

Robert Noyce:  
A Man and His Invention

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An Essay  
Presented to  
the California Pioneers  
of Santa Clara County

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## Preface

With the advent of the chip in 1959 mankind took a giant step onto the road of "El Dorado". The "monolithic idea" had finally come to roost in two brilliant minds of the semi-conductor industry. Jack Kilby of Texas Instruments was the first to conceive and develop the integrated circuit, otherwise known as the chip. But Robert Noyce came up with a version on his own, just a few months after Kilby introduced his to his colleagues at T.I., that was even more efficient and practical. Today, both men are recognized for contributing to the invention, of the chip, but for a decade following the chips introduction a battle in the courts brewed. Each side sought control of the patent rights to the integrated circuit. Three years before the courts came up with a decision, Fairchild and Texas Instruments granted each other full patent rights.

From 1959 to the present day, the chip has revolutionized our living conditions, for in the households of millions of Americans a person can find an integrated circuit in virtually every electronic component.

Robert Noyce is truly a man who has changed mankind's future. His management ideas are still being used as guidelines for running new semi-conductor companies. His integrated circuit has launched mankind onto "The Second Industrial Revolution" and can be found in virtually every household item. And lastly, Noyce's leadership qualities were probably one of his most important contributions to the

world. Without his leadership, it is possible that  
Fairchild or Intel may have never become the flagships of  
Silicon Valley.

## Noyce's Beginnings

On December 12, 1927, Ralph and Harriet B. Noyce had their third son, Robert N. Noyce. The Noyce family had moved quite often during Noyce's childhood, but they finally settled down in Grinnell (a small rural town in Iowa). In 1948, the year Noyce was introduced to the transistor, there was still some people left that knew the founder of the town, Josiah Grinnell.

Robert Noyce was considered to be one of the most brilliant students at Grinnell High School. But his experiments with nitroglycerin and old motors caused many townspeople to be very wary of his activities. By the time, Noyce was a senior in High School, Grant Gale, a professor of physics at Grinnell College, began to notice the brilliance Noyce exhibited. Gale subsequently urged Noyce to enroll in his freshman physics course at the local college. After Noyce graduated from High School in 1944, he enrolled in a full college course at Grinnell College.

During Noyce's years at Grinnell College, he became one of Gale's star pupils and the most tireless worker. But despite his obvious grasp of the sciences, Noyce turned out to be an extremely well-rounded student. As well as being the star diver on his college swim team, he sang in choral groups, played the oboe, and was an actor in the college dramatic society. Noyce was also a leading man on a local radio soap opera.

Life at Grinnell was going smoothly for Noyce until he

and a couple of his friends decided to have a Luau, which had been popularized by the War in the South Pacific in World War II. The main course at their Luau was going to be a roast pig, but the problem was they didn't have a pig. So Noyce, because of his build, and another participant were sent to a farm just outside of Grinnell to steal a pig. They arrived back safely with a twenty-five pound pig. But when morning came Noyce and his accomplice had a change of heart and decided to go back to the farm and confess that they stole the pig. This sense of morality displayed by the two, although sincere, did not impress the farmer. He urged the sheriff to press charges against Noyce and the other boy.<sup>2</sup>

There wasn't much Noyce's father could do to help his son since he was obviously involved. But Grant Gale was a well-respected third party, and he negotiated a compromise with both the police and the school. The compromise was a semester suspension from the school. During that semester Noyce's parents arranged a job for him at Equitable Life in New York.

Upon Noyce's return to his studies at Grinnell, Grant Gale was further impressed by how confidently he returned. In only three years at Grinnell, Noyce had accumulated so many credits that he only needed this last semester to graduate with the senior class of 1949.

In 1948, Grant Gale had noticed an article in the paper explaining a new invention developed by Bell Labs. But what caught Gale's attention was not the invention, but the man

involved in inventing this "item", the transistor.<sup>3</sup> At the time of the invention, the transistor was only considered as a novice item. The name Gale had recognized was John Bardeen. Bardeen had been a classmate of his at the University of Wisconsin where both had majored in electrical engineering.

When Gale saw the article, he immediately wrote to Bardeen and Oliver Buckley asking for some transistors to set up a course study at Grinnell. Oliver Buckley was the president of Bell Labs and a graduate from Grinnell. The request was granted and Grinnell College became the first educational institution to offer a course in solid-state electronics. Solid-state electronics dealt with the effects of electrical currents passing through solids. One of the early recipients of this breakthrough course was Robert Noyce.

After Noyce graduated from Grinnell with a B.S. in physics in 1949, he went to Massachusetts Institute of Technology to begin his graduate work. But he was crestfallen when he discovered that they did not offer a course in solid-state electronics. Noyce then settled for a course in "Photo electric study of Surface States on Insulators" which was at best a background course to the solid-state course. So, for four years, Grant Gale remained as the only person Noyce was able to exchange notes with about the transistor.

## Shockley and Fairchild

Following Noyce's graduation from MIT, in 1953, Bell Labs, IBM, and RCA offered him jobs at their research labs. Although MIT had not realized the implications the transistor could be applied to until 1953, companies like IBM and RCA were anxious to get upstart engineers with Ph.D.'s like Noyce to work in their research labs.

In 1953 Noyce ended up accepting a job offer from Philco, an upstart company. At first the job seemed to be exactly what he wanted, a new company with a chance of rapid advancement. Instead, it became a huge letdown. Philco was only interested in building transistors that would maintain its competitiveness with RCA and GE. So when William Shockley, the co-inventor of the transistor, offered him a job at his research lab at Palo Alto, Noyce immediately accepted. In 1956 Noyce resigned from Philco and moved his family to what is now Silicon Valley to start work at Shockley Semi-conductors.

Noyce had met his wife, Elizabeth Bottomley, when he started to go over to Tufts College in the summer of 1953 to sing and act in musicals presented by the college. At that time Elizabeth was a costume director from Barrington, Rhode Island. She had just graduated from Tuft's College with a degree in English. Then in the following fall Noyce and Betty were married and by 1956 they had two children. Bill was only two and Penny was barely six months old when they had moved.

For the first few months at Shockley Semi-conductor, Noyce and the other engineers had a great time being able to do pure research. But the atmosphere soon deteriorated because Shockley always treated his employees as little children and never trusted them. He was always accusing his employees of being spies, until one day seven of the engineers decided to pull a defection from Shockley. These seven defectors realized that very little capital was needed to start up a semi-conductor business. All the equipment that was really needed consisted of a shack big enough for worktables, some goggles, kilns, microscopes, tweezers, diamond cutters, and either silicon or germanium which came from coal and dirt. This concept, conceived by these seven defectors, would make the young semi-conductor business as wild as show business.

The seven, now determined men, took this idea to Wall Street to seek some financial backing. While searching, they encountered a problem. What they hadn't thought of was who would lead the group? Immediately they contacted Robert Noyce and asked him to join them. Noyce agreed. He was their obvious choice because in the report cards that Shockley made everyone do, Noyce always received the highest marks. These reports were given by his peers.

The eight defectors then met with Arthur Rocke of Hayden Stone to discuss what their plans were and how much money they needed. After contacting twenty-two firms, Arthur got Fairchild Camera and Instrument Company to back the eight defectors from Shockley. In the deal, the

original Fairchild company would be allowed to buy Fairchild for three million dollars within eight years of the start up.

Fairchild opened their doors in 1957 on Charleston Ave. in Mt. View, just twelve blocks from Shockley's company. From the start Noyce, serving as the Director of Research, displayed his distaste for the traditional style of management which had its birthplace on the East Coast. Noyce detested the social classes developed by the CEO's and Vice Presidents. He was disgusted by the beauracracy and feudalistic behaviors of management. So when Noyce had the chance to manage a company from its beginnings, he was determined to try to create a democratic atmosphere where even the lowest engineers could speak up and share their ideas. He encouraged his employees to take on the responsibility of going on their own or questioning an authority like himself.

## The Integrated Circuit

In the early 1950's the engineering community faced a problem that could possibly halt their recent advances with the transistor. This problem was referred to as "the interconnections problem", "the numbers barrier", or "the tyranny of numbers".<sup>4</sup> This problem had surfaced among the minds of engineers but had not yet been introduced to the public. Americans were looking forward to the advances predicted by Hollywood and science-fiction writers. But this new era of miniaturization would not come, if this problem was not solved.

Every facet of the engineering community from all over the world was in a race to create a solution to the tyranny of numbers. But all of them except two engineers pursued the problem the wrong way. At Texas Instruments in Dallas, the top engineers tried to develop "Micro-Modules" to solve the problem. The modules would be built with the same size and shape and the capability to be snapped together to form a complete circuit. Jack Kilby who was a newly arrived engineer at the company disliked the concept from the very start.

Kilby believed that the "Micro-Modules" were a complete flop and useless. The flaw, Kilby recognized, in the modules was that it didn't solve the actual problem. What it could do was to make connecting the circuits, transistors, capacitors, resistors, and diodes a much easier process. But that would still leave an enormous amount of

connections.

When Kilby's colleagues left to go on their yearly vacations in July of 1958, he was determined to seek an alternate solution to the tyranny of numbers that would be more beneficial. By 1958, it was already known that silicon could be made to perform as transistors and diodes if they were contaminated with the proper impurities. Kilby puzzled over the problem and then finally realized the solution. If silicon was not mixed with impurities, it would act like an insulator thus being a resistor. And if he could utilize the P-N junction (the line between the positive and negative sides of a contaminated piece of silicon) to create a capacitor, it could be possible to build an entire circuit on a single piece of silicon. A capacitor is a device that is able to store electric current. This solution first conceived by Jack Kilby would soon be known as the "Monolithic Idea".

A few months later Noyce who was still at Fairchild in 1959 came up with the same principle solution. But Noyce's design was much more practical because it used the "planar process". This made it possible for Noyce to print copper connections between the components. The "planar process" was developed by Jean Heorni, one of the original defectors from Shockley. It was originally used to protect the transistors from further contamination. The process employed a silicon oxide to coat the transistor.

During the court fight, which began in May of 1962, for the full patent rights to Kilby and Noyce's invention of the

integrated circuit, Texas instruments and Fairchild Semi-Conductor argued vigorously for their engineer's behalf. But the "planar process" made Noyce's version more practical, and thus the courts granted Fairchild and Noyce full patent rights in 1969 even though Kilby was first to perceive the "Monolithic Idea". But, because Fairchild and Texas instruments granted each other full rights to the integrated circuit or the chip three years before the court's decision, the engineering community did not drastically change. Nonetheless, historians give credit to both Noyce and Kilby for the invention of the integrated circuit.

## Intel and Noyce's Legacy

During the time Noyce was at Fairchild many of the employees pulled defections that were similar to his. Even Jean Heorni, and three other engineers from the original eight defectors from Shockley pulled a redefection. They formed the company Teledyne. The concept developed by the original seven defectors was now known as "Defection Capital". After things quieted down it wasn't a surprise to find more than fifty companies that were started by defections from Fairchild. These defections were what metamorphosed the rural Santa Clara County into "The Silicon Valley". Even the state of California recognized this boom into Silicon Valley by building "Route 280". Because of these defections the news of Robert Noyce and Gordon Moore, two engineers from the original eight defectors, leaving Fairchild received a muffled surprise by the engineers in Silicon Valley, who were used to this kind of news.

In 1959, Fairchild's namesake in New York exercised their right to buy Fairchild for three million dollars. Following the buy-out, Noyce became severely frustrated because he had to dress in a suit and fly to New York for meetings to update the heads of the company as to what was going on over in Silicon Valley every so often.

In frustration, Noyce and Moore left Fairchild to start up a new company, Intel. To receive backing, Noyce and Moore contacted Arthur Rocke and explained to him their situation. After their conversation, Rocke rounded up two

and a half million dollars in backing and an extra 300,000 dollars from Grinnell College. Noyce had been a member of the board of trustees at Grinnell since 1962. Noyce and Moore also put up 500,000 dollars of their own money into the company.

In 1968, Noyce and Moore opened the doors of their new company, Intel at 3601 Juliette Ave. in Santa Clara. They realized that with the integrated circuit having been introduced for almost a decade, no one had yet to use the idea of the circuit to replace the large memory ringlets widely used. In the first two years of their start-up, Intel focused on producing a memory chip which they premiered in 1970. The 1103 Memory Chip contained 4,000 transistors and was able to do the work of thousands of ringlets. With the help of the 1103, Intel increased its revenue from 3,000 the first year to 23.4 million dollars four years later. The following year they nearly tripled their revenue to sixty six million dollars.

But the good fortunes of Intel didn't stop with the 1103 memory Chip. In 1970 Ted Hoff, a thirty two-year old engineer at Intel, invented the microprocessor. It would later be known as a "computer on a chip" because it was able to do all the arithmetic and logic functions of a computer. What made the microprocessor so amazing was that it was only the size of a tack.

Noyce took the accomplishment by Ted Hoff and used it as an example of his beliefs. He believed that in such an environment where social classes were non-existent and where

any person was allowed to speak out against even the co-inventor of the integrated circuit, ideas would flourish and produce results such as the microprocessor.

Up until the late 1970's, American semi-conductor businesses were not stressed over any foreign competition, especially from Japan. At the start of the recession in 1973 companies began to slow down production to sustain a stable profit margin. But after the recession ended in 1976, when the economy roared back, many semi-conductor firms could not supply the amount of chips that computer companies demanded, due to their slow down in production during the recession. Because of the lack of production of the much needed chips, computer companies began looking toward Japan for their memory chips. To the surprise of many American firms the Japanese competitors had amazingly higher quality chips than their American counterparts. So they began to buy more and more of their chips. This news propelled many semi-conductor firms to reorganize their production line to stress quality control rather than increases in production. Also, since the Japanese began to gain a considerable amount of the world market, the semi-conductor industry formed the SIA, the Semi-conductor Industry Association, "to fight off the foreign challenge".<sup>5</sup> In 1983 they chose Robert Noyce as their spokesman. Noyce's job was to present the status of the industry week after week at hearings, seminars, conventions, and press conferences all over the country. Besides being the SIA's spokespeson, Noyce was also elected in 1983 to be the

president of Sematech, a company created by the government to boost American competition in the world market of chips.

Noyce had lived a private life in that he never drew publicity. He was rarely seen on the front page of the paper, but occasionally might be mentioned in an article in the business section. Noyce didn't live in a mansion out in the countryside but rather in a Los Altos house he had bought in 1960, following the Fairchild buyout. Besides spending a fortune on landscaping, he spent little to nothing for his house.

Noyce loved letting his "hide hang out" while cruising around in his Porsche, but most of all he loved taking risks. Whether on his plane, a 1947 Republic Seabee, or hanggliding with his daughter, he loved living on the edge.<sup>6</sup>

In 1974, he and his wife, "Betty", of twenty-one years were divorced, a situation many engineers faced in Silicon Valley. Following their divorce Betty sold her half of their Intel Stock for six million dollars which shookup Intel's stock for a while. She then moved to a village off the coast of Maine. Noyce kept the house in Los Atos. Within one year after the divorce, Noyce intramarried with a thirty-seven-year old personnel director at Intel. Her name was Anne Bowers. "Intramarried" is a term used to describe a marriage within one's own field of employment.

When Sematech, a company created to increase U.S. competition in the World Market of Microchips, was looking for a president, they naturally turned to Noyce. Noyce had

begun a gradual trend out of the labs and into management right after he solved the tyranny of numbers with the integrated circuit.

Within Noyce there was a certain confidence and composure that made the people around him look toward him for leadership. It was the same kind of confidence Grant Gale had observed while Noyce was at college. The reason for this compelling force to trust him wasn't his confidence, but his attitude toward others around them. He demanded their best and they gladly gave it to him. Noyce tried his hardest to create a community at both Fairchild and Intel. He wanted a community with thinkers free to think and without the bothers of a beauracracy. Noyce eliminated the social classes within his companies and urged others to question his ideas. And he eliminated the feudalistic management of CEO's and vice presidents poduced by the East Coast. These were the management ideas that brought companies like Intel into the forefront of technology.

Robert Noyce died on June 3, 1990, at Seton Medical Center, seventeen years after relinquishing day to day command of Intel. The Semi-conductor industry was truly saddened and shocked by the unusually vibrant sixty-two-year old's death. News coverage remained at a minimum.

If Robert Noyce could be measured by how his invention impacted the world, the measurement would surely be high. But if he was measured by how he touched and encouraged people to pursue their dreams, the measurement would surely

be incalculable by any computer.

The integrated circuit has now been among us for over thirty years. And within that time mankind has used it to send satellites clear across the solar system, and ourselves to the moon. Most of all mankind has used the integrated circuit on a daily basis for practically everything from coffee makers to space shuttles. Wherever one walks, he or she may find an integrated circuit.

## Notes

1. T.R. Reid, The Chip: How Two Americans Invented the Microchip and Launched a Revolution (New York: Simon and Schuster, 1984), p. 23.

2. Tom Wolfe "The Tinkerings of Robert Noyce," Esquire, (December, 1983), p. 347.

3. Ibid, p.348.

4. Reid, Op. Cit., p. 10.

5. Ibid, p. 174.

6. Wolfe, Op. Cit., p. 371.

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