Lange Zietwerk – the movement…how does it work?

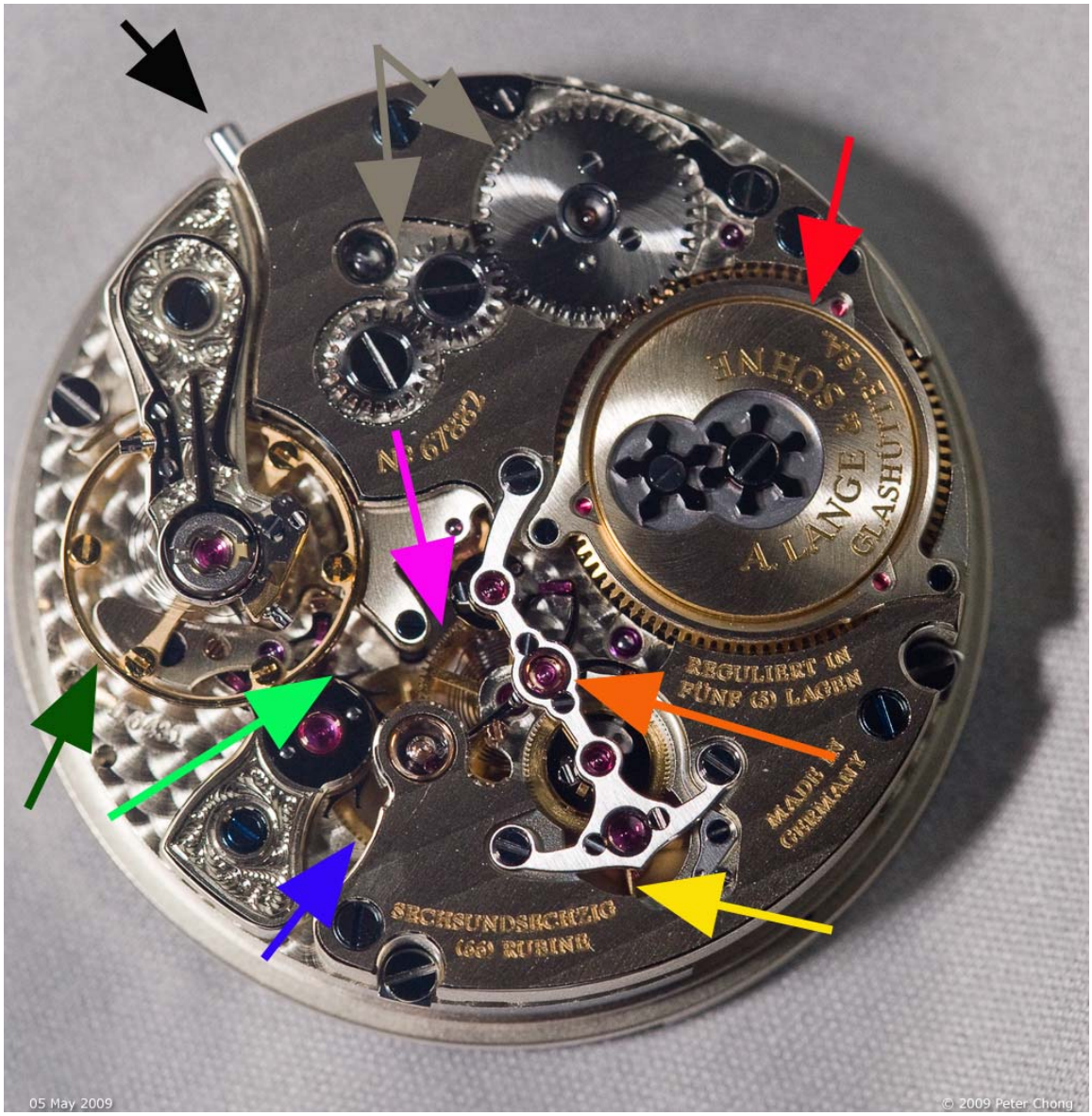
Text and pictures by Peter Chong

The Lange Zietwerk is a phenomenal piece of design…a departure from the norm…a new epoch. As radical as is the design of the dial side, inside the case, the movement is even more fascinating.

As usual, the movement is finished to the typical high horology fashion we have come to expect from Lange. While some of the pictures shown in this article may show rough edges, this movement pictured is for illustration, and is from a movement which is not cased and as such, will bear the marks of being handled directly.

The movement is significant at several planes. First the winding and barrel mechanism is remarkable. Next the remontoir system is extremely complex and leading edge. And finally the time changing disk mechanism is innovative.

First a walk through and name the major parts of the movement.



The coloured arrows show the following:

Black: crown. From here is is clear that there if the crown were to occupy the traditional place at 3, the winding stem would have to occupy the space now occupied by the balance wheel.
Grey: the winding gears to reduce the power required to wind the barrel. This will become apparent later during the discussion on the barrel, but these gearing is critical to ensure ease of winding.
Red: is the flying barrel. On top, is a stop work mechanism like a maltese cross to halt the movement at the end of its power reserve of 36 hours to ensure the mainspring does not wind down so much that there is insufficient power to move the disks.
Orange is the bridge carrying the remontoir mechanism.
Yellow: a flywheel damper. This flywheel uses air resistance to reduce shock to the time disks when it is jumping.
Purple are the two third wheels. This is driven by the second wheel which one level below and hidden. You can make out below this third wheel, is a spring which connects the upper third wheel to the lower third wheel. This spring is the remontoir.
Blue shows the fourth wheel, which spins at the rate of 1 revolution per minute.
Light green is the fifth wheel, or the escape wheel
Dark green is the inhouse inertia balance wheel.

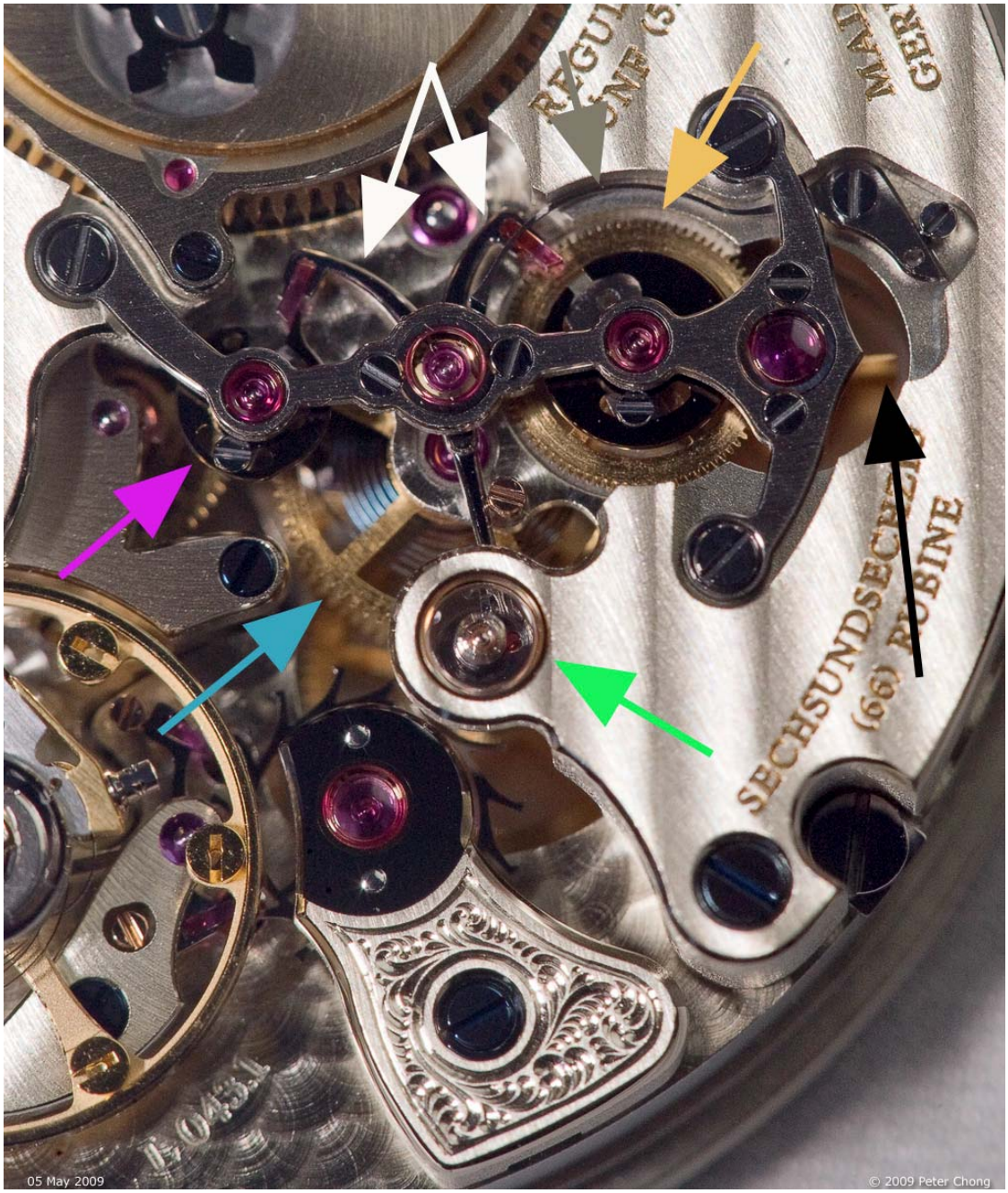
The Barrel

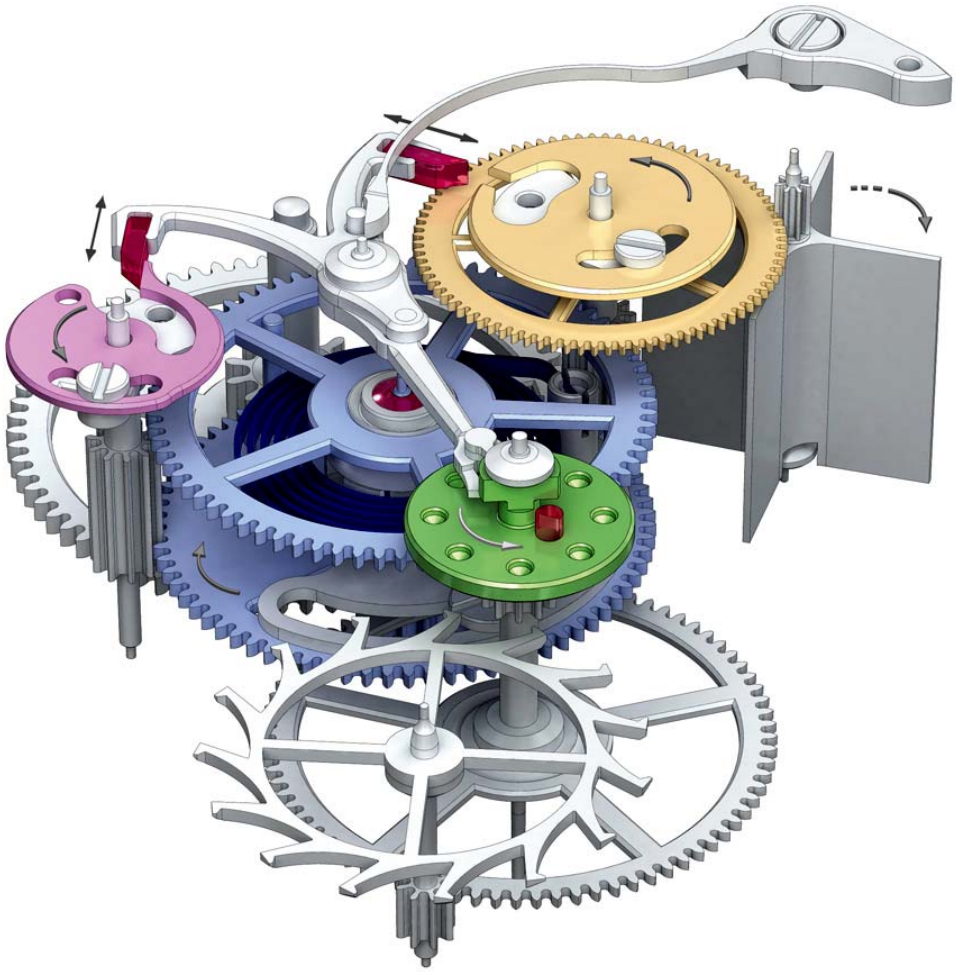
The jumping time display requires a lot more power to move than just 2 hands. The disks are heavier, and have more inertia, and also the movement needs to be executed in a short instant. To ensure that the mainspring has sufficient power at all times three features are incorporated:

1. a maltese cross arrangement, seen as two star wheels – one six armed, the other five arms. This provides a stopwork mechanism and will stop the barrel from unwinding after 36 hours.
2. the mainspring is made extra powerful. The torque developed by this mainspring is even higher than the one used in the Lange 31. However, the spring is shorter, but thicker.
3. in order to maximize the power of the mainspring, that is, all the torque is used to jump the disks and as little torque is wasted as possible. This is achieved by turning the principle of the unwinding barrel upside down. The barrel is suspended between two jeweled bearings. The lower one is connected to the mainplate and the upper one to the barrel itself. During winding the crown drives the mainspring barrel via the intermediate transmission wheels. As the barrel winds, it entrains the mainspring inside which is attached to the inner side of the barrel…causing it to tension up against the arbour. As the mainspring discharges, it drives the wheel train via a barrel wheel located on the dial side of the movement. This arrangement allows the lowest friction bearing to be used by the unwinding barrel, and the higher friction bearing to be used for winding – opposite to what is typical. But in exchange for a slightly harder winding, it preserves as much power as possible to enable the magic of the jumping disks. I wound the watch several times, and found that the additional effort required is minimal, and I wouldn't have noticed it if Tony deHaas did not mention it to me.

The remontoir

A remontoir is a small spiral spring, intermediate to any two wheels in a train and wound at regular intervals by the mainspring, and supplies a constant power to the escape wheel. (definition is slightly abridged from George Daniels Watchmaking).





The picture and drawing are color coded for reference. The color of the arrow corresponds to the color of the wheel in the drawing.

The L043 is designed with two independent, but exactly the same third wheels, one on top of the other. The blue arrow points to this arrangement of third wheels and the remontoir. The lower third wheel is driven by the seconds wheel as is usual in any watch. The lower wheel is connected to the upper wheel by a spring – known as the remontoir. This remontoir is the only connection between the two third wheels.

The mechanism works by blocking the power from the mainspring at the lower third wheel, and using the remontoir to run the rest of the train from the upper third wheel to fourth wheel, escape wheel and balance wheel. The remontoir provides power to the escapement when the lower third wheel is blocked, and once a minute, the lower third wheel is unblocked. During this unblocking, the mainspring snaps it forward one revolution, only to be blocked again. In this process, it recharges the remontoir and also drives the disk mechanism.

How does this locking and unlocking occur? Let's examine the blocking wheels.

The purple wheel is one of two blocking wheels. As seen in both picture and drawing, this wheel is locked by the jewel on the left arm of a lever, shown in the picture by the white arrows. As can be seen, this lever is Y shaped…the left side engaging with the left stopwork (purple), and the right side engaging with the right stopwork (beige), and the lower engaging

like with the pin driven by the fourth wheel. In this position, the lever is not locking the beige wheel, but locked by the purple wheel.

Two toothed wheels (the one driving the purple wheel can be seen as grey in the drawing below the purple wheel. A similar toothed wheel drives the beige wheel on the other side of the remontoir) provides power from the lower third wheel to each of the stop works. But in this position, the purple wheel is locked, so this also locks the lower third wheel, and blocks the power of the mainspring.

The remontoir is a spring attached to the arbour of the lower third wheel, and the inside of the outer edge of the upper third wheel. As the lower third wheel is blocked, the remontoir is able to unwind and drive the upper third wheel, which in turns turns the fourth wheel, shown as green. As usual, the fourth wheel drives the escapement wheel, and the balance wheel. But as the remontoir spring is small, and rewound once every minute, it is able to provide a more constant torque to the fourth wheel and escape wheel. This provides the benefits of a more even power discharge, and better timekeeping of the constant force escapement.

However, note that the top of the fourth wheel is rigidly attached to the green wheel, which carries a jeweled pallet. At the position shown now, the pallet is not engaged with the lower end of the Y lever. But as the fourth wheel turns, the pallet jewel will engage with the fork of the lower part of the lever. As it enters the fork, it will push the lever to the left against the pressure of the grey spring. This action unlocks the lever on the purple wheel and at the same time engages the right lever to fall inside the slot cut in the beige wheel. At this point, the disk mechanism is armed, and typically occurs about 8 seconds before the second hands reach 0. This arming can be seen…exaggerated in the prototype movement in this video. Click on picture to see Quicktime video.

This pre-arming is important to ensure that the disks jump at precisely 0, and not a moment before or after. If you examine earlier digital watches…from the Vianney Halter Goldfiel to the Palweber, you will see that the jumping may occur anywhere from –10s to +5s from 0. The De Bethune Digitale avoids this problem by not showing the seconds hand. In the Zeitwerk, this does not happen…each jump is precisely on the dot.

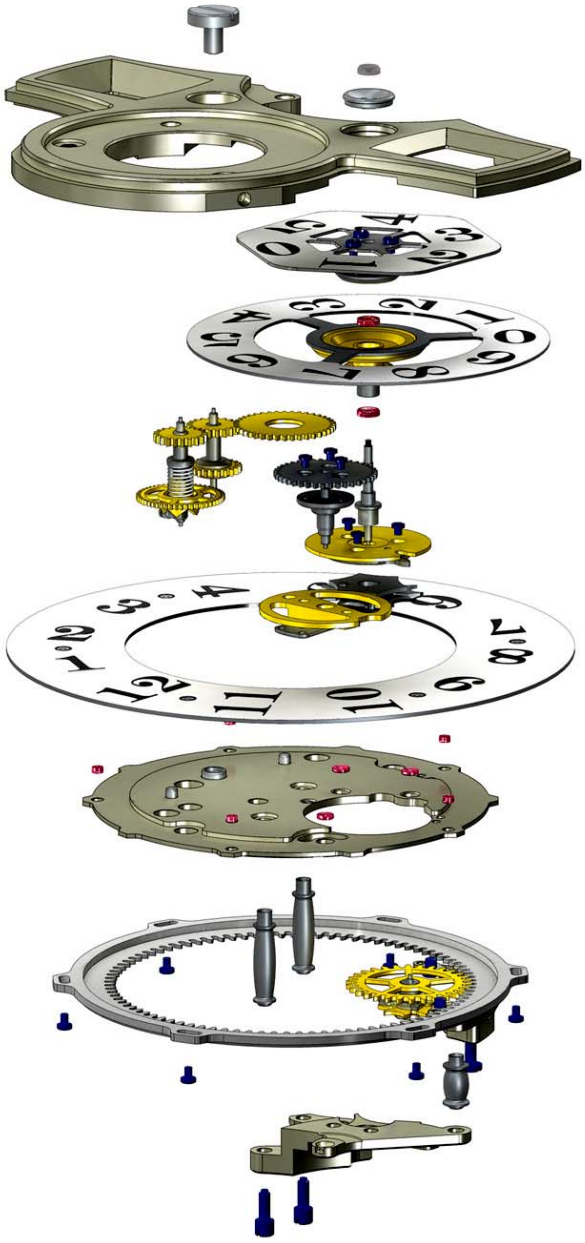
Note that the video is of the prototype, the final released version will have a smaller adjustment during arming.

The mainspring power is still blocked at this point, but this time by the beige wheel. At precisely 0 seconds, the pallet on the green wheel leaves the fork of the lever. This causes the lever, which is under tension by the grey spring to swing the fork back to the right, unlocking the beige wheel. At this moment, the power of the mainspring is released, and instantaneously snaps both purple and beige wheels counter-clockwise. But at the end of one revolution, the left purple wheel is again locked by the left arm of the lever. And the cycle starts again.

When the mainspring releases the power, the purple wheel rotates 72 degrees, and as its pinon is connected to the jumping date mechanism, it causes the mechanism to advance one position instantaneously.

The flywheel shown in yellow is driven by the beige wheel and provides optimal air damping to the snapping power of the mainspring and reduced slap and wear on the bearings.

The jumping disks



The arbour of the decimal digits and the units digits share the same arbour. As described above, the remontoir mechanism delivers an abrupt impulse turning the connecting wheel 72 degrees each minute. As the connecting wheel is attached to the unit disk, this advances by as much. Every 10th impulse, this wheel gives an impulse to the decades wheel, advancing it also by the same impulse but because of the gearing advances the decade disk by 60degrees. And once every 60 minutes this advances the hour wheel by exactly one step.

This switching mechanism is seen in between the disks in the drawing above.

In order to ensure that the disks do not move during time setting, a novel blocking mechanism is developed. Moving the crown in time setting mode will move the disks by 1 minute at a time, in both directions. This can be seen as the disk jumping forwards and backwards precisely.