Spring Drive: A "Mechanical Quartz" Movement Developed by Epson Artisans

By Tony McNicol

Seiko Epson Corporation ("Epson") has never forgotten its watch-making roots. It was in 1942 that the company's predecessor, Daiwa Kogyo Ltd., was set up to produce Seiko-brand watches in Suwa, Nagano Prefecture—an area known as "The Switzerland of the East" for its concentration of precision technology.

The sobriquet was apt, as Epson's engineers were soon to rival Switzerland's finest watch-smiths. By the end of the 1960s the company was making some of the world's most reliable and accurate watches under the Seiko brand, and it built the world's first commercial quartz watch, the Seiko Quartz Astron, in 1969.

The overwhelming strength of quartz watches is their accuracy. Even today's most advanced mechanical watches lose or gain 10 to 20 seconds a day. Quartz watches, on the other hand, are accurate to ±15 seconds a month. One weakness of quartz watches, though, is their need for a battery. If a quartz watch is left unused for a while—which is not uncommon among collectors of luxury watches—the battery may run out, and the watch will not work.

Epson's radical idea—which first germinated in the 1970s—was a watch with a "mechanical body and a digital brain."

TONY MCNICOL

Around 30 of Epson's most highly skilled technicians hand-assemble Seiko-brand Spring Drive watches.

Combining 40 years of mechanical craftsmanship with the latest electronics, Epson succeeded in developing the Spring Drive watch, released in 1999.

In Spring Drive watches, the mainspring is either wound by hand or, in automatic watches, the movement of the wearer's arm. Power from the mainspring is transmitted to the gear, which turns the rotor and produces electricity in the copper coil. That electricity vibrates the quartz oscillator, which in turn regulates the rotor speed using an integrated circuit to ensure that the mechanical movement maintains quartz accuracy. The watch has no battery, works immediately after being wound 4 to 10 times, and yet is accurate to within a second a day.

"This watch is special because it's a high-performance mechanical timepiece with a sweeping second hand that doesn't need a battery," says Hirokazu Imai, a senior manager at the Watch Marketing Department of Epson's Shiojiri Plant.

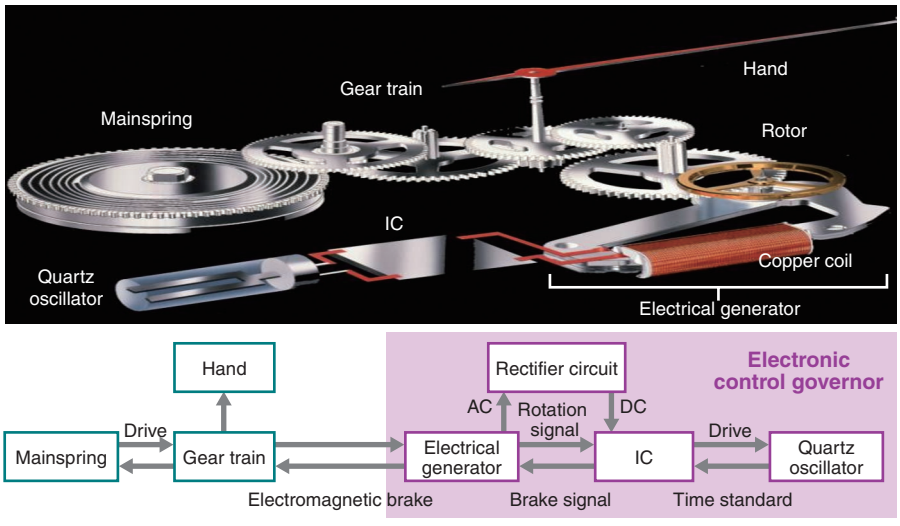
"The biggest advantage is that you can use it any time you want," adds Osamu Takahashi, manager of Epson's Micro Artist Studio, also in Shiojiri. "Having to wind a watch is another plus, since it can deepen the interactive experience for an owner."

Technical Challenges

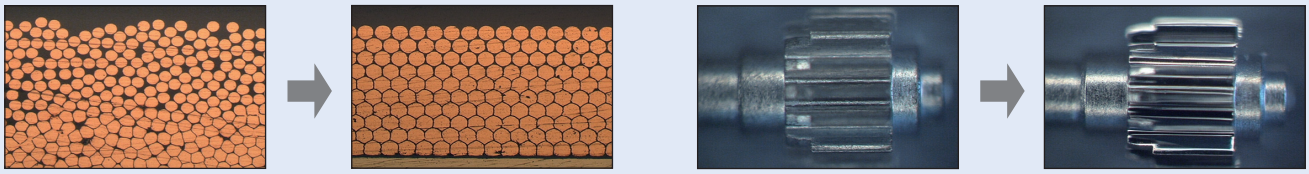
Epson's engineers initially found that the mechanical power generated by the mainspring was not being converted into electricity very efficiently. As a result, when the first prototype was made in 1982 it ran for only 4 hours on one winding. Even the second prototype, developed in 1994, ran for just 10 hours. One strategy was to reduce the power consumption of the IC.

"The IC was the biggest challenge," says Takahashi, who joined the development project in 1993. Epson's expertise in semiconductors was tapped to develop an ultra-low-power-consuming IC in house. By inserting a thin layer of silicon oxide film between a MOS-IC and a silicon substrate, they were able to produce an ultra-low-voltage, low-power circuit. This unique MOS-IC reduced power consumption to

Spring Drive Mechanism



Improvements to Coil Alignment and Gear Polishing



Conventional coil | New coil | Before polishing | After polishing

just a tenth of other quartz watches. The power requirement was so low, in fact, that if everyone in the world wore a Spring Drive watch, the combined wattage generated would still barely power a 150-watt light bulb.

The team also focused on other ways to enhance energy efficiency, such as by reducing friction between the mechanical parts. The miniscule gears in the movement were polished to a surface roughness of less than 20 nanometers with a beech wood wheel. The team designed an ultra-efficient, ultra-small copper coil, since the size of the coil was also found to be a significant factor behind the power loss.

A special machine was made to wind 30,000 turns of a 200-meter-long, 13-micron thick copper wire as tightly as possible. When the first Spring Drive watch went on sale, it ran for 48 hours on a single winding, and the power consumption of the quartz oscillator was a thousandth of Seiko's first quartz watch made three decades earlier.

Traditional Craftsmanship

Today, the jewel in the crown of the Spring Drive range is the Sonnerie complication watch unveiled to the world at the 2006 Baselworld Watch Expo in Switzerland. Technical advice concerning the polishing of parts was given by master Swiss watchmaker Philippe Dufour, and all of its 630 parts are hand-assembled. This is much higher than the 100-plus parts contained in a standard mechanical watch. Just five of the ¥15.75 million watches are made each year for sale worldwide, and 15 have been sold to date.

The Sonnerie is made at Epson's Micro Artist Studio in Shiojiri, where the company's renowned watch-making expertise is concentrated. Among the 12 Micro Artists who work there, several have earned gold medals at the biennial Worldskills competition. "All the Micro Artists are master craftsmen," says Takahashi. "They have the dedication and concentration to produce something very special."

Sonnerie means *ring* in French, and the watch's most remarkable feature is that it contains a traditional Japanese bell called an *orin* that rings every hour on the hour. The bell, normally used at Buddhist altars, is prized for the exquisite lingering purity of its sound. One technical challenge was to include gaps in the casing to let the sound out, but not dust in. Another was to ensure the movement was completely silent to highlight the *orin*'s chimes. To that end, the bell is timed by a specially designed governor that uses the viscosity of air to remain perfectly silent.

Above all, Epson's Micro Artists wanted to create a watch that could have originated only in Japan. "This was our way of creating something very distinctive while paying homage to the top watch-makers in Switzerland," comments Takahashi.

The painstakingly analog craftsmanship of the Micro Artist Studio might seem miles away from Epson's high-precision electronics, but the Studio's soul is very much alive in the company's other precision technologies, such as the miniscule nozzles of its inkjet printer head. A perfect synergy of traditional craftsmanship, electronics expertise, and precision manufacturing, the Spring Drive Sonnerie is a quintessentially Epson product.

The Spring Drive Sonnerie

The Sonnerie complication watch is made by Epson's Micro Artists.

TONY MCNICOL

Tony McNicol is a freelance writer and photographer based in Tokyo.