Watch Knowledge

Rise of the Machines

QP looks at the myriad ways in which computers have transformed watchmaking

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It's hard to imagine, but until relatively recently this was a world devoid of computers, mobile phones, or any of the gadgets that vastly facilitate our lives nowadays. Wristwatches have been around for over a hundred years, but it has still fallen to the computer to rescue the mechanical version from the brink of oblivion posed by the cheap-and-cheerful quartz revolution, and to ensure a healthy future of variety and complexity.

Automatic pinion cutting machine used by the Waltham Watch Company in 1892. The curved arm would automatically pierce a piece of metal from the carousel and the machine turned it into a watch pinion. All the operator had to do was to fill the carousel.

For most of their history, watches were, like most good things in life, only available to the wealthy. It was American entrepreneurs who realised that the common man could provide a market for consumer goods, but only if they were produced cheaply enough. The great intuitive leap was that mass production of interchangeable parts using automatic machines and line assembly could achieve this. Henry Ford, with his famous Model T automobile, was actually following the example of American pocket watchmakers, who were in turn following Civil War gun manufacturers.

Out with the old…

The same principles continue to the present day, but computers have brought a dramatic change to the production process. Well into the 1990s, the automated lathes and milling machines essential to watchmaking were analogue devices operating entirely mechanically, using cams and levers. When I first visited Jaeger-LeCoultre in Le Sentier in 1991, a line of Tornos repeating lathes stretched into the distance, occupying the major part of a vast factory floor. Nowadays, only a handful of the modern machines are required; smaller watchhouses make do with just one or two.

The movement of the cutting tools must be very precise. Not only was designing and making the old machines' cams a highly skilled job in itself, but each set was specific to a particular watch part. Moreover, setting up and adjusting the lathe to produce that part could take up to two days. Watch companies therefore had separate machines dedicated to making each specific part and were understandably reluctant to make any changes in watch design. A similar situation applied to those parts produced by stamping machines using press tools. The advent of computerised control changed this forever.

The stepping motor

The key exponents of computer-controlled machinery are stepping motors. Watch buffs will be familiar with these; every analogue quartz watch has at least one, chronographs may have several. As the name implies, a stepping motor turns in discrete steps in response to individual pulses of electricity. The turn of such a motor can be controlled very precisely, subsequently allowing precise positioning of cutting tools in computer numerical control (CNC) lathes and milling machines. Their operation becomes a simple matter for a computer program, rather than a cam.

These machines are fascinating to watch. Tools move into position rapidly, stopping just before contact with the workpiece and advancing imperceptibly. They then withdraw quickly, are perhaps re-set automatically from a selection on a carousel, and the next stage of the machining process continues. Such machines can be made to produce one type of part, then switched to another simply by changing the program.

As the tools and workpiece need to be securely positioned, the machines need to be large, robust, and therefore expensive. But even the best machines cannot cut really hard material. Watch parts that need to be particularly strong or resistant to wear are machined from metal in its 'soft' form and the parts are subsequently hardened by heat-treatment. This may cause distortion and certainly introduces additional steps to the production process.

EDM machines

Beyond the lathes and milling machines that shape metal using cutting tools, a further important change in modern watchmaking was the development of electrical discharge machining (EDM).

No cutting tools are used in EDM. Amazingly, no contact is made with the material at all. Instead, a high electrical potential is maintained between the wire and the target material, which is vaporised as the wire approaches. Because the heat of the discharge affects the wire, it is continually moving, thus constantly renewing the surface.

Like the other machines discussed, EDM is computer controlled (more stepping motors) and will cut any profile you can draw with a computer program. As the wire does not touch the material, there is no cutting friction and holding the workpiece is not a problem. Nor does it matter how hard the material is, so hardening after cutting is not necessary – yet another major breakthrough for the watch industry…

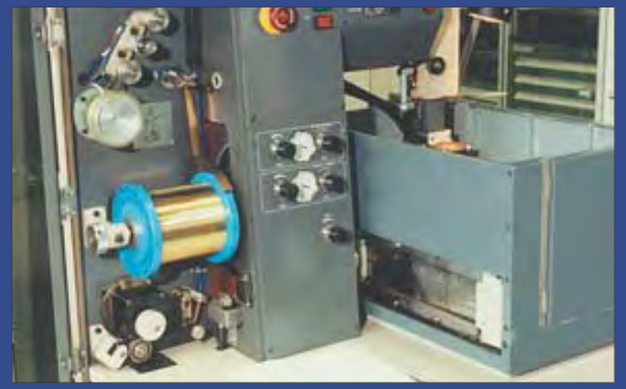
Press tools

Many watch components are stamped out of a sheet of material using press tools, working in principle rather like an office hole-puncher. The set-up has to be made precisely so that the 'tool' (the male part) fits the 'die' (the female part) with the correct clearance. The material from which these tools are made has to be hard and therefore capable of punching out thousands, if not hundreds of thousands of parts.

Press tools for complex shapes are very difficult and expensive to make by traditional methods; having made the press tool for a particular part, a company would be reluctant to make any design changes. Nowadays, EDM can be used to make the faces of the tool and die from tungsten carbide, so press tools are relatively cheap to make.

EDM therefore works on two levels. For companies with small production runs, EDM is used to make the watch components. For large-scale production,

Modern Tornos lathe at Jaeger-LeCoultre. Tools are moved by stepping motors controlled by computer programs.



Wire EDM machine at IWC producing jumper springs for a star wheel in a calendar mechanism. The spark erosion takes place under water. Note that several sheets of metal can be cut at the same time and that they can be held in place by a simple spring-clip. This is because the spark vaporises the metal and no physical force is applied.

Modern Press Tool at Nivarox FAR, forming the lever for the Omega Coaxial Escapement.

These two watches, by Chronoswiss (left) and Alain Silberstein (right) have the same tourbillon movement, shown by the fact that all screws and jewels are in the same place. The bridges have been made on the same computer-controlled milling machine by using different programs which can be changed instantly.

EDM is used to make the press tools that make the components. CNC has made all of this very flexible, of course.

Versatility and flexibility

The inherent versatility of the computer-controlled devices used in watchmaking has advantages for both the producer and consumer. Because CNC-controlled machines can easily be switched from the production of one part to another and can run for long periods unattended (overnight if necessary), the number of machines required is greatly reduced and the initial capital cost of becoming a watchmaker has declined. Parts can also be produced in the exact quantities needed, rather than in vast surplus as was traditional, virtually eliminating inventory costs.

It is also very easy to make small changes in the design of a component to ease assembly or improve performance. Even if a new press tool is required, the expense is not vast. With machines producing components that will function without further tweaking on the assembly line, staff can spend time on those aspects of finishing only achievable by hand. It is this ability to make components that function perfectly, virtually without human intervention, that enables Rolex to produce 750,000 high-grade mechanical watches a year; an astonishing feat.

Branching out

As well as watches that approach technical perfection, the consumer can be provided with an unprecedented choice of new models, varying both in style and substance. These include what the motor trade call 'halo models'; those exotic beasts produced in small numbers, thus adding to the allure of the brand and helping to sell the basic range. In the watch world these are the tourbillons, minute-repeaters and perpetual calendars, most parts of which are made by CNC EDM.

One-man watch companies have also flourished thanks to this silicon revolution. If you own a computer and the appropriate software, anyone so inclined can design a watch or a choice feature for a watch. The necessary components can be made just by providing a specialist engineering firm with a CD of the program.

This near-ubiquitous marriage of computers and machines has clearly been a fortuitous one; not only can watch companies provide a rich variety of watches, but the watches themselves are being provided by an ever-blossoming abundance of watch companies. For better or worse, automation will continue to guarantee a vibrant market, fit to burst with both choice and quantity. O