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What the Legendary Bell Labs Can Teach Us About Innovation

The R&D organization had an outsize influence on 20th-century technologies. What was the secret to its success?

By Jon Gertner

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In April 2025, several hundred scientists and engineers made a pilgrimage to a big birthday party in Murray Hill, N.J. The occasion was the 100th anniversary of Bell Labs, the legendary research-and-development organization that was once the innovation engine within the old AT&T and is now part of Nokia, the Finland-based telecommunications vendor.

A lab can churn out a lot of ideas over the course of a century. Yet it’s almost certainly the case that no organization has had quite the impact on modern technology as Bell Labs.

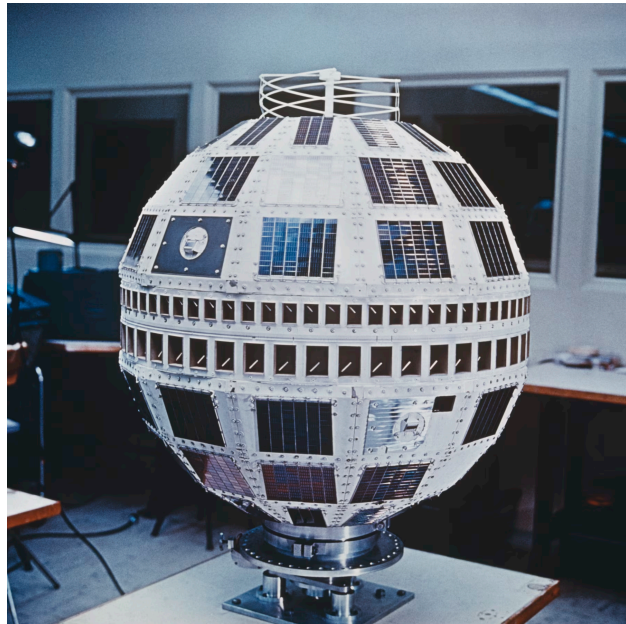
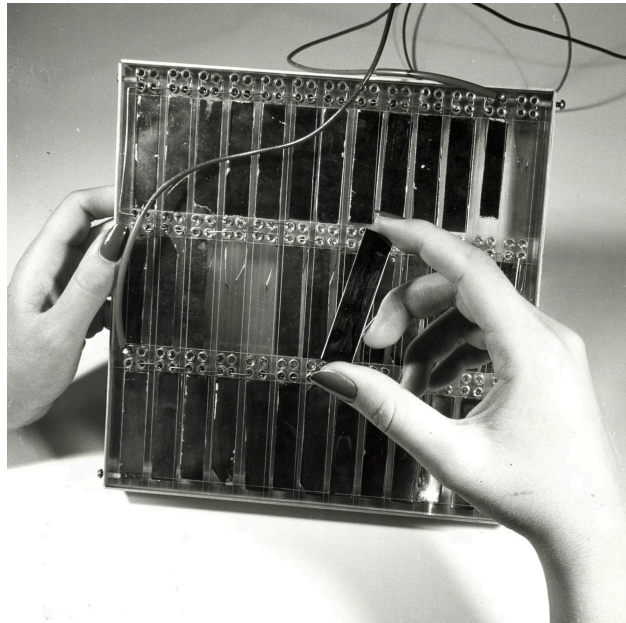
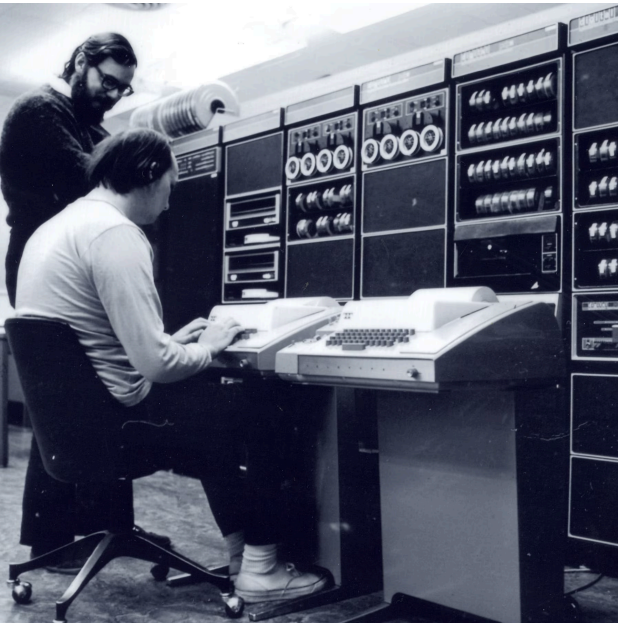
From its establishment on Jan. 1, 1925, when it was first housed in a huge industrial building in New York City’s Greenwich Village, Bell Labs technologists created many of the foundational innovations of the modern age. In the late 1940s, most of its employees moved from Manhattan to the leafy suburban campus at Murray Hill. Later still, the organization expanded into a more-modern lab, in Holmdel, N.J., which is now the Bell Works mixed-use complex and serves as the fictional headquarters for Lumon Industries in the Apple TV+ series “Severance.”



Bell Labs in 1964, when it had moved to Holmdel, N.J. AT&T ARCHIVES AND HISTORY CENTER

Consider just a partial list of what emerged from Bell Labs: transistors, cellphone networks, telecommunication satellites, early lasers, solar power, digital imaging, digital transmission, transoceanic phone cables, the UNIX operating system, the C programming language. At nearly any moment of a day—at your coffee maker, on your computer or television, in your car, on your iPhone—you are tapping in to the legacy of Bell Labs' work. Its technologies not only pervade the modern world; they buttress the global economy.

The riddle of Bell Labs—indeed, the great mystery of innovation itself—is how, over many decades, its employees came up with ideas and products that ultimately changed the world. Though there were misses like the 1960s-era Picture Phone, which was too expensive and clunky for its day, its golden age lasted from the late 1920s until the 1980s.



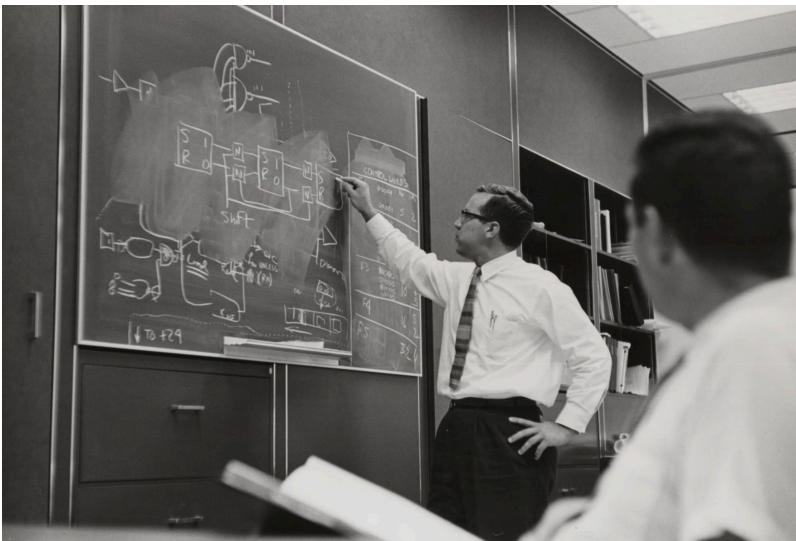
Bell Labs' projects included, clockwise from upper left, the development of UNIX, solar cells, the Telstar satellite and fiber-optic cables.

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Did the organization merely get lucky, again and again? Or did the managers and employees truly understand what levers to push to succeed at such a trick?

Patents and prizes

One of the numbers frequently cited as a testament to Bell Labs' innovation is the patents the organization amassed—now around 30,000. Another measure is the Nobel Prizes (now 11) that have been awarded to its scientists.



Bell Labs in the 1960s. AT&T ARCHIVES AND HISTORY CENTER

Such metrics are remarkable. Yet they don't necessarily capture the scope of the Labs' innovative capacity, seeing as some Nobels were awarded for theoretical breakthroughs that never led to an immediate technology.

Innovation, of course, is a fuzzy construct. Originally used in 16th-century England to describe a new idea in philosophy or religion, the term can be used to define almost anything, from a new sunscreen lotion to an mRNA vaccine. At Bell Labs, an innovation was something that made an existing service or good either cheaper or better, or both cheaper *and* better. What's more, a Bell Labs innovation was defined as a new product or process that had achieved both impact and scale.

At Bell Labs, a new idea for solving a problem was a good start. But if you hadn't designed, manufactured, marketed and deployed this new product (or process) it wasn't really an innovation.

For instance, the invention of the transistor at Bell Labs in December 1947 was just that—a tiny and wondrous invention for amplification and switching that used little power and could conceivably replace vacuum tubes in many devices. Only when it was deployed at scale—first in hearing aids; then in military machinery and in the phone network; and finally in small radios and computers—did it become, at least in the eyes of Bell Labs managers, an innovation.

To unravel the innovative winning streak of the Labs, start by looking at what might be called its *situational* advantages. Years back, one of its Nobel laureates, Arno Penzias, told me: “You have to understand, this was a problem-rich environment.”



Bell Labs programmers review traffic data and analysis reports from the Total Network Data System (TNDS), in Holmdel, N.J. AT&T ARCHIVES AND HISTORY CENTER

It was Bell Labs' responsibility, in other words, to create technologies for designing, expanding and improving an unruly communications network of cables and microwave links and glass fibers. The Labs also had to figure out ways to create underwater conduits, as well as switching centers that could manage the growing number of customers and escalating amounts of data.

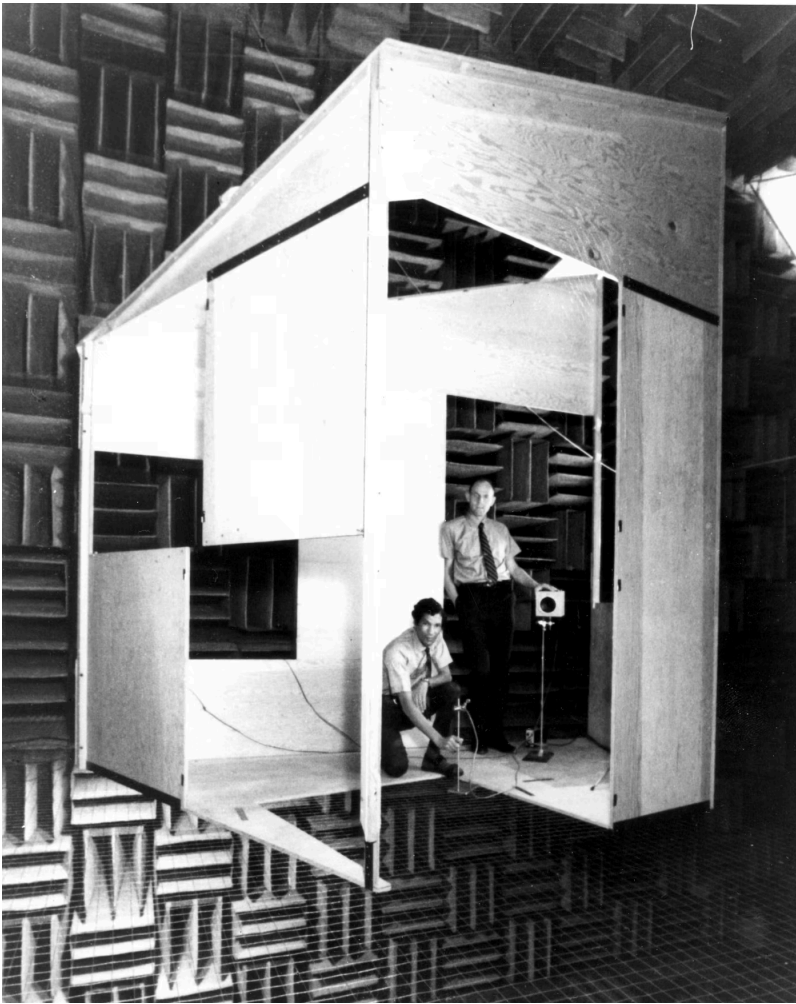
But everything about this network was new. No one had created these kinds of systems before. How do you get a phone call from New York to London? How do you get it there with better fidelity and a lower cost? Then how do you get a million calls there every day? How do you bill everyone for the service?

There was no end to the technological problems that had to be solved.

Money helps

Money mattered, too. Being connected to AT&T, the largest company in the world, was an advantage. The Labs' budget was enormous, and accounting conventions allowed its parent company to make huge and continuing investments in R & D.

The generous funding, moreover, allowed scientists and engineers to buy and build expensive equipment—for instance, anechoic chambers to create the world's quietest rooms. Money also allowed the organization to hire the smartest Ph.D.s and engineers. In the late 1960s Bell Labs employed about 15,000 researchers, technicians and support staff; in the early 1980s, the number had grown to about 25,000. By that point its budget was \$2 billion annually, or roughly \$7 billion in today's dollars.



James West and Gerhard Sessler in the world's oldest wedge-based anechoic chamber at Murray Hill, N.J., 1969. AT&T ARCHIVES AND HISTORY CENTER

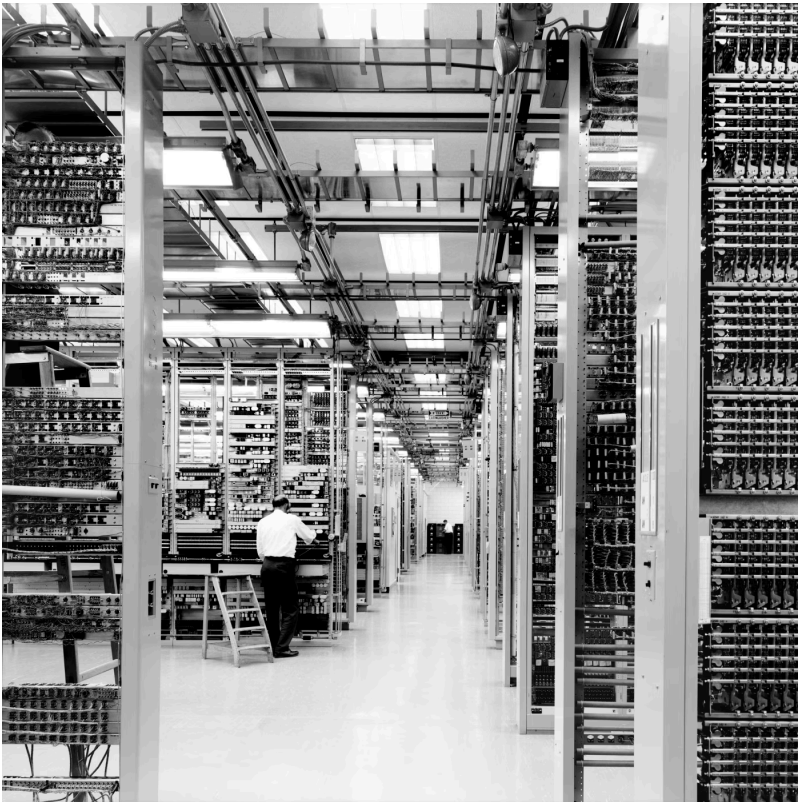
The most fortunate part of Bell Labs' situation, however, was that in being attached to a monopoly it could partake in long-term thinking. We tend not to associate monopolies with innovation. But this can be a mistake. Without competition nipping at its heels, Bell Labs engineers had the luxury of working out difficult ideas over decades.

The first conceptualization of a cellular phone network, for instance, came out of the Labs in the late 1940s; it wasn't until the late 1970s that technicians began testing one in Chicago to gauge its potential. The challenge of deploying these technologies was immense. (The regulatory hurdles were formidable, too.) And as much as we might think innovations happen fast—perhaps true in software but rarely in other areas—Bell Labs' example shows that breakthroughs often happen slowly, and with painstaking effort.

And what about the handicap of being big and stodgy, rather than small and nimble? At Bell Labs, it was often the case that small groups of scientists and engineers were encouraged to take the initiative, and ended up creating some of its greatest breakthroughs. But around them was a

massive company with nearly bottomless resources, along with vast amounts of industrial and theoretical expertise. It could be tapped at any time.

Thus the Labs would act like a startup sometimes. But it could also flex like a giant.



The right organization, at the right time: Bell Labs in Holmdel. EZRA STOLLER/ESTO/REDUX

Taking advantage of luck

Some of these situational advantages could be construed as luck. Founded at a moment when modern communications technologies were just getting going, Bell Labs was the right organization, working in the right field of electronics, at the right moment in time. The Labs was boosted by contemporaneous work for the U.S. military, in World War II and during the Cold War. Its defense links pushed the organization to create tech for radar and weaponry (such as ballistic missile defense sensors in the Arctic) that led back to ideas and new materials it could use for consumers.

Still, being in a lucky situation is one thing. Parlaying fortune into repeated success is another. In this regard, we might take note of what could be called the Labs' *opportunistic* advantages.

One of the most crucial dates back to the Great Depression. A young manager at the Labs named Mervin Kelly, who later went on to become the Labs president, went around the country and made offers to some of the brightest scientists. When he went to visit a young physicist at MIT, William

Shockley, Kelly chatted with him and then called New York for authorization to make an offer. “I had to decide right then and there,” Shockley would later recall. He told Kelly he would accept.



Mervin Kelly speaking to a transistor symposium at Murray Hill, 1951. AT&T ARCHIVES AND HISTORY CENTER

In short, Kelly had access to funding in a decade when most executives and universities didn't. And he saw this as a chance to bring in researchers—Shockley, Gerald Pearson, John Pierce and others—who later worked on the transistor, the solar cell and the first communications satellite. At a difficult moment, he invested in people who ensured the Labs' success and momentum for the next several decades.

His visionary management would define the organization in other ways. The Labs' involvement in World War II suggested to Kelly that an exciting postwar era of electronics was approaching, but that the technical problems would be so complex that they required a mix of expertise—not just physicists, but material scientists, chemists, electrical engineers, circuitry experts and the like.

At Bell Labs, Kelly would sometimes handpick teams and create such a mix, as was the case for the transistor invention in the late 1940s. He came to see innovation arising not from like-minded or similarly trained people conversing with each other, but from a friction of ideas and approaches. It meant hiring researchers who had different personalities and favored a range of experimental angles. It also meant personally designing a campus in Murray Hill where departments were spread

apart, so that scientists and engineers would be forced to walk, mingle and engage in serendipitous conversations and debate ideas. Meanwhile, under Kelly, the Labs focused on hiring people who were deeply curious, not just smart.



Bell Labs, Murray Hill, in 1979. AT&T ARCHIVES AND HISTORY CENTER

Kelly saw it as his professional duty to do far more than what was expected, with his laboratory and vast resources, to create new technologies.

To be sure, it was Bell Labs' responsibility to make near-term technological improvements in the phone system and consider what longer-term strategies might be necessary. But John Mayo, a president of Bell Labs in a later era, told me we can only speculate as to what prompted Kelly and the Labs' executives of his era to invest so heavily in what Mayo called "the unknown."

They weren't forced to pour money and talent into the early research and development of solid-state materials, for instance, or to fund mathematicians such as Claude Shannon, whose prescient theories of communication in 1948 enabled a later era of digital networks. Other telecom companies around the world didn't do that kind of work.

Mayo believed it was also likely these managers understood the risk that their investments could be the Labs' undoing, as competitors used Bell Labs innovations and improved upon them. Because the federal government allowed AT&T a monopoly as long as it confined its business to the

communications sector (and shared or licensed Bell Labs patents for a modest fee) innovations could lead to a blowback effect—which is in fact what happened.

Then again, to Kelly, an opportunity not taken was tantamount to an opportunity lost.

The ultimate secret

The breakup of AT&T's monopoly, which led to a steady shrinking of Bell Labs' staff, budget and remit, shows us that no matter how forward looking your employees and managers may be, they will not necessarily see the future coming.

It likewise suggests that technological progress is too unpredictable for one organization, no matter how powerful or smart, to control. Famously, Bell Labs managers didn't see value in the Arpanet, which eventually led to today's internet. And yet, for at least five decades, Bell Labs created a blueprint for the global development of communications and electronics. In understanding why it did so, I tend to think its ultimate secret may be hiding in plain sight.

The secret has to do with Bell Labs' structure—not only being connected to a fabulously profitable monopoly, but being connected to a company that could move theoretical and applied research into a huge manufacturing division that made telecom equipment (at Western Electric) and ultimately into a dynamic operating system (the AT&T network).



Alfred G. Richardson designs and produces samples of prototype lightwave undersea telephone cable in 1982. AT&T ARCHIVES AND HISTORY CENTER

Some of the crucial work done at Bell Labs might now seem mundane: for example, how to fabricate sheathing so undersea cables wouldn't be chewed through by Toredoworms. But scientists and

engineers at the Labs understood their ideas would be implemented, if they passed muster, into the huge system its parent company was running.

In evaluating Bell Labs' success, this may perhaps be the most important takeaway to any new company focused on innovation: The research staff knew they were working within the realm of business and practicality. With their ideas—simple and high-minded—they were there to make a system of communications better, or cheaper, or both.

I came upon a perfect example of this some years back, when I visited a former high-ranking Bell Labs executive in Short Hills, N.J., named Morris Tanenbaum. Before he became a manager, Tanenbaum was a brilliant researcher, and in the early 1950s he was tasked at Bell Labs with trying to change the makeup of the then-new transistor, which was constructed from a rare metal called germanium. He was seeking out a better, more available, more temperature resistant material that might also be functional, such as silicon.

He worked at it through months of frustration, but one evening, while his wife enjoyed a bridge game with friends, he drove back over to the Labs and tried a different approach. He was experimenting on a tiny sandwich of silicon, one with controlled impurities (later known as “doping”) that his metallurgy colleagues had specially prepared. He made a connection by melting thin aluminum wires through the surface. The day I visited, Morry took me upstairs to his office to show me his lab notebook from that night. “This looks like the transistor we’ve been waiting for,” he had written with excitement on March 17, 1955, after successfully testing the device. “It should be a cinch to make.”



Inspecting a transistor (held with tweezers), and transistor assembly at Western Electric's Allentown, Pa., plant in 1960.

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He could see, on that evening long ago, that this transistor would be easily manufacturable—manufacturable in great quantities. That was key. Within the Bell system it could be deployed, and within the Bell system it would gain economies of scale. But it was clear the innovation wouldn't necessarily be limited to telephones. Tanenbaum seemed to glimpse, at that moment, that our future would be silicon. And the rest, as we tend to say, is history.

Jon Gertner is the author of "The Idea Factory: Bell Labs and the Great Age of American Innovation." He can be reached at reports@wsj.com.

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