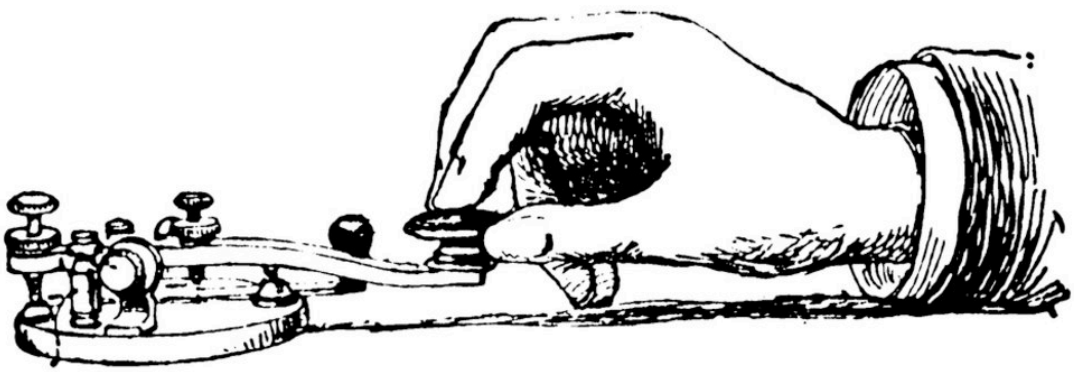
The Telegraph



Future Chapter

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2 Age of the Telegraph

The story of HF radio communications actually began in 1837 with the invention of the electric telegraph, some 50 years before the discovery of radio waves. The telegraph was a mature highly successful world wide industry in 1886 when Heinrich Hertz first proved conclusively that radio waves existed. By the early 1880s the telegraph was providing, for the first time in history, a high speed communication system that connected together much of the world, as shown in Figure 1-4. Most of the early radio developments were a natural extension of telegraph technology. Early theories on the long distance propagation of radio waves (Hertzian waves as they were then known) were based on experience gained with the telegraph. Radio, after all, was simply a wireless telegraph. The wireless telegraph caught the imagination of the public and newspaper editors with Marconi's first transatlantic radio transmission in November of 1901. But not everyone looked favorably on this new technology. Wireless technology was vigorously opposed by telegraph companies who saw the wireless as direct threatening competition to their well establish industry, and its hugely expensive infrastructure of world wide telegraph lines, undersea cables, and many thousands of telegraph offices. Radio did not emerge into its own until the beginning of voice transmissions following World War I.

Daniell Cell

2.1 The Many Early Forms of Telegraph

Samuel Morse is credited with inventing the telegraph as we know it today. The first public demonstration of Morse's invention was on January 11, 1838 at the grounds of the Speedwell Ironworks Factory in Morris County, New Jersey (near Morristown). However, the concept of the telegraph as a signaling device had been known and used for hundreds of years prior to Morse's invention.

Speedwell Ironworks Factory

2.1.1 Signal Fires

In ancient times watch towers were built on mountain tops as early warning systems to communicate the advance of an invading army while the army were still a long way off. Similar watch towers were built along the Great Wall of China for the same purpose. The watch towers were manned continuously in time of war. If a watch tower saw an advancing army, it immediately built a large bonfire signaling approach of the enemy. A watch tower on an adjacent mountain top, seeing the bonfire, would rely the alarm by building its own bonfire. In this manner notice of the advancing army was passed from one watch tower to the next. The chain of watch towers were very affective at relaying warnings of approaching danger, doing so much faster than could be conveyed by a courier.

In the American west the plains Indians made extensive use of smoke signals. Burning damp grass, and other vegetation produced a fair amount of smoke. Holding a blanket over the fire trapped the smoke allowing it to build up. When the blanket was pulled away a dense puff of smoke, visible from many miles away, rose into the air above the hill top. Simple messages could be sent by controlling the spacing between the puffs of smoke.

2.1.2 Visual Telegraph Systems

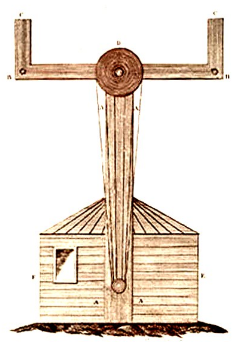
In the early 1700s visual telegraph systems began to immerge. These systems typically used flags, torches, and other similar devices to convey information from one relay post to the next.

One of the first uses of these systems was to report the sighting of an arriving ship. With today's instant world wide communications we know when a ship has left its departing port. We have continuous very precise information on where the ship is and its status as it makes its ocean crossing, and can predict days in advance when the ship will arrive at its destination port. But that was not the case in the past. Prior to the late 1800s there was no way for those expecting the arrival of a ship to know when, or even if, the ship left its departing port. Once at sea, all knowledge of the ship's location and its fait was unknown. Thus, spotting of a ship approaching its destination was of considerable importance and excitement. Telegraph Hill in San Francisco, and in many other coastal cities, did not refer to the telegraph as we know it today. Instead it refer to a hill on which personnel were stationed to spot approaching ships and to visually signal (telegraph) port authorities concerning the ships approach.

2.1.3 The Chappe' Telegraph System

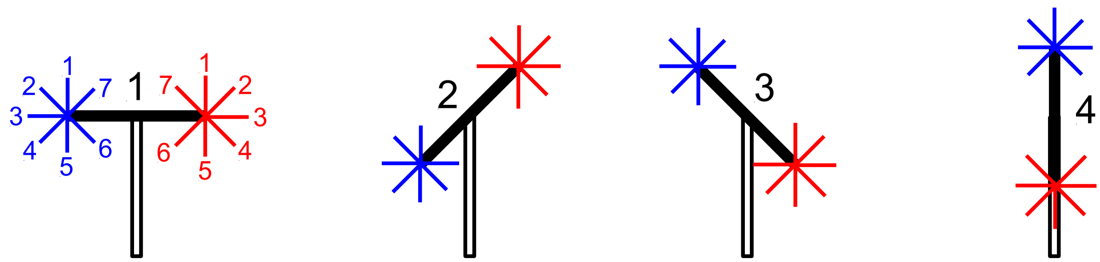
The Chappe' visual telegraph system, used extensively in France from 1794 to the mid 1800s, was the most successful telegraph system of its time.

Claude Chappe' (1763-1805), working with his three brothers, experimented with a number of different techniques for sending messages, including a system using static electricity. However, none of these schemes proved practical. In 1791 they discovered that a device consisting of movable arms could be used to send relatively complex messages. No doubt, their own arms were used as the initial model for this device. They also discovered that a large version of the device could be seen from several miles away and the position of its arms accurately read. They became convinced that a network of these large signaling devices, each acting as a relay station, could be used to send messages a long distance. The sketch below illustrates their basic idea.



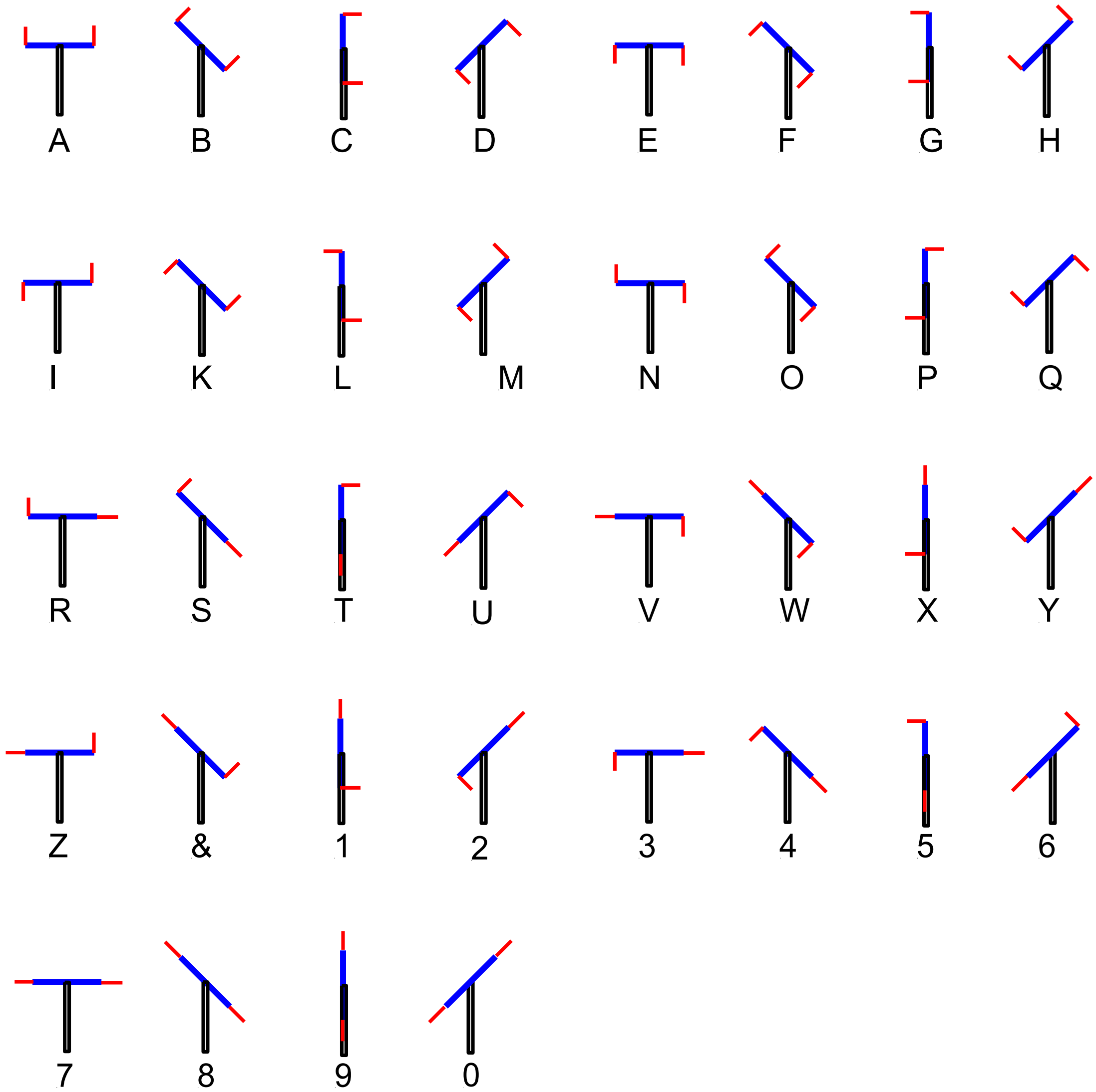
Their final design consisted of a 13 foot (4 m) rotating cross beam (the regulator) supported in the middle by a vertical tower. The rotating arms (the indicators) on each end of the cross beam where 6 1/2 feet (2 m) in length. The rotating arms had to be counter balanced with metal weights to permit proper operation of the device. The counter balance weights are visible in the pictures shown below. The cross beam and the arms were painted black for better contrast against the sky.

Their design allowed the cross beam (the regulator) to be tilted in four different positions, horizontal, vertical, 45 degrees clockwise from vertical, and 45 degrees counter clockwise from vertical. Each arm (indicator) was designed to be independently set in one of seven positions, each of the positions 45 degrees apart. The seven permitted indicator positions are shown below. Consequently, the cross beam in combination with the two indicator arms could be placed in 196 different positions (4 x 7 x 7 = 196).



In a telegraph line only half of these positions (96 orientations) were clearly distinguishable. However, 98 usable positions is still a considerable code set for such a seemingly simple device. Using this code set the Chappe's developed a remarkably sophisticated communications protocol containing control codes in addition to codes for letters of the alphabet and for numbers. The beam and arm positions representing the alphabet and numbers 1 through 10 is shown below.

The Chappe's tried to interest the French Government in their invention with no initial success. Their timing could not have been worse. The Chappe's invented their signaling device in the middle of the French Revolution. The French Revolution was a period of radical social and political upheaval in France which lasted from 1789 to 1799. The revolution marked the decline of powerful monarchies and churches within France and the rise of democracy.



In the midst of all of this turmoil, the Chappe's eventually gained support from the new authorities in the French Government and were given money to build an experimental visual telegraph line. This experimental line was successfully demonstrate in July 1793. The first operational line was built from Paris to Lille, via Montmartre, a distance of about 143 miles. This line began operation in May 1794. A second line was built from Paris to Strasbourg in 1798. In 1799 Napoleon Bonaparte seized power. Napoleon recognized the political and military importance of the Chappe' system and ordered the network to be extended.

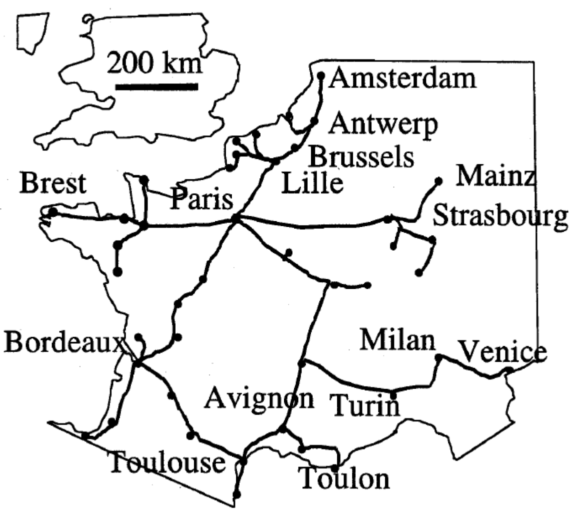
A telegraph line was built by constructing a string of signaling stations located 6 to 10 miles apart. Any relatively tall building capable of supporting the Chappe' signaling device could be used as a station. Typically belfries and church towers were used. When necessary, special signaling station buildings were constructed.

Each signaling station required at least three operators. One operator manipulated the ropes necessary to position the cross beam and the indicator arms. The other two operators used telescopes to read the signals being transmitted by the distant stations (one up line station and one down line station).

Transmitting a message involved most of the same problems encountered in today's communication networks. A station wishing to send a message had to indicate that by sending what amounted to a "connect request" signal (a particular orientation of the cross beam and indicator arms). It might be some time before the operator at the receiving station, periodically looking through his telescope, noticed the request. When the request was observed, the operator at the receiving station had to send back a ready to copy signal (adjusting the orientation of his cross beam and indicator arms accordingly). Transmission of the message could begin once the coordinating "handshaking sequence" was completed. A similar sequence indicated the end of transmission. The receiving operator copied down the message calling out each character as it was received. To achieve the performance claimed for the system, the signaling device operator at the receiving station had to forward each character of the message to the next station down the line as soon as the character was received. The retransmitted characters were observed not only by the next station, but also by the up line sending station. If a character was received or retransmitted incorrectly, the up line sending station would know that and, using the appropriate protocol, retransmit the word in question.

As laborious as this process seems, performance of the Chappe' telegraph system was actually quite remarkable. As an example, a little over 2 minutes were required to send a short message from Lille to Paris, a distance of 143 miles. Over 10 hours were required to carry the same message from Lille to Paris via horse back courier.

Additional lines were built connecting major French cities to Paris. By 1846 the network had grown to 556 stations using 3000 miles of lines. Most of the lines were built in France. However, some lines were also built to Amsterdam, Brussels, Mainz, Milan, Turin, and Venice. The figure below shows the extent of the network, although not all parts of the network were operational at the same time.



The Chappe' telegraph system was in use for 61 years. While the Chappe' telegraph was the most successful of its time, it had problems. It was difficult and expensive to run. It was limited to government use, unable to operate at night, and its operation was seriously impaired by bad weather. However, the Chappe' telegraph system proved that complex messages could be transmitted quickly over long distances, establishing the feasibility of future long distance communication systems including both the electric telegraph and radio.

In 1846 France began to gradually replace the Chappe' visual telegraph system with the electric telegraph. France was slow to accept the electric telegraph because of its reluctance to abandon the Chappe' technology in which it had been the world leader.

In today's high tech world we are aware, often painfully so, of the enormous cost, pressure, and stress involved in developing and rushing to market new products, hopefully ahead of competitors. We long for the good old days when it was all different and more relaxed. One of the lessons learned from the Chappe' telegraph system is that it never was different. Under extreme pressure in 1805 to get a new telegraph line built from Paris to Lyons, and involved in endless conflicts with competitors and others claiming rights to his system, Claude Chappe' become despondent and took his own life at age 42. His brothers continued the family business.

Morse knew all of this. His purpose in the early 1830s was not to invent the telegraph but to develop a new improved telegraph capable of sending messages faster and over longer distances by using electricity.

2.2 Samuel Morse and Invention of the Electric Telegraph

2.3 Morse Code

2.4 Telegraph Systems Wire the World

2.5 Electric Telegraph Implementation

References

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