The Rise of Silicon Valley: From Shockley Labs to Fairchild Semiconductor
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Introduction

Most people know that Fairchild Semiconductor spawned many semiconductor companies (including Intel, National Semiconductor and AMD) in what was then known as Santa Clara Valley. But how many are aware that the predecessor company was Shockley Labs – the Valley's first semiconductor company? Or that Bob Noyce and Gordon Moore worked there, and were two of the eight Shockley Labs "renegades" who left in 1956 to found Fairchild Semiconductor (a division of Fairchild Camera and Instruments)? Or that those eight dissidents wanted to develop advanced transistors, while William Shockley (who co-invented the transistor while at Bell Labs in 1947) was zealously focused on creation of a multi-layer diode for potential use in cross-point telephone switches?

These and other themes were discussed in an enlightening and lively panel session at the Computer History Museum in Mountain View, California on Feb. 27, 2006. Physics and technology historian Michael Riordan moderated the session. Panelists were early Shockley employees Jim Gibbons, Jay Last, Hans Queisser, and Harry Sello.

Opening Remarks

Mountain View mayor **Nick Galiotto** stated that February 2006 marked the 50th anniversary of Shockley Labs, which was founded in Mountain View – the "birthplace of Silicon Valley."

Executive Director & CEO **John Toole** said that the mission of the museum was "to share the talents, stories and histories of computing." He invited the public to visit the museum's exhibits and to take a virtual tour of computing via the museum's Web site. Toole also issued a call for participation in the museum's Semiconductor Special Interest Group (SEMI SIG), which will be expanding its activities in the next few years.

Michael Riordan told us that Shockley's invention of the junction transistor in 1951 was more commercially significant then the invention of the first, or "point-contact" transistor in 1947. The junction transistor was made of germanium and looked like a sandwich, with two layers of n type of semiconductor surrounding a layer of p type semiconductor between them. The previous "junction" transistor used tiny wires delicately positioned on the surface of a germanium crystal, analogous to the "cat whisker" tuning circuits of early crystal radio sets. As anyone who has built such radio sets knows, "tuning" is as much black magic as science. It was Shockley's groundbreaking work in the theory of the junction transistor that revolutionized the field and laid the groundwork for production of the junction transistor we know today, moving transistors away from laboratory curiosities to mass-produced devices.

Shockley, together with Caltech alumnus Arnold O. Beckman (founder and CEO of Beckman Instruments) founded Shockley Semiconductor Laboratory on Feb. 13, 1956. The venture was established in a former fruit-packing shed at 391 San Antonio Road, Mountain View, as a research division of Beckman Instruments. Well known as the most important figure in semiconductor physics, Shockley was able to recruit top physicists, chemists, metallurgists, and electrical engineers to his new company. To his consternation, eight dissidents left to found Fairchild Semiconductor on September 19, 1957. Fairchild developed and perfected "planar" technology – in which the various positive and negative regions of a transistor are formed by forcing chemicals under pressure into areas exposed according to a mask. This supplanted the "mesa" technology of the day and is the basis of today's integrated circuits. While Fairchild developed and extended new forms of the transistor, Shockley Labs continued to work on multi-layer diode technology until it closed down in 1966.

Panelists' Prepared Comments

(Bios of the panelists are at: http://www.computerhistory.org/events/index.php?id=1138162360)

Jay Last began working as a physicist at Shockley Labs in December 1955 (before Shockley Labs was officially formed). By the end of February 1956 there were 12 employees, which grew to 23 by the spring of that year. Hardly anyone had experience with semiconductor diodes, let alone using silicon as a fabricating material. Shockley maintained a close relationship with Bell Labs, especially in the subject areas of impurity diffusion and oxide masking. Last learned about the theory and design of semiconductors while working at Shockley Labs. He was not necessarily interested in diodes as was the rest of the company. Two key decisions shaped the kind of work undertaken at Shockley Labs:

1. The use of silicon as the principal semiconductor material
2. The use of diffusion technology to make the semiconductor devices

In September 1957, 18 months after the inception of Shockley Labs, the group of eight founded Fairchild Semiconductor and transformed themselves from research scientists to production engineers. Most importantly, they needed to make diffusion a reliable production process. Fairchild delivered its first transistors, to IBM, in August 1958 – after only 45 weeks in business. Last expressed "a great depth of gratitude to Bill Shockley for getting Silicon Valley started," even though Shockley never talked to him again after he left to co-found Fairchild.

Harry Sello started as a chemist at Shockley Labs in April 1957 and joined Fairchild two years later in April 1959. He then remained a Fairchild employee for 22 years. Sello stated he was a physical chemist – one who "boils pots and understands what he is boiling." His first job at Shockley Labs was to find a substitute for the "black wax" that was used in masking semiconductors (the effort was a failure). After that, he became an assistant to Bob Noyce. Sello noted that Shockley had an uncanny intuition about semiconductor device physics, something heard repeatedly from those who worked with Shockley, and that he was usually capable of defining the "definitive experiment" because of such intuition.

Jim Gibbons joined Shockley Labs as an electrical engineer in August 1957 (one month before the exodus of the eight dissidents), while teaching half-time as an assistant professor at Stanford. Gibbons stated that in the next four years he learned a tremendous amount from Shockley. Bill Shockley made a significant contribution to the Solid State Laboratories at Stanford University, according to Gibbons. He was full of suggestions for building those labs, while continuing to write relevant scientific research papers. Shockley developed quantitative models, which captured the essence of semiconductor physics. "He knew what had to be done and how to do it."

Hans Queisser was born in Berlin, Germany. He joined what was then renamed the Shockley Transistor Corporation in October 1959 and remained there through 1963. He worked on two principal projects there:

1. A multi-cell solar battery
2. Identification of the best material and maximum criteria for a solar cell (more theoretical)

He and Shockley co-authored a paper in the *Journal of Applied Physics* (Vol. 32, 510, 1962) on the efficiency of solar cells, which is now considered a key contribution in this field.

Queisser described Shockley as "an impatient genius – the Moses of the Silicon Valley who showed us the way to the Promised Land, but didn't reach it himself."

Panel Discussion led by Riordan

1. Riordan: How did Shockley's personality influence the course of events at Shockley Labs?

Harry Sello responded: Shockley looked at everything analytically. He was so concerned with making four-layer pnpn diodes (targeted at electronic switching systems being developed by the Bell System) that he frequently disappeared from view. Shockley's attention span was not good, so Sello could not depend on him for much guidance and often worked by himself or with a few others such as Sam Fok and C. T. "Tom" Sah before they left Shockley Labs for Fairchild in 1959.

2. Riordan: Why did the group of eight leave Shockley Labs to form another company?

Jay Last said that Shockley wanted to focus on the four-layer diode, while the group of eight wanted to make transistors, which is what they originally signed up to do. Shockley was focused on research versus development. He was so caught up in research that he sometimes neglected getting product developed and out the door.

Jim Gibbons opined that Shockley was more concerned with his won reputation as a pre-eminent researcher and scientist. Focus was not his strong point. He often flip-flopped between writing important research papers and developing commercially viable products.

Hans Queisser had the "utmost respect" for Shockley's scientific nature in approaching practical problems. However, there was a certain tragedy in this. Doing "good science" did not in any way guarantee having a profitable company. Shockley had a sense of what was conceptually beautiful and wanted his name carried as an original inventor.

The original goal of Shockley Labs – making diffusion-based transistors – was not a significantly challenging proposition for Shockley. He was more interested in development of a bi-stable pnpn diode for use in a telephone cross point switch. He would've been the only one in the world making this four-layer diode at high yield and low cost. According to Queisser, Shockley had "brain lock" on this initiative.

Jim Gibbons said that Shockley was devastated when the group of eight left. His interactions with him at that time were very intense. Shockley was concerned about re-establishing a team as good as the Fairchild defectors. He was a fierce competitor, who several times remarked, "We're going to beat those guys." Gibbons said that Shockley was so upset with the group of eight dissidents that he called them "traitors."

Queisser stated that it was ironic that Shockley's Nobel Prize was for inventing the transistor, but he did not win any prizes for his work on the pnpn diode. (There was a question later in the session about the Nobel Prize. It was awarded explicitly for the invention of the transistor – not the junction transistor. Shockley was included in the prize for leading the Bell Labs research team and for his own work on inventing the junction transistor.)

3. Riordan: What cultural impact did Shockley Labs have on the high-tech workplace?

Despite Shockley's authoritarian management style, an egalitarian approach to doing scientific and technological work began to emerge at Shockley Labs. This was especially evident among the eight dissidents who later left to found Fairchild Semiconductor, where that work style flourished. There were no set work hours at the Labs; whatever had to be done, got done during anytime of the day or night. (Riordan thought that this reflected what was actually happening at that time, but the panel did not have enough time to sufficiently explore the work ethic and culture.)

While it would have been informative to get more opinions on this important question, it was 8:45 p.m. and past the scheduled ending time. The session had lasted 1:45 minutes and was officially closed by Riordan.

Footnote: The eight dissidents that left Shockley Labs to found Fairchild Semiconductor in 1957 were Julius Blank, Victor Grinich, Jean Hoerni, Eugene Kleiner, Jay Last, Gordon Moore, Robert Noyce, and Sheldon Roberts. Their goal was to make silicon transistors (at the time, germanium was the material of choice). Over subsequent decades, Fairchild spawned scores of spin-offs that helped create the semiconductor and high-tech industry in Silicon Valley. Noyce and Moore later started Intel as a semiconductor memory company and became worldwide icons.

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