From the Workbench

The Watch Movement

Part 2

QP examines just what it is that makes a watch tick

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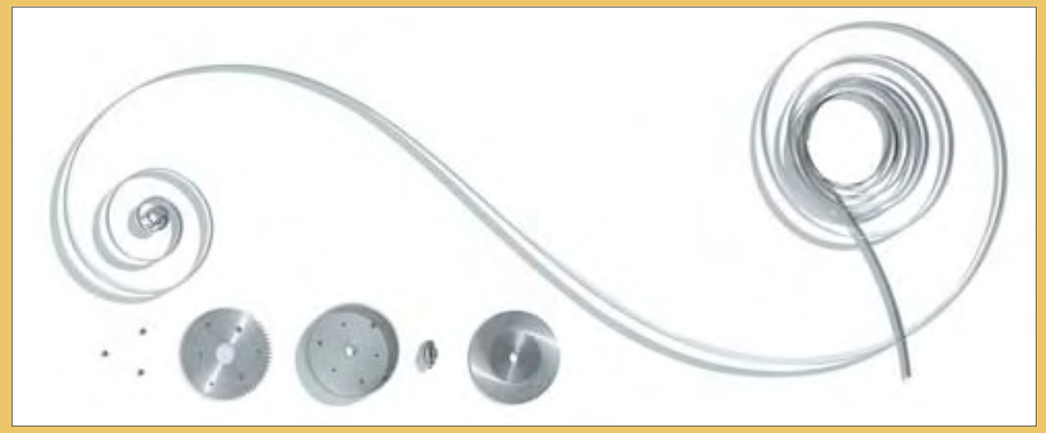
In Part 1 we saw how designers and engineers, aided by computers and machines, set out the foundation of a watch's external and internal layout. Whilst many of today's watches contain finely crafted complications and extras, there are some mechanical structures that are present in all watches, whether displaying perpetual calendars or just hours, minutes and seconds. Within the often daunting interior, three component groups are ever present: the mainspring, going train and escapement.



The mainspring is the energy store for every function of a mechanical watch. Timepieces with greater autonomy need longer mainsprings in which to store the extra power.

Energy

There is no mystery involved when it comes to discussing a watch's energy source: whether manually wound or automatic, it is the wearer who supplies the power! This energy, stemming either from your fingertips or the spinning of the automatic's rotor, must be stored somewhere. In a wristwatch, this energy is accumulated in the mainspring. In either instance, every turn of the crown or every shake of the wrist is translated into the turning of the winding barrel, within which the mainspring is attached, slowly tightening it. The mainspring itself is a marvel of material science, the result of years of accumulated research and experimentation. Made of a special alloy using beryllium, cobalt, chromium, nickel and iron, it is anti-magnetic, reasonably insensitive to temperature and able to keep its "springiness" even after many thousands of windings. Only a couple of firms in the entire world are able to produce this alloy, and only a handful are capable of actually manufacturing the springs themselves.

The amount of energy stored in the mainspring is described as a watch's "autonomy". Simply put, it is the length of time that a watch will go on ticking after being rewound. Some of the older models have only 36 hours, whilst today 40–48 hours is the norm. (Some watch houses have pushed the autonomy envelope a long way. Chopard have developed watches utilizing four winding barrels to produce 9 days of autonomy, Patek use two large barrels supplying 10 days and Ulysse Nardin have one large spring, as used in the Freak, to produce about 7 days' power.)

Letting go – the going train

It is wonderful to have energy to spare, but without a means of distributing and regulating its expenditure, it would not be of use to anybody. This is where the gears and the escapement – the ticking heart of the wristwatch – come into play.

The gears of a watch have two basic functions: stepping down the tremendous forces held within the mainspring for the delicate gears, and the distribution of this energy from the mainspring to the escapement. Simply put, each tick of the escapement is one tiny dose of energy that is being released – at exactly the correct moment and in an exact amount. The gears literally feed the escapement with the mainspring's energy, for they are all directly or indirectly connected to it. With each tick, each release of energy, all the gears are allowed to turn little by little, synchronous with the mainspring's relaxation.

Gearing

The gears in a wristwatch are somewhat mundane in comparison with the highly active escapement, which more easily captures the imagination, especially when viewed through a glass-backed case. For the watch enthusiast the mechanical attraction of gears lies in their regularity of profile, the polished edges of the teeth (which all have specific types of profile and shape) and the feeling of harmony they evoke, always in a constant state of interaction with one another. Achieving regularity in the cutting of the teeth was an important issue in early horological circles, especially for pinions, with their high-profile teeth requiring exceptional accuracy, and it is one of the first areas in which machines were devised as an aid to the watchmaker. Calculating the correct ratios and sizes is a highly complex procedure, even with computers to help.

Additionally, gears that turn rapidly or that must carry large stresses will be seated in jewels to protect them and ensure a microscopic pool of oil in which to turn; other slow-turning gears will simply be seated between the baseplate and a bridge, both without jewels. (These aspects will be covered in the next issue of *QP*, when the assembly of the watch will be discussed.) Hardened brass is the most commonly used material, but nearly anything that can be finely machined and is hard wearing can be used, including rock crystal.

Altogether, the set of gears distributing energy from the winding barrel is called the "going train". If we include the escape wheel in this group, only four gears are required in the going train of a basic wristwatch.

The great escape

The escapement – which for our discussion comprises the balance wheel, balance spring, anchor and escape wheel – has one job: to allow energy to "escape" in a regular fashion. Any irregularities in this section of the watch's interior lead directly to large inaccuracies. For that reason, research into improving, refining and developing the watch escapement has been ongoing since the 17th century. New escapement designs are always on the horizon, in part spurred on by the higher accuracy of parts manufacture, the discovery of new materials and oils, and mathematical computation. In modern times both individuals such as George Daniels and companies like

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Ulysse Nardin have released new escapements, and many others are hard at work behind the scenes right now, meaning there are still surprises in store for those of us who love mechanical wristwatches. But why is this? Is the Swiss lever escapement, used in millions of wristwatches year upon year, really so problematic?

The way in which it all works is very straightforward. The escapement wheel is the last wheel of the going train receiving energy from the winding barrel. The balance wheel, with its attached balance spring, rotates back and forth over and over again. With each change of the balance wheel's direction, the anchor, so called because of its shape, is also rocked back and forth As the anchor rocks back and forth, it alternately releases and holds the gear wheel, and with each release another pulse of energy is allowed through the train. In a typical wristwatch there will be 21,600 of these beats per minute. Additional gears with hands attached, communicating and turning with

For a mechanical watch to work, all that is needed is a mainspring, a going train and an escapement. Despite the myriad forms wristwatches take, most are pretty similar when you look under the dial.

the going train mentioned above, provide us with the hours and minutes of timekeeping.

The ticking you hear when you hold your watch to your ear is the sound of the pallets – the long jewels held on the tips of the anchor – striking against the escapement gear. The escapement, just like the human heart, is in constant motion. It is expected to function accurately and without a hitch for literally millions of cycles, rocking back and forth before requiring care or attention, not to mention the shocks, bumps and movements inherent in daily life on a wrist. This puts extraordinary demands on the entire escapement: the escapement wheel, anchor, balance wheel, balance spring and all its subparts.

Lubrication is also a serious issue. The Swiss lever escapement requires oil to function correctly, but of course oil can thicken over time and become displaced, causing extra wear and tear on the watch parts. Fine-tuning over centuries has perfected the Swiss lever system, but the search is unending for the ultimate escapement. Whatever that future outcome might be, the Swiss lever escapement in its present form gives fantastic results when properly adjusted and cared for.

So next time you are late and rushing to your next appointment, remember that your wristwatch keeps perfect time via the *release* and *control* of energy. What a calming thought that is!

Next issue: The watch movement – Part 3