INVENTION AND INVENTORS: In Paris, shortly after World War II, two German scientists, Hubert Mataré [left] and Heinrich Welker, invented the “transistor,” a solid-state amplifier remarkably similar to the transistor developed by Bell Telephone Laboratories at about the same time. In this X-ray image of a commercial transistron built in the early 1950s, two closely spaced metal point contacts, one from each end, touch the surface of a germanium slice. A third electrode contacts the other side of the slice. Mataré is now retired and living in Malibu, Calif.

HISTORY

The most important invention of the 20th century was conceived not just once, but twice

HOW EUROPE MISSED THE TRANSISTOR

BY MICHAEL RIORDAN
shortly after Bell Telephone Labs announced the invention of the transistor, the surprising reports began coming in from Europe. Two physicists from the German radar program, Herbert Mataré and Heinrich Welker, claimed to have invented a strikingly similar semiconductor device, which they called the transistron, while working at a Westinghouse subsidiary in Paris.

The resemblance between the two awful contraptions was uncanny. In fact, they were almost identical! Just like the revolutionary Bell Labs device, dubbed the point-contact transistor, the transistron, while working at a Westinghouse subsidiary in Paris, developed them independently, he confided in a 14 May letter to the French Téléphones (PTT), the ministry funding Mataré and Welker’s research, announced the invention of the transistron to the French.

The two metal points (chercheurs) connected the surface of a germanium crystal (cristal). A technician adjusted the positions of the two contacts to give the proper electrical characteristics, while viewing them through a window (fenêtre). The interface structure is similar to Bell Labs’ first prototype, which is shown in the picture produced in 1948.

In January 1944, the company shifted much of its radar research to Breslau in Silesia (now Wroclaw, Poland). Mataré worked there until the end of the war, when he fled to England, had given Mataré and other radar researchers a much better understanding of what was being done. As the war ground on, the leaders of the Berlin-based German electronics industry, which had served as an open-cockpit fighter pilot in World War I, was hastily abandoned, and all of Mataré’s lab books and records were burned to keep them out of enemy hands. The group attempted to reconstruct its R&D program in central Germany, but the U.S. Army terminated this effort when it swept through in April 1945, mercifully sending Mataré home to rejoin his family in nearby Kassel.

At the time, German radar systems operated at wavelengths as short as half a meter. But the systems could not work at shorter wavelengths, which would have been able to discern smaller targets, like aircraft. The problem was that the vacuum tubes, which rectified current in the early radar receivers could not function at the high level of impurities in the available samples. When for-}

By varying the voltage on one he could influence the current from the other—a phenomenon he dubbed “interference.” It seemed as if one of his points could affect a region extending far beyond the narrow barrier layer predicted by Schottky’s theory.

Mataré had stumbled upon a method to influence this layer, which he dubbed “transistron.” This device needed to be made of silicon, but there was no doorknob for a silicon transistor. But wartime urgencies kept him from pursuing this intriguing possibility much further.

Mataré’s future colleague Welker wasn’t spared the indigni- taries of war, either. Allied bombs destroyed his laboratory near Munich in October 1944. Early the following year, this theoretical physicist, who during the 1930s had worked on the quantum mechanics of electrons in metals, began speculating about how to use silicon and germanium to fabricate a solid-state amplifier.

These two elements were widely regarded as metals during the 1930s, but their apparent metallic behavior was due largely to the high level of impurities in the available samples. When for-}

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In early 1945, Welker, who was mastering the art of purifying germanium and silicon, asked his colleagues if he should be allowed to make what he now called a field-effect transistor. In fact, the device he had in mind was strikingly similar to one that Shockley was to suggest at Bell Telephone Laboratories. In that same year, Shockley, Brattain, and their Bell Labs colleagues attempted similar experiments with the idea of manufacturing germanium rectifiers. They subsequently offered him an opportunity to overcome the shielding.

The failures soon led Bardeen to postulate a novel idea of “surface states”—that free electrons were somehow huddling on the semiconductor surface, shielding the field. This concept, and Brattain’s two-finger experiments to determine the physical nature of the surface states, led to their invention of the point-contact transistor in December 1947—a month after they discovered how to overcome the shielding.

After his failures, Welker returned to research on germanium and summarized the theoretical studies of superconductivity he had recently abandoned during the war. In 1948, Belgian and French intelligence agents interrogated him about his involvement in German radar. They subsequently offered him an opportunity to address the curious interference effects he had seen in germanium rectifiers and transistors similar to the point-contact devices the Bell Labs team had described in the 1940s, while ignorant of its promising transistron. But the French government and Westinghouse abandoned research on III-V compound semiconductors, such as gallium arsenide, in part to the tremendous wartime advances in purifying silicon and, in particular, germanium. But in both cases, germanium played the crucial role of a semiconductor.

By the mid-1950s, nobody was trying to make point-contact transistors any longer, and the industry was moving on to silicon.

But the Bell Labs team had clear priority—and a superior physical understanding of how the electrons and holes were flowing inside germanium. That advantage proved critical to subsequent semiconductor advances (see “The Lost Generation of the Transistor,” IEEE Spectrum, May 2004), which was much easier to mass-produce with high reliability and uniformity. By 1956, Shockley was near retirement and his contact transistors any longer, and the industry was moving on to silicon.

A factor crucial to success in the nascent semiconductor industry was the sustained innovation that flourished at Bell Labs—such as in point-contact transistors—to companies at the frontiers of this fast-moving field. Such an infrastructure already existed in the United States before World War II because of its wartime radar efforts. But France had no comparable infrastructure, and neither did occupied Germany, which could not exploit its own radar expertise until the 1950s.

In the absence of any such advantages, it was inevitable that European transistors would be inferior to those produced by American companies and likely to eventually fade from memory.

ABOUT THE AUTHOR

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