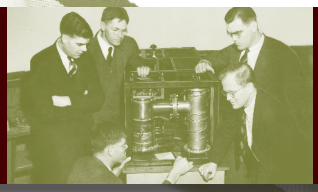
Russell and Sigurd Varian

Inventing The Klystron And Saving Civilization



In today's semiconductor-driven world, it's easy to forget just how essential vacuum tubes were to electronics—and everyday life—during the middle decades of the 20th century. How essential? Well, it's no exaggeration to say that one particular type of tube played a crucial role in saving Western civilization.

During the early days of World War II, German U-boats ruled the North Atlantic, attacking and sinking ships almost at will. The British had a new technology, called RADAR (RAdio Detection And Ranging), that could spot U-boats lurking in the waves. But they couldn't make the hardware small and light enough to use in fighter planes. Fortunately for the British, and posterity, Sigurd and Russell Varian had a solution.

UNIQUE INDIVIDUALS

The Irish-American Varian brothers, who grew up in Palo Alto and Halcyon (near San Luis Obispo), California, were a decidedly unmatched set. The elder Russell (1898-1959) was dyslexic at the time when the condition was little understood, meaning that most of the people close to him thought he was either "slow" or downright stupid.

Yet while Russell was a slow learner, he wasn't unintelligent. More than anything else, he was a hard worker. It was through sheer force of will that he managed to graduate from Stanford with BS and MS degrees in physics.

The younger brother, Sigurd (1901-1961), was gregarious, inventive, and adventuresome. Most of all, he was too impatient to spend countless hours in classrooms and study halls working toward a degree. Sigurd attended California Polytechnic for a time, but dropped out to tinker on cars, experiment with airplanes, and take flying lessons. He never earned a college degree.

Despite their differences, the brothers were close and very focused on advancing their respective careers. Russell found employment in San Francisco with television pioneer Philo Farnsworth. Sigurd, meanwhile, began a career in aviation that included barnstorming and, eventually, a job as a Pam Am pilot, blazing new routes into Mexico and South America.

WAR CLOUDS

By the mid-1930s Sigurd, like millions of people worldwide, was becoming increasingly alarmed by German acts of unprovoked aggression in Spain and elsewhere. "He felt that Hitler could easily establish bases in Central America, from which his planes could fly into the United States at night, or at low elevations, and drop bombs, without ever being detected," recalled Ed Ginzton, who worked closely with both brothers, in a 1990 interview republished in the book *The Tube Guys*, by Norman H. Pond (2008, Russ Cochran).

Sigurd felt that he and his brother could do something to help counter the growing threat. While discussing the gloomy situation in Europe with Russell, he proposed that they jointly develop a radio-based technology that could detect airplanes at night or in clouds. Russell agreed, and they immediately began developing a plan, innocent of the fact that British engineers were already developing the top-secret RADAR technology.

The brothers quit their jobs and moved back home to Halcyon. Once there, relying on Russell's theoretical and technical knowledge, and Sigurd's mechanical abilities, they began developing plans for a device that could detect a signal bounced off of an airplane several miles away.

Such a technology would need to generate short and powerful radio waves, capable of focusing on a single aircraft. No such device currently existed, but one soon would. It would be called the klystron, and the Varians would invent it.

INVENTING THE KLYSTRON

While the brothers had a general idea of where they were headed with their radio-detection research, progress was slow. Working in self-imposed seclusion, the Varians were unable to bounce ideas or problems off of colleagues. To pick up the pace, Russell suggested they reach out to his former Stanford roommate, Bill Hansen, who was now a physics professor at the university. Sigurd agreed and Hansen was brought into the loop.

Hansen's input proved invaluable. Most importantly, he brought the brothers into the Stanford community and, in 1936, to the attention of physics department chief David Webster as well as other university leaders. The Stanford researchers

WORKING TOGETHER TO SAVE THE WORLD

In the photo, physicists Sigurd Varian, David L. Webster, W.M. Hansen (standing, left to right), and Russell Varian (seated) team up with builder John R. Woodyard to build the klystron at Stanford University. *(courtesy of Stanford News Service)*

saw promise in the Varians' plans and offered them a not-so-generous deal.

"They would be allowed to work on their inventions, with the understanding that they would be given one room and $100 a year for supplies, and that the university would get half the royalties from any patents that they might obtain," Ginzton recalled.

The brothers still didn't exactly know how they were going to create a radio tube that could generate powerful signals at very short wavelengths, but at least they now had some formidable support resources on their side.

Numerous designs were tested and rejected over the following months. The "eureka moment" came when Russell devised a method for controlling electron speed that could allow them to flow in bunches. The "velocity modulation" approach was an entirely new electronics principle. Most importantly, when packaged in a new type of tube—the klystron—it supplied the signal and wavelength characteristics they were looking for.

"It was a triumph for Sig, who had pushed to get the project started and worked so hard to complete it," wrote Dorothy Varian, Russell's wife, in her book about the brothers, *The Inventor and the Pilot* (1983, Pacific Books).

The *Palo Alto Times* of Jan. 30, 1939, reported Stanford's klystron announcement in a front page story with a headline that at the time probably seemed like a prime example of journalistic hyperbole: "New Stanford Radio Invention Heralds Revolutionary Changes." Yet looking back at the headline now, with the help of six-plus decades of microwave communications hindsight, it reads almost like an understatement.

The klystron proved to be the key to practical microwave-based radio detection, and RADAR system developers in the U.S. and Britain quickly embraced the device. The compact tube enabled RADAR developers to create systems that were light and compact enough to fit into aircraft, including the North Atlantic fighters targeting U-boats.

VARIAN ASSOCIATES

While RADAR was the klystron's first and most important application, additional uses were soon found in other technologies, including microwave communications, particle accelerators, and even some early microwave ovens.

To exploit the klystron's commercial and military possibilities, and to investigate promising new microwave tube technologies, the Varians, Hansen, and Ginzton founded Varian Associates in 1948. The company's initial accommodations were hardly luxurious—a one-floor building, measuring 30 by 40 feet, on an unpaved street in San Carlos.

As in the past, the brothers divided their work responsibilities. "While Sig solved technical problems, Russell directed his attention to the more theoretical aspects of their contracts," wrote Dorothy Varian. The company gradually built up an extensive customer base.

"At the end of the company's first 10 years, Varian Associates occupied several large buildings in the Stanford Industrial Park; more than 1300 people were employed; annual sales were $20,000,000; and earnings were expected to reach $1,000,000 for the first time," Dorothy Varian wrote.

For the brothers, however, the end was near. Russell succumbed to a heart ailment in 1959 while he was visiting Alaska. Two years later, Sigurd fatally crashed his private plane while he was attempting a landing near his home in Puerto Vallarta, Mexico.

THE LEGACY

Varian Associates would continue to grow and prosper without the brothers. In 1995, the company spun off the business unit that included the Varians' electron device business. The new firm, Communications & Power Industries, continues to produce microwave devices.

Then, after over 50 years of cutting-edge technology development, Varian Associates dissolved. In 1999, the company split into Varian Inc. (scientific instruments), Varian Semiconductor (ion implantation equipment), and Varian Medical Systems (x-ray tubes and medical equipment).

Microwave tubes continue to be a highly viable—even robust—technology, although some observers predict that solid-state devices eventually will replace the components. Yet in whatever ways microwave technology evolves over the upcoming decades, the electronics industry—as well as proponents of Western civilization—owe a tremendous debt to the Varian brothers. **ee**