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The Trans-Axial Remontoir Tourbillon

A New Jumping Dead-Seconds Watch by Andreas Strehler

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Andreas Strehler's latest watch is the Trans-Axial Remontoir Tourbillon. This wristwatch combines tourbillon, remontoir and jumping dead-seconds. All of these are interesting devices and they have been combined in an unusual configuration.

Strehler, who won the Gaïa Award in 2013 and is a member of the AHCI, is a noted specialist in a number of disciplines including micro-epicyclic gearing, bevel wheels with true conical form, and a jumping-dead seconds indication he calls Sauterelle. Through his movement production company, UhrTeil SA, he has developed a number of calibres for various makers, including the UT-G01 by Garrick (*HJ*, December 2018). We also reported on his high-precision lunar train with three-hour vernier indication in the *HJ*, February 2018.

Looking at the front of the watch, we find a three-armed tourbillon, a state-of-wind indicator, and jumping dead-seconds indication. The open-worked design is aided by the inclusion of transparent sapphire wheels to the motion work, and it also allows sight of the conical winding pinion.

Eschewing any tendency toward the poetic, Strehler's name for the watch gives us a perfect menu as a refresher for studying its various functions.

Remontoir

A decidedly uncommon device in horology: it takes the torque from the mainspring and uses it periodically to re-wind a smaller, lighter spring close to the escapement. In the case of this watch, the remontoir spring is re-wound every second. This allows the balance to maintain a constant amplitude throughout its run. As is normal in high-grade work, the balance staff tips are shaped by burnishing so that there is minimal amplitude variation between vertical and horizontal positions.

Tourbillon

A pivoted carriage holds the balance, pallets and escape wheel. This allows them to rotate about some axis, which in turn cancels out those poise errors that arise when using flat or Breguet balance springs.

Strehler's carriage does the usual one rotation per minute. A typical tourbillon carriage has a pinion fixed to it so that it can be driven by the wheel train. In a one-minute tourbillon, this pinion is equivalent to the fourth pinion, and is driven by the train third wheel. Thus impelled, the carriage rotates, carrying all the escapement components around with it. Without any further intervention, the watch would simply run down, there being no connection to the escapement. In order to drive the escape wheel, there is a wheel fixed to the frame of the watch, with internally-cut teeth. This engages with the escape pinion, which is therefore forced to roll around its own axis as the carriage goes round. In Strehler's watch, however, the carriage is not driven by a pinion, as we shall see.

Trans-Axial

In this watch, the tourbillon and remontoir axes are in alignment, one above the other. The lower pivot of the tourbillon runs in a jewel that is itself mounted atop the rotating central part of the remontoir arm.

The remontoir body, in turn, is ring-shaped, **Figure 2**. This annulus is recessed at its rim, something like (if the maker will forgive the comparison) a tyre-less bicycle wheel. Three equi-spaced rollers sit within the recess, supporting it axially and laterally in space, without it needing pivots.

This is an unusual arrangement, rare in horology. There are some self-winding watches with ring-shaped winding weights supported at the edges, while the BHI's 150th Anniversary Clock also has its drive barrel supported by the outer edge.

The action of remontoir is described in the box 'Remontoir with Jumping Dead-Seconds' comes from Strehler's Sauterelle watch, which has a fixed escapement, although the operating principle is identical. In the Sauterelle watch, however, the remontoir spring acts on the fourth wheel of the watch, whereas in the Trans-Axial watch, the remontoir spring acts on a post affixed to the tourbillon carriage – the spring therefore pulls the carriage round directly. This means that the tourbillon needs no driving pinion.

Jumping Dead-Seconds

One of Strehler's signature features is jumping dead-seconds. His first watch with this feature was the Sauterelle (French for grasshopper). In that watch, the jumping seconds hand was attached directly to the remontoir arbor. This differs from the Trans-Axial watch, whose seconds hand is indirectly driven, described later.

In the Trans-Axial watch, the remontoir has been moved to the underside of the movement. In order to bring his signature jumping dead-seconds to the dial side, there is a pinion planted to one side of the large gilt third wheel that dominates the rear of the movement. The pinion has the same number of leaves as the remontoir driven pinion, thereby receiving the same once-per-second motion as the remontoir itself.

However, we all know that indirect seconds are prone to quaver because there is no permanent torque applied to the pinion. In between steps, the pinion can float within the constraints of its backlash. In the case of the Trans-Axial watch, this has been overcome with a truly elegant arrangement, namely a saw-tooth wheel. This is mounted to the pinion, and has a ruby pallet acting in the tooth spaces, performing service as a brake and a back-stop. This creates a very positive jumping dead-seconds action.

Bringing the seconds hand to the front of the watch in this location required the unusual step of planting the arbor through the centre of one of the barrel arbors.

The watch has a number of other technical features. For example, the twin mainspring barrels (acting in parallel) are limited by what Strehler calls the 'epicyclical mainspring limiter'. This stop work takes the form of a pinion fixed to one of the barrel arbors. It gears with an internally-toothed ring that is mounted, free to rotate, in a recess in the barrel cap. The recess is cut eccentrically with respect to the barrel arbor. The ring has one tooth space cut shorter than the rest. In winding, the pinion drives this ring round in its recess. When the low space engages with the pinion, further winding is blocked. The reverse happens as the watch runs: the barrel carries the ring around with it and eventually the short space blocks further motion, stopping the watch before it unwinds fully.

As ever, Strehler has produced a highly engaging watch, whose features are self-assuredly technical, seeking consistency of rate. At the same time, they are also accessible to those whose interest in horology is aesthetic or based on an appreciation of high craft.

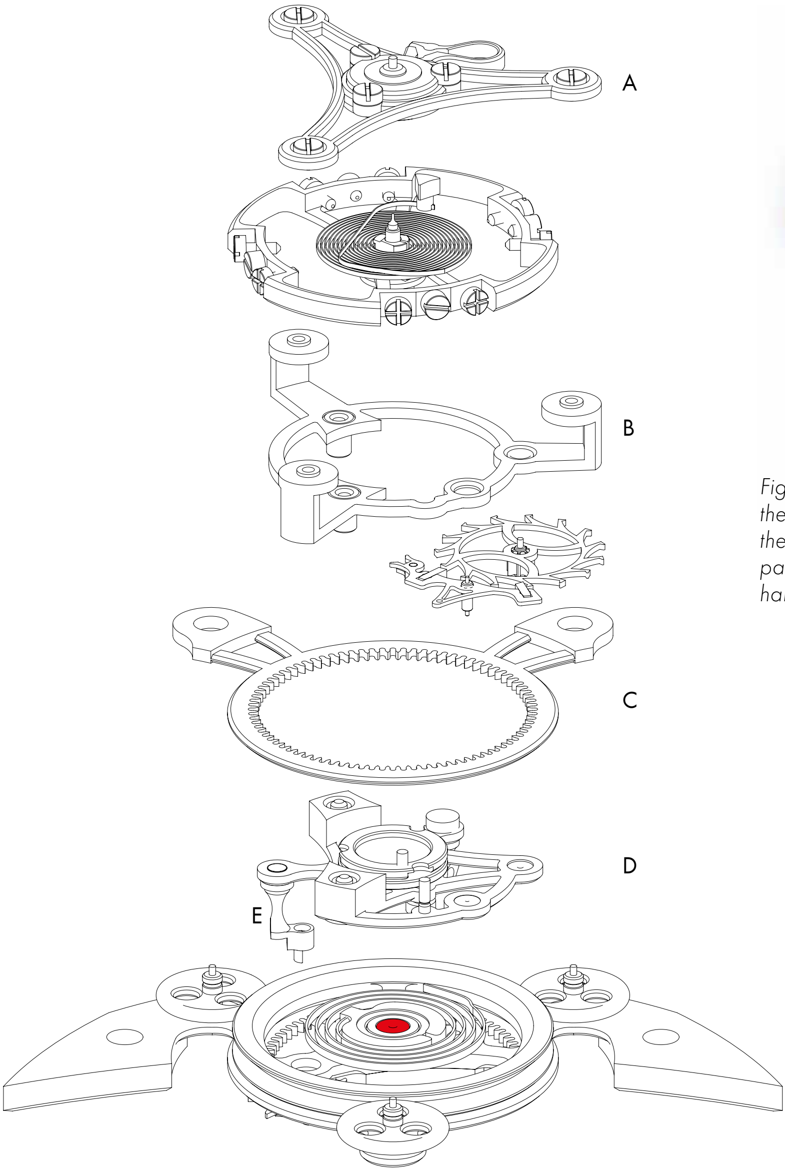


*Figure 1. In this exploded view, the tourbillon carriage comprises parts **A**, **B** and **D**. The fixed fourth wheel with internal teeth is labelled **C**.*

*Of note is the remontoir locking ruby, fixed to a post, **E**, on the underside of the carriage. It thus moves continuously with it.*

The spiral remontoir spring can be seen in the lower part of the illustration. The outer end of this spring is fixed to a part of the carriage that is hidden from view in the drawing, so that the carriage is pulled round with the spring as it winds and unwinds. This differs in layout from the Sauterelle watch. There, the inner end of the spring is fixed closest to the escapement; but there is no practical difference between one arrangement and the other.

The lower bearing, shown in red, for the carriage can be seen mounted on a boss on the remontoir wheel. Also visible are the bun-shaped bearing rollers.

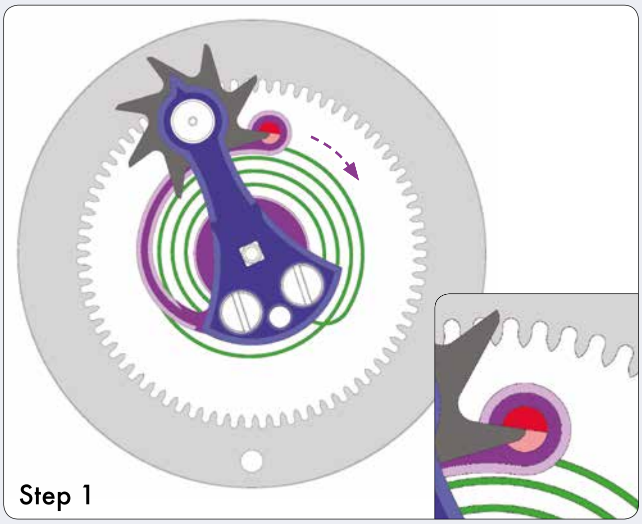
Figure 2. A view of the movement after assembly. The large gilt wheel is the watch third wheel. At left, it drives the remontoir pinion, and at right, the jumping dead-seconds saw-tooth wheel. The pinion of this wheel passes through one of the mainspring barrel arbors so that the seconds hand may be fitted to the dial side.

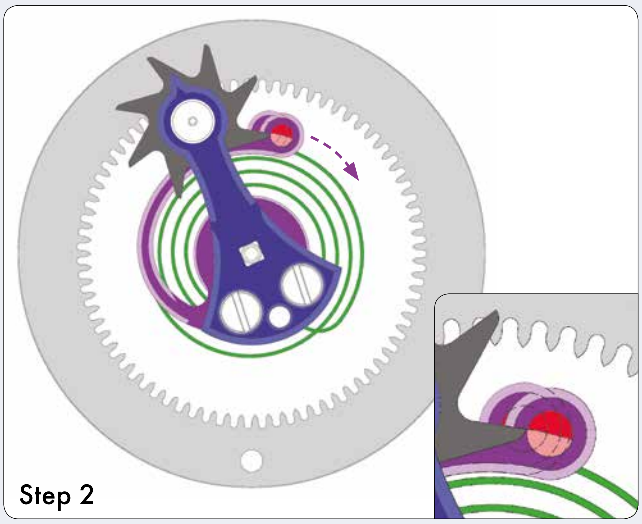
Figure 3. The remontoir arm with its pinion and star wheel. Strehler calls this the satellite. The recessed rim is so that it can be supported on bun-shaped rollers pivoted in the main plate.

Figure 4. The post that carries the remontoir locking ruby.

Remontoir with Jumping Dead-Seconds

Please note that these illustrations refer to the Sauterelle watch; the layout in this watch is less compact than the Trans-Axial, making it easier to study, although the principles are identical.





The blue remontoir arm is locked by virtue of the star wheel resting against the locking ruby. This arm is impelled clockwise by a pinion (not visible in these illustrations) at its centre, situated in line with the square. This pinion is geared with the watch third wheel.

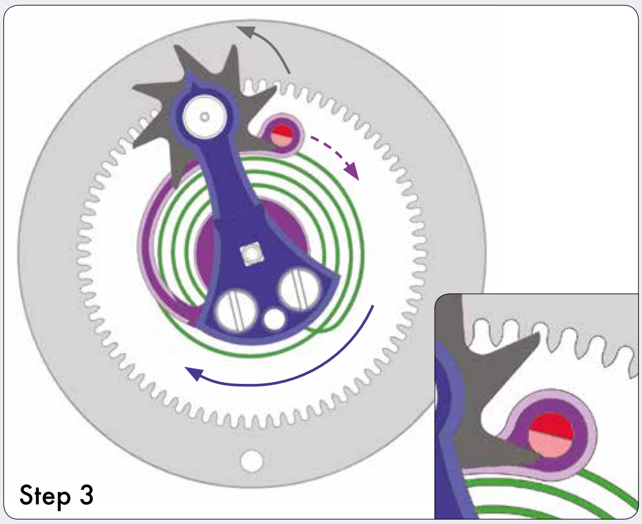
The star wheel also has a pinion fixed to its underside, geared with the internally-toothed ring.

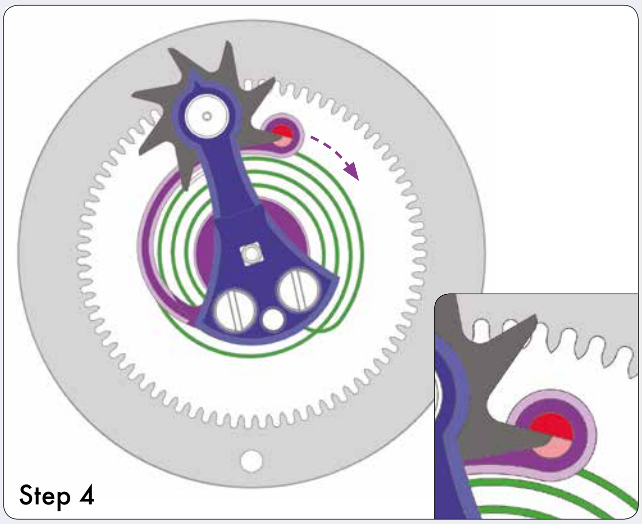
The locking ruby is fixed to the curved arm (in purple) seen to the left of the blue remontoir arm. Although it curls towards it, it is not connected to the remontoir arm; it is connected to the fourth wheel arbor which is pivoted concentrically below. The ruby moves with the fourth wheel – continuously, or as continuously as we may assume any fourth wheel to move, notwithstanding the stop-start of the escapement.

In this illustration, locking of the remontoir has just occurred.

As the watch runs, the locking ruby progresses clockwise along the locked star tooth to the position shown here, which is exactly at the point of release. In the illustrations, the ruby is drawn with its straight locking face coincident with the face of the star tooth, but in reality, the Strehler sets this stone slightly clockwise, so that the star tooth makes only point contact with the ruby. This causes the star to advance imperceptibly with every beat of the watch, but it reduces oil drag which would otherwise be unacceptably high if the faces were coincident.

Now, the remontoir has just been released, and is about to spring forward under power from the third wheel.





The remontoir arm has begun to move clockwise, while the star rolls anti-clockwise around its own pivot. The spiral remontoir spring in green has its outer end fixed to the remontoir arm, and its inner end to the fourth wheel arbor. The remontoir now winds up the spring. This spring is the only thing that powers the escapement, there being no other connection between it and the wheel train.

The remontoir is once again arrested by the ruby; it has advanced six degrees, winding up the spring by the same amount. This process repeats itself until the mainspring torque drops so low that it can no longer wind the remontoir spring. Without a remontoir, the big difference in torque between the fully-wound mainspring and unwound will be directly felt by the escapement. With this remontoir, the only variable effect that can be exerted by the mainspring is the pressure of the star tooth on the locking ruby.

Portescap Constant Force Escapement

The Strehler remontoir is based on the constant-force escapement built in the late 1960s by the Swiss company Portescap. Portescap designed and made a number of very useful horological devices including other types of constant-force escapement, escapement shock-settings, and electronic watch-testing equipment. Today they are noted for their small-size high-precision high-torque electric motors, used in avionics and robotics.

The Portescap design places the constant force element directly on the escape wheel, re-charging the remontoir at every beat of the watch. The beauty of this design is that the remontoir is only re-charged during the run to banking, after impulse has been completed, the impulse is therefore never affected.

One of the most perfect escapement remontoirs is that devised by the Swiss watchmaker Xavier Theurillat. A beautiful example of this was built into a carriage clock by his son in-law, the British watchmaker and Gaïa laureate, Anthony Randall FBHI. The pair to this clock, by the same maker, incidentally has the world's first multi-axis tourbillon, a double-axis tourbillon which he patented in 1978. Both clocks were part of the collection of Seth Atwood's Time Museum.

A later development of this was the triple-axis tourbillon, which Richard Good FBHI and his son, Timothy, built into a carriage clock. For this clock, he used a portescap constant-force escapement.

In a classical tourbillon, the force applied at the drive wheel needs to be much greater than at the equivalent point in a normal watch, due to the requirement of extra energy needed to overcome the inertia of the tourbillon itself, including the mass of the balance and escapement. When the escapement locks, the lever bankings take the full shock of this extra energy at every beat, adding great strain to the system.

In the Portescap device, the shock of excess energy is taken up by the remontoir locking ruby striking the star wheel tooth, thus relieving the escapement of this duty. The escape wheel, pallets and bankings never need to dissipate much more energy than any normal watch, as supplied by the remontoir spring. This can be adjusted to maintain the balance at a desired amplitude.

Good believed he would not have been able to get his clock to run were it not for this feature of the Portescap escapment, because the triple-axis tourbillon had vastly more inertia than any escapement to date.[1]

Strehler has moved the device upstream by one wheel. In doing so, he increases the size of the device somewhat, which he indicated makes for better serviceability, and affords an automatic jumping dead-seconds indication. He told me that the remontoir locking still happens mostly during the run to banking, although not as cleanly at a low state of wind.

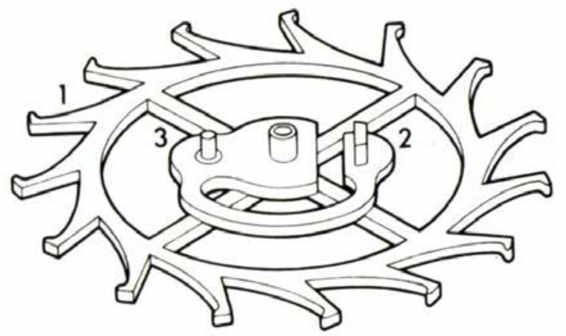


Figure 5. The Portescap escape wheel. The wheel, 1, runs freely on its arbor. The remontoir locking ruby is at 2, and a further cylindrical jewel, 3, takes the pressure of the remontoir spring (S, in Figure 7).

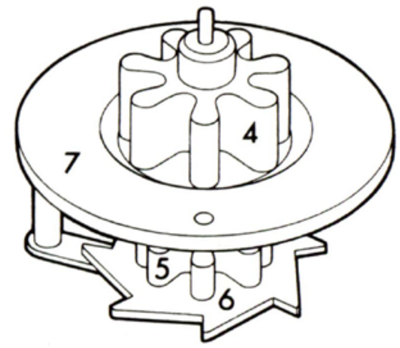


Figure 6. The escape pinion assembly, shown from the underside. The pinion itself is shown at 4. This is driven by the fourth wheel in the usual way. At 5 and 6 are the remontoir pinion (gearing with an internally-toothed wheel, not shown here), and the remontoir star wheel. The ring is marked as 7.

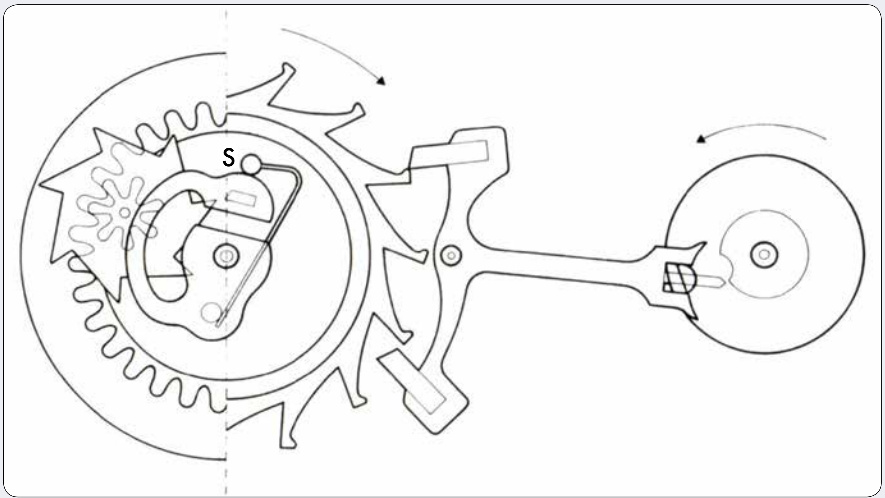


Figure 7. The device assembled. In the position shown, impulse has just been delivered; the locking ruby has dropped off the remontoir star tooth, allowing it to run freely. The fixed end of the remontoir spring S is part of the assembly, and so also moves clockwise. In so doing, the free end is cocked by virtue of it bearing against the cylindrical ruby fixed to the escape wheel. When the following star tooth is arrested by the locking jewel, the device comes to rest, with the spring pre-loaded to deliver the next impulse.

ENDNOTE

1. Richard Good, 'The First Triple-Tourbillon', *The Horological Journal*, vol. 125, (April 1983), pp15–19.
Figures 5, 6 and 7: drawings by David Penney, published in *The Horological Journal*, op. cit.

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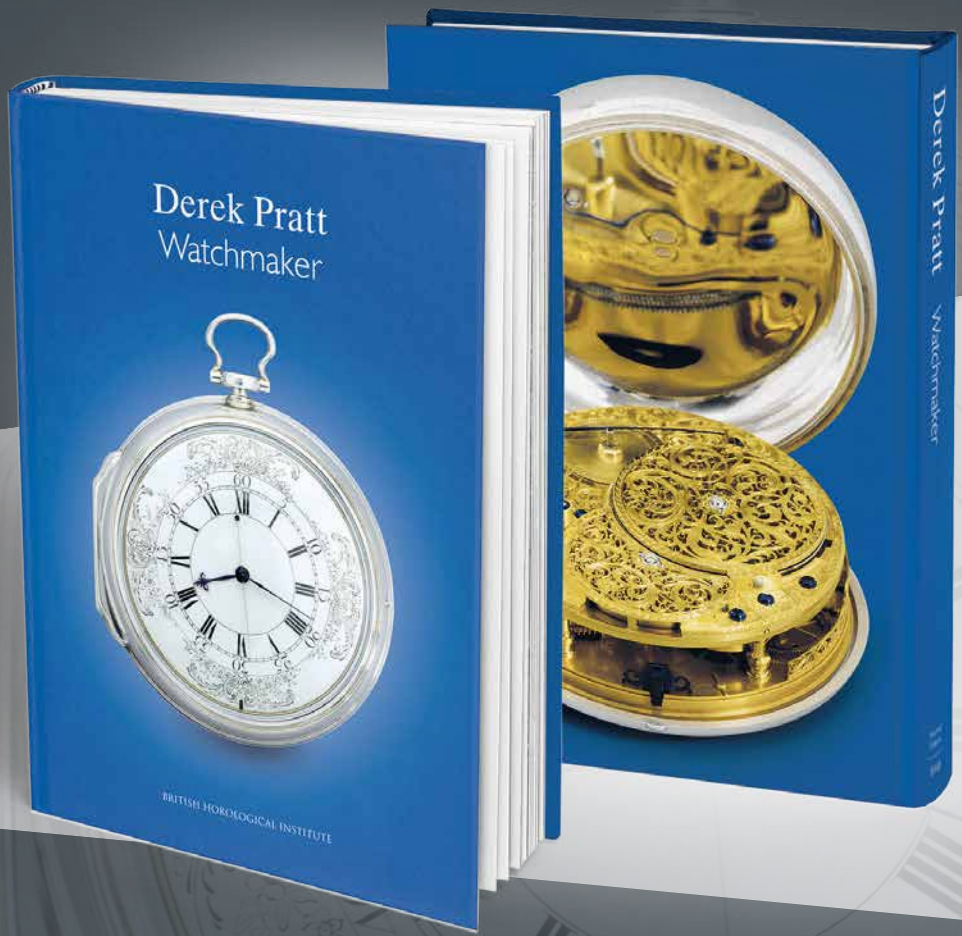

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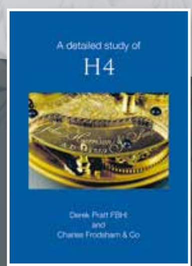

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