Who Really Invented The TELEPHONE?

These days, nobody thinks twice about the telephone—but it wasn't always that way.

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WE'VE BECOME SO USED TO THE TELEphone that it is noticed only when it doesn't work. Most of the time any location in the U.S. can be reached in 10 to 15 seconds. And it takes only a little longer to be connected with most parts of the world. It was not always like that.

The telephone has a long and fascinating history. Today, we credit Alexander Graham Bell with the actual invention, but he was only one of many who contributed to the development of the speedy, generally reliable communications tool that the telephone has become.

The word "telephone" dates back to 1796. First used in Germany, it was derived from the Greek words "tele" meaning far and "phon" meaning speaking. Thus, a far-speaking instrument. The word was used then to describe a directive megaphone.

Samuel Morse had invented the telegraph in 1838, as well as a code of dots and dashes to transmit messages over a wire. Due to the success of his invention the goal of the would-be telephone inventors was to send the human voice over the telegraph wires. Among many who tried was an American, C.G. Page. In 1837—before Morse had perfected the telegraph—Page was the first to demonstrate that it was possible. With his device, the pitch of a tone could be heard but not the actual words. His device was lost, but his work inspired the next inventor.

Philip Reis, a German, made his contribution about 1860. From written descriptions of his instrument, his idea for a transmitter was to apply the principle of the human ear—a membrane.

He stretched a cow's bladder over the side hole of a barrel. (No one can accuse him of using exotic materials for his experiments.) Touching the membrane was a pair of insulated wires carrying an inter-

mittent electric current. The ends of the wires were wrapped around a magnetized knitting needle. The needle was inserted into the body of a violin. That was the receiver. When the membrane over the barrel was made to vibrate it caused the current in the wires to vary in intensity. As the current varied so did the position of the magnetized needle. This effect was based on the magnetostrictive principle discovered by Page. The strings of the violin vibrated sympathetically with the motion of the needle and a tone was heard. The device was undeniably crude. Nevertheless, he was very, very close to achieving his goal.

In fact, he was so close that his invention was brought into court 20 years later in an attempt to answer a suit brought by the Bell Telephone Company against the Dolbear Electric Telephone Company claiming patent infringement. Dolbear was trying to overthrow Bell's patent by proving that Reis's invention predated Bell's. Dolbear lost his case. In spite of fiddling and making adjustments during the trial he could not get Reis's device to work—much less speak.

Back to Bell

We've jumped a bit ahead of our story. Let's turn next to the man who deserves the credit for the invention of a working instrument capable of transmitting and receiving the human voice. Just like his father, Alexander Graham Bell's life work was dedicated to teaching the deaf to speak intelligibly. In that era, a deaf person was an object of shame and was shunted off by the family. Bell, highly sympathetic to the tragedy of the deaf, taught his father's method of "Visible Speech." He used a code of symbols that represented the exact position as well as the actions of the tongue, throat and lips while speaking. Due to his knowledge of the physiology of speech he became engrossed with the possibility of the transmission of the human voice over wires. Two hundred years before, experiments showed that the voice could be transmitted over a taut wire. Remember the "telephone" you built as a child using a piece of string with cans tied to each end?

While teaching at a school for the deaf in Edinburgh, Bell read a report in German by Hermann von Helmholtz on speech theory. In the course of his experiments with electrically-driven tuning forks he found, as he explained in his report, that he could reproduce vowel sounds by mechanical means. Bell, not understanding German very well, got the impression that the German had transmitted those vowel sounds over a telegraph wire. The mistake shifted Bell's interest in the use of electricity as a carrying force.

Because of his health, Bell moved to Boston, but continued his teaching. Adding to his determination to produce a telephone was his love for a deaf pupil. Her family was wealthy and he realized he could never make enough money from his teaching to be allowed to marry her. He devoted his evenings to tinkering in his little home lab trying to work on another idea of his: an improvement of the telegraph. Misinterpreting Helmholtz, he thought he could activate several different tones on different tuning forks at the receiving end of the line. That would allow several messages to be sent simultaneously over the same set of wires.

Of course, the inevitable happened—he ran out of money. Gardiner Hubbard, his future father-in-law and Thomas Sanders, the father of another deaf child, came to his aid. They formed a company to finance his experiments and perfect his ideas about the telegraph. In fact, his partners believed that Bell was devoting his entire time to improving the telegraph. They had no faith in his ideas about a telephone. Two patents were issued to the new company. The first, No. 161,739, was for "Improvements in Transmitters and Receivers for the Electric Telegraph." Patents then were issued on an idea; it did not have to be proven to work. Bell's telegraph didn't. The second patent was not to come until later.

The funds from his partners allowed Bell to hire a young mechanic, Thomas Watson, who built equipment following Bell's ideas. By this time Bell had become dissatisfied with his progress using tuning forks so he began working with metal organ reeds. He believed reeds could be made to vibrate sympathetically, like violin strings, in response to the human voice. Basing his experiment on his knowledge of the anatomy of the human ear, Bell attached one end of his metal reed to a diaphragm; the diaphragm resembling the ear drum. As the reed vibrated in response to a modulated tone, the current would flow varying in intensity. He still had no results.

One day, Watson tightened the reed so that it could not vibrate loosely as in the previous experiments. That mistake was the first breakthrough. Trying to free the tightened reed, Watson pulled it and it twanged. Bell at the other end had another reed close to his ear; that reed twanged in response. The experiment took place in early 1875. It was the first really important step toward the successful telephone.

The early inventors believed that an intermittent current was necessary to transmit the voice. Watson by tightening a screw provided a steady-state current. The result was a partial success. A few words that could be heard—once in a while.

Now comes the part of the story that has remained controversial to this day. On February 14, 1876, Bell filed a patent application with the Patent Office in Washington. It was on the setup that he and Watson had been working on. During all those months of experiments Bell knew that he was racing against time as another inventor, Elisha Gray, with several inventions to his credit, was also working on the idea of transmitting the human voice over telegraph wires.

By a curious coincidence, Elisha Gray filed a "caveat" on the same day. That was not a true patent application but rather a form of warning to other applicants of his work on a speaking telephone. Caveats do not exist today. In any case, Gray's caveat shows the stamp from the Patent Office as having been received four hours after Bell's. Apart from the coincidence of both men filing on the same day, Bell's application has hand-written marginal notes that refer to a method of achieving transmission. It was not known that Bell had been working on such an approach. It was similar to Gray's approach to the problem. Bell was issued Patent No. 174,465, called "Improvement in Telegraphy," it was mis-named. It was in reality, as might be expected, an improvement on the telephone. Regardless of its name it was the most valuable patent ever issued.

The question comes up: "Was it possible that Bell's attorney had the opportunity to study Gray's caveat illegally?" Considerable correspondence was exchanged between the two men, and Gray was later to write that he was far from achieving the results obtained by Bell. But then why did he file that caveat? The answer will never be known.

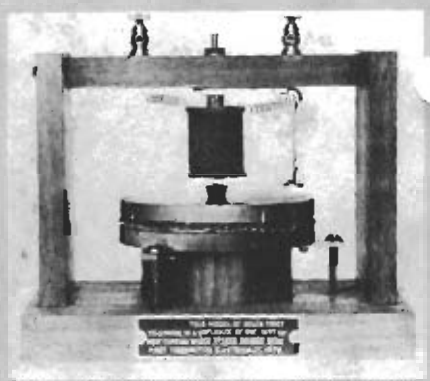

FIG. 1—ONE OF BELL'S early phones. It was called the gallows phone because it resembles a gallows used for hanging.

Bell continued to improve the crude device. Under his direction Watson built a frame that enclosed a tightly stretched membrane. From its shape it was called the "Gallows" telephone (see Fig. 1). The sound waves from the voice caused the membrane to vibrate, causing a steel reed to vibrate in harmony. Over the years of working with the deaf, Bell had developed a powerful voice with precise enunciation. So he could make his device work up to a point. But others without his voice training found that when they tried his telephone they had to repeat whole sentences. Words could be distinguished only after constant repetitions.

The first real success

Like many other breakthroughs, Bell's breakthrough with the telephone came

FIG. 2—THE LIQUID TELEPHONE. It was over this device that the historic words "Mr. Watson, come here, I want you!" were spoken on March 10, 1876.

about because of an accident. The happy accident took place in Bell's laboratory on March 10, 1876. He dropped a jar of sulfuric acid while Watson was on a floor below. Needing Watson to mop up, Alexander said, "Mr. Watson, come here. I want you." At that moment Watson was making adjustments on the latest device (see Fig. 2). He heard and understood the sentence and thinking it was another test, he rushed up the stairs. This was the first sentence ever to take place on the telephone. The age of the telephone had begun.

Gray, meanwhile, formed a partnership to establish a company called Western Electric. After battling with American Bell, the latter took over Western Electric and made it its manufacturing arm.

Thomas Alva Edison, with a keen eye for the commercial value of an idea, also worked on the telephone. In 1877 he invented a carbon-button variable-resistance transmitter (a mouthpiece) that was far superior to Bell's.

Then Francis Blake invented a transmitter that was still better; even that was further improved by Emile Berliner in 1877. (Berliner is best known for his work on the phonograph.) The Berliner transmitter was a variable-contact device. In it, a loose contact was used to transmit a current of varying intensity over the line.

That invention came at a moment when American Bell was in dire financial state. It had the advantage that the transmitter and the receiver were separate and thus ended forever the shuttling of mouth to ear during a conversation.

Improvements on the telephone continued to flow fast and furiously from many sources. The momentum gathered speed and was not about to stop. The telephone was too much a part of everyone's life to be ever considered anything but a necessity.

Turning a crank on the telephone generated current from a magneto (see Fig. 3). The crank had to be turned as long as the call lasted. One advantage comes to mind. It kept conversations from lasting too long. You could talk only as long as your arm muscles held out. Those gymnastics ended when the magneto was adapted so as to be used only to alert the operator that a subscriber wanted to make a call.

The telephone remained unreliable. Still subscribers were willing to shout themselves hoarse so as to be able to use that "newfangled gadget." It was as much a status symbol as it was a convenience for a businessman.

It was not until the latter part of 1876 that a simultaneous, two-way con-

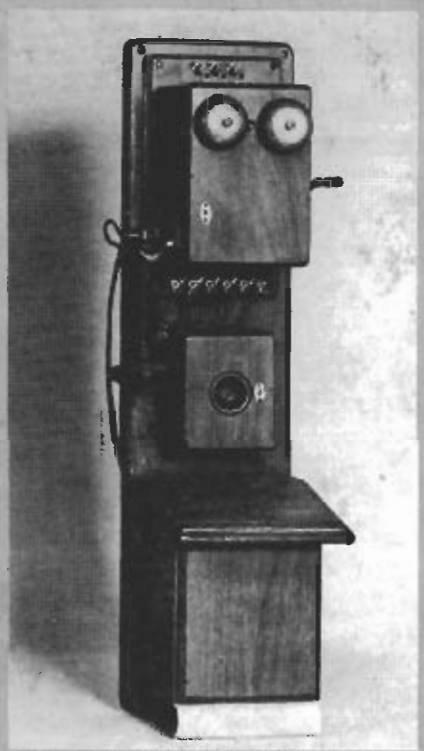

FIG. 3—THE MAGNETO WALL SET. This hand-cranked telephone used Blake's transmitter and Bell's receiver. It was the first telephone built by Western Electric for Bell.

versation—full duplex—was possible. Five years later the need arose to establish long distance lines. The first was opened to general use in January of 1881. It ran from Boston to Providence, Rhode Island, a distance of 45 miles.

The technique then was to use an existing telegraph wire for one side of the circuit while the other side was obtained by using the ground as return. The results were poor. Traffic on the line caused too much interference to make it an unqualified success. Later the fidelity was increased dramatically when both sides of the circuit were on wire and the ground was eliminated.

FIG. 4—OPERATORS AT WORK at a central switching office in 1896.

Subscribers were limited to talking to only the other party with whom they were wired. That was changed in 1878 when the first practical exchange appeared. There were 21 subscribers to that central office. Young boys were used as the operators, but because of their unruliness and habit of swearing at the subscribers, they were replaced by lady operators who were more genteel and reliable (See Fig. 4).

Switching was a manual operation. As an outside call came in the operator thrust a flexible wire with a slender connector at each end into the socket of the incoming call and into the socket of the party being called.

During peak hours an operator needed more hands than ordinarily come with a human body. The speed and accuracy of the completion of the calls depended entirely on the dexterity of the operator. For over a dozen years inventors exercised their wits to find some way to replace the operators.

Automatic switching

The eventual solution was invented by a man whose work was far removed from telephony, yet he created an exchange so dependable and so simple that they are still operating as part of the telephone system's central offices.

The inventor was Almon B. Strowger, who was, of all things, an undertaker in Kansas City. Angered by what he felt was the ineptness of the operators who caused him to lose business by shunting his calls to a competitor, he decided to see if he could find a way to eliminate them.

He made his prototype using stiff celluloid collars, as worn by gentlemen of that period, plus a few hairpins borrowed from his wife. Two pencils were used to represent the moving parts of the switch. The Strowger switch is as simple as were the ingredients that composed the model. His patent was filed in 1889; it was the first electro-mechanical switch.

Capable of serving 99 telephones, it was operated by the subscriber's own telephone instrument. In one fell swoop manual switching was eliminated. The original phone was equipped with two buttons. An array of 10 by 10 terminals were arranged in a cylindrical arc about a

FIG. 5—A STROWGER automatic telephone (dial-type). The invention of this phone eliminated the need for manual switching.

vertical shaft. Pressing the first button seven times, for example, raised the vertical shaft seven steps; a ratchet mechanism was driven by an electromagnet responding to the pulses. The second button rotated the switch horizontally to the number of pulses sent by the second button. The mechanism was held during the call. When it was over the switch returned to its normal position ready for the next call. Later the two buttons were replaced by a dial as seen in Fig. 5. The year 1892 saw the installation of the first automatic exchange in La Porte, Indiana.

An important change took place when a battery system was patented in 1888. It provided current from a central switching exchange to all the connected telephones. Previously one battery was needed for the switching mechanism while the subscriber needed two: one for the speaking end and another for the receiving.

By the turn of the 20th Century there were 1,356,000 telephones in the U.S. Long distance calls could be made provided the distance between the two cities was not more than a thousand miles. (See Fig. 6.) Beyond that, the signals became too faint due to line losses. A repeater, somewhat like an audio amplifier, was placed in the line to make up for the losses. Initially, a three-element vacuum tube, called a triode, developed by Lee de Forest in 1907, was used. One of those repeaters was required for each mile of line.

Once the triode was perfected, it made for a good repeater—but, problems remained. Those are the same problems associated with using a vacuum tube in any circuit. That is, they require high voltages, they develop a large amount of heat, and their life is short. The cost and trouble of maintaining long-distance lines that use vacuum-tube repeaters is therefore high.

FIG. 6—AN EARLY LONG-DISTANCE phone call. Here, Bell himself is placing a call from New York to Chicago. The year is 1892.

The unexpected contribution

It was in their search for an alternative to tube repeaters that Bell Labs, the research and development arm of American Telephone and Telegraph, the company that the Bell Telephone Company had grown into, came up with its most famous achievement in 1947. Doctors Brattain, Bardeen, and Shockley invented the transistor working at Bell Labs. Here was the ideal replacement for tubes as repeaters. Low cost, long life, and little maintenance made long distance lines cheaper to keep up.

And now our story returns to and ends with Alexander Graham Bell. During the last years of his life he thought of transmitting voice over a light beam (see Fig. 7). His "Photophone" was, however, unsuccessful. It depended on sunlight for transmission and no one was interested in replacing the telephone. After all, millions of dollars had already been invested in equipment. He was ahead of his time. With fiber optics Bell's dream has become

FIG. 7—BELL'S PROPOSED PHOTOPHONE. It was an idea many years ahead of its time.

a reality. Optical fibers, not much thicker than a human hair, emit no heat and have less line loss than wires or cables. The fibers can be bundled and a bundle the diameter of one's finger, including the sheath, can transmit 8,000 calls.

The story of the telephone is really not over. Nor will it ever be be as long as inventive minds are at work. R-E