

Telegraph

The electrical telegraph grew out of advances in electrical science between about 1800 and 1840, particularly the discovery of galvanic electricity by Luigi Galvani and the invention of the electrical battery by Alessandro Volta around 1800, and research into electromagnetism by Hans Christian Ørsted, Andre-Marie Ampère, Joseph Henry, and Michael Faraday during the 1820s and 1830s. The first two telegraph lines opened in Great Britain in 1837 and the United States in 1844. The telegraph was the only form of electrical communication until the invention of the telephone in 1876, and it remained the mainstay of rapid long-distance communication until the development of practical long-distance telephony after 1900. After 1920, as long-distance telephone rates dropped and many countries introduced airmail service, telegraphy’s share of the long-distance communications market entered a long decline. By 1970 the overland telegraph industry in the industrialized world was dead or dying. Submarine telegraphy survived longer; it was the only medium for rapid overseas communications until the advent of transatlantic radiotelephony in 1927, and it remained the cheapest and preferred medium until the installation of undersea telephone cables in the 1950s. After 1980 other technologies, such as facsimile and electronic mail, took over the role of long distance record communications formerly supplied by the telegraph.

In technological and scientific terms, the telegraph was important for three major reasons. First, telegraphy was the first major application of discoveries in electrical science, and it was one of the first technologies with a firm scientific foundation. Second, telegraph electricians during the mid-19th century helped to establish the discipline of electrical engineering. Finally, technical problems, especially in submarine telegraphy, stimulated major advances in physics, oceanography, marine engineering, and electrical engineering.

Telegraphy was the first technology to sever the connection between communication and transportation. Because of the telegraph’s ability to transmit information almost instantly, it affected many aspects of society, culture, politics, international relations, and economics after 1840. It helped to create integrated national and international markets, sped the dissemination of news, provided a model for new literary forms, aided Western imperialism, and spurred national governments to develop telecommunications and technology policies.

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Optical or Semaphore Telegraphs

Semaphore telegraphs were precursors to electrical telegraphs. Although they were technologically very different, semaphore systems contained several elements that electrical telegraph networks would later incorporate: an alphabetic code, a corps of trained operators, and (except in the United States) control by national governments. Although humanity had long dreamt of transmitting information faster than it could be carried on foot or by horse, this capability only arose during the French Revolution. The five Chappe brothers developed a workable semaphore system that they demonstrated publicly in 1791. The Chappe system used wooden arms mounted on towers. These arms encoded letters and numbers through arm positions. Operators in adjacent towers, spaced about 10 km apart, read the signals by observing with telescopes the positions of the arms.

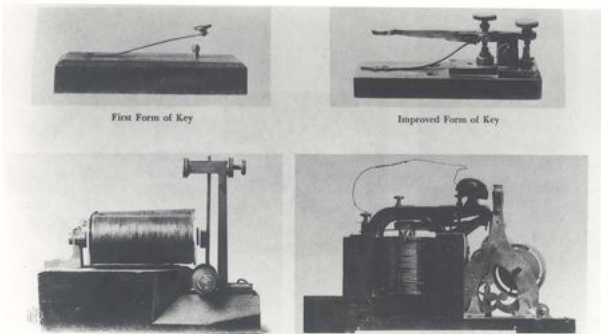
The French government adopted the Chappe system to handle official military and government traffic—these lines handled limited private traffic during and after the 1820s. The first line began operations in 1794 to connect Paris to Lille, near the Belgian border. It soon proved its usefulness by transmitting messages in as short a time as 30 minutes over a distance of about 230 km. At its height, the French network spanned nearly 5,000 km spread over several lines radiating from Paris as the hub. It remained in operation until it was replaced by the electric telegraph in 1853.

Several other countries followed suit and built semaphore telegraph networks, particularly Sweden, Russia, and Great Britain. In Sweden, Abraham Edelcrantz developed a system using shutters instead of arms to indicate letters and numbers. In 1795, Edelcrantz built the first line from Stockholm to the fort of Vaxholm, a distance of about 20 km. The system remained in use to connect the capital to a network of fortifications around the city until the 1860s. The Russian government built lines to connect Moscow and St. Petersburg to the Prussian and Austrian borders. Great Britain built three main lines to connect the Admiralty to ports and shipyards.

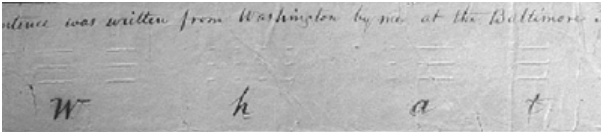
In the United States, several privately operated semaphore systems existed in the major port cities. These were used to report the arrival of ships entering the harbor—merchants subscribed to these to get advance notice of ship arrivals. The most important system was in New York harbor, with a station at Sandy Hook, New Jersey, transmitting information to the financial district at Wall Street. The New York system had been in operation since the War of 1812.



In 1844 Samuel Morse used this telegraph key to send the message “What hath God wrought” on the experimental line between Washington, DC and Baltimore, Maryland. Courtesy: Smithsonian Institution



Telegraph Keys



A detail of the first telegraph message sent by Samuel Morse in 1844. The word represented is the “What” in the message “What hath God wrought”. The handwriting is Morse’s, although his penciled text was written over in ink by a friend. Courtesy: Library of Congress, Samuel Finley Breese Morse Papers.



The Great Eastern

Although semaphore telegraphs were capable of transmitting information rapidly, they had several disadvantages relative to the later electric telegraph. They were expensive to operate due to labor costs. Stations were spaced about 10 km apart and required a staff of two or three operators at each station. In addition, they could not operate at night or during bad weather because of reduced visibility. Their bandwidth was quite low, which limited their use to official government business, or in the case of the American harbor telegraphs, to straightforward news of ship sightings. Because of these limitations, researchers in several countries began to investigate the use of electricity to transmit messages. (Hereafter, the term “telegraph” will refer to electrical telegraphs.)

The Telegraph in Great Britain

In the mid 1830s William Fothergill Cooke developed a telegraph that indicated letters by using the transmitted electrical current to deflect magnetized needles at the receiver. During the same period Charles Wheatstone conducted several important experiments on the long-distance transmission of electricity. In February 1837 the two men pooled their efforts and in June they obtained a patent for an electromagnetic telegraph using five wires to deflect five needles in order to indicate letters of the alphabet. They built their first commercial line in 1838 and 1839. In late 1842 Cooke patented an improved telegraph that used two wires and needles, instead of five, to indicate letters; this halved construction and installation costs.

During the early 1840s railways were the major customers of the telegraph. In 1846 Cooke and a group of investors founded the Electric Telegraph Company to build a commercial telegraph system for the use of the press and businessmen. By 1855 its network encompassed nearly every important town in England and Ireland. For the next quarter century the Electric company dominated the industry but competed with four other companies for business. During this time the industry shifted from the Cooke and Wheatstone two-needle indicating instruments to various forms of printing or recording telegraphs.

By the mid-1860s much of the British public, Parliament, and civil service supported the nationalization of the telegraph industry, claiming that Post Office operation would reduce rates, expand the network, and provide better service. In 1868 Parliament authorized the purchase of the telegraph lines, and the Post Office began operating them in February 1870. Despite initial successes, it was soon apparent that the British postal telegraph faced serious financial obstacles, including an inflated purchase price, unremunerative press and railway rates, commercial rates which barely broke even, and competition from the privately-owned telephone industry.

At the turn of the century telegraph traffic peaked at some 90 million messages. Throughout the following decades, traffic dropped and fiscal losses mounted because of competition from the telephone and the letter post which delivered letters within the British Isles within 24 hours of posting. The telegraph’s heyday was over by 1920, and by 1970 the telegraph had ceased to be an important communications medium in Britain.

The Telegraph in the United States

In 1837, Captain Samuel C. Reid, a naval hero of the War of 1812, petitioned Congress to build a telegraph line between New York and New Orleans. Reid had some experience operating a telegraph in New York harbor since about 1823. He claimed that his system could transmit a message from New York to New Orleans in about two hours. Spurred by Reid’s memorial, Congress directed Treasury Secretary Levi Woodbury to investigate the matter. Woodbury issued a circular letter to customs collectors, commanders of revenue cutters, and the public generally. He received seventeen replies, all of which agreed that a government-operated telegraph would be useful for national defense, official government messages, and commerce.

Congress, Woodbury, and all but one of his respondents had in mind an optical telegraph similar to the French system. It is entirely possible that the federal government could have developed a semaphore telegraph network spanning the country. One reply, however, came from an unlikely source—a painter and professor of fine arts at New York University, Samuel. F. B. Morse. Morse’s telegraph, powered by electric batteries and using electromagnets to record messages onto a moving strip of paper, could operate at night and in any weather and could fit onto a tabletop.

In 1837 and 1838 Morse publicly demonstrated his electromagnetic recording telegraph to prominent scientists and government officials. Morse’s system at this time comprised an alphabetic code of dots and dashes, a telegraph key to encode messages, and a receiving register that embossed signals onto a moving strip of paper. Morse believed that the federal government should own and operate his telegraph, and hoped to convince the American government to purchase his system. In 1843 Congress gave Morse \$30,000 to build an experimental line between Washington and Baltimore. This line began operation in May 1844, but the government refused to fund an extension of the line northward to New York. In 1846 the government turned over the Washington-Baltimore line to private investors. Over the next fifteen years, the telegraph network spread rapidly. By 1850 lines reached every important point east of the Mississippi River, and by 1861 a transcontinental line reached California. The major change to telegraph equipment in this period was the elimination of the recording register; operators shifted to sound reception by deciphering the clicks of the receiving magnet. During the late 1840s and early 1850s a confused welter of several dozen companies sprang up to build telegraph lines, many of them poorly organized and short-lived. During the late 1850s a cartel of six companies coalesced and provided stability to the industry.

The end of the Civil War in 1865 sparked a final wave of consolidation, and Western Union emerged in 1866 as the country’s telegraph monopoly. During the remainder of the 19th century telegraph technology remained relatively static, except for two major advances occurring around 1870. In 1867, Edward Calahan invented the stock ticker, a printing telegraph that recorded stock sales, including a two- or three-letter abbreviation for the stock, the amount traded, and the sale price. Other electricians, especially Thomas Edison, significantly improved Calahan’s design by 1875. The ticker allowed market participants to place trades at a distance from exchange floors, and thus modernized stock and commodity trading. The second major technological advance of the period was multiplexing. In 1868, Joseph Stearns, president of the Franklin Telegraph Company, a small line that connected Boston and New York, perfected a duplex system that permitted the simultaneous transmission of two messages on a telegraph wire, one in each direction. Stearns’ insight was to add capacitance to the system. A few years later, Stearns sold his patent to Western Union, which promptly hired Thomas Edison to protect Stearns’ patent by inventing as many multiple transmission methods as possible. In the course of his work, Edison hit upon a diplex, a system that permitted the transmission of two messages simultaneously in the same direction. He combined the duplex and diplex to create the quadruplex, an instrument that allowed the simultaneous transmission of four messages on one telegraph wire. The quadruplex effectively quadrupled Western Union’s bandwidth on major trunk lines.

Despite these major breakthroughs, Western Union largely abandoned technological innovation as a corporate strategy and continued to rely on its monopoly market power to dominate the telegraph industry. Between 1866 and 1910 Western Union faced two major challenges to its dominant position in the American communications market. During this period a vocal and vigorous movement arose to nationalize the telegraph and place it under postal administration, and Western Union officials spent much time and energy defending their private monopoly to the public and to Congress. The telephone, independently invented in 1876 by Alexander Graham Bell and Elisha Gray, was Western Union’s second major challenge. Bell offered to sell Western Union his patent, but Western Union

refused and established a competing telephone system in the late 1870s using Gray's and Edison's patents. Because of Bell's superior patent position, Western Union withdrew from the telephone market in 1879 in exchange for Bell's promise not to compete with Western Union's long-distance telegraph business. In the 1870s and 1880s the telephone could not operate over distances longer than a few dozen miles. However, by about 1890 telephone engineers expanded the range of audible conversations to a few hundred miles, culminating in the establishment of Bell's transcontinental telephone service in 1915. As Bell's long-distance network expanded and rates declined, the telephone steadily eroded the telegraph's share of the long-distance communications market.

Under the leadership of Theodore N. Vail, American Telephone and Telegraph (AT&T), Bell's parent company, was powerful enough to acquire working control of Western Union in 1910. AT&T's control of Western Union demonstrated that the telephone had eclipsed the telegraph as the nation's preferred long-distance communications medium. AT&T voluntarily relinquished its Western Union holdings in 1914 to forestall federal anti-trust proceedings. Although short-lived, Vail's administration modernized Western Union's antiquated accounting and management structure and spurred the company to replace its Morse instruments with automatic telegraph equipment.

Between 1915 and the end of World War Two in 1945 the telegraph's share of the long-distance communications market continued to decline because of competition from the telephone, government air mail service, and AT&T's teletype service inaugurated in the 1930s. During the War the Federal Communications Commission forced Western Union to divest itself of its international cable network and to consolidate with its sole remaining competitor, the bankrupt Postal Telegraph Company, two moves which weakened Western Union's long-term financial position.

Following World War II Western Union's managers attempted to modernize the company's physical plant and to preserve a market niche for record communications. Between 1945 and 1980 the company undertook three major modernization programs, the development of analog facsimile technology, the construction of a microwave beam network to replace its wires and cables, and the launching of communications satellites. Although these systems were technologically successful, they failed to reverse Western Union's declining market share with respect to the telephone; by 1990 Western Union was defunct except for its money-transfer service.

Telegraphs in Asia and Africa

The first telegraph in India, constructed by two British army officers, opened in 1851. During the 1850s the British government encouraged the construction of a government-owned telegraph network to link the major trading and political centers, and by 1856 India had some 7000 km of telegraph line and 45 offices. The French telegraph network in Indo-China was also an instrument of colonial control. France began telegraph construction in 1861 and by the turn of the century the Indo-Chinese network comprised about 12,000 km of land lines and cables connecting over 200 offices. After 1880 the colonial powers occupying Africa built land and cable networks to connect their possessions with the home countries. The Indian, Indo-Chinese, and African telegraph networks were primarily instruments of imperial control and only secondarily commercial systems.

The Chinese government regarded telegraphy suspiciously, as a tool of the Western powers to gain control of their country. During the 1860s Russian, British, and French entrepreneurs and government officials began pressuring China for telegraph concessions. Chinese officials resisted until the 1870s when they granted foreign companies limited franchises to build telegraph lines. In 1881 the government established an Imperial Telegraph Administration to build and to operate a national network, but officials continued to resist the wholesale construction of foreign-owned telegraph lines. However, several European countries used the Boxer Rebellion of 1900 as a pretext to extract political and economic concessions, including the right to build telegraphs, from the weakened Imperial Chinese government.

Whereas Chinese government officials sought to shield the country from foreign influences in the second half of the nineteenth century, in Japan the Meiji Restoration of 1868 brought to power an elite eager to modernize the country along Western European lines. Japan's new rulers embraced the telegraph and hired a British telegraph engineer in 1869 to build a line between Tokyo and Yokohama and gave landing rights to a Danish cable company. By 1872 Japan enjoyed direct telegraphic communication with Europe. During the next two decades the Japanese telegraph network expanded rapidly. By 1891 Japan had over 400 telegraph offices connected by nearly 12,000 km of wire.

Submarine Telegraphy

The successful development of submarine telegraphy between 1851 and the First World War established an international communications network and helped Western nations to pursue their imperialist and commercial ambitions in Africa, Asia, and Latin America. From 1850 to the early 1870s engineers confronted and solved several problems in submarine telegraphy: insulation, cable laying ships and equipment, signal distortion and attenuation, and sending and receiving apparatus. British scientists, engineers, and entrepreneurs played leading roles in all four areas.

In 1851 a British firm laid the first successful undersea cable between Dover, England and Calais, France. British and American entrepreneurs and government officials soon began exploring the feasibility of a transatlantic cable. In 1856 the American Cyrus Field and the British telegraph engineers John Brett and Charles Tilson Bright headed a group of investors who started the Atlantic Telegraph Company. The company received subsidies and naval support from the American and British governments. After two failures in August 1857 and July 1858 the company successfully laid a cable between Ireland and Newfoundland in August 1858. The cable failed, however, after a few weeks of weak and intermittent signals. The 1858 cable's failure, the straitened finances of the Atlantic Telegraph Company, and the American Civil War (1861-1865) all combined to delay a renewed attempt until 1865. Under the leadership of John Pender, the newly formed Anglo-American Telegraph Company successfully laid two cables in July 1866, marking the start of uninterrupted electrical communication between the two hemispheres. During the last third of the nineteenth century the Atlantic cables were instrumental in establishing global markets in news, agricultural commodities, and financial securities.

During the late 1850s and 1860s British telegraph engineers and government officials sought to connect Britain with its possessions in India, southeast Asia, and Australia. In 1870 they successfully laid a cable from England through the Mediterranean, Red, and Arabian Seas to Bombay. In 1872 an extension from India provided direct telegraphic connection to Singapore and Australia. Between 1870 and 1914 several American and British cable companies competed for the telegraph business of the Caribbean and Latin America, a competition which mirrored and fueled the general commercial rivalry between the two countries in the region.

On the eve of the First World War, about 500,000 km of undersea cables existed, over half under British control and one-fifth under American control. France, Denmark, Germany, and the Netherlands accounted for the remaining cables. This global submarine cable network helped Western nations to attain economic and political dominance of Asia, Africa, and Latin America. During the First World War, British leadership in cable and wireless communications played an important role in the Allied victory over the Central Powers.

During the 1920s demand for international communications boomed and the submarine telegraph industry reached its peak. Furthermore, American Telephone and Telegraph (AT&T) introduced a major technological advance, inductively loaded cables which increased message-handling capacity by a factor of five. Western Union installed the first inductively loaded cable in the Atlantic Ocean in 1924, and the new cables ensured that submarine telegraphy would occupy a central place in global communications over the next several decades. However, economic depression and world war between 1930 and 1945 reduced demand for international communications generally.

After World War II, two new technologies, telephone cables and satellite communications, converged to make international telephoning easier and cheaper, and hence to render submarine telegraphy obsolete by 1980. AT&T laid the first transatlantic telephone cable in 1956, and by 1983 7 transatlantic cables provided over 11,000 voice circuits. During the 1970s satellite communications reached maturity, and by the early 1980s satellites provided about 50,000 voice circuits. The installation of digital fiber-optic cables during the 1980s increased the number of international telephone circuits by an order of magnitude and greatly reduced the cost of overseas telephone calls.

During its heyday, the submarine telegraph industry had profound effects on diplomacy, journalism, and financial markets. Before the advent of the cable network, diplomats had great latitude during international crises. They could act more or less independently within broad parameters. After cables connected ambassadors to their home governments, however, their conduct was subject to near real-time control and scrutiny by foreign ministers and heads of government. In addition, the cable network acted to inflame public opinion during international crises, such as the Cuban crisis that led to the Spanish-American War in 1898. In many cases, policymakers found their choices circumscribed in ways that made war more likely. The connection of the world's financial centers by submarine cable facilitated the globalization of capital. For example, by the turn of the 20th century, financiers located in Europe routinely traded stock on American stock exchanges, and vice versa.

The submarine telegraph industry also drove important innovations in electrical engineering. Because of the high distortion and attenuation of signals transmitted through long undersea cables, engineers worked to improve transmission and reception methods, and to control the characteristics of the transmission medium (the cable itself) more closely. After the invention of the siphon recorder by Sir William Thomson (later Lord Kelvin) in 1867, engineers could work with visual representations of transmitted and received signals and modify sending and receiving equipment to optimize transmission quality and speed. Collectively, these advances led to the discipline of analog signal processing.

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