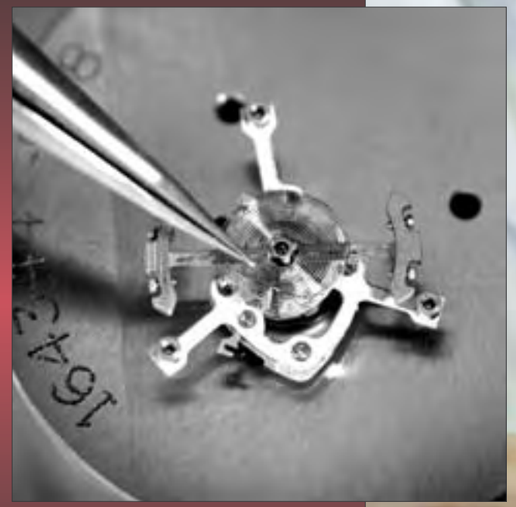
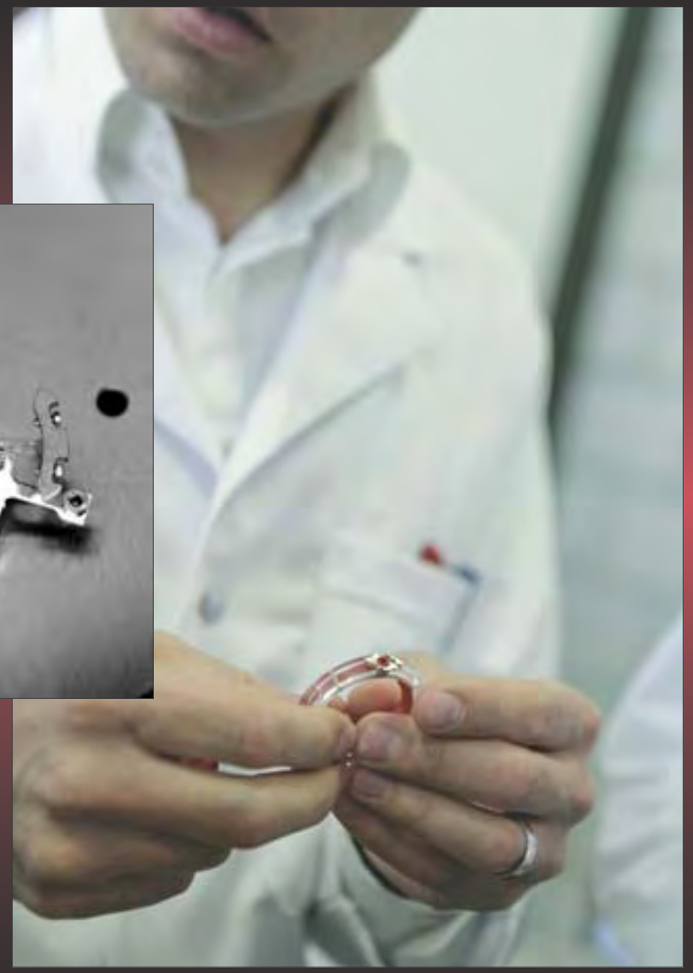
Service Not Included

The Master Compressor Tourbillon Extreme Lab (€200,000) is packed with new high-tech alloys and ceramics as well as a unique H-shaped balance in a magnesium tourbillon carriage. Like the Master Tourbillon its layout is based on, the date display leaps over the tourbillon from 15 to 16. The grey disc in the centre of the tourbillon bridge is made of Easium, a novel ceramic that replaces the sapphire normally used in watch bearings – one of the main reasons why this watch requires no lubrication.

The day before Baselworld opened this year, Jaeger-LeCoultre audaciously sought to steal the show with the press launch of the Master Compressor 'Extreme Lab' tourbillon. A cocktail of exotic materials and the even-more exotic techniques required to use them, the Lab was the answer to a simple brief: "Create a watch that requires no lubricant, oils or grease, that will require no servicing." Nothing less than the grail of watchmakers. With every element of the movement looked at afresh, to say that the Lab is simply a €200,000 tourbillon is not even to introduce the watch. But where the real interest lies is how its innumerable innovations will trickle into Jaeger's oeuvre over the forthcoming years. *QP* dons its lab coat.

Timothy Treffry





(Above) The H-shaped balance is made from platinum iridium, one of the densest materials known. The shape is optimised aerodynamically (less 'skin friction') and the inertia:mass ratio, aided by openworked arms, makes it a better oscillator. Note the gold timing screws; this is a 'free-sprung' balance.

(Right) A J-LC boffin demonstrates calibre 988C's suspension mounting – a supple, red polyurethane material. The calibre and winding stem are 'free floating', and the whole assembly is rigid yet mobile, absorbing adverse shocks and protecting the movement within.

The truncated, H-shaped balance will excite genuine controversy among watchmakers.

If it meets the claims made for it, the Jaeger-LeCoultre Master Control Extreme Lab is the most remarkable mechanical watch ever made. The Achilles heel of the mechanical watch has always been its need for lubrication, especially at the escapement. Oils deteriorate in four or five years, hardening into a varnish. The movement then needs dismantling, cleaning and re-lubricating. The great French horologist, Breguet, once famously said: "Give me the perfect oil and I will give you the perfect watch." The calibre 988C movement used in the Extreme Lab provides another way of achieving perfection: it has no conventional lubricants. It should never need servicing unless physically damaged or something wears out. It is even said to function perfectly over a temperature range of –40 to +60°C, which is more than can be said for any likely wearer. This approaches the specification of mechanisms used in the aerospace industry.

All change

A major feature of the 988C is the amount of up-to-the-minute, new technology it contains (see box overleaf). For most of the last century, the Swiss mechanical watch industry has been entirely introverted and, with the exception of special alloys introduced to springs and balances several decades ago, has generally stuck with brass and steel. Not until the late 1990s, when Omega adopted the Daniels Co-Axial escapement and Ulysse Nardin produced the Freak with silicon escape wheels, did any maker step beyond its comfort zone and attempt to make a better watch. Companies largely remained content to produce miniaturised adaptations of 19th-century technology or rely on celebrity endorsements and lifestyle associations to shift the merchandise.

Now a new generation of designers and engineers at Jaeger-LeCoultre has suddenly been prepared to take a look at appropriate technical developments in the outside world, producing a watch in which almost every part is different from those in current production. Although the Extreme Lab is a concept watch, costing, as a limited edition tourbillon, €200,000 when it is available in 2009, the company says that most of the technology used will soon spread across its range of movements throughout the next five years.

The use of non-traditional materials starts with the case. The bezel is silicon carbon nitride, a particularly tough and light ceramic, and the remainder is a titanium and carbon-fibre sandwich. The crown is red anodised aluminium and the main bridge on the top half of the dial is black. The tourbillon bridge is an aluminium-titanium carbide composite with the lightness of aluminium and the hardness of steel. Furthermore, the tourbillon carriage itself is pure magnesium, which is just 40% the weight of steel. Rather than being rigidly attached within the case, the whole movement is supported on a ring of resilient polyurethane material.

One major contributor to the freedom from lubrication enjoyed by the 988C movement is the grey disc seen in the centre of the tourbillon bridge. This is made of Easium, a novel carbon nitride ceramic (see box overleaf) that replaces the normal sapphire used for bearings and end-stones. If you judge a watch by the number of 'jewels', this one will disappoint – jewels are yesterday's news.

Balancing act

Working back through the movement, we now get to the balance. This is very unusual indeed and will excite genuine controversy among watchmakers: it is a

(Anticlockwise from top) Magnesium after 'decolletage', the milled magnesium alloy block, and the final tourbillon carriage before assembly. The alloy is two-and-a-half times lighter than titanium, and reduces energy loss due to friction and thus further improves the exceptional efficiency of the regulator.

New Technology

The historic ceramics formed by heating clay to make pottery have been known for thousands of years. They are made from aluminium, magnesium and potassium silicates and are hard, brittle and porous, with a crystalline matrix. In the 1950s, when the chemical structure of classical ceramics was better understood, materials scientists began to study the possibility of making special-purpose ceramics based on other elements in the periodic table. They were particularly needed for high-temperature environments in jet engines.

Easium is a trade name for a novel ceramic, carbon nitride, made by a specialist manufacturer, Easyl SA, in France but on the outskirts of Geneva. Its pure form, C_3N_4, carbon nitride, seems to combine the virtues of carbides and nitrides and is, theoretically, harder than diamond; the only problem is that it has only ever been made in thin films. Although Easium is some sort of carbon nitride, its exact formulation remains a commercial secret. It is made by subjecting a mixture of very fine powders to heat (800°C) and pressure. Under these conditions atoms can rearrange themselves and form crystals, just as they can in the more familiar liquid chemistry taught in schools. One of the initial powders is titanium nitride. This is of interest as titanium nitride is known to act as catalyst for the formation of carbon nitride crystals. Easium, the final product, does not contain titanium; what happens to it, or what the source of the carbon is, is not revealed. The material produced is described as being 'an alternative to diamond' and is used in industry for wire-drawing dies and straightening rollers. It has a low friction co-efficient and a low wear rate. It can be machined with diamond tools and is readily shaped by spark erosion. Interestingly it is also micro-porous. We are not told if the Easium used as the Extreme Lab's 'jewels' is impregnated with any slippery substance, but perhaps this porosity simply reduces the contact between pivot and bearing.

Polycrystalline diamond is a synthetic diamond that can be made in large sheets by chemical vapour deposition (CVD). It is used in electronics as a heat sink because diamond has the highest thermal conductivity known. It is useful for the small scalpel blades used in microsurgery. It is also the hardest material available, and a perfect candidate for the Extreme Lab's escapement pallets.

Molybdenum sulphide is applied to the watch pinions by sputtering in a magnetron; the same thing found in a microwave oven but much more powerful. The frictional co-efficient of the resulting surface is almost too low to measure by conventional means.

Nickel-PTFE is plated on a clean, metal surface by an electrochemical ('Electroless') process. The nickel bonds micro-spheres of PTFE to the surface to produce a particularly wear-resistant coating for the Extreme Lab's winding wheels.

truncated 'H' rather than the usual ring. Careful research by Jaeger-LeCoultre has shown that this shape has better aerodynamic properties and an inertia:mass ratio that makes it a better oscillator. It is made of platinum iridium, the densest non-toxic material available, providing maximum weight for minimum surface area. Practical measurements comparing the traditional circular balance to a balance of the new shape with the same inertia, spring, staff, lubrication and bearings, indicate that the quality factor of the new shape is twice as good as that of the traditional balance. This means that when both are set swinging at the same amplitude, the new shape will make twice as many oscillations before its amplitude drops to half its initial value. The results indicate that the surface area, or 'skin friction', is the major factor in balance performance (other things being equal).

Elsewhere in the escapement, the pallet stones are black polycrystalline diamond rather than the usual red sapphire, and the escape wheel is made of silicon – again, this diamond/silicon combination requires no lubrication. All of the pivots in the wheel train are coated with molybdenum disulphide – a substance known for many years to be found in greases. Here however there is no grease; the MoS_2 is permanently bonded to the steel and produces a virtually frictionless interface with the Easium.

When we come to the mainspring barrel, things are a bit old fashioned. Its interior is charged with that well-known dry lubricant, graphite (the 'lead' in your pencil). But the high-tech story isn't quite over. The teeth of the winding wheels are coated with nickel-PTFE (see box), the winding rotor is mounted on ceramic ball bearings, and its carbon-fibre arms support a platinum iridium weight – the same material used for the balance, which gives a certain symmetry to the story.

In a single blow, Jaeger-LeCoultre has distinguished itself as a watchmaker with the potential to offer so much more than just nice watches. To achieve this in the same year as the ingenious Duometre chronograph – subject of *QP's* next 'Technology' installment – is no less than incredible.

Most of the technology used in the Extreme Lab will spread across Jaeger's range of movements in the next five years.

(Right) The rear view of the Extreme Lab shows the platinum-iridium winding weight, which is supported on carbon-fibre arms. The central bearing has ceramic balls. Note the unusual case screws limiting access to authorised repairers.

Further information: Jaeger-LeCoultre UK, Tel: 0800 587 3420, www.jaeger-lecoultre.com