GENEQUAND, a Novel Watch Regulator based on Compliant Mechanisms

F. Barrot, G. Musy, F. Cosandier, I. Kjelberg, P. Renevey, L. Giriens, P. Schwab, P. Genequand •, Y. Petremand, O. Dubochet, F. Ganny ••, T. Hamaguchi ••

Together with his industrial partner Vaucher Manufacture Fleurier, CSEM has developed a novel watch regulator which is six times more efficient than those used in traditional mechanical watches in term of mechanical losses. This breakthrough has been achieved by combining two fields of expertise of CSEM: the design of compliant mechanisms and the technology of silicon etching.

A watch regulator, which is made of the association of an oscillator and an escapement, is subject to losses due to friction and shocks. Limiting these losses can drastically increase the power reserve of mechanical watches.

Pierre Genequand, a former researcher at CSEM, had a long experience in the design of high precision mechanisms based on the use of "flexure hinges", also commonly referred to as "compliant mechanisms"; such an approach enables precise, frictionless and lubrication free movements. Several demanding mechanisms targeted for space or astronomy applications have been produced at CSEM with this approach. But Pierre Genequand had always in mind that, some of the small size and high precision components found in mechanical watches, could also greatly benefit from the "compliant mechanisms" design approach [1].

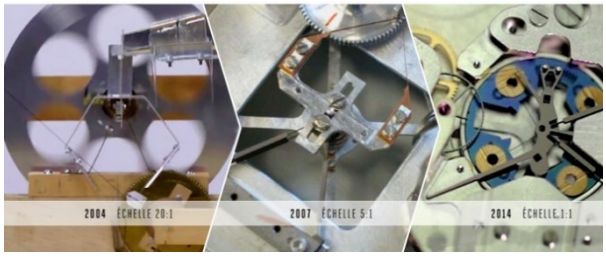

Figure 1: The Genesis of the Genequand regulator. From the 20:1 wood scale model (left) to the 1:1 silicon based prototype (right).

Based on this conviction, he designed the first version of his regulator and successfully implemented it on a 20:1 scale model wood based prototype. The hair spring and the ruby bearings of the classical oscillator were replaced by a flexure based pivot. In parallel, the classical Swiss anchor was replaced by a permanent contact anchor guided on a flexure based pivot and exhibiting flexible arms to cooperate with the escapement wheel. Convinced by the potential of the idea, CSEM worked to shrink down the prototype to the 5:1 scale before submitting this invention to several watchmakers. Seduced by the approach, Vaucher Manufacture Fleurier (VMF) decided to join the adventure and to work together with CSEM on the further miniaturization and the integration of the concept into a wrist watch.

That is when CSEM's knowhow, in silicon etching, comes into play [2]; CSEM's mastering of DRIE (deep reactive ion etching) micro-structuration techniques made it possible to produce small size high precision mechanical parts taking full advantage of the excellent mechanical properties of silicon [3]. In this implementation several functions traditionally played by different components are gathered into one single part:

- At the oscillator level: a monolithic flexure based oscillator combines the functions of hair spring, oscillator pivot (ruby bearing + pivot shaft) and balance wheel into one single silicon component.
- At the anchor level: a monolithic flexure based anchor combines the functions of anchor pivot (ruby bearing + pivot shaft), pallet-stones and anchor into one single silicon component.

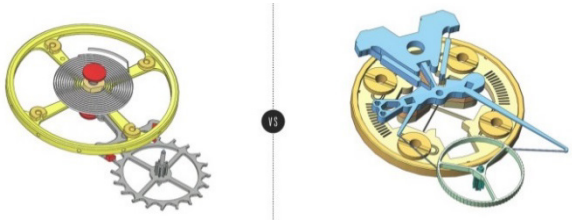

Figure 2: the classical Swiss anchor based regulator (left) versus the Genequand regulator implemented at the watch scale (right).

The first watch scale prototype was integrated in a VMF caliber in 2014 [4]. A first test campaign validated the strong innovation potential of this novel regulator which enables to foresee the creation of mechanical movements with up to 30 days of power reserve.

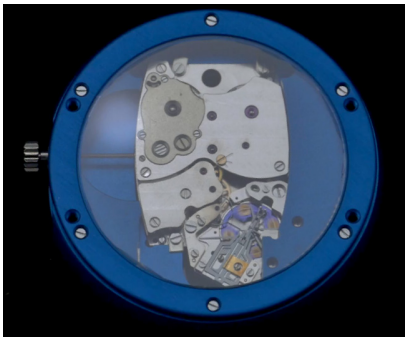

Figure 3: The Genequand regulator integrated in a VMF 6000 caliber.

• retired from CSEM

•• Vaucher Manufacture Fleurier

[1] P. Genequand, M. Bogdanski, I. Kjelberg, "Elements flexibles usinés pour applications microtechniques", Bulletin de la Société Suisse de Chronométrie, SSC, no. 33, 2000

[2] A. Perret, "Le silicium comme matériau dans la fabrication de pièces mécaniques", Bulletin de la Société Suisse de Chronométrie, SSC, Neuchâtel, CH, no. 38, 9 novembre 2001.

[3] S. Jeanneret, A. Dommann, N. F. de Rooij, "Procédés de micro-fabrication avec application horlogère", développements récents, SSC, 2008

[4] F. Barrot, P. Genequand, I. Kjelberg, T. Hamaguchi, Un nouveau régulateur mécanique pour une réserve de marche exceptionnelle, SSC, 2014