History of Communications

Edited by Mischa Schwartz

Introduction by Editor

Readers of this column will have noted that we have been publishing three kinds of papers: recaps of the development of significant communication systems some time ago by engineers involved in their original design and/or implementation; tributes to outstanding engineers and scientists of the past who contributed a great deal to the history of our profession; and articles providing new insight into the history of communication technologies. The article following, written by a historian with particular expertise in the history of telegraphy, is in this last category. It provides new insight into, and attempts to clear up, possible misconceptions of the relative contributions to the early history of telegraphy in the United States by Samuel Morse, Alfred Vail, and Joseph Henry. The author's conclusion is clear: Morse was the one who succeeded in reducing the invention of telegraphy in the United States to practice, but he relied on the substantial contributions to the then-new science of electricity by Henry and the mechanical ingenuity of Vail. Without the help of either one, the Morse telegraph would not have been successful as a commercial system. As another interesting note, the author points out that the Morse code was developed by Morse himself, despite frequent comments that Vail was the one who developed the code. I found the article not only of great interest but exceptionally well written. Readers with knowledge of telegraphy will, I am sure, find their knowledge enhanced by reading and studying the article. Those readers with no or little knowledge of the history of telegraphy will, I am equally sure, learn a great deal about the field and find their appetite whetted to learn more.

—Mischa Schwartz

Two Controversies in the Early History of the Telegraph[1]

David Hochfelder

Shortly before Samuel Morse's death in 1872, a book called *The Great Industries of the United States* appeared. The book's article on telegraphy was especially harsh toward the 80-year-old inventor, allowing him only "the most meager part" in the development of the telegraph. The author asserted that "there never was a more ludicrous and lamentable delusion" foisted "upon the credulous masses" than Morse's claim to be "the inventor of the practical telegraph known by his name." Morse, the account continued, had only "vaguely conceived that something more or less like it might be desirable." He was just "a dreamer, and speculator with certain forces… His efforts were, in short, all abortive; for he groped about in ignorance" for several years until the physicist Joseph Henry and the skilled technician Alfred Vail transformed Morse's crude speculations into a working telegraph. Samuel Morse, the author concluded, was merely "a sort of providential hyphen, or unwitting magnet, by which Prof. Henry's science became at last united to Mr. Vail's constructive genius."[2]

This criticism of Morse, that he merely combined Joseph Henry's scientific discoveries in electromagnetism with Alfred Vail's mechanical genius, has overshadowed the popular (if not scholarly) history of telegraphy since Morse's death.[3] Professional historians of technology are well aware that invention is rarely the work of a lone individual, but the 19th-century patent system did not recognize invention as a collaborative or simultaneous process. The general public, too, delights in stories of brilliant underdog inventors denied their due by unscrupulous rivals or associates. Other noteworthy examples include Edison and Tesla, and DeForest and Armstrong.

[1] *Readers interested in learning more about the early telegraph can consult the following sources.*

Two excellent biographies of Morse are Ken Silverman, Lightning Man: The Accursed Life of Samuel F. B. Morse*; and Carleton Mabee,* The American Leonardo: A Life of Samuel Morse. *Morse's son Edward Lind Morse excerpted and collected Morse's correspondence to produce a somewhat biased but still useful biography,* Samuel F. B. Morse: His Letters and Journals *(available for free on Google Books). Morse's papers are at the Library of Congress, and some 6500 of them are online at http://memory.loc.gov/ammem/sfbmhtml/sfbmhome.html*

Joseph Henry's scientific work is well documented. For an excellent scientific biography see Albert E. Moyer, Joseph Henry: The Rise of an American Scientist. *Thomas Coulson's older biography,* Joseph Henry, His Life and Work, *is useful also. All of Henry's scientific writings are collected in the two-volume* Scientific Writings of Joseph Henry *(available for free on Google Books). Since Henry was the first Secretary of the Smithsonian Institution, his papers are housed at the Smithsonian's Archives. The staff of the Joseph Henry Papers project completed a twelve-volume selected edition of his papers. A description of the edition along with some sample documents is at http://siarchives.si.edu/history/jhp/jhenry.html*

Unfortunately, no comparable amount of material for Alfred Vail exists. Vail's son J. Cummings Vail culled Vail's diaries and letters to produce a partisan biography, The Early History of the Electro-Magnetic Telegraph. *Vail himself wrote a description of Morse's telegraph in 1844,* Description of the American Electro-Magnetic Telegraph *(available for free on Google Books). Vail's personal papers are at the Smithsonian Institution Archives and the New Jersey Historical Society, Newark.*

[2] *"The Magnetic Telegraph," in* The Great Industries of the United States: Being an Historical Summary of the Origin, Growth, and Perfection of the Chief Industrial Arts of this Country *(Hartford: J.B. Burr & Hyde, 1872), pp. 1240–42, 1249.*

[3] *Vail's tombstone in Morristown, New Jersey credits him with the invention of Morse code, and the statue of Joseph Henry at the Albany (New York) Academy, site of his early electromagnetism experiments, credits him with anticipating Morse's telegraph.*

Eminent electrical inventor Franklin Pope also thought that Morse did little more than meld Henry's scientific discoveries to Vail's mechanical genius. Franklin Leonard Pope, "The American Inventors of the Telegraph, with Special References to the Services of Alfred Vail," Century Illustrated Magazine *35 (April 1888), 924–45.*

See also Thomas Coulson's 1950 biography of Henry in which he asserts that Morse's "first conception had been completely discarded in favor of devices suggested to him by Gale, Henry, Vail, and Cornell." His "personal contribution to the telegraph" was merely that he "made it practical by his perseverance." Coulson, Joseph Henry: His Life and Work *(Princeton, N.J.: Princeton University Press, 1950), p. 221.*

The website for Historic Speedwell, Vail's home and the site of the first public demonstration of Morse's telegraph, claims, "History glorifies Morse but credits little, or nothing, to Alfred. The reasons are complicated, unfair and more than a little sad." (http://www.morrisparks.net/speedwell/home.html; viewed on September 18, 2009.)

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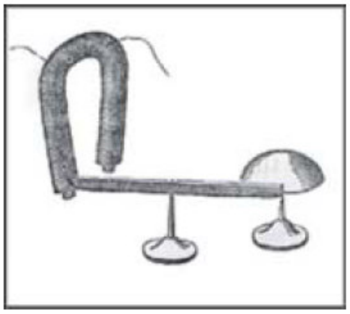

Figure 1. *Sketch of "telegraph" Henry showed his classes at the Albany Academy. From Smithsonian annual report for 1857, p. 105.*

Tesla and Armstrong were of course accomplished and talented engineers. Morse was not: It is one of history's surprises that a portrait painter with little formal scientific or technical training established the first electrical communications system in the United States. As this article shows, Morse succeeded partly through his own hard work and perseverance, but also because he sought out the assistance of those who had the necessary skills and training, particularly Joseph Henry and Alfred Vail. Henry and Vail made indispensable contributions to the science and machinery that made telegraphy possible, but the fundamental achievement — commercially viable electrical communications — was Morse's.

JOSEPH HENRY'S IMPORTANCE TO THE TELEGRAPH

Joseph Henry made pioneering discoveries in electromagnetism, most importantly the theory and construction of electromagnets that were powerful enough to transform electrical energy into useful mechanical work. His research, along with that of his British counterpart Michael Faraday, laid the foundations for later developments in electrical communications and power. Much of Morse's telegraph did indeed rest on Henry's discovery of the principles underlying the operation of such electromagnets.

The science of electromagnetism began in 1819 with Hans Christian Oersted's discovery that an electrical current passing through a wire deflected a nearby compass needle. His discovery immediately set physicists to work on the relationship between electricity and magnetism. Several sought to harness this new force for purposes of long-distance communication. Within a year of Oersted's publication, the eminent French physicist André-Marie Ampère used the newly invented galvanometer as a way to communicate telegraphically, reporting that his experiments were "completely successful." Unfortunately, he did not pursue the matter further. In 1824, however, the English researcher Peter Barlow dampened enthusiasm for an electromagnetic telegraph. "The details" of such a device, Barlow wrote, "are so obvious, and the principle on which it is founded so well understood," that the only open question was whether the electrical current could deflect a magnetized needle after passage through a long wire. To his disappointment, he reported that he could deflect a needle through only 200 feet of wire and no further, a result that "convince[d] me of the impracticability of the scheme." Barlow's result seemed to present an insurmountable barrier to using this newly discovered physical force for long-distance communication.

Enter Joseph Henry. He began his research into electromagnetism in 1827, while he was an instructor at the Albany Academy in New York. By 1830 he had developed two forms of electromagnets, a "quantity" magnet capable of lifting heavy weights and an "intensity" magnet that could be actuated at great distances from a battery.[4] Henry published his results in January 1831, showing how his improved magnet designs overcame Barlow's 200-foot distance barrier and concluding that his results were "directly applicable to Mr. Barlow's project of forming an electro-magnetic telegraph." This was not an offhand remark. Henry set out to demonstrate the practicability of an electromagnetic telegraph immediately after his paper appeared. His prototype consisted of a small battery and an "intensity" magnet connected through a mile of copper bell-wire strung throughout a lecture hall. In between the poles of this horseshoe electromagnet he placed a permanent magnet. When the electromagnet was energized, the permanent magnet was repelled from one pole and attracted to the other; upon reversing battery polarity, the permanent magnet returned to its original position. By using a pole-changer to switch the electromagnet's polarity, Henry caused the permanent magnet to tap a small office bell. He consistently demonstrated this arrangement to his classes at Albany during 1831 and 1832.

In 1832 Princeton hired him as professor of natural philosophy, what we today call physics. He reconstructed his telegraph prototype on the Princeton grounds, this time stringing a wire between two campus buildings. He not only continued to demonstrate electromagnetic communication at a distance, but in 1835 he also developed a primitive relay. He used an "intensity" magnet, which worked well at low power over great distances, to control a much larger "quantity" magnet supporting a load of weights. By closing the "intensity" circuit, he opened the "quantity" circuit, causing the weights to crash to the floor — while he remained at a safe distance. Students remembered that he described the arrangement as a means to control mechanical effects at long range, such as the ringing of distant church bells.

So by 1835, Henry had demonstrated, at least in a laboratory and lecture hall setting, that an electromagnetic telegraph was possible. His "intensity" magnet would become the basis of Morse's repeater, which allowed signals to travel great distances; his "quantity" magnet formed the heart of Morse's recording instrument; and his "intensity" to "quantity" relay became, with some modification, Morse's arrangement for connecting his local receiving circuit to a long-distance telegraph line. But Henry never sought to commercialize his system, or even to demonstrate it on a larger scale. He saw his telegraph as a particularly effective lecture hall demonstration of the principles of electromagnetism. Princeton students vividly recalled Henry's telegraphic demonstrations, just as they remembered him electrocuting chickens and shocking classmates.

HENRY AND MORSE

Morse claimed that he conceived of his recording telegraph during a long Atlantic crossing in October 1832. By early 1836 he managed to construct a simple prototype, which used a one-cell battery and a crude electromagnet. With this primitive apparatus Morse was able to record signals, but only to a distance of about 40 feet. To increase the range of his device, Morse sought the aid of Leonard Gale, professor of chemistry at New York University, where Morse taught painting. Upon seeing his prototype in January 1836, Gale immediately urged him to read Henry's 1831 paper which described the construction of suitable electromagnets. After using a higher-voltage 20-element series battery and an electromagnet of several hundred turns, Morse and Gale were able to send messages through 10

[4] *"Quantity" and "intensity" were contemporary terms for current and voltage, respectively.*

Figure 2. *The frontispiece of Samuel Irenaeus Prime's 1875 biography of Morse. As an indication of Morse's desire for scientific recognition, this image shows him displaying scientific medals awarded him by seven European countries. His telegraph instruments are at his right hand.*

miles of wire. Morse chose this distance for two reasons. First, it was the upper range of distances used in optical or semaphore telegraphs, like the French system that Morse had witnessed in operation in his European travels. Second, Morse had conceived of the idea of an electrical relay, and was confident that he could develop a commercially practical system using electromagnetic relays placed at 10-mile (or greater) intervals. This success emboldened Morse to reveal his invention to the world. He demonstrated his telegraph publicly for the first time on September 2, 1837; solicited government support from the secretary of the Treasury a few weeks later; and filed a caveat (an advance notice of his intention to file a patent) with the Patent Office at the beginning of October.

Thus, Henry's research on electromagnets was essential to the operation of Morse's telegraph — indeed, all versions of the electromagnetic telegraph — over long distances. Henry's discoveries also aided the British telegraph inventor and scientist Charles Wheatstone, who was able to send signals great distances after his erstwhile partner William Cooke failed to do so. Although this article focuses on the invention of the electrical telegraph in the United States, several other inventors around the world developed electrical telegraphs at roughly the same time (Gauss, Weber, and Steinheil in Germany, and Schilling in Russia being the most prominent). Thus, the telegraph was an excellent example of simultaneous invention, verifying Henry's 1842 statement that "science is now fully ripe" for electrical telegraphy.

Between 1839 and 1842, Morse frequently corresponded with Henry, seeking both scientific advice and public endorsements of his telegraph. Henry gave both willingly. But he also made it quite clear that he regarded Morse's machine as the application of scientific principles discovered by himself and other scientists. In an oft-quoted letter that he wrote in February 1842 to help Morse obtain Congressional funding, Henry asserted that the idea "would naturally arise in the mind of almost any person familiar with the phenomena of electricity." Although he noted that several European scientists were working on other telegraph designs, Henry concluded, "I should prefer the one invented by yourself."

Unfortunately, relations between Morse and Henry — both proud men — quickly deteriorated. As the inventor became embroiled in bitter litigation over the validity and scope of his patent, his need to establish originality and priority clashed sharply with Henry's assessment of the prior art. The first sign of a break occurred in the fall of 1845. At that time, Morse's assistant Alfred Vail published a book giving a history and description of Morse's electromagnetic telegraph. Vail clearly acknowledged that "the electro magnet is the basis upon which the whole invention rests in its present construction; without it, it would entirely fail." Yet Vail barely mentioned Henry's work. Henry regarded this as a deliberate snub, exclaiming to British physicist Charles Wheatstone that he intended to "inform Mr. Morse if he suffers any more such publications to be made by his assistants he will array against him the science of this country and of the world." Morse, it turned out, had enjoined Vail from revealing too much about prior scientific research on electromagnets for fear that doing so would jeopardize his claims to priority of invention.

The second major rupture between the inventor and scientist occurred in the fall of 1849, when Henry was dragged into a patent infringement suit. The defendants, who were using a telegraph that clearly infringed Morse's patents, hoped Henry's testimony concerning the prior art would invalidate the patent's key claims. Henry, for his part, claimed that he did not wish to become a party to this controversy and that he gave his statement unwillingly, only under subpoena.

In his deposition Henry claimed that his 1831 paper had proven that "the electric telegraph was now practicable." He also stressed that he demonstrated to his Princeton classes after 1833 "how the electro-magnet might be used to produce mechanical effects at a distance adequate to making signals of various kinds." He did not "reduce these principles to practice," because he regarded this to be "of subordinate importance" to his scientific work. Besides, Henry concluded, scientists were disinclined to "secure to themselves the advantages of their discoveries by a patent." While Henry regarded Morse's machine as "the best" of several telegraphs under development in the mid-1830s, all of them "applying the principles discovered" by himself and others, he denied that Morse had made "a single original discovery, in electricity, magnetism, or electro-magnetism, applicable to the invention of the telegraph. I have always considered his merit to consist in combining and applying the discoveries of others in the invention of a particular instrument and process for telegraphic purposes." Henry summed up his testimony later, that he had "always been careful to give Mr. Morse full credit for his invention, though I cannot award to him the exclusive right to use the scientific principles on which his invention is founded."

Morse's patent litigation dragged on for several years, until the U.S. Supreme Court narrowly ruled in his favor in 1854. Still, the ruling rankled Morse, as the Court rejected Morse's broadest patent claim, that his patent covered all forms of communication using electromagnetism to make signals or record signs. The ruling limited Morse to his particular telegraph design and opened up the telegraph industry to competing designs. Morse blamed Henry's testimony, that Henry and other scientists had anticipated Morse in using electromagnetism to send signals, for the Court's ruling. Both men remained bitter enemies until their deaths in the 1870s.

ALFRED VAIL'S CONTRIBUTIONS TO TELEGRAPHY

Few Americans today remember Alfred Vail. Over the past century or so he has largely dropped out of our history, even though he was instrumental in the

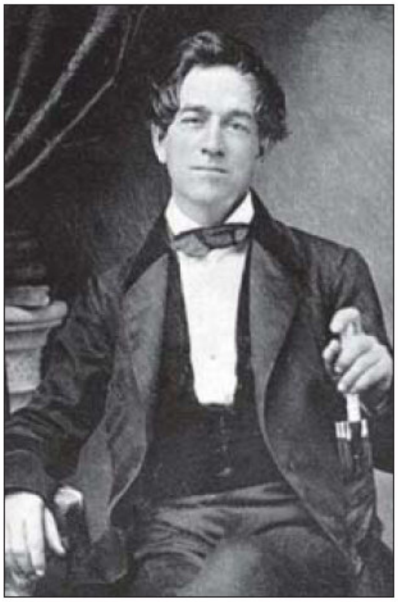

Figure 3. *Alfred Vail, from a daguerreotype taken around 1850.*

development and commercialization of the telegraph. After all, there are book-length biographies of every important person connected with the early telegraph industry, except for Vail. Consider also the three major biographical encyclopedias of the past century, standard reference works available in most libraries. Vail appears prominently in the first biographical encyclopedia, the *National Cyclopedia of American Biography*, published in the 1890s. This entry gives him credit not only for the telegraph key and recording register, but also for inventing the telegraphic alphabet commonly known as Morse code. The *Dictionary of American Biography*, published in the 1920s and 1930s, also has an entry on Vail. While the author of this entry did not take sides in the controversy over the alphabet code, he concluded that "Vail profited little from the telegraph… and he died poor and unhappy." The latest biographical encyclopedia, the *American National Biography* published in the 1990s, contains no entry for Vail.

This historical amnesia is unfortunate. Vail was essential to Morse's work on his telegraph between 1837 and 1845. Morse himself called Vail "my right hand man in the whole enterprise,… more essential to the success of the Telegraph than any two persons that could be named." A skilled and creative machinist, Vail refined Morse's crude mechanical design and made his telegraph fit for public demonstration, a necessary step to secure Congressional funding. Vail helped Morse build his first line between Washington and Baltimore in 1844 and served as the operator on the Baltimore end. He superintended the construction of the first commercial telegraph line between New York and Philadelphia in 1845. Finally, Vail conducted pioneering electrical experiments to conserve battery power, and to understand the behavior of electromagnets and line resistances during electrical storms and other transient phenomena.

Vail inherited his mechanical skills from his father, Stephen, who ran a machine shop in Morristown, New Jersey. Stephen was a domineering father, and Alfred longed to escape Morristown and make his own way in the world. He graduated from the University of the City of New York (now New York University) in 1836 and cast about for a career afterward. Vail was one of the witnesses present at Morse's public unveiling of his telegraph prototype on September 2, 1837. Vail was impressed at the possibilities of Morse's telegraph for long-distance communication, but he knew that Morse lacked the mechanical skill to make it commercially feasible. He agreed to improve Morse's instruments in exchange for a quarter-share in any future U.S. patent (later reduced to an eighth share). Vail returned home to Morristown and spent the fall refining Morse's instruments in his father's machine shop.

Morse and Vail's immediate objective was to construct instruments suitable for demonstrating the telegraph to scientific societies and Congress. Vail did the majority of this work, since Morse was present only part of the time. By January 1838 the telegraph was ready to exhibit publicly. They gave Stephen Vail the honor of drafting the first message, "A patient waiter is no loser." Morse and Vail traveled to Washington to demonstrate the telegraph to Congress, President Van Buren, and the public. In April the House Committee on Commerce recommended passage of a bill appropriating $30,000 to build an experimental telegraph line. Although this bill would not pass both houses of Congress until 1843, Vail's refinement of Morse's telegraph was crucial to their efforts to get public funding.

As is well known, Morse built his first telegraph line in 1844, thanks to this Congressional appropriation. The instruments used on this line were largely of Vail's design, including the modern sending key, and a compact and reliable register to record messages visually. Vail took particular pride in both the key and register design. Stationed at Baltimore, he received Morse's famous first message "What hath God wrought" and engraved his signature on that register in nine places. Since few people wanted or needed to send telegrams a mere 30 miles from Baltimore to Washington, Vail had much time on his hands. He used it profitably to conduct experiments with the line. In his diaries he recorded 58 separate experiments on conductors, batteries, electromagnets, galvanometers, and relays. He succeeded in radically reducing the amount of battery power required to work the line. He also developed a wireless river crossing using buried metal plates. One way to think of Vail's experiments was that he was developing a basic vocabulary of electrical components and how they behaved in circuits. He was quite proud of this work, and complained that Morse did not understand or support his experiments.

Morse had hoped that the successful operation of this first line would convince Congress to buy his patent or fund the line's extension to New York. But Congress took no further interest in his telegraph, and he sought private capital to build telegraph lines. He relied on Alfred Vail to superintend the construction of the first privately owned line between Philadelphia and New York in 1845. Vail later oversaw the construction and operation of the first telegraph line extended southward from Washington. As superintendent of these two pioneering lines, Vail developed operating procedures and practices widely adopted later throughout the industry. However, Vail left the telegraph for good in 1848 after a salary dispute with the Washington and New Orleans Telegraph Company, writing Morse, "I have made up my mind to leave the Telegraph to take care of itself, since it cannot take care of me. I shall, in a few months… bid adieu to the subject of the Telegraph for some more profitable business."

As this letter suggests, Vail felt that Morse and the industry had failed to grant him the recognition and compensation he deserved. Vail thought Morse arrogant and condescending, and bridled when Morse called him his assistant. Vail wanted Morse instead to acknowledge him as a full partner in the invention, not simply as a hired mechanic. For example, he pasted a note to the bottom of his recording register he had used in Baltimore in 1844:

"This lever and roller were invented by me in the sixth story of the New York Observer office, in 1844, before we put up the telegraph line between Washington and Baltimore… I am the sole and only inventor of this mode of telegraph embossing writing. Professor Morse gave me no clue to it… and I have not asserted publicly my right as first and sole inventor, because I wished to preserve the peaceful unity of the invention, and because I could not, according to my contract with Professor Morse, have got a patent for it." In 1852 he complained to Morse's business agent Amos Kendall, "I have the smallest mite" while others "have grown fat upon the Telegraph… . Even some little portions of the Telegraph which I invented have never been publicly awarded to me … I cannot but consider myself as not treated fairly in many instances."

The most controversial question surrounding Vail's work on the telegraph is whether he invented the alphabetic code commonly known as Morse code. However, this claim surfaced only after his death in 1859; his widow and sons seem to have generated this claim to enhance his reputation. In both his public and private writings Vail himself never claimed to have invented the code, but forcefully asserted his claims to the sending key and recording register. On the contrary, during the few times he discussed the code he always credited Morse. For example, in February 1838, while Alfred and Morse were exhibiting the telegraph at Philadelphia's Franklin Institute, Alfred wrote his father, "Professor Morse has invented a new plan of alphabet and has thrown aside the Dictionaries."

CONCLUSION

Two related questions emerge from these controversies over the invention and early commercialization of the telegraph. First, how could Morse, a man with little scientific training or mechanical skill, invent the telegraph? Second, how should we apportion credit for the telegraph among Morse, Henry, and Vail?

Morse's success as an inventor had much to do with the undeveloped state of electrical science in the 1830s and 1840s. At that time, science could explain the effects of electricity, but could not explain what electricity was. In other words there was a wide gap between electrical theory and practice. For example, Vail himself remarked in his 1845 book on Morse's telegraph that "the effects produced by the galvanic fluid… are generally well known. But of the character of the fluid itself, its own essence or substance, we know nothing." Morse and Vail's business agent, former Postmaster General Amos Kendall, remarked in 1847, "I know little of electricity — and I believe nobody knows much." Even the celebrated British physicist Michael Faraday admitted his "total ignorance of the nature of electricity."

Thus, the idea for a telegraph did not require sophisticated scientific knowledge, only a basic familiarity with how electricity and magnetism behaved in practical terms. Morse obtained this basic familiarity with the effects of electricity because of the widespread popularization of science in America in the 1830s, through such institutions as public lectures, accounts in magazines, and mechanics' institutes. Hundreds and sometimes thousands of people attended scientific lectures, particularly spectacular ones involving chemistry and electricity. Morse eagerly attended these public lectures and participated in electrical experiments as an amateur in the 1820s and 1830s. By the time he began work on his telegraph in the 1830s, Morse was a liberally educated amateur scientist.

Yet Morse's amateur knowledge could take him only so far. Recall that his first prototype was capable of sending messages through only 40 feet of wire. He needed Henry's scientific expertise to transmit messages over commercially viable distances. Similarly, Morse did not have the mechanical ability to build reliable and efficient telegraph instruments suitable for public demonstration and commercial operation. Alfred Vail provided this much needed mechanical skill. Vail deserves full credit for making the Morse telegraph into a commercially practical communications system through his refinement of the register and invention of the sending key. Upon hearing of Vail's death in 1859 Amos Kendall, Morse's business agent, said, "If justice be done, the name of Alfred Vail will forever stand associated with that of Samuel F. B. Morse in the history and introduction into public use of the electro-magnetic telegraph."

Morse was a proud, somewhat arrogant man who staked out a too-large claim for himself and his telegraph. He often wore scientific medals awarded him by European countries and, he claimed that his patents covered all sorts of telegraph instruments even when they were radically different from his. His ego and his need to protect his patents led him to downplay the assistance he had received from both Henry and Vail.

Finally, we must understand that the telegraph was a transitional technology in the history of American invention. It was one of the first technologies to rely on recent scientific discoveries. Thus, the crux of the conflict between Morse and Henry involved the different values and reward structures among scientists and technological entrepreneurs. Henry the scientist regarded basic research as of prime importance and thought of technological advances as the mere application of scientific discoveries. He relied on the open publication of his work to achieve professional respect and success. Morse the inventor regarded scientific discoveries as abstract and barren things, until someone like himself made them concrete and fruitful. Morse regarded his invention as intellectual property, and relied on the patent laws to protect his rights and to reap a financial reward for his labors.

In Morse's day nearly all inventions were the work of lone inventors who needed little scientific or mathematical training. Within a generation, however, more and more inventions relied on advances in physics and chemistry. As science-based innovation became more common, lone inventors gradually disappeared, and inventions were more often the product of guided research and development teams. (Thomas Edison's Menlo Park, New Jersey laboratory of the 1870s comes to mind here.) Morse was neither lone inventor nor research team leader but a bit of both. Put differently, modern technological innovation is the successful combination of scientific discovery, reduction to practice, and entrepreneurship. Morse brought all three of these elements together to create the electrical communications revolution that continues unabated today.

BIOGRAPHY

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