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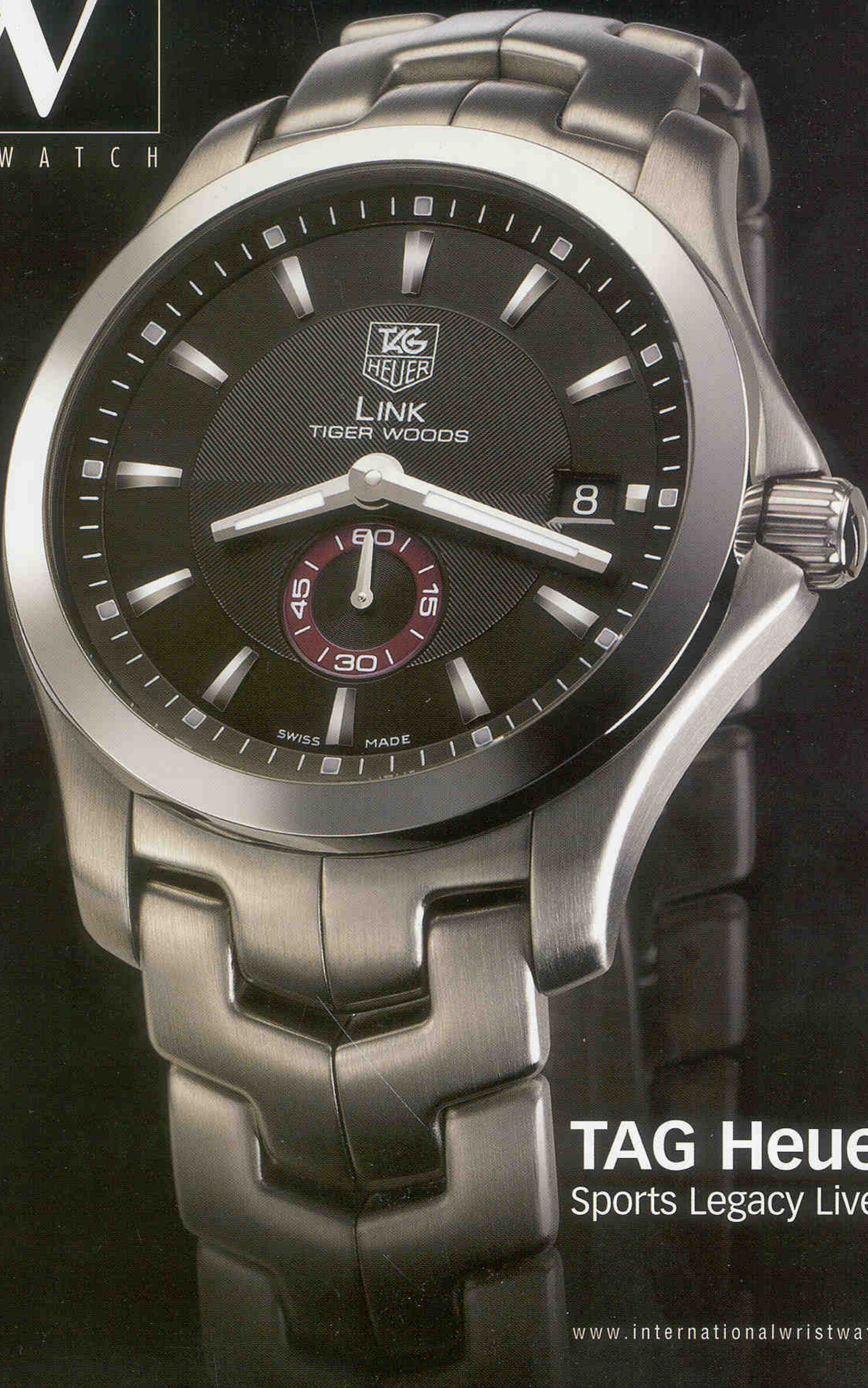

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World's Most Complicated Watch

The final segment on Paul Gerber's work of art

BY MAGNUM BOSSE AND JOHN DAVIS

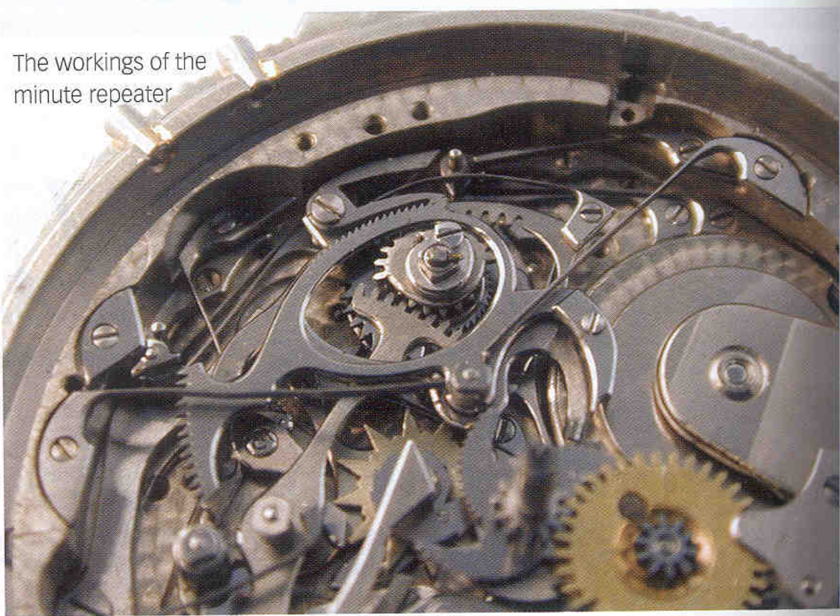
Journey with us into the mechanical marvels inside the movement of the world's most complicated wristwatch.

With such an array of complications to discuss, I've decided to follow the history of the watch and present the complications in their historical order. To that end, we must first discuss briefly the grande et petite sonnerie and minute repeater. I won't attempt to discuss its mechanism in detail, as such a dissertation could fill volumes (if I was qualified to write such a thing). In addition, the design of the original mechanism is so classical as to have already been discussed in several volumes at least already, this example is distinguished largely by its diminutive size and exemplary execution. Instead, I'll simply offer an overview of what the mechanism does.

The Sonnerie and Repeater

One of the most challenging and certainly the most complex classical grand complications, the grande et petite sonnerie and minute repeater is an extremely exotic animal. Even

today, there are only a handful of examples of this grandest of complications and their numbers diminish exponentially as their size decreases. For Philippe Dufour to make a grande et petite sonnerie and minute repeater in a wristwatch size in the late twentieth century is a major accomplishment. For Louis-Elysee Piguet to do so in a similar



The workings of the minute repeater

The perpetual calendar mechanism

size 100 years earlier is nothing short of mind-boggling.

A sonnerie is a watch that strikes the time in passing, much like a grandfather clock. In "grande strike" position it will strike the number of hours on a single gong at the turn of the hour, and at the passing of each quarter hour it will strike the hours with single chimes and the quarters with double chimes (on two different gongs). In "petite strike" position, the hours will be struck on the hour and the quarters only as they pass. For occasions when such music coming from your wrist might not be appropriate, it is equipped with a silent position as well.

To realize a complete array of passing strike options like this in a clock the size of a small closet and powered by the falling of large weights requires some ingenuity and engineering prowess, but to do so in a mechanism small enough to be worn on the wrist borders on the incredible. Sharing all the complexity of a minute repeater and then some, it is no wonder that most grande sonneries are also minute repeaters.

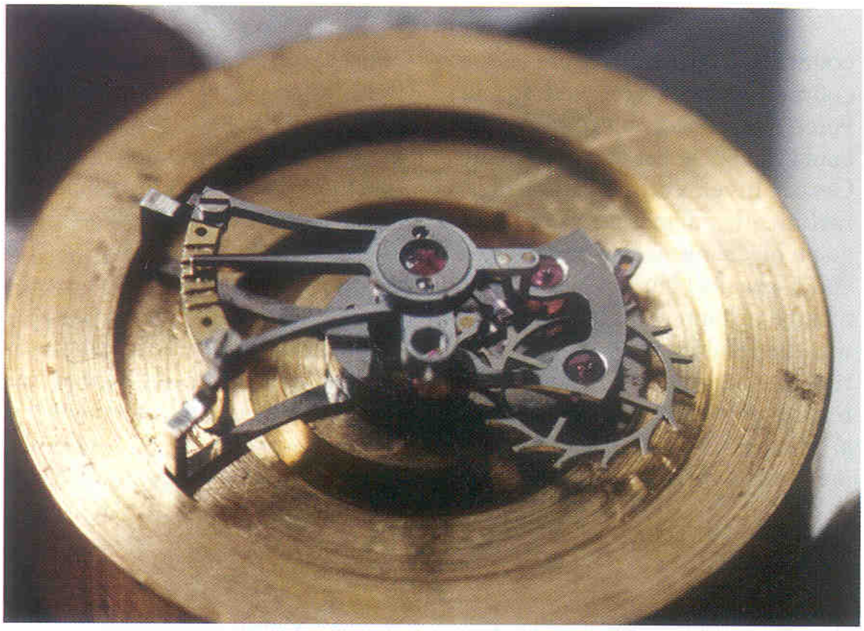
The Perpetual Calendar/ Thermometer

The perpetual calendar has become a standard in the world of complicated watches, but perpetually has its charm as a mechanism that knows a little bit about the future. It "knows" how the date indications will be set in, say, ninety-seven years (needing the adjustment of a single corrector in the year 2100!).

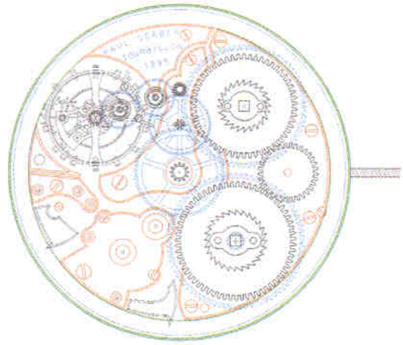
Franck Muller, at the very beginning of his impressive and successful career, added the perpetual calendar together with a thermometer. As far as can be judged from pictures, the perpetual calendar plate is of excellent execution and classic design as would seem most appropriate to add to such a traditional movement. The notable exception is the retrograde month indication, forecasting the multitude of retrograde indicators that Franck Muller has become known for in recent years.

The Tourbillon

The first item on Paul Gerber's agenda was the construction of the flying tourbillon. One can hardly believe that not only is this Gerber's first tourbillon, it is also the world's smallest flying tourbillon. A special challenge here was that both the original balance and hairspring of the Piguet movement should be used in the tourbillon. These constraints necessitated the "flying" mounting of the tourbillon cage. To place the regulator as close as possible to the balance axis, Gerber made a new hairspring with Breguet over coil and Phillips terminal curve (no. 57.5 according to the Phillips classification). He also implemented a new escapement with lateral pallet. That this construction is also more sophisticated, more difficult to assemble and a more visually appealing construction are merely welcome side effects.



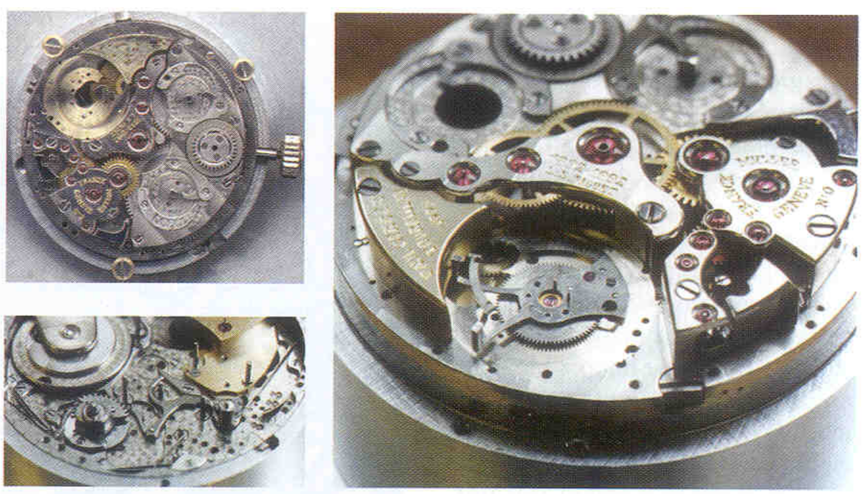
The tourbillon carriage



Computer drawing of the tourbillon

To place the tourbillon in the movement, the cocks for the balance and escape wheel and the bridge for the pallet lever had to be removed and extra space for the tourbillon cage and its intermediate wheels had to be milled into the movement's base plate. It bears repeating that the pressure on Gerber at this stage, where irreversible alterations are made to the main plate of the movement, was immense. To account for the increased need of power for the tourbillon, two further modifications had to be applied: a stronger mainspring (which is shorter and has a thicker blade strength to optimally use the barrel space—1/3 barrel, 1/3 barrel core, 1/3 free); and two additional jewel bearings had to be inserted with the help of an additional tourbillon bridge on the dial side of the movement that also supports the mainspring barrel.

The tourbillon itself is of classic flying construction. In the first implementation, it was fitted with ruby bearings for the balance axle. Ever the perfectionist, Gerber decided to change to a diamond cap jewel: A simple modification one might think, but that was not the case. The tourbillon top bridge had to be made a second time completely from scratch to take into account the now increased diameter of the diamond end stone: 1mm instead of 0.7mm of the ruby stone. Consequence: the two screws that fix the cap jewel plate had to move outward. That means the cap jewel plate as well as the entire top tourbillon bridge had to be redone.



Modifications made to the main plate to fit the tourbillon

The Chronograph

The construction of a new chronograph mechanism is quite a technical feat that very few *manufactures* undertake. The broad use of the handful of commonly available chronograph calibers is ample evidence of this. A split-seconds chronograph is particularly challenging, many times more difficult than a simple chronograph even, because of the incredible tolerances that must be realized to keep from putting a critical strain on the movement when the chronograph is engaged and especially when the split-seconds mechanism is activated. The fine adjustment necessary and infinitesimal loads that must be balanced against each other make a rattrapante possibly the most challenging complication to properly setup and adjust.

In this special case, the mountain of difficulties was two or three times higher than usual: An incredibly complicated movement, a unique piece, should be upgraded with a split-seconds flyback chronograph, operated by a column wheel, of course. Challenging even more so because the gongs of the sonnerie and repeater were in the way of the chronograph pushers.

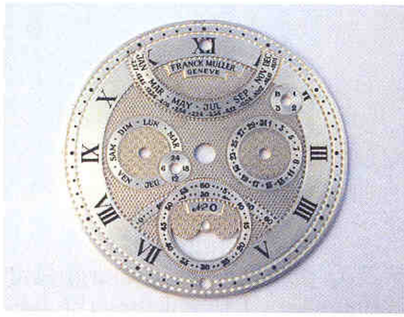
The existing beautiful dial should be used, which fixes the placement of the chronograph hands. Last but not least the movement should not gain much height, since that would make the use of the platinum case impossible. Is it any wonder this challenge kept a master watchmaker working for eight years?

Since the movement was not intended to be fitted with a time-counting mechanism, there was of course no space reserved for it. Forced to use every bit of space that could hold a wheel or a lever, Paul Gerber invented one of the most technically demanding chronograph mechanisms ever seen. In the end, a classical but uniquely implemented column wheel chronograph was the result of years of construction, testing, modification, further testing and finally approval. Several characteristics of this astounding mechanism should be covered more in detail.

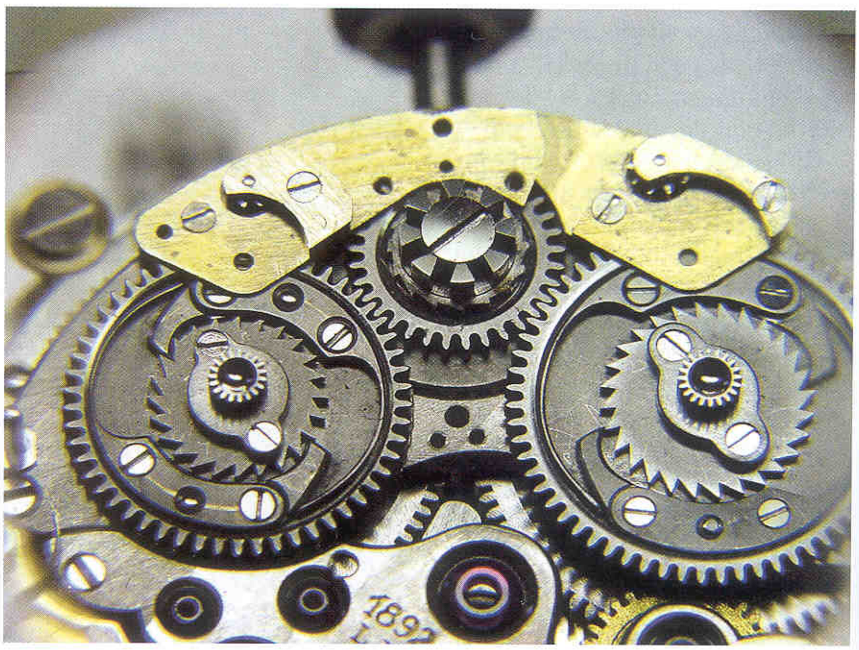
The Control Mechanism

It is not surprising that Gerber chose to employ a column wheel for the chronograph controls. The column wheel has a lower portion with sixteen ratchet teeth and an upper portion with half as many columns. The ratchet teeth are advanced one tooth at a time by an operating lever and held in place by a jumper. As the column wheel rotates, the ends of the levers for the coupling lever and the brake alternately fall on a space or are lifted by the columns.

One of the remarkable things about this implementation is the exotic shape required of the coupling lever for it to weave its way through the rest of the mechanism. In order to accommodate the power reserve mechanism, the end of the



Above: The existing dial
Below: Column wheel



coupling lever became increasingly thin and curvy until its final form was realized.

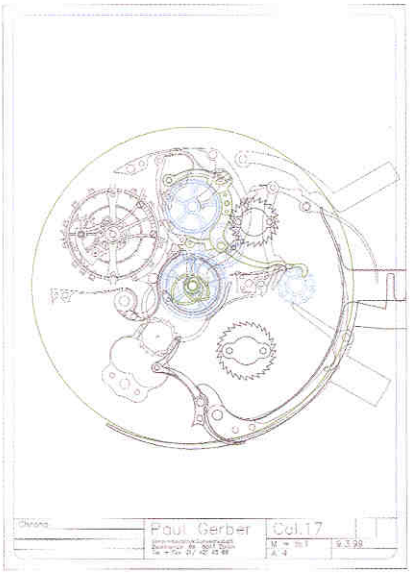
Here is a description of some of the many details of this highly complicated lever:

- This slot serves two purposes during the resetting procedure: First, it moves the coupling lever out of the power train during resetting (via reset lever); second, it also moves the click of the chronograph minute wheel (this click ensures proper positioning of the minute wheel).
- In this hole the operating lever for the jumping minute counter is mounted and coupled in and out of the power train.
- This small indentation helps to control the depth of the allowed movement of the coupling lever. It is adjusted by an eccentric screw mounted on the movement plate.
- Here the jewel for the intermediate wheel is fixed.
- Bow, necessary to guide coupling lever around blocking lever.
- Beak that interacts with the column wheel through which the lever is operated.

The Jumping Minute Counter

As mentioned before, the existing case should be kept. This means that the additional chronograph should not "overegg the pudding" too much. One measure to minimize the need for space and fitting points was the use of a jumping minute counter, which by the way counts a full hour instead of being limited to thirty or forty-five minutes.

Since such a construction utilizes levers to transport the motion of the center seconds counter to the minute counter, Gerber was more flexible with the placement of the axes. Additionally, less energy is needed.



Computer drawing of the chronograph mechanism

The chronograph minute indication is located concentrically to the continuous small seconds at 6 o'clock. That means that the counted time is transported from the drive wheel on the seconds arbor of the base movement via the intermediate (coupling) wheel to the chronograph wheel (in the center). From here, the impulses for the elapsed minutes are passed back to the chronograph minute wheel, via a snail mounted on the arbor of the chronograph center wheel. This is a more complicated, technically challenging and elegant solution than the common semi-instantaneous minute counter, where a finger on the chronograph wheel flicks an intermediate minute counter wheel once per minute.

The jumping minutes counter principle is similar to a retrograde seconds mechanism—to some degree: A lever gauges the snail fixed on the chronograph center wheel. After fifty-nine seconds it falls back to the zero position, thereby using this energy to transport the chronograph minute wheel one unit forward (read: one minute indication). Such a jumping construction demonstrates a charming perfectionism: technically not necessary, but aesthetically a *ne plus ultra*, especially if viewed from the movement side.

The Reset Mechanism

Everyone can imagine that a chronograph is only useful if it can be reset to zero. This was not possible with the first pocket watch chronographs. Finally, when the watchmaker Adolphe Nicolet invented the heart cam in 1884, a chronograph could be reset to zero after timing an interval without waiting for the chronograph counters to arrive back on zero.

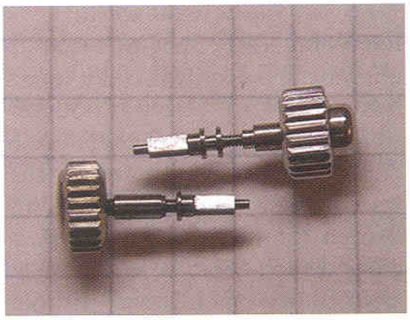
This is achieved with the use of a reset lever with flat, hammer surfaces pressing against the heart-shaped discs that are fixed on the chronograph counters' arbors (each arbor of the chronograph—seconds, minutes and hours—needs a heart cam to reset to zero). The reset hammers press against the edge of the heart cams (in whatever orientation they have stopped), causing them to rotate until the hammer is resting against the flat portion of the cam and the counters are reset. A simple principle, but there is again our old challenge: no space. As you have probably already guessed, Paul Gerber found a way.

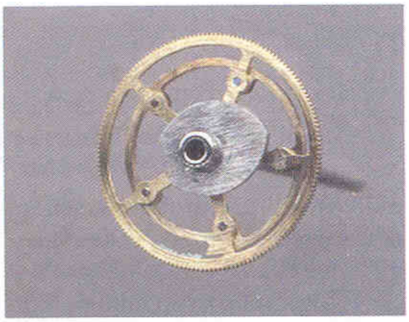
The Split-Seconds Mechanism

Never satisfied with "good enough," Lord Arran (the owner of the watch) wanted to have a rattrapante or split-seconds chronograph mechanism installed. Gerber embraced the challenge as an impassioned watchmaker and as a perfectionist. The result, like the other complications, is a beauty in its own right. As a matter of course, this mechanism also looks like it belonged there from the beginning.

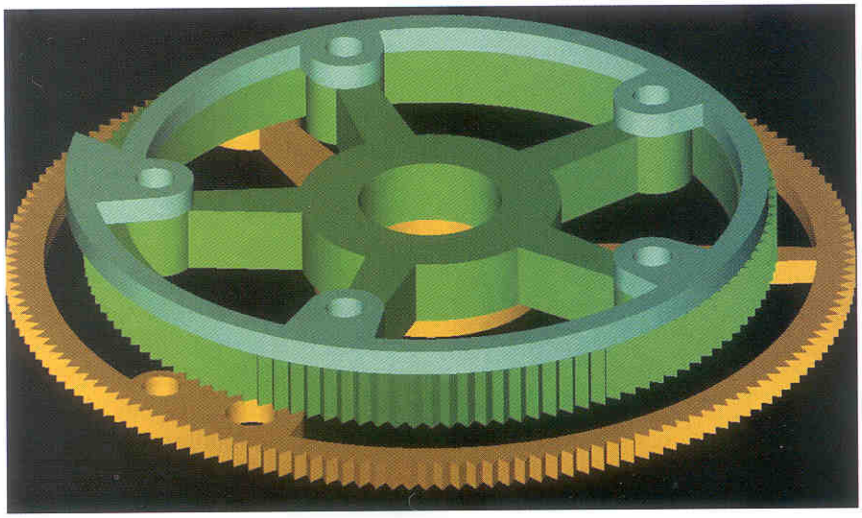
Operated by a pusher mounted coaxially in the crown and controlled by an octogonal rim wheel, the delicate, pincer-like, split-seconds brake levers gently clamp the split-seconds wheel and stop it. A second push of the split-seconds button moves the rim wheel another step, the brake levers release the split-seconds wheel, and it "catches up" with the chronograph wheel. The catching up action occurs because of the tiny split-seconds lever, mounted on the split-seconds wheel, which presses against an auxiliary heart cam mounted on the chronograph wheel arbor. The tension of this lever must be very precisely adjusted so that the split-seconds wheel catches up properly without placing an undue strain on the mechanism while the chronograph is running and the split-seconds wheel is stopped.

One of the main challenges in the construction of the split-seconds mechanism (in addition to the slender column/rim wheel) was to get the operating lever to connect the pusher in the crown to the rim wheel (around the gongs). Gerber also mastered this problem. "Of course," one is tempted to say.





Above Left: Crown, old and new, to accommodate split-seconds button
Above Right: Chronograph/split-seconds runner
Bottom: A 3D-view of the chronograph/split-seconds runner



Square Peg in Round Hole

How could Paul Gerber get all these magical works into the movement?

The implementation of the chronograph mechanism caused some changes to the existing movement. Two changes should be highlighted here. One is a problem of thickness. The additional arbors for the chronograph wheel and split-seconds wheel had to find their way through the central axis of the movement, and the jumping minute counter arbor likewise had to find its way through the seconds wheel pinion. Because of this, new larger pinions were necessary and consequently, new jewels with larger holes.

Gerber found himself confronted with replacing excellently executed vintage jewels with modern ones, so shaping and polishing a jewel practically from scratch was the best solution. The bearing surfaces of the jewels are slightly domed and the insides of the holes in the jewels are curved. These "olive" jewels have two major aims: to minimize the friction between pivot and jewel, and to assure that the parsimoniously applied drop of oil will be held in place.

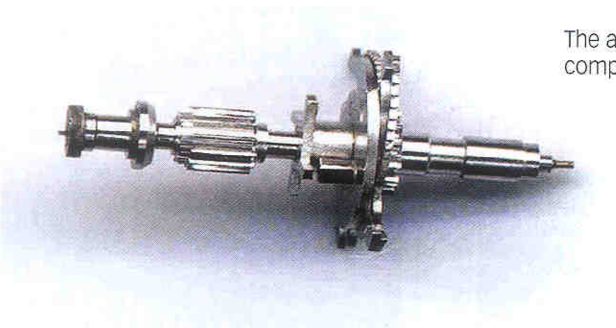
The next step was the construction of a new center wheel pinion that could allow the passage of the two new chronograph arbors (for the chronograph and split-seconds wheels). This turned out to be one of the most challenging parts to manufacture since incredibly small tolerances had to be handled with utmost precision.

In a simple watch, this central axis already bears the center wheel, center wheel pinion, the cannon pinion (and minute hand), the hour wheel (and hour hand) and sometimes the seconds pinion (and second hand). In the case of a striking watch, the center axis also has to carry the respective control discs for the striking mechanism. In the end, the final center wheel pinion is a work of art in its own right. It consists altogether of eight parts: the split-seconds arbor, the chronograph wheel arbor, the center wheel pinion and the cannon pinion, which carries the quarter snail, minute snail and surprise piece, and the four-lobed trigger star for the sonnerie. Put together, this complicated piece looks a bit like something out of an automobile engine.

The chronograph wheel arbor and the split-seconds arbor are exercises in precision machining. Less than 0.5mm had to be drilled out of the chronograph arbor. One can imagine how many attempts Gerber had to make to drill a precise hole in the chronograph arbor. In addition to the center wheel pinion, the pinions for the seconds wheel and minute counter had to be made from scratch. A much easier task, but nevertheless it had to be done—several times.

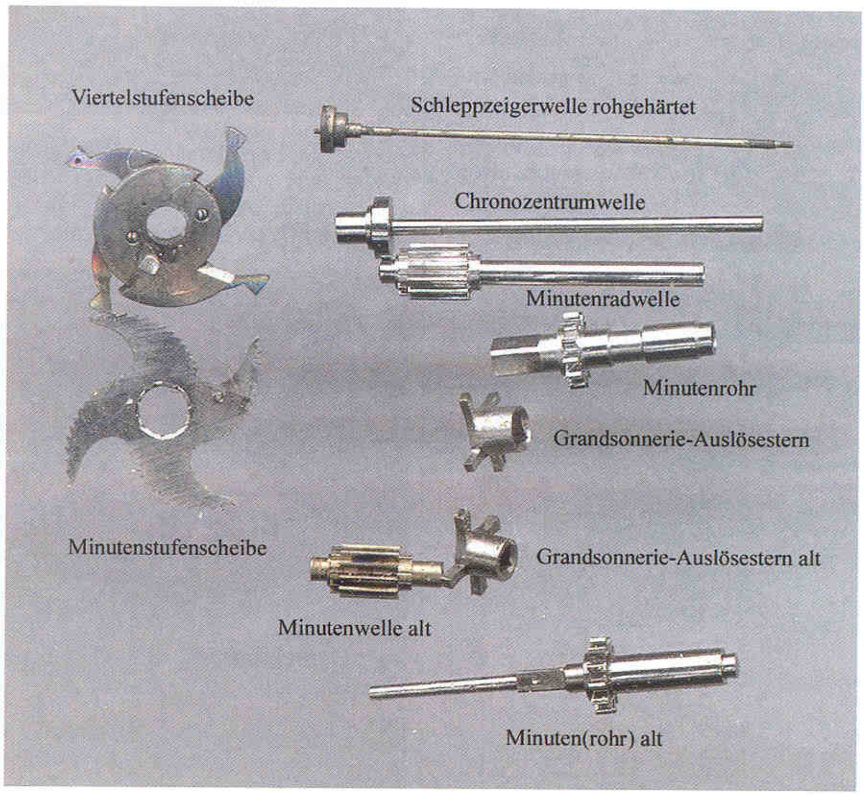
The Power Reserve

Lord Arran also wanted to have an indication for the power reserve of both the timekeeping train and the striking mechanism. Gerber fulfilled



The assembled component

The various parts with their German names



this desire by placing these indications around the column wheel of the chronograph.

The power reserve is a little complex in that it gets information from the barrel and the ratchet wheel with two differential gears (for each barrel). This made it nesessary to add a pinion to each barrel to drive the differential gears.

As you can see in the CAD drawing, the bridge for the power reserve had to curve around the column wheel. In the end, as with the other complications, the power reserve fits perfectly, with beautiful symmetry. It seems to unify the timekeeping and the striking mechanism, and the initals of the owner preside over the complete movement.

Maybe you can imagine the feelings Lord Arran experienced when he had the chance to handle, hear and feel this masterpiece, after fourteen years of waiting, fully completed for the first time!

Above: Close-up of mainspring section of movement and one of the power reserve indicators.
Below left: CAD drawing of power reserve
Below right: Power reserve indicator