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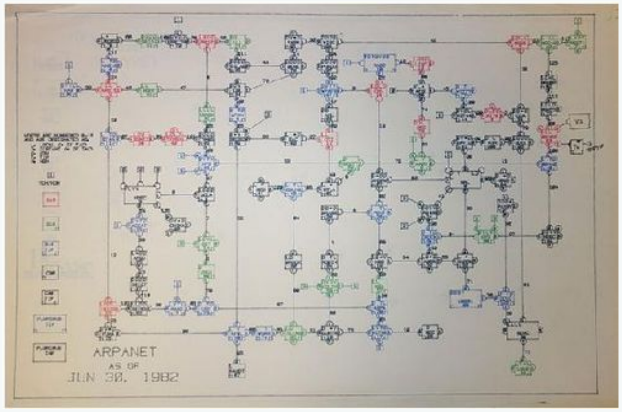
The Origins of the Internet

By ReadWorks



All of the men were nervous as they waited. But Len Kleinrock was the most nervous. The year was 1969, and just over 20 people were crowded into the room. A group of pale men in their 20s and 30s, the computer scientists stood beside executives from big telephone companies. The men tapped their feet impatiently. They waited.

The computer itself loomed along the wall, 15 feet wide and 35 feet long. A long grey cable snaked from the computer to a smaller machine, the router or "switch," in the corner. The two machines were important, but the real reason the men had gathered was the activity happening in that long grey cable. They were about to see whether information could successfully flow between a computer and router, for the first time in history.

At the center of the group was Len Kleinrock, the 35-year-old star of computer networking. Kleinrock was a professor at UCLA and was the one who had engineered this system. "Everybody was ready to point the finger if it didn't work," said Kleinrock. "Happily, the bits began to flow from the host to router. I like to refer to that day as when the Internet took its first breath of life, first connected to the real world. It's like when a baby is born and has its first experience of the outside world."

For Kleinrock, that moment had been almost a decade in the making. He originally became interested in the problem of network connection while working on the East Coast. He recalled, "I looked around at MIT and Lincoln Laboratories [*sic*]: I was surrounded by computers and recognized

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that one day they're going to have to talk to each other. And it was clear that there was no adequate technology to allow that."

At the same time that Kleinrock was growing absorbed in the problems of network connection, the United States government was ramping up its investment in science and technology research. The Soviet Union's famous launch of a satellite called Sputnik had been an embarrassment for the United States—the United States thought that it should be the leader of space travel. Eisenhower created a branch within the Department of Defense to ensure that the scientific leadership of America wouldn't be eclipsed again in the future. This new organization, the Advanced Research Projects Agency (ARPA), became one of the major engines of technological innovation throughout the 1960s and 1970s.

In 1962, while Kleinrock was finishing up graduate school, ARPA created a new department devoted to computer science. The head of this division was J.C.R. Licklider, a fellow scientist at MIT who also worked on network structures.

"He was one of those visionaries who foresaw the advantages of combining humans with computer," said Kleinrock of his former colleague and boss. "He created a concept called man-computer symbiosis, recognizing that if you put the two together, you could get very significant results." Licklider ran into political problems at ARPA and ultimately left to return to MIT, but not until he had planted the idea of networking as a concept worthy of funding.

Bob Taylor took over ARPA's computer science division in 1966 and reinvigorated the project. Taylor had been funding different projects in computer science departments at universities across the country and realized it was growing too costly to give each department the machines and resources to do every task. What he needed was a way for geographically far-flung research centers to somehow share each other's computing resources. Taylor needed to create a network. The man he brought in to build it, Larry Roberts, happened to be Kleinrock's old officemate at MIT.

"We were all intimately familiar with each other's work, so when they asked, Roberts said, 'Look, I know exactly what this technology should be, and I know it can work. Len Kleinrock has already proven it,'" recalled Kleinrock. "And bang, the project came to life. After a number of years, it came to action."

And so it was that all of the men were crowded into the room watching a long grey cable. An air

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conditioner hummed in the background, fighting against both the heat outside and the heat generated by the massive machine in the room. Cheers broke out when they saw that the information was flowing, but the real test was to come a few weeks later.

The first message between two computers was sent on October 29, 1969. This time the room was empty, except for Kleinrock and one other engineer. They didn't know that it was such an important milestone, so there was no camera or tape recorder. The two men were trying to log onto a computer at the Stanford Research Institute and successfully got through two letters of the message "login" before the system crashed.

"It was not until this thing called the Internet hit the consumer world that we recognized this network was really important. At that point we looked back and said, 'What was the first message ever sent on the Internet?'" Kleinrock remembered. "Samuel Morse sent, 'What hath God wrought?' Alexander Graham Bell said, 'Come here Watson I need you.' Neil Armstrong had his giant leap. These guys were smart and they understood media. We had no such concept, but the message we created, 'lo,' [short for 'login'] that's the most prophetic, succinct, powerful message we could have come up with by accident."

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Practice Makes Perfect

By ReadWorks

Look around you. Most of the objects you interact with every day are the result of hundreds of years of tinkering. Your table is the way it is because someone thought they could make a better table than the ones that already existed. Your chair is how it is because someone had the idea to improve upon a previous version of a chair, taking some bits and leaving others behind. Your shirt, your telephone, all the result of someone (or a team of "someones") setting their minds to a particular design task, and working hard until they got the thing they set out to make.

This process of imagining something and then building version after version until you get it *just right* is called "iterative design." The term "iterative" refers to the different versions—or "iterations"—of a thing you produce on the way to making the right version. It is admitting, ahead of time, that you probably aren't going to get it right the first time. Rather, you know that designing something really great is going to take lots of tries. And you're committed to doing it over and over until you get it right.

Aisen Caro Chacin is very familiar with this process. When she was a student in a technology program at a design school in New York City, she had an unusual idea for her thesis project. She wanted to make a device you could wear in your mouth through which you could listen to music. She knew it would take many tries to get it just right.

She imagined the device as a cross between a video game controller, a stereo, and a "grill"—a kind of mouth jewelry. The device worked by using a small motor to vibrate the wearer's teeth—a process known as bone conduction, which, in this case, means the teeth and facial bones carry or "conduct" the sound. It looked like a mouth guard with a video game controller's directional pad:

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the plus-shaped part of a controller that moves up, down, left or right. She called her creation, "The Play-a-Grill."

There were many unanswered questions. What was the best way to assemble the device? How would a wearer control it? How big could it be? Chacin began her design process with that last question. She devised a simple test to determine how much room a person has, on average, on the roof of their mouth. She gave them as much gum as they could possibly fit onto the roof of their mouths, and had them spit the gum out, preserving its shape as much as possible. Taking that shape into account, she made a mold of the wearer's teeth using the same technique as dentists.

She then poured hot glue into the mold, and heated it to let it take its shape. She remembers with a laugh describing this dangerous, time-consuming, and decidedly low-budget process later to a horrified technology journalist. "He was like, 'uh, wait, what?'" she says. "It's not a material that's made for being inside the mouth for long periods of time." It was also bulky and uncomfortable. This first version connected to an audio source through a traditional headphone jack.

"The first version," she said, "was basically just to test the technology." Could a device like a mouthpiece made out of glue actually vibrate and let a wearer hear sound? As it turned out, it could. With one successful test under her belt, Chacin set about a major aesthetic and practical overhaul.

For the second version, Chacin changed virtually all of the grill's features. She used a different material to construct the grill itself, the same substance used to make tooth-whitening mouth guards. This made it more streamlined and comfortable. She added a microchip to the base of the device, so that it was self-contained. She also attached the directional pad to the part of the grill that covers the palate, which allows the wearer to control the volume of the music, as well as skip songs. She also made part of the front out of silver, to give it a classic jeweled aesthetic.

While this version was much more successful, Chacin knew it could be improved upon further. In her next version, she tried to improve the user interface, making it easier for a user to press the tongue controls. "You can apply more pressure with a finger than you can with the tongue." She also further refined the aesthetic, adding the word "TECH" in capital letters to the front.

Three versions and roughly three years from beginning her process, Chacin is still far from satisfied with her product, and plans to further refine several major areas in future iterations. The first is the electronics, the second are the motors, and the third is the Play-a-Grill's overall

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aesthetics.

Even in its latest iteration, Chacin acknowledges, the Play-a-Grill is too bulky. The primary reason for this is the electronics. Namely, the components which control the storage and playback of the MP3s, as well as the user tongue controls are too large, much larger than they would be in the final, consumer-focused iteration of the Play-a-Grill. "I probably need to get into a clean room to really get them small enough," Chacin says, referring to the static and (at least theoretically) dirt-free rooms staffed by scientists in hazmat suits that most professional electronics companies use to produce today's highly compact personal electronics. Until she can access a truly professional-grade facility like this, she feels her product won't be as advanced as it could be. She would also like to add a more professional grade lithium battery to her device. While it *does* currently contain a lithium battery (the same kind used in devices like pacemakers which are implanted in the body), it is consumer grade, and not the kind used by professional implant producers.

Chacin also wants to further refine the motors the Play-a-Grill uses. Again, the motors produce the vibrations that the wearer eventually perceives as music. In the first version, she used one motor. In the second and third, she used two, figuring this would produce a proportional increase in the volume and quality of the sound. This, as it turns out, was not the case.

"The new motors weren't as good of quality as the first one (I had changed the type of motor)," she explains, "and so I think that the first one worked better. It's a process! You think, 'Okay, let's change the design to make it more comfortable, this seems like it would work.' But then the component itself might not be as strong. And even though I added an amplifier to it, it still wasn't as good."

Finally, Chacin wants to improve the device's aesthetics. "The silver front of the actual grill, I chose not to do in silver, for the most recent version," she said. "I think that was kind of a mistake. It kind of took away from that rapper culture aesthetic the other one had."

While she may not be entirely satisfied, Chacin should be proud of what she's accomplished. She's gone from a relatively out-there idea—a piece of mouth jewelry that plays music by vibrating your skull—and turned it into a reality. Her device has been written about many times in the press, and featured on television. She's done this through hard work, and demonstrating a willingness to always go back to her piece and try again.

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In making version after version of a device to get closer to a final thing she's happy with, Chacin is doing her work like countless other designers before her. Rockets, racecars, and smartphones were all designed in the same way. There's often no real way to get a true sense of how a design will perform without building and testing it. So, that is what people like Chacin have been doing for hundreds of years. Having an idea, building a version, testing it out, and seeing how it goes.

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The Mighty Semiconductor and the Rise of Silicon Valley

By ReadWorks

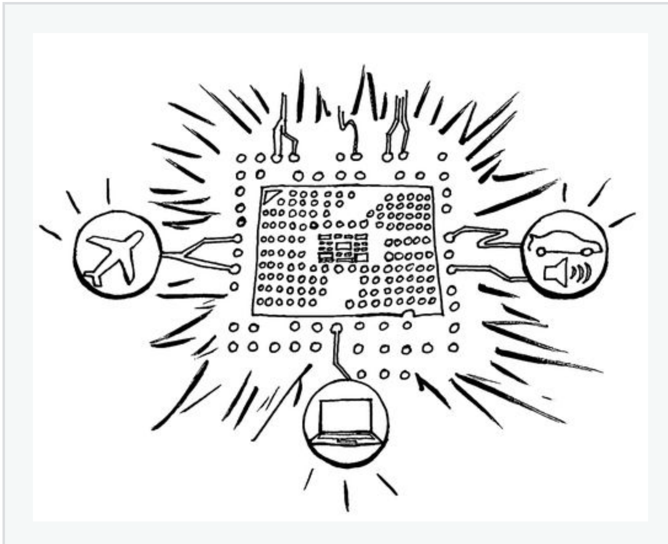

Illustration Credit: Nishan Patel

For thousands of years, people lived in a world without computers. There were no video games and no smartphones. Now computers are part of the daily life of many people, and it's hard to imagine a world without them.

What is it that makes a computer work? Inside every computer is a tiny circuit called a semiconductor. Often, a semiconductor is essentially a couple wires attached to a piece of silicon (a mineral like quartz). Though semiconductors are very small, they are important. Semiconductors are what make many electronics work, from car radios to the systems that pilots use to fly airplanes. For a computer to work, it needs electricity. Semiconductors carry the electric signals in computers.

In the United States, almost all semiconductors are made in a place called Silicon Valley. Silicon Valley is just outside of San Francisco and is home to some of the country's smartest scientists. The history of Silicon Valley is tied to the history of the semiconductor.

The first mass-produced semiconductor was designed in the 1950s in Silicon Valley by a company called Fairchild Semiconductor. The engineers at Fairchild were interested in finding ways to make

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machines faster and smaller. Before Fairchild, people knew how to make semiconductors, but they didn't know how to make large batches of them.

In those early years, Robert Noyce was the boss at Fairchild. He was in charge of making sure the company built cutting-edge products the world had never seen before. Robert wanted his company to be a community where everyone was equal. At Fairchild, an engineer could rise to the top quickly, as long as he or she had a good idea. Everyone pitched in to help with problems, and everyone celebrated when a problem was solved.

Engineers loved working at Fairchild, and the company grew quickly. NASA needed semiconductors for the computers in their new spaceships. The United States Department of Defense needed semiconductors for planes and other military vehicles. Computer systems were being put into all kinds of devices, and every single computer needed semiconductors.

Soon engineers at Fairchild began quitting. They had exciting ideas and wanted to start their own companies. More than 50 other semiconductor companies were started by former employees at Fairchild. Most of these companies stayed in Silicon Valley. Soon it made sense for other high-tech companies to move to Silicon Valley, since there were already so many talented engineers in the area. In the 1970s the area began to be called "Silicon Valley," after the mineral that was the backbone of the semiconductor.

As computers spread throughout the country, Silicon Valley grew along with the industry. Soon it wasn't just semiconductor companies. There were companies that made personal computers, printers, software... the list went on and on. Apple, the maker of the first personal computer, had headquarters close to Silicon Valley. Years later, Google's headquarters were set in Mountain View, in the exact same city as Fairchild Semiconductor's first building.

Companies like Apple and Google have been attracting thousands of engineers from all over the world, making Silicon Valley a wealthy and thriving area. Investors have also followed engineers to Silicon Valley looking for promising companies with big futures. These new investors—known as venture capital firms—give a company the money it needs to start a business. Then if the company becomes big, a large chunk of the money it makes goes back to the investors.

But it isn't just the money that draws workers to Silicon Valley—it's also the opportunity. In Silicon Valley, there are new companies being created every week. There is money to invest in new

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companies. Silicon Valley has become a new global center of technology.

As of 2013, Silicon Valley is home to more than 3 million people. Many of them came from other countries, and in over half of the homes in Silicon Valley, families speak another language besides English. Both immigrants from other countries and people who move to Silicon Valley from other parts of the United States bring new ideas to Silicon Valley. Soon these people may start their own companies, and those new companies may attract more engineers from other parts of the world. And so, Silicon Valley will continue to grow.

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From the Earth to Outer Space

By ReadWorks

Many years ago, people here on Earth decided that they wanted to go into outer space.

This is something people had imagined for a very long time, in books and movies and stories grandparents told to their grandchildren. However, in the 1950s, people decided they really wanted to do it. There was just one problem: how would they get there?

One of the earliest movies about flying to the moon was made by Georges Méliès and released in 1902. It was called *A Trip to the Moon*. In this movie, the moon was made up of a man's face, covered in cream, and a whole tribe of angry natives lived there. That part was not very realistic. However, the spaceship didn't seem too far-fetched: it was a small capsule, shaped like a bullet, that the astronauts loaded into a giant cannon and aimed at the moon.

This movie was based on a book that came out many years earlier by an author named Jules Verne. One of the fans of the book was a Russian man, Konstantin Tsiolkovsky. The book made him think. Could you really shoot people out of a cannon and have them get safely to the moon? He decided you couldn't, but it got him thinking of other ways you could get people to the moon. He spent his life considering this problem and came up with many solutions.

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Some of Tsiolkovsky's solutions gave scientists in America and Russia (where Tsiolkovsky lived) ideas when they began to think about space travel. They also thought about airplanes they and other people had made, and even big bombs that could fly themselves very long distances. How could they take all these ideas and make them into one thing that would safely get astronauts into space?

Many scientists spent years working together to solve the problem. They drew and discussed different designs until they agreed on the ones that were the best. Then, they built small models of those designs, and tested and tested them until they felt ready to build even bigger models. They made full-scale rockets, which they launched without any people inside, to test for safety. Often the rockets weren't safe, and they exploded right there on the launch pad, or shot off in crazy directions like a balloon that you blow up and release without tying it first. After many, many tests, they started to send small animals into space. Only after a long time did they ever put a person inside a rocket and shoot him into space.

Even after they began sending people into space, during the Gemini program in the 1960s, scientists were still trying to improve the shape of the rockets. The design changed many times, and eventually ended up looking like a half-rocket and half-airplane. This rocket, called the space shuttle, was used for many years. Now, the government lets private companies try their own designs for spaceships, and they have come up with many different, crazy-looking machines.

There is no single solution for sending a person into space. Thanks to the imaginations of people like Jules Verne and Konstantin Tsiolkovsky, and the hard work of the scientists who built and tested rockets over the years, humanity has developed reliable technology for space travel. Still, the work continues. Every day, the people who work on this problem share new designs, build test models, and try to imagine better ways to explore the vast deep mystery that is outer space.

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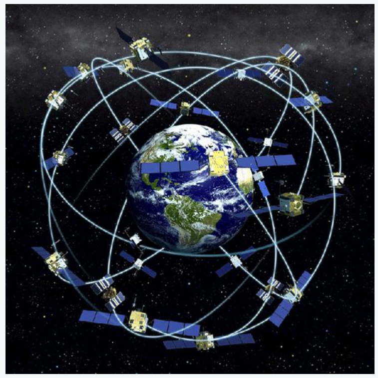
Satellites and Gravity



You may have heard the story of how Isaac Newton discovered gravity. As the legend goes, Newton was sitting under an apple tree when, all of a sudden, an apple dropped from the tree and fell on his head. This incident made him wonder why the apple fell toward the ground and not in any other direction.

Nowadays, it seems quite silly to think that an apple might fall up, or sideways. That's because now we know that Earth's gravity makes everything fall down, toward the planet's center. Gravity is the reason we are able to stand on the earth. Without it, we would all float off into space!

Gravity is also necessary for the operation of satellites. Usually when people talk about satellites, they are referring to manmade objects that have been sent into orbit. However, the moon is also a satellite! A satellite is any object that revolves around a planet in a circular or elliptical path. The path of a satellite is its orbit.

Manmade satellites have all kinds of important applications. Communications satellites, for instance, are satellites that are sent to orbit the earth for the purpose of sending communication signals or messages. Though we might not think about it when we're on the phone, using the Internet, watching television, or listening to the radio, many satellites help make those activities possible for us to enjoy.

Scientists have used observation satellites. These are satellites that have been specifically designed to monitor the earth. Observation satellites are used to keep track of the weather, detect

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changes in the environment, and create maps of the earth. They can be very useful for scientists in monitoring natural disasters, global warming, pollution, and other changes to the planet. The military also has spy satellites (very similar to observation satellites) that help them to peek in on other people around the world.

If you're ever in the car and need to find directions to go somewhere, you have probably used the Global Positioning System, also known as GPS. This is a network of 24 satellites that people with a GPS receiver can use to determine their location.

These are the main applications of satellites you may have encountered in your everyday life, but of course there are countless others! Satellites are incredibly useful, but how exactly do they stay in orbit?

It might seem strange that gravity doesn't cause satellites to just fall straight down to Earth, like Newton's apple. Why is that? It turns out that the earth's gravitational pull on an object weakens the farther away it is from the planet's surface. Satellites orbit far above the earth's surface at a set speed. Earth has an "escape velocity," which is the minimum speed necessary for an object to escape the earth's gravity entirely and fly off into outer space. Earth's escape velocity is more than 25,000 miles per hour. Engineers don't build satellites that travel faster than that because they don't want their satellites flying off into space.

Satellites are designed to achieve a balance. They revolve around the earth slowly enough to avoid drifting off into space, but fast enough to avoid getting pulled completely down toward the center of the earth by the force of gravity. At the correct velocity, a satellite is pulled by the earth with just enough force to maintain its orbit. The closer a satellite is to the earth's surface, the faster it needs to go in order to stay in orbit. And satellites have a circular or elliptical orbit because they are constantly being pulled toward the earth's surface, which is curved.

Therefore, gravity is an important part of our daily lives, whether it's keeping our feet firmly planted on the planet's surface, or keeping our satellites in orbit to help us communicate with one another and learn more about the world we live in.

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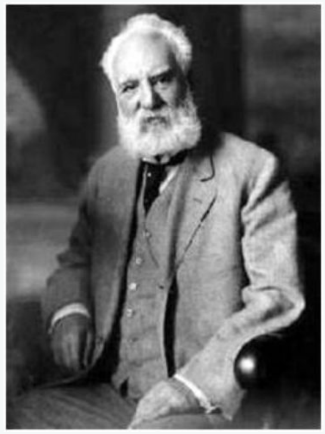
Alexander Graham Bell

By Noah Remnick



Alexander Graham Bell was in his laboratory, working on a device that would allow people to talk to one another through wires, even when they were not in the same room, or even the same city. Today, we take for granted that we can communicate in real time with people around the corner and around the globe. But in the 1870's, when Bell was experimenting with his new project, such an idea was like a fantasy.

On March 10, 1876, that fantasy came to life. It is unclear what exactly unfolded that day, but one story says that while working on his voice transmitter, Bell accidentally knocked over a bottle of transmitting fluid, burning his skin. Instinctively, he called out to his assistant, Thomas Watson, to come help: "Mr. Watson. Come here. I want to see you."

Watson heard those words and was startled. They had come crackling across the earpiece of what the two inventors had labeled the telephone. The experiment was successful. It was the first telephone call.

Alexander Graham Bell's interest in communications devices traced back to his childhood in Edinburgh, Scotland. He was born on March 3, 1847 to a father who was an expert in speech production and a mother who was a gifted pianist despite being profoundly deaf. The perseverance and success of his mother in the face of such adversity taught young Alexander that problems were surmountable and that he could help people to overcome them.

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From a young age, Alexander's curiosity propelled him to find solutions to problems. When he was 12 years old, he came up with his first invention. While playing in a grain mill with a friend, he was frustrated by the lengthy time it took to remove the husk from the wheat grain. He went home, thought about it, and created a gadget that used rotating paddles and nail brushes to strip the husk off the grain. It was the first of dozens of varied devices that Bell would invent.

Bell's curiosity and ingenuity were nurtured by his grandfather, a teacher of speech and elocution. When Bell was 15 years old, he went to live with and care for his grandfather, who was aging and ailing. The two grew very close, and the grandfather encouraged Alexander to pursue his inventive streak.

In 1870, the Bell family's life changed rather abruptly when they moved to Canada. Bell's two older brothers had died of tuberculosis, and Alexander's health had been failing, too. His parents were convinced that America would be a healthier environment and moved, first to Ontario, Canada, then to Boston. Bell thrived. His health improved. Eventually, he began to tutor deaf students in Boston.

The parents of two of his students were excited by Bell's idea to invent a device that transmitted multiple signals over a single wire. One of the parents learned, however, that another inventor, Elisha Gray, was working on a very similar project at the same time. To encourage Bell and to help rush his work along, the parent hired an electrician by the name of Thomas Watson to be Bell's assistant. He hoped that between Bell's clever ideas and Watson's practical skills, the two men would succeed quickly. However, instead of focusing on a multiple-signal transmission device, Bell and Watson focused much of their time on a device to transmit the human voice over wires. To protect their experiment, Bell and Watson's voice-transmitting device was registered with the United States patent office. Lewis Latimer, another inventor, helped Bell by drafting the drawings of the device for the patent. The patent was well timed: Gray attempted to file for his own "telephone" the very same day, but he was turned away because the idea was already protected and owned by Bell and his supporters.

On that March morning in 1876, Bell's dream was achieved when the words "Mr. Watson. Come here. I want to see you" traveled from the room Bell was in to the room Watson was in across telephone wires. The two men took their incredible telephone device on the road, demonstrating its proficiency in city after city. The year after his telephone came to life, Bell married Mabel Hubbard, one of the deaf students whose fathers supported Bell's dream of inventing the

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telephone.

Bell was challenged dozens of times in lawsuits by people trying to discredit his patent, especially by other inventors who claimed to have invented the telephone before him. He won every time. Bell created the Bell Telephone Company, and in the first 10 years of its existence, telephone ownership in the United States grew to more than 150,000 people. Bell improved the device over the years. For example, he added a microphone that amplified the voice. He also went on to invent and patent many other devices that would have pleased his mother because of the way they helped people to solve problems.

When Bell died on August 2, 1922 in Nova Scotia, Canada, the entire telephone system was shut down for one minute in tribute to the man who revolutionized communications.

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