From 'Electric Universe'; lightly edited from chapters 8 and 10. I describe how two researchers at Bell Labs – Walter Brattain, and John Bardeen – created a device where solid chunks of silicon or related element could remain seemingly still, while ultra-small electrons shifted course within them. Switchings took place with no discernible friction. It was the first workable transistor.

MABEL'S LEGACY

...The first application came easily. The Bell companies had long had a tradition of making devices to help the deaf – a legacy from Alec's love for Mabel – and it was natural to use transistors to make them smaller. This was helped by the fact that John Bardeen himself was married to a woman who was hard of hearing.

Hearing aids are a bit like phones that have to be carried around. But ordinary telephones were clunky machines, dating from the Victorian era, with big wires and switches. They needed many, many trillions of bouncing electrons to transmit even a dim whisper. With transistors inside, however, 'switches' were immensely smaller, and it was possible to rely on far smaller batteries, for fewer electrons needed to be shunted around. Hearing aids shrank, and could be used almost everywhere.

ENTER SHOCKLEY

Bardeen and Brattain found it hard to take their invention further, however, because at Bell Labs they suffered from being under the supervision of William Shockley – and Shockley was a man with very strange views. When he'd first met Bardeen's wife, Jane, he'd told her that his own children were inferior to him. Jane had demurred, thinking that she hadn't heard him properly. But no, Shockley explained, it was a fact, and the reason was that his own wife was genetically inferior to him as well.

After Bardeen and Brattain succeeded with the first transistor, Shockley was beside himself. How could these men have gotten there before him? The fact that Brattain had grown up on a cattle ranch in Oregon – and so was a cowboy! a hick! – made it even worse.

Shockley tried to take credit for the work. He hogged the microphone at the first press conference, and when an electronics magazine came to take a photo of the great transistor discoverers, he pushed Bardeen and Brattain aside and sat himself at the lab desk they had used. Although he did improve their initial ideas considerably he wanted everyone to believe he had, basically, done it all. Bardeen left, and then others, and with no one remaining to browbeat, Shockley left as well.

A CREATIVITY CENTRIFUGE

This had a remarkable effect. Shockley was so skilful in giving the impression that he had been the brains behind the transistor, that when he left Bell Labs to create his own fortune in the apricot groves and scattered factories of a valley south of San Francisco, many of America's most skilful engineers and physicists wanted to work with him. He was, after all, the man on the cover of Electronics magazine, peering into a microscope at his desk at Bell Labs; he had been fêted at the press conference announcing the transistor; there were rumors that a Nobel Prize might soon be his.

What young engineer wouldn't want to travel to this semi-rural valley and become rich?

They came, they saw Shockley in action, and they fled. But while the engineers he'd forced out of Bell Labs dispersed across the entire country, those he forced from his new company (modestly named after himself) liked the California sun so much that they didn't go far. Shockley became a vast centrifuge, an inadvertent innovation machine. The bright people his reputation attracted quickly bonded with one another when they realized how awful he was, and kept those bonds when they were flung out to create their own firms nearby.

He managed to lose not just Robert Noyce, who co-created the modern technique for printing vast numbers of transistors on individual chips. He also lost Gordon Moore, who co-founded Intel, the most successful of all companies for fabricating those chips. Noyce became a millionaire, Moore probably a billionaire, while Shockley – never making any money, unable to get the ingrates who flocked to him to recognize his genius - kept on repelling more ambitious bright engineers, who joined forces with his competitors. The apricot groves had a new name: Silicon Valley was born.

And the world changed again.

SOCIAL EFFECTS

...Small gadgets can have unexpected effects. The first transistor radios went on sale in the 1950s, and the quantum effects they harnessed used so little power that their batteries were small. This plus the small size of transistors made them easy to carry around, which meant kids no longer had to listen to the same music their parents did. Teenagers more and more formed their own subculture, and a new market for popular music was born. With cheap electric guitars and low-cost amplifying speakers – also made popular by silicon – small groups could match the volume of big bands. Obscure start-ups could flourish. Elvis and then Motown and the Rolling and soon many others appeared.

The economic landscape changed. Huge chains of retailers could use computerized inventory control to fine-tune their offerings and to lower their costs in a way traditional stores couldn't. Behemoths such as Wal-Mart began clomping across the landscape; malls became virtually indistinguishable from one another as they filled with the same stores.

Traditional notions of community began to fade. Radio and TV, when they began, sent out signals that flew equally in all directions, hence the word *broad*casting. This encouraged simple national brands and simple large clusters of consumers. Even when mail-order catalogs were delivered, there were only a few sorts, sent in huge batches that couldn't target niche customers Transistor-based switches, however, can quickly sort through many, many choices. This led to targeted direct mail (by the early 1960s), and soon after to increasingly specialized radio stations, cable television networks, and the like.

People no longer had to respond as part of a group. There was more nomadism, and more starkly individual choices of where to live, whom to marry, how to worship, and when to vote – all trends that the internet has accelerated greatly.

Democracy changed. Before the computerized satellite links of the early 1960s, ordinary people never expected to see vivid, real-time footage of foreign disasters, rebellions, or famines. (All they did occasionally see were brief extracts, edited in occasional newsreels at the movies.) It was natural to defer to government leaders, who had their own superior sources of information - generally ambassadors or other emissaries, who communicated with them at relatively great expense by telex, telegram, or plane. But now? The moment when a fresh image rushes in from abroad, no one knows more than anyone else. A new mistrust of government was born – helped as always by other factors – and has persisted ever since.

...Traditional information was stored by means of ink marks that were soaked into the thin slabs of modified wood pulp we call paper. But ink is big. Atoms are small. The archivists who looked through stored books, or even microfilm indexes for those books, were clumsily looking at immense lakes of electrons and other sub microscopic particles.

Web searches are faster. Hit a key on a laptop or touch a letter on a smartphone, and long-stretching tunnels of electrons in wires beneath our keyboards are ready to begin their hunt. Our fast finger-taps are ungainly, ponderously slow thumps to them, so there's plenty of time. (Every key on an ordinary laptop is sampled dozens of times each second, with electrons constantly reporting ‘No hit, No hit’ to the central processors until, wondrously, one of the keys does slowly lower itself as we type.) For centuries humans lived separated from the flurrying fast inner world of electrons, or at least could scarcely control it. That has ended....

WALTER BRATTAIN left Bell Labs to teach at the small college in Oregon where he had first been a student in 1920. He remained modest about his great achievements, though he did once suggest that rock-and-roll musicians used his transistors for more amplification than he'd intended. JOHN BARDEEN moved to the University of Illinois and earned a second Nobel Prize (for work on superconductivity), the only physicist ever to be so honored.

He remained even more modest than Brattain. At one point, after both Nobels, a long-term golfing partner asked him just what was it he actually did for a living.

After the failure of his Silicon Valley ventures, WILLIAM SHOCKLEY abandoned all science research. Shunned by his professional colleagues for his increasingly racist views – and divorced by the wife he'd deemed inferior – he began donating sperm to a foundation designed to create genetically superior white children.

There’s a famous photograph of Shockley looking through a microscope while Bardeen and Brattain stand looking on. It's used in innumerable textbooks and histories, but it has as much accuracy as the ones emanating from the Kremlin in its Politburo days. Walter Brattain can be seen directly behind Shockley, who's peering aimlessly through what's actually Brattain's own microscope. When Brattain was young he’d once spent almost a full year in the mountains, largely on horseback, guarding a cattle herd with a rifle on his lap. In the photo one can see his tensed hands, tilted slightly forward, in a path that, if continued, would let him wring Shockley's neck. Forty-five years later Bardeen was interviewed about that day. ‘Boy, Walter sure hates this picture’, the mild Bardeen explained.