1 The birth of an industry

On the evening of March 3, 1843, Professor Samuel Morse and his friend, Mr Henry Ellsworth, were standing in the lobby of the United States Senate. There was tension in the air. It was the last day of the Congressional session, and any Bills that had not been signed into law by midnight would be lost.

Morse had known failure before. After he demonstrated the operation of his electric telegraph to President Van Buren in 1838, a Bill had been introduced into Congress to provide $30,000 to build an experimental telegraph system between Washington and Baltimore. The Bill had been favorably reviewed by the commerce committee, but had made no further progress. Similar Bills had been introduced in each succeeding session of Congress, but had been equally unsuccessful.[1]

A friendly senator approached Morse and informed him regretfully that there were 119 Bills ahead of his in the queue for voting. This meant that the chances of the Bill being put to a vote that evening had effectively disappeared. Morse was so discouraged that he left the Capitol, bought a train ticket to New York City for the following morning, and returned to his boarding house to pack. As he retired to bed that night, he resolved to waste no more time on the electric telegraph.

But Henry Ellsworth was not so easily defeated. He remained where he was, and continued to lobby for the Bill. Finally, with 5 minutes to go before the Senate adjournment, the Bill was passed without a vote. The President signed the Bill into law moments before the midnight deadline.

The next morning, Ellsworth sent his 17-year-old daughter, Annie, round to Morse's boarding house to tell him the good news. She arrived while he was having breakfast. In the excitement of the moment, Morse promised Annie that she would be the first to send a message over the new telegraph system when construction was complete.

Today, most people have largely forgotten the electric telegraph. However, it can still be seen in Western movies when the clerk is desperately tapping out a message to warn that the Indians are coming. From the creation of the first practical telegraph systems in the 1830s until the invention of the telephone in the 1870s, the telegraph was the only available method of sending messages at high speed over long distances. It continued to be widely used until well into the twentieth century, and its impact on the Victorian world was every bit as significant as the Internet has been in more recent times.

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A. Wheen, *From Dot-Dash to Dot.com: How Modern Telecommunications Evolved from the Telegraph to the Internet*, Springer Praxis Books, DOI 10.1007/978-1-4419-6760-2_2,
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Samuel Morse was an unlikely inventor. He had been born in 1791 in Charleston, Massachusetts, and had shown an early interest in drawing. In 1805, he entered Yale College to study chemistry and natural philosophy, and it was there that he received his first instruction in electricity from Professor Jeremiah Day. In 1809, he wrote that:

> "Mr Day's lectures are very interesting; they are upon electricity; he has given us some very fine experiments, the whole class, taking hold of hands, form the circuit of communication, and we all received a shock apparently at the same moment. I never took an electric shock before; it felt as if some person had struck me a slight blow across the arms."

However, the young Morse showed more of an aptitude for art than for science, and he eventually wrote to his parents informing them that he had decided to become a painter:

> "My price is five dollars for a miniature on ivory, and I have engaged three or four at that price. My price for profiles is one dollar, and everybody is willing to engage me at that price."

In 1811, he moved to London, where he exhibited at the Royal Academy and achieved considerable success. Returning to America in 1815, he established a studio in Boston, from where he subsequently moved to New York. By 1829, he was back in Europe, studying in Paris and in Italy. Here, he remained until 1832, when he returned to New York.

By 1837, Morse had become disillusioned with art. He had been forced into portraiture in order to earn a living, but many of his paintings had been of questionable quality. Furthermore, he had been deeply disappointed by his failure to win an expected commission to paint a mural for the Rotunda in the Capitol building in Washington. It was time to try something completely different. . . .

During his voyage back to America in 1832, Morse had struck up a conversation with a fellow passenger, Dr Charles T. Jackson. Jackson had been studying electricity and magnetism in Europe, and their conversation covered many recent developments in the field. It appears that Morse was captivated by the idea that electricity could be used to transmit information at very high speed over long distances.[2] The remainder of his voyage was spent drawing up plans for an electric telegraph.

Morse's telegraph was based upon the use of an electromagnet[3] and a battery. In concept, it was no more complicated than a door bell where the pushbutton and the bell are separated by a very long length of wire. Although Figure 1 does not correspond exactly with the system developed by Morse, it helps to illustrate the principles involved.

A Morse telegraph key is simply a switch. When the telegraph key is closed, current flows from the battery to energize the electromagnet, and this causes the armature to move downwards. When the key is opened, the electromagnet is de-

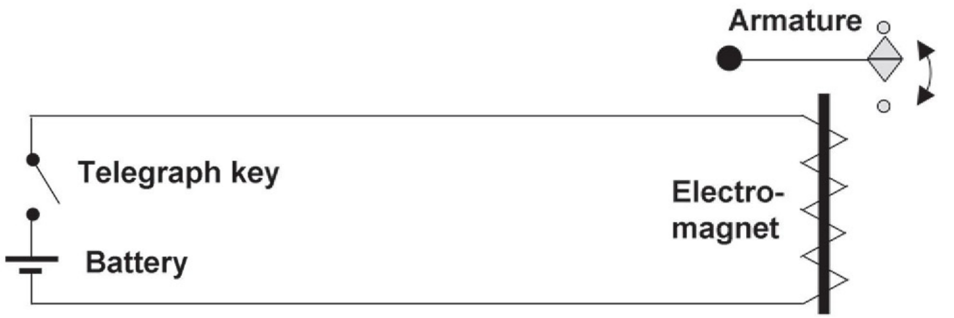


Figure 1. Basic telegraph.

energized and the armature springs back to its former position. As a result, the position of the armature at the receiver always indicates the setting of the telegraph key at the transmitter.

This, clearly, has the potential to allow communication at a distance, but it is not sufficient as it stands. If the operator at the receiving end notices that the armature is moving back and forth, it tells him that someone is fiddling about with the key at the transmitter, but it does not convey much useful information. In order to convert the telegraph from a communication device that can convey just one message (such as a doorbell or a fire alarm) to a communication device that can convey any required message, some form of code is required.

Morse recognized this problem. His solution has become known as the Morse Code and it was an integral part of his design for the electric telegraph. Morse Code represents each letter of the alphabet as a series of dots and dashes, as shown in Table 1.[4]

Table 1. Morse Code.

A	· -	N	- ·	0	- - - - -
B	- · · ·	O	- - -	1	· - - - -
C	- · - ·	P	· - - ·	2	· · - - -
D	- · ·	Q	- - · -	3	· · · - -
E	·	R	· - ·	4	· · · · -
F	· · - ·	S	· · ·	5	· · · · ·
G	- - ·	T	-	6	- · · · ·
H	· · · ·	U	· · -	7	- - · · ·
I	· ·	V	· · · -	8	- - - · ·
J	· - - -	W	· - -	9	- - - - ·
K	- · -	X	- · · -	.	· - · - · -
L	· - · ·	Y	- · - -	,	- - · · - -
M	- -	Z	- - · ·	?	· · - - · ·

As can be seen, some letters (such as E) require fewer dots and dashes than others (such as Z). The aim here is to assign the shortest codes to the letters that occur most frequently in English, thereby reducing the length of the coded message. Morse determined the letter frequencies by counting the number of copies of each letter in a box of printer's type.

Although Morse Code can be transmitted at any speed that suits the operators at the transmitter and receiver, the relative timing of the dots, dashes and gaps is critical. Clearly, a dot must be significantly shorter than a dash if the two are to be correctly distinguished at the receiver. It must also be possible to differentiate between similar dot/dash combinations such as J (· - - -) and A (· -) M (- -). For these reasons, the rules state that:

- a dash should be equal to three dots;
- the space between parts of the same letter should be equal to one dot;
- the space between two letters should be equal to three dots;
- the space between two words should be equal to five dots.

Not surprisingly, telegraph operators required a significant amount of training.

The development of Morse Code was driven by the needs of the telegraph, but it turned out to have a much wider range of uses. Morse Code was adopted for radio communication in the 1890s and was used as an international standard for maritime communication as late as 1999. Morse Code is still used by amateur radio enthusiasts and there have even been suggestions that it might be integrated into mobile phones to supplement SMS text capabilities. The telegraph may have died, but Morse Code lives on!

In 1832, Morse was appointed Professor of Painting and Sculpture at the University of the City of New York—a post that seems to have provided him with plenty of time to pursue his experiments with telegraphy. In 1835, he built a working prototype and the following 2 years were spent making a series of improvements to the equipment. By September 1837, Morse was able to demonstrate his telegraph operating over 1,700 feet of wire laid out in coils across a room. He immediately filed for a US patent. Three months later, he made his formal request to Congress for the funds to build an experimental telegraph between Baltimore and Washington.

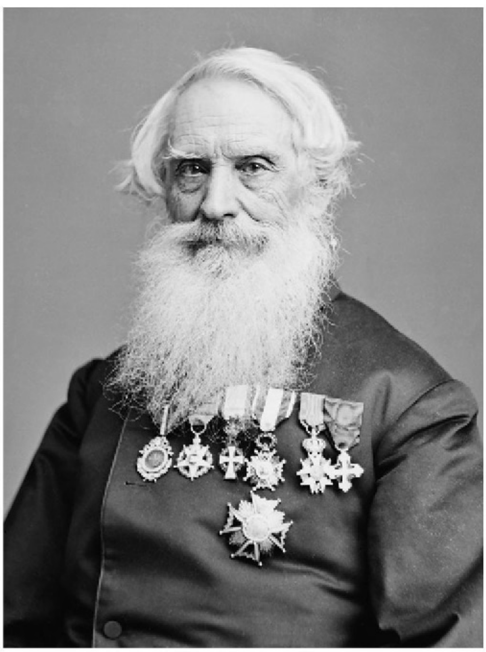
The primary challenge faced by Morse once the funding for his experimental telegraph had been approved was to install the cable. The original plan had been to encase the cable in lead and bury it underground using a specially designed plough. The two conductors would be given an insulating coating by wrapping them in cotton and then dipping them in a bath of hot gum shellac. However, the distance between Baltimore and Washington is approximately 40 miles, and it was found after 10 miles of cable had been buried that the insulation had been damaged by the process of encasing the cable in lead. This was a major crisis. Twenty-three thousand dollars of the government's $30,000 appropriation had been spent, and the installed cable was completely useless.

Many around him felt that the situation was hopeless, but Morse proved equal to the challenge. Recognizing the need to keep his problems out of the newspapers, he arranged for the plough to "accidentally" hit a protruding rock and suffer serious damage. The newspapers carried sensational accounts of the incident, suggesting that it would take several weeks to complete the repairs. However, the gentlemen of the press failed to detect the much bigger problem that lurked, quite literally, beneath their feet.

After some consideration, Morse concluded that the only viable option would be to dispense with the lead casing and mount the cable on poles. Overhead wires could be mounted far enough apart to avoid the need for an insulating coating and glass insulators could be used to prevent any electrical leakage through the poles. This form of construction had originally been rejected because it was feared that the cable would be vulnerable to vandalism, but the pressures of the situation—coupled with the news that overhead wires had been used successfully in England—convinced Morse that it was the only acceptable solution. To this day, we refer to poles carrying telephone lines as "telegraph poles".

The line was finally completed in May 1844. Morse remembered his promise to Annie Ellsworth and asked her if she had chosen the inaugural message. She replied that she and her mother had selected a biblical quotation: "What God hath wrought!"[5] On May 24, 1844, Morse successfully transmitted this message from the Supreme Court chamber in Washington to the Mount Clare depot in Baltimore.

For many people, this was the event that marked the birth of the telecommunications revolution. However, a public telegraph service had started operating in London 5 years earlier. As is so often the case with pivotal moments of this type, the invention of the telegraph was the sum of the accumulated efforts of a number of talented people over many years. Without detracting from Morse's extraordinary achievements, it must be recognized that he had the good fortune to be working in the field at the moment when these individual contributions coalesced into a viable new technology.



Samuel Morse.

* * *

The need to communicate rapidly over long distances has existed for as long as human beings have been around. However, for most of recorded history, the available techniques have been rather unsatisfactory. Messengers on horseback can travel long distances, but it can still take a considerable time for the message to arrive at its destination, and the system is inherently unreliable and insecure. Systems based upon beacons or semaphore flags are much faster but are useless in fog or heavy rain.

The idea of using electricity to send messages down a wire has a surprisingly long history. As early as 1753, a letter appeared in the *Scots' Magazine* under the heading "An Expeditious Method of Conveying Intelligence". This letter is believed to have been written by a Scottish inventor called Charles Morrison, although it was signed simply "C.M.". Morrison proposed—but never built—an electrostatic telegraph system in which 26 insulated wires conducting static electricity from a Leyden jar[6] would be able to cause movements in 26 small pieces of paper carrying the letters of the alphabet.

However, static electricity creates very high voltages. These voltages would have been difficult to handle with the cable insulation materials that were available at the time, so the requirement to use 26 separate wires—each adequately insulated from all the rest—would have presented major technical challenges. To address this problem, a number of alternative systems requiring fewer wires were proposed over the next half-century.

In 1816, Francis Ronalds demonstrated an electrostatic telegraph based upon Morrison's original concept, but using just one wire. A friction-based electrostatic machine was used to charge the line and pith ball electroscopes detected the presence of charge at the receiver. The system is illustrated in Figure 2.

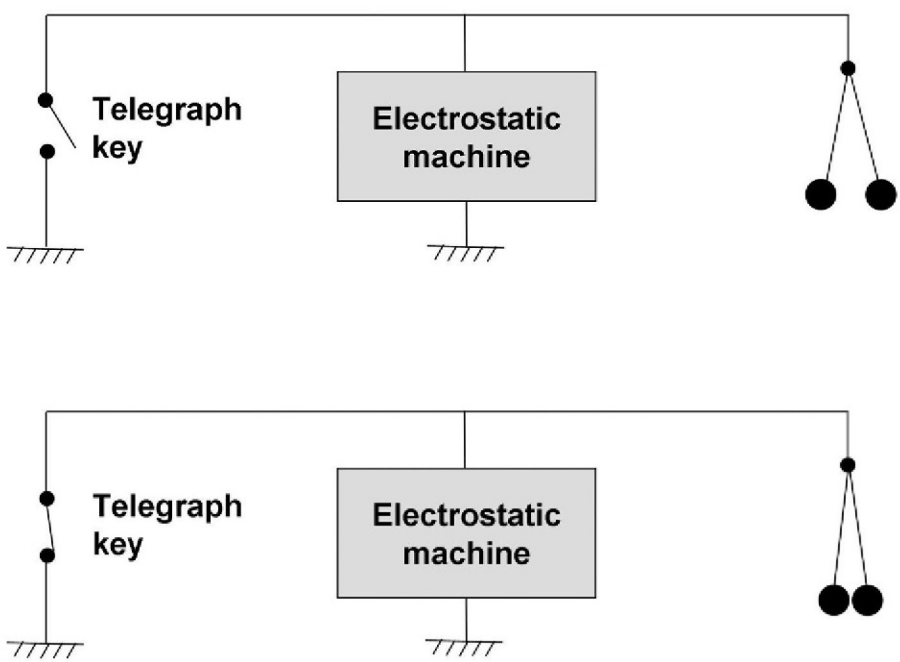


Figure 2. Pith ball telegraph.

The pith ball electroscope consists of two small balls hanging in contact with each other on pieces of thread. If the telegraph key is opened, then the balls will be charged by the electrostatic machine; since like charges repel, the balls will fly apart. When the telegraph key is closed, the balls are discharged and so will no longer repel each other. In other words, the spacing of the pith balls at the receiver provides a direct indication of the setting of the telegraph key at the transmitter.

Although this arrangement is sufficient to tell an operator at the receiver that there is someone operating the telegraph key at the transmitter, the problem of how to transmit an intelligible message from one end to the other has not yet been solved. Which letter of the alphabet is the sender trying to convey with each closure of the telegraph key? Morrison's approach had been, in effect, to build 26 parallel telegraphs—one for each letter of the alphabet—but Ronalds had already decided that his system would operate over a single wire. Ronalds's solution to the problem required a clock at each end of the link. The second hand of each clock was replaced by a circular disk carrying the letters of the alphabet written around its edge. A mask with a small window in it was placed in front of the disk so that only one letter was visible at a time. As the disk rotated, a sequence of letters was displayed in the window. If the clocks at the transmitter and the receiver were synchronized, then they would display the same letter at any given moment. Once this had been achieved, a message could be transmitted by momentarily opening the telegraph key whenever the next required letter appeared in the window.

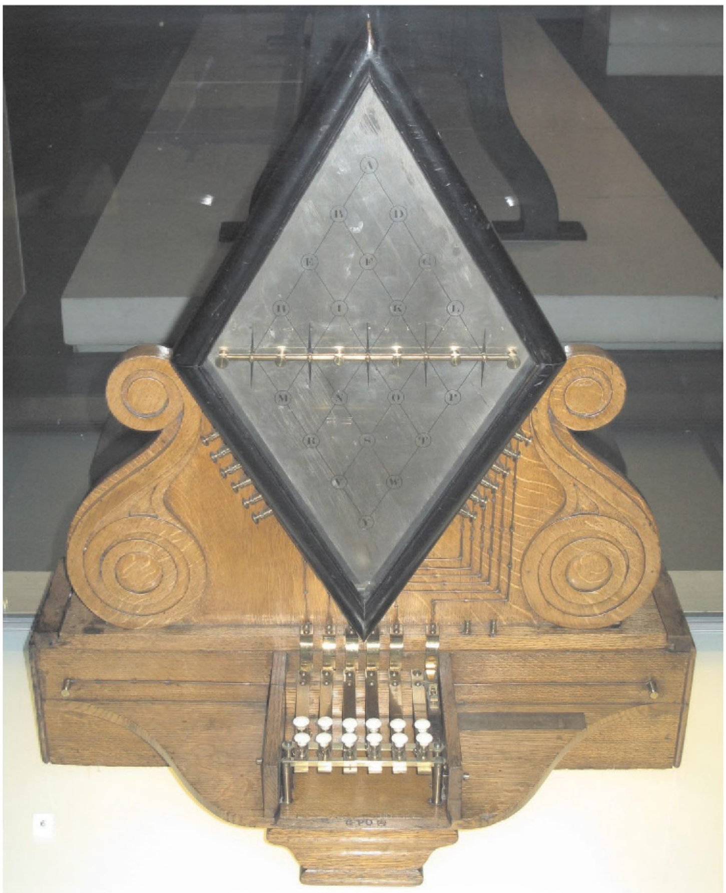
Ronalds demonstrated a working telegraph in Hammersmith in 1816—a remarkable achievement for the time. However, with the benefit of hindsight, we can see that the system had a number of weaknesses. To begin with, it was slow. After each letter was transmitted, the sender needed to wait until the next required letter appeared in the window before he could transmit again. If the required letter had only just passed the window, then there could be a significant delay. This delay could be reduced by increasing the speed of rotation of the disk, but there comes a point at which mistakes start to be made because the receiving operator cannot determine whether the required letter is the one just leaving the window or the one just appearing. This problem would become worse if the two clocks were running at slightly different speeds; whilst ways could be found to align the clocks at the start of a message, they would gradually drift out of alignment. The solution to these problems arrived less than 20 years later with the invention of the Morse Code. Although Morse Code could only be used by trained operators, it proved to be a faster and more reliable way of communicating.

A further problem with Ronalds's telegraph was its limited range. Ronalds was able to operate his system over a distance of 8 miles, but it is not clear how a telegraph based on electrostatic principles could have been extended to cover much longer distances. Morse's use of batteries rather than an electrostatic machine proved to be critically important in freeing the telegraph from the constraints of distance and opening up the way for the development of a global communications system.

* * *

Seven years before Morse's telegraph transmitted its first message between Washington and Baltimore, William Fothergill Cooke and Charles Wheatstone had successfully transmitted and received a message over a telegraph line running along the railway track between Euston and Camden Town in North London. In 1839, the world's first public telegraph service had opened on a 13-mile route between London Paddington and West Drayton, providing members of the public with the opportunity to send messages for 1 shilling a time.

Cooke and Wheatstone's telegraph was based on a discovery in 1820 by the Danish physicist, Hans Christian Oersted, that an electric current carried by a wire can cause a compass needle to deflect. A horizontal row of five iron needles was arranged across the middle of the diamond, as illustrated in Figure 3. These needles hung in a vertical position when no current was flowing in the wires.



The Cooke and Wheatstone telegraph. The arrangement within the diamond-shaped part of the apparatus is illustrated in Figure 3.

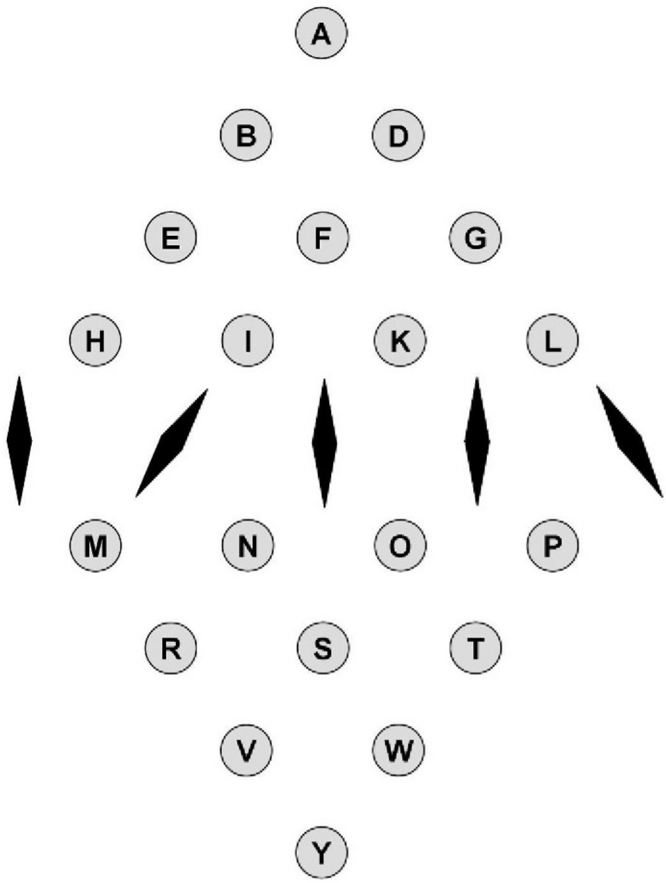


Figure 3. Cooke and Wheatstone telegraph.

However, by pressing the appropriate combination of switches at the transmitter, a pair of needles could be deflected so that they pointed to one of the 20 letters displayed on the diamond. In the case shown in Figure 3, the letter D has been selected.

By adopting this design, Cooke and Weatstone had restricted themselves to 20 of the 26 letters of the alphabet. The letters that they chose to omit were C, J, Q, U, X and Z, so words such as "quiz" would have presented quite a challenge! However, the telegraph operators soon found ways around this problem. A classic example occurred on January 1, 1845, when the telegraph played a crucial role in the capture of a murderer.

On that day, Mr John Tawell traveled to Slough with the intention of poisoning his mistress. It appears that he had expected her to die quietly and was greatly disconcerted when she let out a bloodcurdling scream. To make good his escape, he dashed out into the street and ran to the train station. There, as luck would have it, he found a train that was just about to depart for London. As he climbed aboard and settled into his seat, he was firmly convinced that he would have disappeared into the London crowds long before news of his crime reached the city.

However, he had not reckoned on Cooke and Wheatstone's telegraph, which had been installed along the railway line between Slough and Paddington. The following message was flashed up the line:

> "A MURDER HAS JUST BEEN COMMITTED AT SALT HILL AND THE SUSPECTED MURDERER WAS SEEN TO TAKE A FIRST CLASS TICKET TO LONDON BY THE TRAIN WHICH LEFT SLOUGH AT 742PM HE IS IN THE GARB OF A KWAKER WITH A GREAT COAT ON WHICH REACHES NEARLY DOWN TO HIS FEET HE IS IN THE LAST COMPARTMENT OF THE SECOND CLASS COMPARTMENT."

The word "KWAKER" caused some confusion at Paddington until it was realized that the intended word was "QUAKER"—the telegraph was not capable of transmitting Q or U. When Tawell arrived in London, the police were waiting for him. He was subsequently found guilty of murder and hanged.

This episode provided confirmation—if any were needed—of the value of the telegraph. However, in addition to its inability to transmit six letters of the alphabet (or any punctuation characters), Cooke and Wheatstone's telegraph had a number of other weaknesses relative to Morse's design. To begin with, their telegraph required six separate wires to link the transmitter to the receiver. Although the number of wires was eventually reduced to one by replacing the five-needle telegraph with a system using just one needle, this change made the system much more complex to operate, so it could no longer be used by unskilled operators. Furthermore, the operator was required to manually record each message as it arrived at the receiver because the power behind a deflected needle was too small to punch holes in a paper tape or to drive the pen for a recording device. By using an electromagnet in his receiver, Morse was able to deliver sufficient power to provide a permanent record of each message.

* * *

The problem of signal attenuation on long cables is one that is still faced by telecommunications engineers today. Although the electrical resistance of a short piece of copper wire is negligible, the resistance starts to become significant if the length of the wire is increased. A strong transmitted signal will become steadily weaker as it travels down the wire. If nothing is done to boost this signal, then it may no longer be intelligible by the time it arrives at the receiver.

Morse was well aware of this problem and he solved it by using a device called a "relay". A relay is essentially a switch controlled by an electromagnet. When an electric current flows in the electromagnet, it attracts a strip of metal and thereby causes the switch to close. When the current stops flowing in the electromagnet, the strip of metal is no longer attracted to it and the switch springs open again.

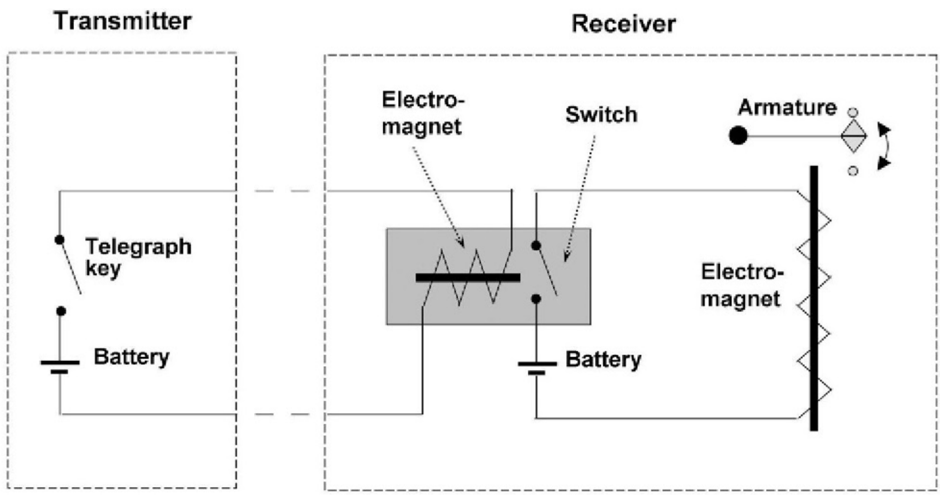


Figure 4. Telegraph relay.

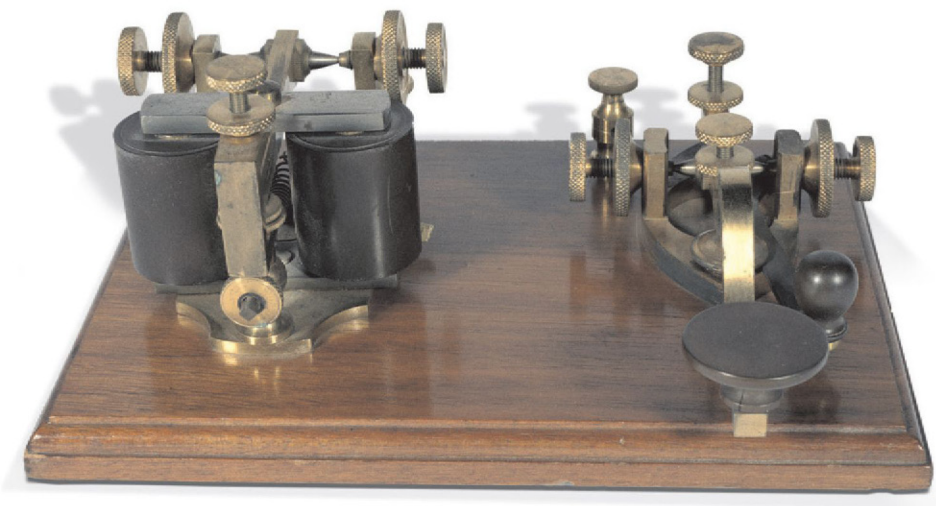
If a relay is placed at the end of a long cable, it can be used to increase the power of received signals. The principle is illustrated in Figure 4, with the relay shown highlighted.

When the telegraph key is closed at the transmitter, current flows in the circuit and the electromagnet in the relay is activated. This causes the switch in the relay to close, thereby causing a second electromagnet in the receiver to be activated. This, in turn, causes an armature to move and create an audible sound. The armature has to be significantly heavier than the switch in the relay and so a larger current is required in the second electromagnet. Notice, however, that the power required to move the armature is not coming from the transmitter—it is being supplied by a second battery located at the receiver. In effect, the relay is enabling the switch at the transmitter to control the delivery of power to the receiver, but *without the need for that power to be transmitted down the line.*

This elegant solution has the additional benefit that the relay can be used to control another relay further down the line. Very long telegraph lines can be built by placing batteries at regular intervals and using relay-based devices called repeaters to regenerate the signal. By 1861, the telegraph system spanned the United States from the Atlantic to the Pacific. A trans-Atlantic link was established 5 years later and by 1872, there was a link to Australia. The telegraph was going global.

* * *

Messages sent by telegraph were known as "telegrams".[7] To send a telegram, it was normally necessary to go to the local telegraph office where the message and the postal address of the destination would be written on a form. This form would then be handed to the telegraph operator—along with the appropriate



Telegraph sounder and key. A device designed for audible reception of Morse Code is known as a "sounder". The photograph shows a sounder (left) and a telegraph key (right) dating from the 1860s.

Telegraph register. If a permanent record of a message was required, the sounder would be replaced by a device called a "register". A number of different forms of register were devised, but they typically used a paper tape that was drawn through the machine by rollers driven by a clockwork motor or a descending weight. An electromagnet was used to bring a metal stylus into contact with the paper tape when current was flowing in the telegraph circuit, thereby causing some form of mark to be left on the paper.[8] The paper moved at a constant speed, so the length of the mark corresponded to the duration of each received dot or dash. The photograph shows a very early weight-driven register dating from 1851.

fee—and the message would be transmitted down the line. At the receiving telegraph office, the armature in the telegraph receiver would create an audible *click-clack* noise corresponding to the dots and dashes in the incoming message. The receiving operator would decode the Morse Code characters as he heard them and would write or type the received message on a blank telegram form. Large numbers of young boys were employed to deliver incoming telegrams to their intended recipients and to bring back any replies to the telegraph office for transmission.

* * *

The development of the telegraph in the middle of the nineteenth century was every bit as significant as the development of the Internet at the end of the twentieth century. A magazine article published in the United States in 1873 gives a rather breathless account of the range of applications for the new invention:

> "Every phase of the mental activity of the country is more or less represented in this great system. The fluctuations in the markets; the price of stocks; the premium on gold; the starting of railroad trains; the sailing of ships; the arrival of passengers; orders for merchandise and manufactures of every kind; bargains offered and bargains closed; sermons, lectures and political speeches; fires, sickness and death; weather reports; the approach of the grasshopper and the weevil; the transmission of money; the congratulations of friends—every thing, from the announcement of a new planet down to an enquiry for a lost carpet-bag, has its turn in passing the wires."[9]

The telegraph was adopted most rapidly in the United States, where the installed length of telegraph cable grew from 40 miles in 1846 (Morse's Washington-to-Baltimore link) to over 12,000 miles by 1850. In Great Britain, there were 2,215 miles of cable installed by 1850 and a number of other countries also had rapidly growing telegraph networks. Even the invention of the telephone did not stop the expansion of the telegraph network—telephones were relatively rare in private homes until after the Second World War,[10] so telegrams were used for rapid communication with non-subscribers.[11]

Many new jobs were created by the technology, while some existing occupations were rendered obsolete. The widespread adoption of Morse Code created a demand for skilled telegraph operators. Telegraphers often had to endure long shifts and unpleasant working conditions, and the repetitive pounding of the telegraph key gave rise to one of the earliest forms of industrial injury (known as Glass Arm or Telegrapher's Paralysis). In spite of these drawbacks, telegraphy was seen as an attractive profession and telegraphers became respected members of the community. For the ambitious, telegraphy provided an escape route from small towns to the big cities; for the restless, telegraphy skills meant guaranteed work wherever they went. The first signs that skilled telegraph operators might eventually become an endangered species did not occur until the 1920s, when teleprinters started to become widespread. These machines could transmit from an ordinary keyboard and so did not require operators with a working knowledge of Morse Code.

It was the need to control the operation of railway networks that drove the expansion of the telegraph network beyond the major cities to smaller towns. The early telegraph pioneers were quick to establish relationships with railway companies and these relationships proved to be highly symbiotic; the telegraph operators gained the rights to install their cables along railway lines (thereby saving the trouble of having to conduct negotiations with a large number of separate landowners), while the railway company gained access to telegraph services (which proved to be critically important to the running of an efficient railway network). Morse's experimental link from Washington to Baltimore was installed along a railway line, as was Cooke and Wheatstone's initial system between Paddington and West Drayton in London.[12]

The British government soon found that the telegraph was an essential tool for running an empire that spanned the globe. In India, the telegraph and the railway enabled the British Raj to maintain control over a huge country with just 40,000 troops. The development of submarine cables meant that it was possible to run cables directly from Britain to outposts of the empire without having to rely on the goodwill of countries along the route. As a result, control of the empire could be centralized in London without having to worry about the security of the communications channels.

One of the earliest military applications of the telegraph occurred in 1844 when Cooke and Wheatstone's system was used to provide a direct link from the Admiralty in London to the naval base at Portsmouth. Telegraph systems were subsequently used in military campaigns during the Crimean War, the American Civil War and the Boer War. A number of military victories have been directly attributed to the effective use of telegraph systems on the battlefield.

Surprisingly, the development of the telegraph was initially viewed as a serious threat by the newspaper industry. Many felt that newspapers would never be able to compete with the telegraph for delivery of up-to-the-minute news and so would have to focus on retrospective analysis and commentary. However, far from killing off newspapers, the telegraph actually opened up new opportunities for the industry. In an era in which news could take weeks to arrive, the telegraph suddenly enabled newspapers to report events that had happened on the previous day. "Time itself is telegraphed out of existence," boasted the *Daily Telegraph*, a newspaper whose name had been chosen to give the impression of rapid delivery of news. The telegraph was still being used by newspapers as late as the 1930s and telegraphers were regularly seen at sporting events, natural disasters, war zones and other newsworthy places.

However, many newspapers could not afford the expense of maintaining reporters in the far-flung corners of the world that had now been opened up by the telegraph. Furthermore, telegraph companies charged by the word, making it expensive to send back long dispatches. The solution to these problems was for newspapers to club together to share the costs, leading to the development of newspaper wire services. Paul Julius von Reuter had established an agency in Europe during the 1840s to distribute financial information by carrier pigeon. However, he soon recognized the potential of the telegraph and when France and England were linked by cable in 1851, he moved his headquarters to London. Although his reports were initially aimed at business customers, he soon started selling dispatches to newspapers. In America, the New York Associated Press began offering similar services to newspapers in 1848.

For most of the nineteenth century, people had to rely upon the accuracy of sundials to set their clocks and watches, and so towns and cities that were just a few miles apart often operated on different local time. This was not a problem while the available forms of travel were all so slow, but the arrival of the railway created the need for a single standard time. In 1883, Western Union launched a time service in conjunction with the US Naval Observatory. On certain telegraph wires, normal service was suspended just before noon and the word TIME was repeated over and over again in Morse Code. At midday, a single dot was sent down the wires, thereby enabling clocks across the United States to be synchronized.

Today, it is hard for us to recognize just how different the telegraph was from anything that had gone before it. Although professionals were quick to grasp the potential benefits of the telegraph for business and commerce, many ordinary individuals found it hard to understand how communication was possible without the physical transfer of a piece of paper. One elderly lady refused to accept a telegram from her son because she was sure that it was not his handwriting on the form. People would hand in messages to be transmitted and then watch the telegraph wires to see if they could see their message as it was sent on its way. Once it became possible to transfer money by telegraph from one place to another, people believed that notes and coins were being physically transmitted and they started turning up at telegraph offices with other small objects that they wished to send by telegraph.

Although telegraph operators were allowed to swap stories of this kind, they were definitely not allowed to discuss the contents of any of the messages that they sent or received. The Rules, Regulations and Instructions of the Western Union Telegraph Company, published in 1866, make this quite clear:

> "All messages whatsoever—including Press Reports, are strictly private and confidential, and must thus be treated by employees of this Company. Information must in no case be given to persons not clearly entitled to receive it, concerning any message passed or designed to pass over the wires or through the offices of this Company."

This rule applied even when messages appeared to be related to illegal activities and discretion was certainly required when transmitting messages of a personal nature. Some business organizations sent their commercially sensitive messages in code so that they would be meaningless to the telegraph operators who handled them.

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How Modern Telecommunications Evolved from the Telegraph to the Internet
Wheen, A.
2011, XVIII, 302 p., Softcover
ISBN: 978-1-4419-6759-6