Timekeeping in the Electronic Century: The Case of the Quartz Wristwatch

By Carlene E. Stephens and Maggie Dennis

Electricity in general and electronics in particular are frequently ignored or understated in most traditional histories of timekeeping. The clock invariably appears on lists of the top ten most important inventions of all time, but, for the most part, survey histories emphasize the progressive technical improvement of *mechanical* clocks and their role in determining and measuring time. [1]

This emphasis on mechanical timepieces persists despite enormous changes in 20th-century timekeeping methods and access to precise time, both of which rely on electronics. By the opening decades of the century, clockmakers had actually perfected the mechanical clock, which helped to confirm that the rotating Earth is an irregular time base. Most of the century was devoted to a search for replacement standards, and gradually quartz clocks and then atomic clocks, both dependent on electronics, became the world's best timepieces.

The timeline of time milestones for the 20th century is usually interpreted through a single engineering problem—how to improve accuracy.[2] But discussing the timeline in only those terms is of little use without discussing a hierarchy of users of time. There has always been such a hierarchy of users, and an accompanying pyramid of demands for accuracy. The few who demand the most accuracy sit at the top.[3] Those on the bottom, the largest group, need the least accurate clocks and time. Sending exploratory rovers to Mars or making sure that electric power transmission moves through the grid require more accurate time and timing, than say, getting to work or school on time. Different devices and systems have evolved to serve different communities of users. And any

given person might move between levels, depending on what his or her time need is at a given moment. So in the hierarchy there is a heterogeneous mix of users, and the boundaries between levels of the hierarchy are permeable.

What follows here elaborates on just one timekeeping milestone in the electronic age, the quartz wristwatch. And specifically the first digital quartz wristwatch, the Hamilton Pulsar. Exploring the history of digital watches reveals much about the bottom of the hierarchy of users, the consumers whose desires and requirements for accuracy create the largest demand for timepieces. This exploration about the digital watch is a preliminary piece in a larger work in progress that will survey the history of timepieces and time distribution systems in the 20th century with special attention to electronic applications and to the diverse needs of the hierarchy of users.

The wristwatch was completely reinvented with all new electronic components in the 1960s. For five hundred years before then, the watch had been mechanical, with a gear train powered from an unwinding spring and with a swinging balance wheel and hairspring to keep time. In the new electronic watch, the time base, the watch's beating heart, is a slice of crystalline quartz. The quartz vibrates more than 30,000 times a second when set in an electronic circuit and keeps the rest of the watch in time. Today almost 100% of watches made are quartz electronic watches, not mechanical ones.

The electronic watch is worth a close look.[4] Along with hearing aids and pocket calculators, the wristwatch was one of the first portable consumer products to participate in the technology paradigm shift, from mechanical to electronic. The combination of a low-power energy source and a tiny quartz oscillator package would become standard in

all sorts of portable consumer products, from laptop computers to “handhelds” to cell phones.

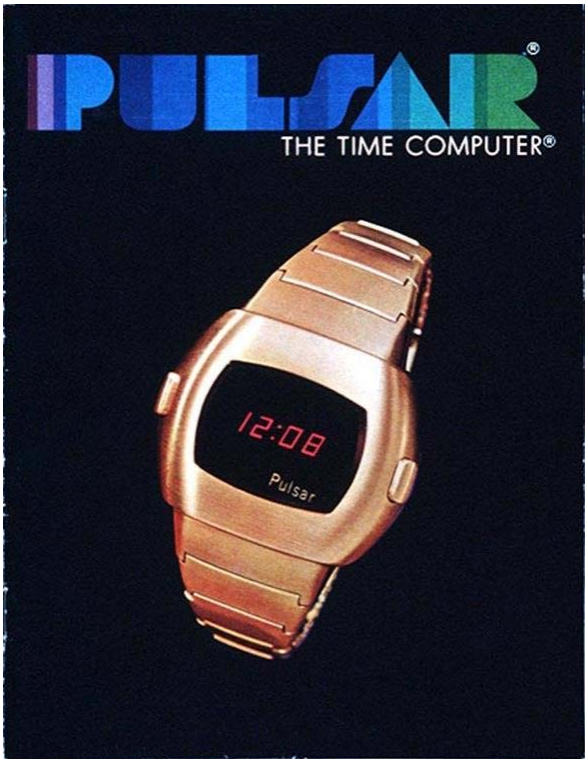
Most Americans first learned about electronic watches in 1972 when the Pulsar came out. The Pulsar was the world's first all-electronic *digital* watch.[5]

Hamilton Pulsar wristwatch with LED (light emitting diode) digital display, 1972.

Pulsar module, 1972. Inside the Hamilton Pulsar wristwatch was this electronic module.

Made by a division of the Hamilton Watch Co. of Lancaster, Pa., the Pulsar had no moving parts. It was huge, ostentatious, and expensive. At $2100, the Pulsar cost approximately the same as a small car.

Hamilton adopted the rhetoric of the space program and the computer age to describe the new watch. In their language, the Pulsar wasn’t just a watch; it was a “Time Computer.”

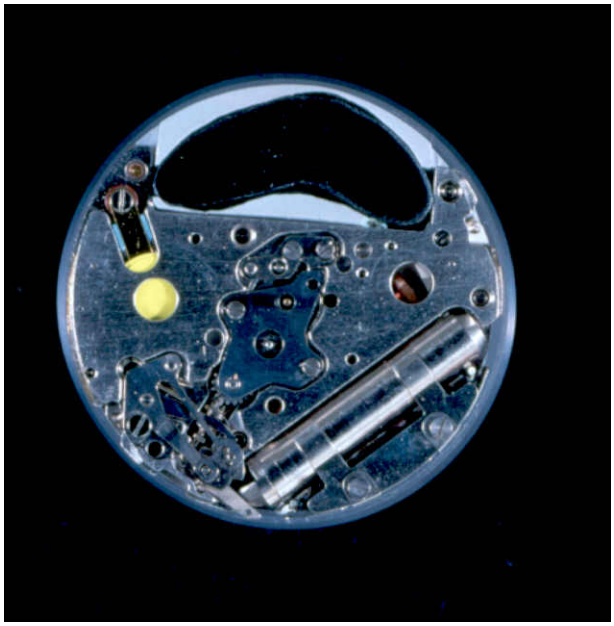


Pulsar “Time Computer” brochure, about 1972.

The ruby-colored "time screen" afforded the user a "space-capsule view" of the "read-out." The display was composed of light-emitting diodes (LEDs) that consumed so much power that the time could not be displayed continuously. To read the watch, the wearer would push the "command button" to illuminate the time. Pressing the button briefly would display the hour and minute. Holding the button down would show the seconds. For these huge inconveniences, Pulsar’s proud owner got the most accurate time then available in a quartz wristwatch. The new technology inside made the watch accurate to within a minute a year, compared to fifteen seconds a day for the best mechanical watch.[6]

The Pulsar wasn’t the first electronic quartz wristwatch. The Japanese had come out with their version earlier than Hamilton, in late 1969.

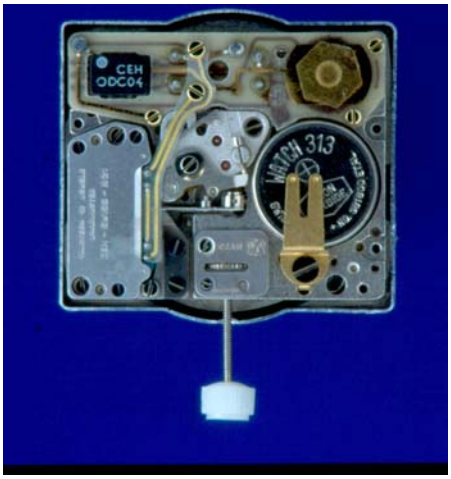
Seiko Astron SQ wristwatch, 1969. The Astron was the first quartz wristwatch sold anywhere in the world.



Seiko Astron SQ module, 1969.

The Swiss with theirs in spring 1970.

Bulova Accuquartz with Swiss-made Beta 21 module, 1970.



Beta 21 module. Watches containing the Beta 21 module went on sale under the brand names of sixteen different Swiss watch companies beginning in 1970.

But these were analog watches, with dial and hands to show the time.[7] Hamilton hoped that the Pulsar's unique appearance would grab consumer attention. Their gamble paid off. The Pulsar was sensation.

The idea for developing a solid-state digital watch came not from Hamilton management, but from two electrical engineers from the company's Military Products Division, John Bergey and Richard Walton. Their inspiration for the digital watch came from both science and science fiction. Bergey remembers that the idea came to him in the late 1960s when Stanley Kubrick hired Hamilton's Military Products Division to design a futuristic clock as a prop for the movie *2001*. At about the same time Richard Walton attended a conference, the Timers for Ordnance Symposium, where he heard a presentation by RCA engineers about their research on C-MOS integrated circuits. Walton realized that these low-power circuits developed for military purposes could be used to make an electronic watch, and he returned to Lancaster to write up a proposal.[8]

In the midst of development work a small Texas Instruments spin-off company, Electro-Data, approached Hamilton with their idea for a digital watch. George Thiess and Willy Crabtree had been developing a solid-state watch with an LED display, and they were looking for an established watch company to market their product. Bergey, by then director of the Watch Division, arranged a contract for the Texas company to produce six prototypes.

On May 6, 1970, a press conference in New York announced the Pulsar to the world. Bergey even took a Pulsar onto Johnny Carson's *Tonight Show*. The watches unveiled in New York were nothing but cranky prototypes that failed to work most of the time. Developing a viable watch began right after the press conference. [9]

Since the prototypes were composed of many circuits wire-bonded by hand, the design was far from ready for economical manufacturing. A single-chip module took two more years to get to market. Components came from a variety of suppliers-- RCA provided the C-MOS chips, Monsanto the LED displays, and several firms the quartz oscillators.

Consumers weren't exactly clamoring for an electronic watch. Hamilton needed to create a market and an identity for the very unusual Pulsar. How did they do that? They targeted men and placed the Pulsar squarely in the category of the accuracy of space-age technology. The Pulsar, claimed Hamilton advertising, was no ordinary wristwatch. It was a computer for the wrist, a high-tech wonder based on the most up-to-the-minute know-how developed by scientists for NASA. Its very name came from outer space, from the stars that emit radio waves at regular intervals.

Hamilton also understood that watches are fashion items. The high costs of production ensured that Pulsar would be marketed as a luxury. Designers created expensive gold and stainless steel cases for the first Pulsars, which were sold only through high-end jewelers. The price tag, unique look, and limited availability created a cachet that led one Tiffany spokesman to gush, "every man in the world wants one."[10]

Hamilton's strategy fit in perfectly with what was happening in men's fashion at the time. In contrast to a conservative style that had persisted since the beginning of the 19th century, men's clothing and jewelry underwent a period of either inspired innovation or temporary insanity, depending on your point of view. Fabrics for clothes came in bright colors, bold patterns and unexpected textures. Where once, only a gold watch and chain had been considered appropriate jewelry for men, now necklaces, often large and

flamboyant, shone from manly chests bared by unbuttoned shirts. Bracelets, gigantic belt buckles, flashy cuff links and rings were everyday attire. In this context a large gold LED watch reinforced the wearer's "mod" masculine image.

Sales really took off when James Bond (the Roger Moore version) wore little more than a Pulsar in a love scene in the 1973 film *Live and Let Die* and inspired a whole new category of gadget lust.

Watches have always been part of 007's equipment. But why watches, or for that matter any of the other fantasy gadgets these films are famous for? It's possible to see a Bond movie as pure entertainment, with the good guys beating the bad in the context of the Cold War. On another level, these films are deeply symbolic--about sex, power, physical strength, and a special kind of refined virility, the kind that goes with a knowledge of fine wines, luxury automobiles and a jet-set existence. The gadgets function as conspicuous and magical enhancements of 007's already considerable power.[11] So what man wouldn't want them? There was even a tinge of the Cold War spy scene about the Pulsar push-button time feature, with "the command button," as the firm dubbed it. Bergey remembers that Pulsar owners wanted to "interrogate their watch," for the powerful feeling of "command" and immediate response. But physicists interrogate their frequency sources, so maybe Bergey was just speaking in technical terms. What is certain is market research indicated that Pulsar wearers, all male at that time, *liked* to get time this way. To this day men of a certain age remember wanting to buy the sexy Pulsar after seeing it for the first time on James Bond's wrist.

Celebrities and politicians sported Pulsars too: Sammy Davis, Jr. Sonny Bono, Richard Nixon, to name only a few. Gerald Ford received one as a gift, which he wore

during House Judiciary Subcommittee hearings on his pardon of Richard Nixon. When an article about Ford's Pulsar appeared in the *Washington Post*, Hamilton dealers displayed the article, with photo, in their stores. With all this attention, Ford quit wearing the watch. But the Pulsar had clearly earned the reputation as the fashion item of choice for rich and powerful men.

Hamilton's success tempted both traditional watch firms and upstart electronics companies to jump into the market with their own products. Pulsar and its early imitators were expensive watches, prestigious gadgets aimed at male buyers. By the mid-1970s about forty American companies were mass-producing electronic watches. Prices crashed. Just four years after the costly Pulsar came on the market, consumers could purchase a digital watch from Texas Instruments for only $20, and then $10. Other manufacturers quickly followed, and cheap digital watches—some with new LCD displays--poured by the millions out of U.S. and Asian factories. These cheap digital watches gave just about everyone access to the split-second accuracy once available to only scientists and technicians

So the electronic wristwatch evolved almost overnight from a rare gadget for rich men to a cheap and ubiquitous throwaway timepiece for men, women and children. Easy availability coupled with the introduction of digital watch displays, radically different in appearance from the traditional dial and hands, generated passionate responses from consumers, both pro and con.

Digital watches were a novelty. Some "early adopters" were real fans of the ultramodern look. To them, time displayed in digits signaled a much more accurate, objective and abstract "scientific" time. But to others, there were lots of things wrong

with digital watches. Some complaints had to do with poor quality and design. LEDs couldn't be read in sunlight, liquid crystal displays (LCDs) were invisible at night. Batteries were annoyingly short-lived. Setting the new watches was always complicated, often required extra tools, and sometimes seemed downright impossible. Really cheap watches just stopped running entirely.

Whatever the reason, buyers returned malfunctioning watches to their manufacturers in record numbers. Manufacturers heard these complaints, made changes, and gave consumers an important role in shaping the form and function of quartz watches.

But consumer concerns went beyond dreadful quality and design. People began to question the very nature of digital time itself, enough to provoke some academic studies, even.[12] A common complaint criticized the digital display because it was *too* accurate. The language of time-telling, long ago established through reading analog dials, is inexact. When faced with the question "what time is it?" the analog-dial user may say "about quarter 'til eight." Ask someone who wears a digital watch, though, and the answer is "7:43." As *Good Housekeeping* magazine noted in its 1976 consumer guide, "Whether or not we ordinary mortals need such accuracy is a debatable point."[13] After more than a century of advertising watches on the basis of accuracy, manufacturers of fine watches had finally exceeded consumer expectations.[14]

By the late 1970s resistance to digital watches in the classroom eventually subsided. It became clear that digital displays weren't going to disappear, and that nothing cataclysmic had happened because digital expressions of time coexisted with analog. The fear that digital watches would make the analog dial extinct turned out to be

unwarranted. Since 1986 people have bought more watches with analog dials than with digital displays, as a matter of fact.[15]

Digital watches haven't disappeared, of course. They have come to occupy lucrative niche markets, where they fill the needs of those who care, in their everyday lives, about fractions of seconds or use the timers or alarms such multifunction watches permit.

The development of the quartz watch is a prime example of innovation as an interactive process, in which the designers and producers worked with marketers and watch wearers to shape the ultimate product. This interaction sits squarely at the "consumption junction"—the place and time, identified by historian of technology Ruth Schwartz Cowan, at which consumers make choices between competing technologies. It is at this intersection that we find a dialog between producers and users about early digital watches, which helped shape the design and function of this new technology. Finding historical sources to document user interaction is often very difficult, but well worth the effort, because users of technology matter.[16]

Grants from the Smithsonian's Lemelson Center for the Study of Invention and Innovation and the Smithsonian Scholarly Studies Program supported the research for this paper. All photographs reproduced with this paper are courtesy of Smithsonian Institution.

[1] Two exceptions that have become classics: Frank Hope-Jones, *Electrical Timekeeping*, 2nd ed. (London: N.A.G. Press, 1949) and J. D. Weaver, *Electronic Clocks and Watches* (London: Newnes Technical Books, 1982).

[2] Harvard historian David Landes has called this horological goal "the pursuit of precision." Landes, *Revolution in Time: Clocks and the Making of the Modern World*, rev. ed. (Cambridge, Mass.: Belknap Press of Harvard University Press, 1983), 98.

[3] Robert Drullinger, an atomic clock designer for the National Institute of Standards and Technology, describes this hierarchy in Gary Taubes, "A Clock More Perfect Than Time," *Discover*, December 1996, 70.
[4] Much of what follows here is derived from a history of the modern electronic wristwatch we have in progress. Our work examines the invention process, consumer interaction with the invention process, and what happened to the way watches were sold and repaired with the coming of quartz watches. For portions of the story published to date, see Carlene E. Stephens, *On Time: How American Has Learned to Live by the* Clock (Boston: The Bulfinch Press of Little, Brown, 2002; Carlene Stephens and Maggie Dennis, "Engineering Time: Inventing the Electronic Wristwatch," *British Journal for the History of Science* 33(2000): 477-97; Maggie Dennis and Carlene Stephens, "Giving Time a New Face: Digital Watch Displays and Changing Perceptions of Time" (paper presented at the annual meeting of the American Historical Association, Boston, January 2001); and Maggie Dennis, "Wrist Computer and Babe Magnet: Masculinity and the Origins of the Digital Watch" (paper presented at the annual meeting of the Society for the History of Technology, Munich, August, 2000).
[5] Hamilton Pulsar watch, National Museum of American History (NMAH) catalog. no. 1994.0354.02.
[6] Hamilton trade literature, "Pulsar, the Time Computer," NMAH, History of Technology Division files.
[7] See Seiko Astron wristwatch, NMAH catalog no. 1998.0248.01, and Beta 21 module, NMAH catalog no. 1999.0294.01.
[8] Hamilton trade literature, "Pulsar, the Time Computer," NMAH, History of Technology Division files.
[9] How this happened is a matter of contention. As Bergey remembers it, Electro-Data's contract ended at this point. But Richard Walton and Willy Crabtree recall they continued to work together toward the commercial product. John Bergey interview with authors, Lancaster, Pennsylvania, 29 October 1998, 17; Richard Walton interview with authors, Tempe, Arizona, 7 January 1999, 15; Willy Crabtree interview with authors, Dallas Texas, 3 June 1999, 19; *Wall Street Journal*, 4 April 1972, 9. See also Hamilton Pulsar watch, NMAH catalog no. 1994.0354.02, and Hamilton Pulsar modules NMAH catalog nos. 1994.0354.01 and 1999.0030.01.
[10] Quoted in Angela Taylor, "A Watch That Takes the Hard Time Out of Telling Time," *New York Times*, 21 July 1973, 21.
[11] Tony Bennett and Janet Woollacott, *Bond and Beyond, The Political Career of a Popular Hero* (New York: Methuen, Inc., 1987), 198.
[12] See for example, William J. Friedman and Frank Laycock, 'Children's analog and digital knowledge', *Child Development*, April 1989, 357-67.
[13] "GH Institute's Complete Guide to Digital Watches," *Good Housekeeping*, May 1976, 192.
[14] Hamilton, for example, well before the Pulsar, had styled itself the watch of railroad accuracy and then airline accuracy.
[15] *The Market for Watches and Clocks* (New York, 1992), 1, 86.
[16]Ruth Schwartz Cowan, "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology," in *The Social Construction of Technological Systems*, eds. Wiebe Bijker, Thomas Hughes and Trevor Pinch (Cambridge, Mass.: MIT Press, 1987), 261-280; Nelly Oudshoorn and Trevor Pinch, eds., *Why Users Matter: The Co-Construction of Users and Technology*, eds. (Cambridge, Mass.: MIT Press, 2003), 16-17.