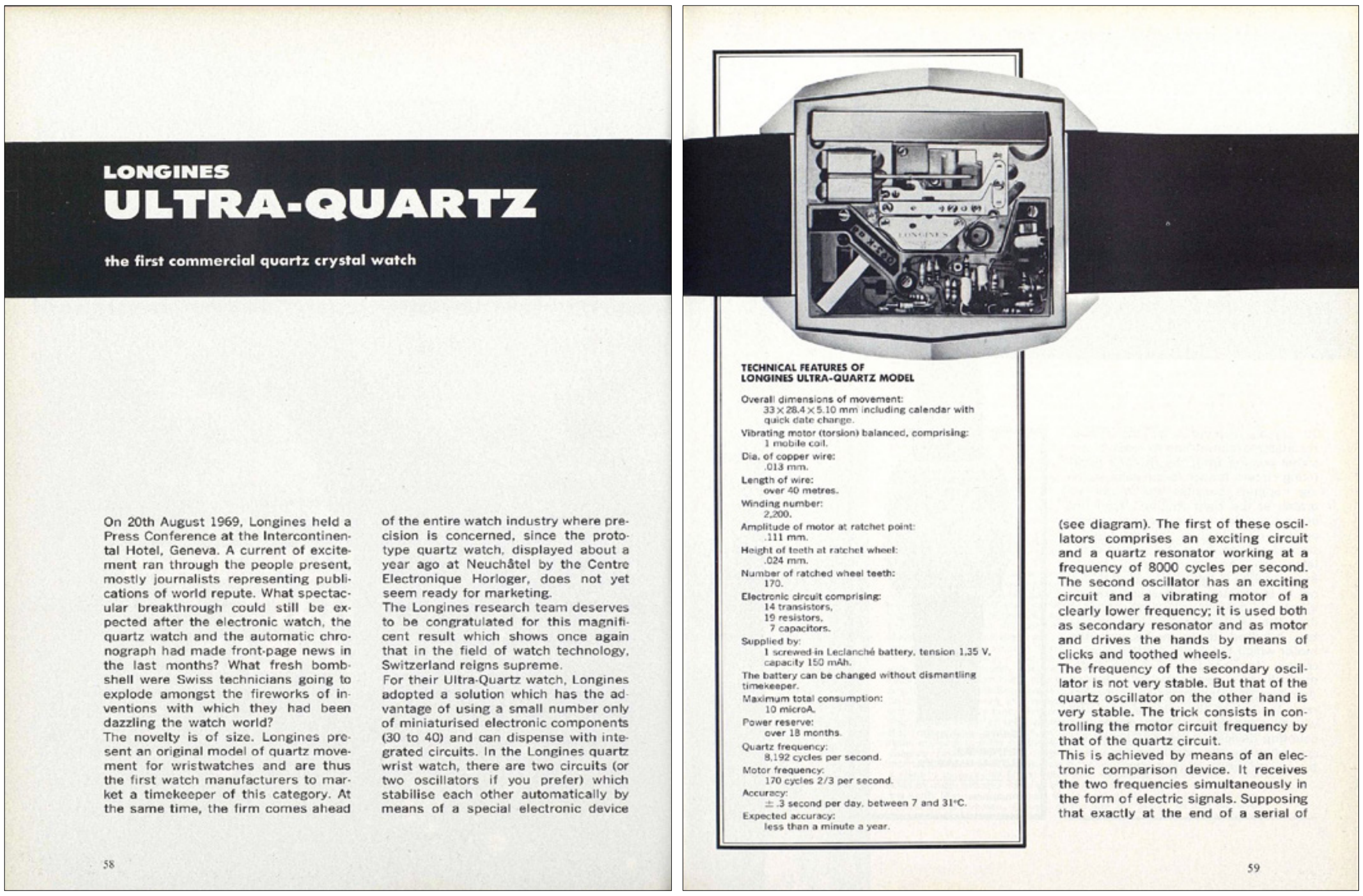
Longines: the forgotten "first commercial quartz crystal watch"



LONGINES
ULTRA-QUARTZ
the first commercial quartz crystal watch

On 20th August 1969, Longines held a Press Conference at the Intercontinental Hotel, Geneva. A current of excitement ran through the people present, mostly journalists representing publications of world repute. What spectacular breakthrough could still be expected after the electronic watch, the quartz watch and the automatic chronograph had made front-page news in the last months? What fresh bombshell were Swiss technicians going to explode amongst the fireworks of inventions with which they had been dazzling the watch world?
The novelty is of size. Longines present an original model of quartz movement for wristwatches and are thus the first watch manufacturers to market a timekeeper of this category. At the same time, the firm comes ahead of the entire watch industry where precision is concerned, since the prototype quartz watch, displayed about a year ago at Neuchâtel by the Centre Electronique Horloger, does not yet seem ready for marketing.
The Longines research team deserves to be congratulated for this magnificent result which shows once again that in the field of watch technology, Switzerland reigns supreme.
For their Ultra-Quartz watch, Longines adopted a solution which has the advantage of using a small number only of miniaturised electronic components (30 to 40) and can dispense with integrated circuits. In the Longines quartz wrist watch, there are two circuits (or two oscillators if you prefer) which stabilise each other automatically by means of a special electronic device

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TECHNICAL FEATURES OF
LONGINES ULTRA-QUARTZ MODEL

Overall dimensions of movement:
33 × 28.4 × 5.10 mm including calendar with quick date change.
Vibrating motor (torsion) balanced, comprising:
1 mobile coil.
Dia. of copper wire:
.013 mm.
Length of wire:
over 40 metres.
Winding number:
2,200.
Amplitude of motor at ratchet point:
.111 mm.
Height of teeth at ratchet wheel:
.024 mm.
Number of ratched wheel teeth:
170.
Electronic circuit comprising:
14 transistors,
19 resistors,
7 capacitors.
Supplied by:
1 screwed-in Leclanché battery, tension 1.35 V, capacity 150 mAh.
The battery can be changed without dismantling timekeeper.
Maximum total consumption:
10 microA.
Power reserve:
over 18 months.
Quartz frequency:
8,192 cycles per second.
Motor frequency:
170 cycles 2/3 per second.
Accuracy:
± .3 second per day, between 7 and 31°C.
Expected accuracy:
less than a minute a year.

(see diagram). The first of these oscillators comprises an exciting circuit and a quartz resonator working at a frequency of 8000 cycles per second. The second oscillator has an exciting circuit and a vibrating motor of a clearly lower frequency; it is used both as secondary resonator and as motor and drives the hands by means of clicks and toothed wheels.
The frequency of the secondary oscillator is not very stable. But that of the quartz oscillator on the other hand is very stable. The trick consists in controlling the motor circuit frequency by that of the quartz circuit.
This is achieved by means of an electronic comparison device. It receives the two frequencies simultaneously in the form of electric signals. Supposing that exactly at the end of a serial of

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Europa Star celebrated the August, 1969 announcement of the Longines Ultra-Quartz, calling it "The first commercial quartz crystal watch". ©Europa Star 4/1969

On August 20, 1969, Longines convened the press in Geneva to announce the world's first commercial quartz wristwatch. Known as the Ultra-Quartz, it was more accurate than any other production wristwatch. Prototypes were shown, photographs and documents were shared, and Longines promised that production would soon begin. Longines appeared to have a convincing lead over Seiko, Girard-Perregaux, Omega, and the Swiss CEH. However, the Longines Ultra-Quartz is nearly forgotten today. What happened?

BY STEPHEN FOSKETT / GRAIL WATCH

In 1969, everyone knew that quartz watches were coming, but the first mover was Longines. On August 20, four months before Seiko and a full eight months before any other Swiss company, Longines announced the first commercial quartz watch. As celebrated in *Europa Star* (see below), the Ultra-Quartz featured a revolutionary "cybernetic" electronic movement that would finally bring quartz timing to the wrist.
Today, most say that Seiko's Astron, announced on Christmas Day, was the first production quartz watch. Others point to the Swiss Beta 21, with a dozen models released at the Basel Fair in early April, 1970. So what happened to the pioneering Longines Ultra-Quartz?

Keeping time with quartz crystal

Although the piezoelectric effect, in which a quartz crystal oscillates in an AC electric current, was discovered by Pierre and Jacques Curie in 1880, the frequency of vibration was too high to be useful in timekeeping. It would be over 60 years before Warren Marrison and J. W. Horton developed a way to couple a vibrating crystal to an electric motor using harmonics. This first electronic quartz clock was built at Bell Telephone Laboratories in New York and presented in October, 1927. In the next decade, quartz clocks were successfully built in the United States, the United Kingdom, and Germany.

Since quartz vibrates at a consistent rate when subjected to an alternating electrical current, it is ideal as a timekeeping organ. It remains consistent even when the energy applied is weak or erratic, having a high "Q factor" as they say in physics. But the rate varies with temperature, so most early clocks housed the quartz crystal in a temperature-controlled oven. Additionally, the electronics required to drive the crystal oscillator and count the cycles produced used an array of large vacuum tubes and other electronic components. Although the concept of a quartz watch was easy to envision, it would be deemed impractical for decades.
Quartz clocks had been the world's most accurate since the 1950s, and the race to miniaturize the technology for wristwatch use was an open secret. In his IEEE paper, "The Electronic Watch and Low-Power Circuits," engineer Eric Vittoz, who worked on quartz clocks for the Swiss Centre Electronique Horloger (CEH), aptly points out the issue. "Hence a quartz wristwatch did not have to be invented: it already existed as a system. The "only" challenge was to reduce its volume to less than 3 cm3, and to lower its power consumption by 4 orders of magnitude, down to less than 10μW."
This was the challenge for the CEH when creating the Beta series of quartz movements between 1965 and 1970, for Seiko with its Astron Cal. 35 project, and for Longines with the Ultra-Quartz.

Longines Quartz Timing

Many Swiss companies and institutes entered the race to develop improved quartz electronic clocks for scientific and sports timing, notably Longines and Omega. In the 1940s, Longines was involved in developing photographic timing for racing, with the "Chrono-Caméra", "Photogines", and "Chronocinégines" incorporating electronic timing. These are detailed in Europa Star's issue 200 in 1993.
In 1952, both companies deployed quartz electronic clocks to the Olympic Games in Helsinki and Oslo, as they vied for the publicity value of timing the games. The competition between Longines and Omega reached a head with the 1968 Olympic Games in Mexico: as both companies realized it was too costly, they combined their efforts as a new entity known as Swiss Timing, which still exists today.
Longines and Omega also competed to develop a quartz electronic chronometer for science and industrial use. In 1954, a Longines quartz clock set the record for precision at the Neuchâtel Observatory competition. This large chronometer was continuously improved for a decade, and in 1965 it reached an astonishing score of 0.05 points, running within one second in three years! These were commercialized and used in scientific studies and broadcasting, packaged in a box the size of a desktop computer.
Miniaturization of quartz chronometers became the next focus for Longines, Omega, and the Hattori (Seiko) company of Japan. Marine chronometers using quartz technology were created in the early 1960s, and were miniaturized to a roughly-50 mm3 in 1964. Longines teamed up with newly-formed quartz innovator Bernard Golay SA to develop a compact quartz movement, and progressed rapidly.
An improved 1965 version of the Golay-designed Micro-Quartz chronometer scored 0.15 in the Neuchâtel Observatory contest, with a daily rate better than 0.1 seconds. This clock used a 12 KHz quartz oscillator with a temperature compensation circuit, enabling it to maintain performance from -20 to +60 C. The frequency divider circuit operated a 4 Hz stepper motor, giving the seconds hand a sweep similar to a conventional watch.
Golay engineer Andre Cachin is credited in patents with inventing many of the components of the Micro-Quartz, including the electromagnetic micromotor and electronic circuit used to sustain the quartz oscillation. Jean-Claude Berney is also named in patents, and would later patent the concept of a quartz watch powered by a mainspring for Ebauches SA, as produced in 1988 by Jean d'Eve and Seiko.
The Golay/Longines concept was further miniaturized, with a true pocket-sized chronometer introduced in 1966. It scored 0.54 points in the Neuchâtel Observatory contest, suggesting that a quartz watch was finally within reach. But it was Armin Frei of the the Swiss Centre Electronique Horloger (CEH), an industry consortium, that would create the world's first quartz watch prototype.
His Beta 1 movement was tested along with the derived Beta 2 and prototypes from the Japanese firm Hattori (known as Seiko) at Neuchâtel in 1967. In all, more than twenty prototype quartz watch movements were tested that year, dominating the results and showing that quartz was the future (see my blog, Grail Watch, for more detail on the development of the Beta 21).

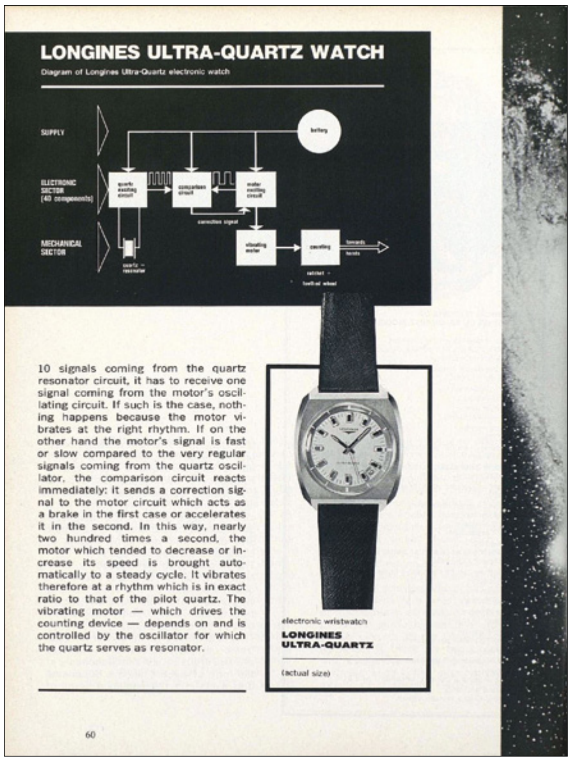
LONGINES ULTRA-QUARTZ WATCH

Diagram of Longines Ultra-Quartz electronic watch

10 signals coming from the quartz resonator circuit, it has to receive one signal coming from the motor's oscillating circuit. If such is the case, nothing happens because the motor vibrates at the right rhythm. If on the other hand the motor's signal is fast or slow compared to the very regular signals coming from the quartz oscillator, the comparison circuit reacts immediately: it sends a correction signal to the motor circuit which acts as a brake in the first case or accelerates it in the second. In this way, nearly two hundred times a second, the motor which tended to decrease or increase its speed is brought automatically to a steady cycle. It vibrates therefore at a rhythm which is in exact ratio to that of the pilot quartz. The vibrating motor — which drives the counting device — depends on and is controlled by the oscillator for which the quartz serves as resonator.

electronic wristwatch
LONGINES ULTRA-QUARTZ

(actual size)

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Europa Star 4/1969

Longines announced the first production quartz watch

Longines and Golay pressed ahead with development of a production quartz watch movement. The challenge of dividing the high-frequency quartz oscillation to drive a wheel train and hands remained, however. Although a series of flip-flop circuits could easily reduce the rate, the sheer number of components required drew too much power to run for long. This is why the CEH focused on Max Forrer's Beta 2 design for their production Beta 21 quartz movement: it used just 5 dividers rather than the 14 of Armin Frei's more elegant design.

Integrated circuits showed promise, and the CEH was making rapid progress in this area. But Longines and Golay did not have access to such technology. Although they were able to make a divider circuit using individual components, this was too costly, power-hungry, and difficult to construct. The production Longines quartz watch would have to use a different approach to obtain a useful frequency from the oscillation of the quartz crystal.

A jazz soloist does not need to match every beat of the drummer, he only needs to "come home" on the downbeat. Longines took a similar approach to create a watch movement that was synchronized to quartz without using a power-hungry divider circuit. Using just 40 electronic components, Longines drove a vibration motor at 170 Hz and adjusted it to match the beat of the 9150 Hz quartz crystal. American mathematician Norbert Wiener coined the term "cybernetic" in 1948, and his concept was to use feedback to fine-tune a system. This was a popular term in the 1969s and would become the name used by Longines to describe their quartz movement. Using a vibration motor to drive the wheel train, similar to the popular Bulova Accutron tuning fork movement, Longines used a flat bar with permanent magnets oscillating between electromagnets. A tiny finger pushes a drive gear forward, one tooth at a time. The CEH Beta 2 used a similar vibration motor driven directly by the reduced quartz frequency, but Longines allowed theirs to vibrate freely like the Accutron. It was adjusted at each beat to match the rhythm of the quartz crystal. Thanks to this breakthrough cybernetic design, Longines engineers felt that they would be able to economically produce a quartz wristwatch.

On August 20, 1969, Longines convened the press in Geneva to announce the world's first commercial quartz wristwatch. Known as the Ultra-Quartz, it was more accurate than any other production wristwatch. Prototypes were shown, photographs and documents were shared, and Longines promised that production would soon begin. Longines appeared to have a convincing lead over Seiko, Girard-Perregaux, Omega, and the Swiss CEH.

The fate of the Longines Ultra-Quartz

Although touted in 1969 as the world's first quartz wristwatch, the Longines Ultra-Quartz is nearly forgotten today. For example, Christian Piguet does not mention Longines even once in his excellent history of the CEH Beta project, "The First Quartz Electronic Watch". But then again he also fails to mention the independent projects at Girard-Perregaux and Omega that were announced alongside the Beta 21.

None of these projects gets a mention in "Engineering Time: Inventing the Electronic Wristwatch" by Carlene Stephens and Maggie Dennis either. And it is frequently repeated online, from Wikipedia to Hodinkee, that the Seiko Astron was the first production quartz wristwatch.

The reason the Ultra-Quartz is overlooked is simply that Longines was unable to produce this revolutionary watch. Developed by Golay and Longines' research department, the Ultra-Quartz required extensive re-engineering before the separate manufacturing division could hope to build it at scale. Fellow Europa Star contributor Pierre-Yves Donzé has written extensively about this, and describes the challenge in his excellent 2019 paper, "Dynamics of Innovation in the Electronic Watch Industry", which served as a reference to this article. Legendary Swiss engineer Claude Ray was given the task of moving the Ultra-Quartz into production and it would take two long years before it was manufactured.


— CONVERSATION PIECES —

FRANÇOIS-PAUL JOURNE'S TWIN-MOVEMENT RESONANCE CHRONOMETER WITH SYNCHRONIZED SECONDS AND POWER-RESERVE INDICATOR

Remarkable as it might seem today, it is still possible to have a watch made for you without having to buy the brand culture and identity as well. Such timepieces are made by the members of the Horological Academy of Independent Creators which brings together 26 watch and clockmakers from 10 nationalities, including Dr George Daniels, inventor of the coaxial escapement, Mr Kiu Tai Yu, Hong Kong's tourbillon specialist, and Mr Jean Kazès, whose signature can be found on the monumental wall clock in Patek Philippe's grand new headquarters.

The academy is where the industry goes to make prestige pieces requiring real watchmaking skills. It therefore has to adopt a relatively low profile so as not to steal the limelight, let alone the discerning connoisseurs of high horology, from the big brands. But those who managed to find the academy's stand at the Basel show were well rewarded by some of the most extraordinary watches of the season. None is more extraordinary than the chronometer invented and made by Mr François-Paul Journe, a resolutely non-conformist watchmaker in the tradition of Geneva's 18th-century cabinotiers and a knowledgeable admirer of Winnerl ("for the efficiency of his watchmaking"), Breguet and Berthoud.

It is the first timepiece to exploit resonance to achieve precision.

Watchmakers have long noticed that the rate of a clock can be disturbed by another in close proximity through the effects of resonance. Marching soldiers notice that if they don't break step over a bridge, they set up a sympathetic vibration that collapses the structure. Mr Journe noticed that if two oscillating balance wheels are brought together progressively, they will at one point vibrate in harmony.

He has thus invented and made a chronometer with two movements side-by-side in a 38mm platinum wristwatch case. Although the movements are completely separate, they are perfectly synchronised. Two balance wheels, just half a millimetre apart, are linked by an invisible wave that keeps them beating in unison, while the twin seconds-hands on the dial march in step. The counter-oscillating balance-wheels are mounted on balance-springs spiralling in opposite directions. This means that any shock or violent motion will have opposite effects on each balance, making one go slow and the other fast. Within a few seconds, the common natural frequency is re-established to bring both balances back into harmony. Mr Journe claims that the uncommonly steady rate, which is the average of two closely adjusted balances, is unaffected by whether the watch is worn or not. The two regulator-style chapter rings on the gold dial indicating the hours and minutes can be set separately to different time-zones by a single crown at 12 o'clock, which also winds both barrels. The two seconds-hands can be zeroed and started on a time-signal by a crown at 4 o'clock. The only indication common to both movementsis a power-reserve indicator. Mr Journe plans to complete the first series of 50 resonance watches this year and make 150 more next year. The entire watch, including all the parts, is made in his Geneva workshops, and signed "J. F. Journe, *Invenit et fecit.*"

François-Paul Journe

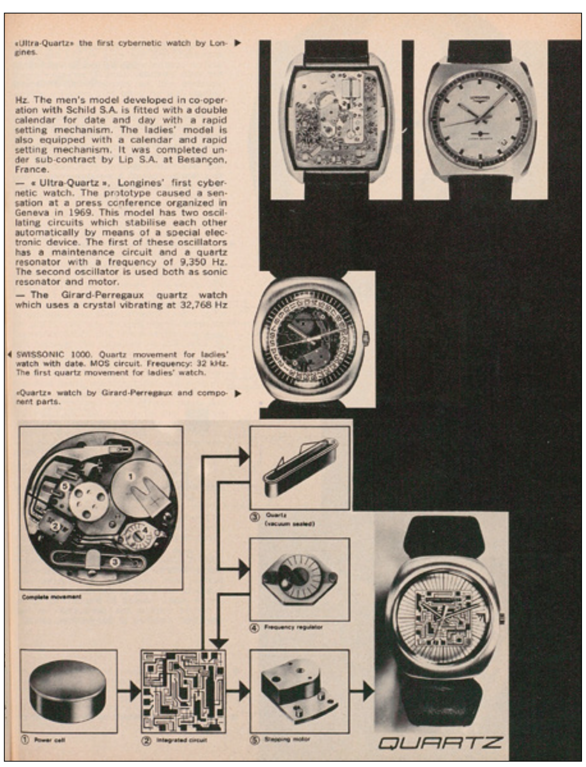
The Chronometer à Resonance

F.P. Journe's Twin-Movement Resonance Chronometer
©Europa Star 3/1999

Seiko produced a few hundred Astron quartz watches and released some for sale before the end of 1969. The CEH members, including Longines and Omega, built thousands of examples of the Beta 21 starting in 1970, showing over a dozen models at the Basel Fair that year. Omega and Girard-Perregaux also showed in-house quartz movements at the fair that year, and all of these quartz movements overshadowed Longines. The CEH was even able to move an updated Beta movement into production before Longines delivered the first Ultra-Quartz to a customer.

In the end, Longines only produced a few hundred examples of the Ultra-Quartz. Ebauches SA became the primary shareholder of Longines during this time, but the firm continued to develop its own quartz technology. After Golay's Ultra-Quartz failed to live up to its promise, the company began work on a new generation of quartz movements. They even worked with Texas Instruments to develop a digital quartz watch, but they did not pursue this direction.

Although they used quartz movements from Ebauches SA for a time, Longines did develop their own in-house technology later in the decade. This was part of a transformation of the company into one of the leading Swiss watch producers through the quartz crisis and into modern times. Golay later developed an inexpensive 32 KHz quartz movement that used an oscillating balance rather than a vibration motor. This was shown on the Corum stand at the Basel Fair in 1972. Known as the TSμ Quartz, the oscillating motor was adjusted using a low-power CMOS integrated circuit.


«Ultra-Quartz» the first cybernetic watch by Longines. ▶

Hz. The men's model developed in co-operation with Schild S.A. is fitted with a double calendar for date and day with a rapid setting mechanism. The ladies' model is also equipped with a calendar and rapid setting mechanism. It was completed under sub-contract by Lip S.A. at Besançon, France.

— « Ultra-Quartz ». Longines' first cybernetic watch. The prototype caused a sensation at a press conference organized in Geneva in 1969. This model has two oscillating circuits which stabilise each other automatically by means of a special electronic device. The first of these oscillators has a maintenance circuit and a quartz resonator with a frequency of 9,350 Hz. The second oscillator is used both as sonic resonator and motor.

— The Girard-Perregaux quartz watch which uses a crystal vibrating at 32,768 Hz

◀ SWISSONIC 1000. Quartz movement for ladies' watch with date. MOS circuit. Frequency: 32 kHz. The first quartz movement for ladies' watch.

«Quartz» watch by Girard-Perregaux and component parts. ▶

Longines lacked integrated circuit technology, so they developed a unique "cybernetic" approach using discrete electronic components with Bernard Golay SA.
©Europa Star 2/1972

Even Bulova got a head start, adding a quartz driver to the Accuquartz and delivering the first low-cost quartz watch in 1972. But American companies like Intersil and Motorola were soon offering commercial quartz watch chips, and the industry was able to produce inexpensive stepper motors in volume. These alternative designs would prove short-lived.

The concept of a cybernetic watch was no longer needed when a low-power IC could match even higher-frequency quartz crystals. But the idea has not passed completely out of the industry. F.P. Journe's fantastic Resonance technology allows two balance wheels to match their beat, improving timekeeping. Armin Strom has also presented an impressive Mirrored Force Resonance model. And advanced watches. like the Urwerk EMC and AMC and Ressence Type 2 have balance wheels which can be adjusted to match an electronic timing source. The only thing missing is the name, which seems positively passé in today's "cyber" world.

It is interesting to look back and see the explosion of new ideas that accompany any technological change. From the automobile to the smart watch, periods of transition also include radical concepts that never take hold. Longines deserves credit for the innovative design of the Ultra-Quartz, and they beat the entire industry to announce the world's first commercial quartz wristwatch. But quicker execution allows Seiko to claim to the crown for first commercial sale, and the cooperation of the entire Swiss industry pushed the Beta 21 to first volume production. Still, it is interesting to consider what might have been if the cybernetic concept had been first! ■