotive instruments, spindles down to 0.3 mm wide for various uses, and of course, watch parts.

In order to achieve the accuracy that it wants, the company does not use machinery off the shelf, according to David Kouidri, the president of Polydec International Inc., the U.S. subsidiary based in Chicago. "We buy machines and then we modify them," he said.

COVERING BASES

A frequent strategy for business development is to encourage broad bases of companies and industries, and spreading the base of wealth is one of the reasons behind Y-Parc in the Canton of Vaud.

Located in Yverdon-les-Bains, Y-Parc bills itself as Switzerland's biggest technology park. More than 100 companies have a presence there. Businesses range from precision instruments and microelectronics to information and medical technologies.

Schott Yverdon manufactures optical components at Y-Parc. It is one of five manufacturing sites operated by Schott Advanced Optics. The others are in Duryea, Pa.; Jiansu, China; Penang, Malaysia, and Mainz, Germany. The company, originally known as Guinchard Verre Optique, opened a factory at Yverdon in 1976 and moved to Y-Parc in 1998. It merged with Schott AG of Germany in 2000.

The company says it has 250 types of glass on hand and will custom-machine shapes to order. Schott claims that it can achieve tolerances of 0.001 mm, or 1 micrometer, and surface flatness of 60 nanometers.

The company sells to customers in a number of industries. According to Schott Yverdon's senior sales man-

ager, Daniel Vasseur, about 19 percent of its business is in sales to the watch industry.

Symbios Orthopédie SA, headquartered at Y-Parc, develops and manufactures hip and knee prostheses, which it markets throughout Europe.

Symbios has developed technology that enables the company to design and manufacture custom stems for hip replacements, made to measure and adapted to each patient's anatomy. It also has developed 3-D planning software, which it calls HIP PLAN, that surgeons may use in planning hip replacements.

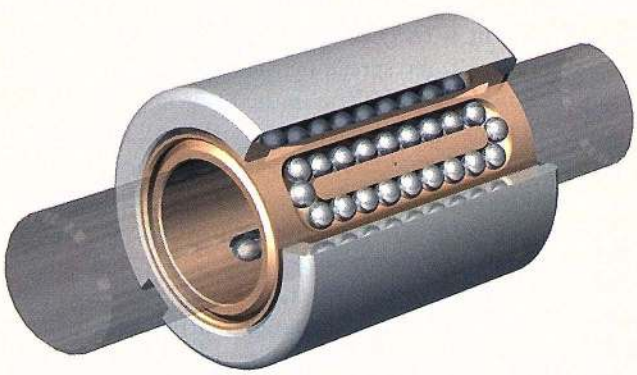
Meanwhile, development officials in the Canton of Berne talk about three industrial clusters that have developed in their region. The information and communications technology cluster, which includes the business and industrial software supplier SAP and a European office of eBay, is the largest, accounting for about 51,000 jobs in the canton.

Precision manufacturing is almost as big. Companies ranging from Rolex and the Swatch Group to Affolter Technologies and Micro Precision Systems AG account for another 50,000 jobs. The medical sector, including hospital employees, comprises about 30,000 jobs in the canton. Medical technical companies—including a unit of Roche, the pharmaceutical giant founded in the 1890s in Basel—employ about 9,000.

That comes to more than 130,000 jobs in a state with a total population of about 950,000 and a workforce of perhaps 500,000.

Micro Precision Systems AG, based in the city of Biel, describes itself as "an outsourcing partner for design and manufacturing of precision, micromechanical solutions."

The company specializes in developing microsystems with linear or rotating movements. It has customers in the watch and medical device industries, and others working in automation and optics. The company's two standard product lines are Microsphere miniature bearings and Microlinea ground ball screws and linear bearings.



▲ Small rollers: The balls in MPS's Microlinea bearings are a half-millimeter in diameter. Applications include medical devices.

According to Véronique Athané, research and development manager, the company's recent projects for clients have included an implantable pump to deliver medicine to treat chronic pain, and a high-speed pick-and-place pickup head with integrated sensors to place components on a printed circuit board.

▲ Even closer: Tolerances for Micro Precision Systems' ball screws are a few micrometers. The company will tighten them upon request.

Affolter Technologies SA, in Malleray, manufactures controls and machine tools for industries that require micromachining, like makers of medical devices and watches. It makes computer numerically controlled gear hobbing machines, for instance, designed for making precision pieces. Brochures for two of the machines, the Gear AF 100 and AF 90, show examples of applications—a watch pinion with double gear, an escapement wheel, and a tiny spur gear.

A unit of the company called Affolter Pignons supplies pinions and wheels for watch movements.

According to Yves Beguelin, Affolter's area sales manager, the company has formed a Shanghai unit to market its tools and software in China.

AN AMERICAN IN SELZACH

One of the stops on the tour was Stryker Medical Technology in Selzach. The site develops and manufactures orthopedic implants and other medical hardware. And it was part of the tour because it is an American company that has a strong presence in Switzerland.

The company has facilities in Geneva and Montreux, as well as in Selzach.

According to Rolf Scheidegger, Stryker Selzach's director of operations development and information technology, the company is adding a new building at the site for R&D, marketing, and manufacturing. Some of the factory's prime pieces of hardware are five-axis turning and milling centers that can simultaneously machine complex components in one setup, Scheidegger said.

Automation advances have reduced manufacturing costs by about 45 percent, he said. Previously, the com-

MICRO PRECISION SYSTEMS AG

pany required one employee for every two machines during each shift. Now, each employee controls about three machines, and a third shift can run unattended

Setup takes three to eight hours, but then the machinery can operate for as many as 60 hours unattended—allowing a ghost shift over a weekend. The machines have duplicate tools and programmed instructions to switch them during extended periods of operation to avoid using a worn or out-of-range tool.

Oerlikon Space AG in Zurich makes a variety of high-tech products for space programs, including the payload fairings for vehicles that carry cargo into space. The fairing has a service life expectancy of about two minutes.

The company also builds delicate instruments, ultra-stable structures, and experiments, all for use in space. Its number-one customer is Arianespace. But according to an Oerlikon spokesman, the company is diversifying its products to build a wider base of customers.

Its Web site has a category called "spinoff products." So far, there is only one, an aperture stop mechanism for semiconductor manufacturing. The mechanism controls the aperture of the high-resolution optical system that prints the mask on chips. The company says it leveraged the experience in high vacuums and surface cleanliness it has gained from manufacturing instruments for space.

Swiss precision manufacturing is an industry built on the watch. But the Swiss almost lost their watch business 20 years ago, as attractive electronic models were introduced in Japan and began to sweep across the world.

The country formed a strategy to compete. The Swatch brand was able to go head to head in the electronics market. Meanwhile, the state poured money into micromanufacturing labs to advance the technology that makes possible the ever-higher luxury end of the market typified by Omega, Tag Heuer, and Stephan Wagoun's employer, Patek Philippe.

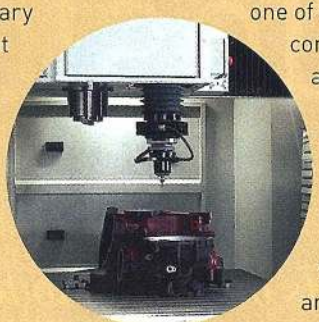
The cachet of "Swiss made" makes possible small companies like Louis Chevrolet, in the farm country at Porrentruy. It buys movements to make its own brand of watches, named for the founder of the Chevrolet car company who was born not far from the factory. It also handles contract work for bigger companies, making their parts or handling their service contracts.

To qualify as Swiss made, the major parts of a watch must be assembled in Switzerland, and at least half the tiny parts of the movement have to be made in the country. To do that, the Swiss need an industry that can make things that small, and do it reliably. ■

Precision by Hand

A company in the suburbs of Geneva specializes in manufacturing equipment that can be described as high precision on a large scale, and it relies on hand finishing for a key part of its products.

SIP describes its products as the result of "effective integration of tool and pallet changers, rotary tables, tool management systems, measuring devices, flexible cells, coolant systems, thermal shields, and a temperature compensation system." According to SIP, each machining center is a configuration of modular systems to fit a customer's needs.



The company was founded in 1862 by Marc Thury, a professor of botany, and Auguste-Arthur de la Rive, a physicist and one of the early researchers of the electrochemical theory of batteries. They formed the company as La Société Genevoise d'Instruments de Physique to produce precision instruments for scientific research.

Today, SIP supplies manufacturers of products ranging from turbine components and helicopter gear housings to dies. About one-fifth of its machining centers are sold to companies that make machine tools.

The company offers its machining centers in various configurations, one of which is a twin-spindle combined milling, boring, and grinding center. One of the centers is called SIP 5000. In its largest configuration, it is rated to handle a maximum table load of 4,000 kg, or four metric tons. Its *x*, *y*, and *z* ranges are 1,600 mm, 1,100 mm, and 1,000 mm, with a positioning precision of 0.003 mm, or 3 micrometers.

The guideways on which the assemblies move get their precision from hand scraping.

As it was explained during a tour of the factory, a color-transfer sheet is pressed against a surface, where it leaves a blue imprint on the high areas. Technicians use an electric-powered scraper to remove fine layers of metal, sometimes as little as 1 or 2 micrometers deep, from the blue areas. The company budgets 600 man-hours for hand-scraping more than 40 surfaces in each machining center.

Big and accurate: SIP manufactures the twin-spindle SIP 5000 (left), which can machine a 4-ton workpiece with 3 µm accuracy.

Guideways are preloaded to account for deformation due to gravity. The machining center's bed rests on three points for geometric stability, unaffected by normal irregularities in a floor.

SIP expects to service each machining center every 15 to 20 years to restore the original accuracy. Servicing may involve taking apart the assemblies and sometimes rescraping the guideway surfaces.

In 2006, SIP was bought by StarragHeckert Holding AG, which operates several machine tool manufacturers around the world and is based in Rorschacherberg, Switzerland.

SIP