Chapter Two

Claude Chappe

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Claude Chappe was an unusual man. Under the most unlikely circumstances, in the middle of an eighteenth century revolution, he managed to build a telegraph network that spanned the entire country of France, with branches leading into Holland, Germany, Italy, and Spain. His success in France inspired similar work in almost every other European country. Optical telegraph lines of many different designs sprang up in Sweden, Norway, Finland, Denmark, England, Poland, and Russia, almost as quickly as the word about Chappe's success could spread.

What characterized Claude Chappe was not luck, but an admirable drive and a relentless dedication to perfection, even under adversity. He faced the violence of the French Revolution, with many people around him literally losing their heads over lesser causes than Chappe advocated. He also faced sometimes severe competition from others who claimed to have built a better telegraph, or a different one, or who simply claimed to have done it all before. Although some of the latter claims may have been partly justified, as we shall see, it was perseverance and dedication that made the difference between Chappe and his predecessors.

[Image Not Included in Original]

Figure 2.1 **Brûlon--Chappe's Birthplace**.

Of Barons and Kings

Claude Chappe was born on Christmas day 1763, in a little town called Brûlon, about 200 km (130 miles) southwest of Paris, in what is today called the Sarthe Department.[1]

At this time, France was still ruled by King Louis XV, living in splendor at the Royal Palace in Versailles, and entertained by mistresses such as Madamede Pompadour. Failing the entertainment of a mistress, the French king could resort to the musical entertainment of performers such as the young Mozart.[2]

Chappe was born into a fairly influential family. His grandfather was a baron. According to the rules of nobility, though, that title could only be passed to the eldest son of the family. In this case, that was Claude's uncle Jean Baptiste Chappe d'Auteroche, about whom we will learn more shortly. Claude's father, Ignace Chappe d'Auteroche (1724-1783), although not himself a baron, was clearly still a man of influence. He worked for awhile as a parliamentary lawyer, and at one time received an appointment as *Directeur des Domaines* of the French king in Rouen.

On 13 February 1762, when he was 37 years old, Ignace Chappe d'Auteroche married 31-year-old Marie-Renée de Vernay de Vert.[3] Within the next eleven years the couple had ten children, three of whom died as infants. The names of the seven surviving children, and the dates they were born, are:

Ignace Urbain Jean	November 26, 1762
Claude	December 25, 1763
Marie Marthe	December 26, 1763
Pierre Francois	August 11, 1765
Sophie Francois	March 4, 1767
René	September 3, 1769
Abraham	May 6, 1773

The eldest son, Ignace Urbain Jean, was born at Laval; all other children were born at Brûlon. Marie Marthe was, of course, Claude's twin sister. We can assume that Claude was born close to midnight, and Marie Marthe shortly thereafter. The birth register in Brûlon names Claude Nouët as ClaudeChappe's godfather. Nouët was a former cavalier in the royal army, and a well-respected friend of the family.

We know very little of what happened to the two sisters, but all four of Claude's brothers, Ignace, Pierre, René, and Abraham, at one time or another became involved in the construction and maintenance of the later Telegraph Administration.

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1 The names of the current departments in France date from around 1790. Before 1790, Sarthe was part of a province called Maine.

2 Mozart (1756-1791) made a European concert tour from 1762 to 1766, visiting the courts in Salzburg, Versailles, Vienna, and London, among others. He was seven years old when he visited Versailles.

3 Ignace Chappe d'Auteroche (1724-1783), caught a severe cold after crossing the Seine on his horse to win a bet. He died of the consequences and was buried in Brûlon. His wife Marie-Renée de Vernay de Vert (b. 1731) was buried beside him in 1803, at least according to the tombstone at Brûlon. Other sources state that Marie-Renée Vernay de Vert lived until 1821, FNARH 1991" "p. 7

The young Claude Chappe was raised for the church, and studied to become an *Abbé Commendataire*. He first attended the *College de Joyeuse* in Rouen. Later, he moved to a seminary at La Flèche, about 30 km (18 miles) southeast of Brûlon.[4] When he graduated from the seminary in around 1783, Claude obtained two religious benefices, Saint-Martin de Châlautre and Baignolet, which provided him with ample funds and few obligations.[5]

During his religious training, Claude showed a strong interest in science. He became acquainted with a group of physicists in Paris, and later joined the prestigious *Société Philomatique*.[6] Chappe performed many experiments in physics, and, starting in 1789, published the results in several papers, some written jointly with other physicists.[7]

Some say that even before 1789 Claude had started performing experiments with telegraphy, attempting to communicate with his brother Ignace who attended a seminary school in Angers, southwest of La Flèche.[8] No record to substantiate that claim can be found today, though. It seems improbable, given that the distance between La Flèche and Angers is about 48 km (30 miles). The various optical telegraph designs developed later by Chappe and others could not have covered that distance. In a book published in 1824, Ignace Chappe recalls that:[9]

> The Chappes corresponded routinely with each other, using this device [the synchronized system -- to be discussed], at a distance of 3 leagues.

The 3 leagues (14.5 km) would clearly not have covered the distance from LaFlèche to Angers, but it is approximately the distance from Brûlon to Parcé, a small town near La Flèche. Brûlon and Parcé were the two sites used in the first reliably documented experiments, as we shall see below.

A FAMOUS UNCLE

The piety of Chappe's youth and his remarkable career as an engineer and inventor may be easy to explain. He almost duplicated the life of his uncle, Abbé Jean Baptiste Chappe d'Auteroche (1722-1769). This uncle was also first ordained as a priest, but later acquired some fame as an astronomer, earning him a membership in the French Academy of Sciences. He worked on cartographical maps of France with César Francois Cassini de Thury, the director of the Paris Observatory and the third generation in a line of famous astronomers and cartographers. In 1752, Chappe's uncle published a translation of the *Tables* of the English astronomer Edmond Halley (of Halley's comet). He first obtained independent recognition in 1761, with the publication of *Voyage en Siberie*. In this book, which can still be found inmost good libraries, the Abbé Chappe described the passage of

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4 This was probably the school that is currently known as Prytanée National Militaire, which served as a Christian Royal College from 1776 to 1792. At the time, it was known as the Collège Royal de la Flèche. Claude's brother Ignace is said to have attended the same school earlier, see FNARH 1991" "p. 15

5 Cf. Jacquez 1893" "p. 6 The precise date of Claude's graduation is uncertain. Abraham Chappe, in his preface to the second edition from 1840 of Chappe 1824" "p. xi, states, though, that Claude graduated before his twentieth birthday (i.e., before 1783).

6 Claude Chappe joined the Société Philomatique in 1792.

7 Some of the papers that Claude Chappe wrote on electricity in collaboration with other physicists are Chappe 1789a, 1789b, 1790, 1791, 1792, 1793 See also Jacquez 1893" "p. 75

8 Shaffner 1859" "p. 27, cf. Jacquez 1893" "p. 6.

9 Chappe 1824" "p. 124

the planet Venus in front of the sun in the early morning hours of 6 June 1761. To make the observation, he had traveled to the Russian city of Tobolsk.

The life of Claude's famous uncle had a peculiar end. A new transit of Venus had been predicted for 3 June 1769, and Jean Baptiste decided to travel to Baja California for the best view. He did so despite reports of contagious diseases ravaging that part of the world at the time. He faithfully made the observation, and as a truly dedicated scientist decided to stay on another two weeks to observe also a lunar eclipse predicted for 18 June 1769. In those two extra weeks he caught yellow fever and died 1 August 1769. He was buried in the village of Saint-Joseph, in California. On 14 November a eulogy was read for him at the Academy of Sciences in Paris. The book describing his observation of the transit of Venus was published by a friend well after his death.

Some of this passion for religion and science must have rubbed off on the young Claude Chappe. Abraham Chappe later wrote that the first book Claude read in his youth was the famous *Voyage en Siberie*. He added:[10]

> Reading this book greatly inspired him, and gave him a taste for the physical sciences. From this point on, all his studies, and even his pastimes, were focused on that subject.

Because of his astronomer uncle, Claude may also have become familiar with the properties of telescopes. A good quality telescope later became one of the most important devices for turning an optical telegraph from a curiosity into a practical device.

The First Experiments

On 14 July 1789 the French Revolution began in earnest with the storming of the Bastille in Paris, and the rules of life changed. In the next few months, Louis XVI and Marie Antoinette were evicted from the Palace in Versailles and moved to Paris. A range of traditional privileges held by the nobility and the religious orders was abolished by a new Legislative Assembly. As a small side effect, Claude Chappe lost his religious beneficeson 2 November 1789, and had to return to Brûlon newly unemployed. In the turmoil of the revolution, Claude's brothers had also lost their jobs and had returned home to Brûlon.[11] Together they decided to set up a shop to work on telegraphs.

This decision to start working on telegraphs was not as unusual as it may seem. Proposals for telegraphs of all different kinds, ranging from the most frivolous and impractical to serious precursors of the later electrical telegraphs, were being pursued by many.

One of the more practical proposals came from De Courrejolles, a captain in the French navy.[12] In February 1783, De Courrejolles was engaged in battle with the English fleet, at what is described as the Turkish or Ionic Isles, about 145 km (90 miles) northeast of Cap Francois. He found himself surrounded by an English squadron commanded by Admiral

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10 In a letter dated 1 February 1805, published in the Journal de Paris. The letter is reproduced in Jacquez 1893" "pp. 72-73

11 Ignace Chappe worked at the time as tax collector in Mans, specifically forcollecting the taxes on salt, which were abolished in 1789. Pierre-Francoisalso worked as tax collector in Mans, for stamp-duties. René was Receveurdes Domaines du Roi in Lassay. Abraham was, like Claude, raised for thechurch. He graduated in April 1789, and was still looking for his firstassignment when the revolution began.

12 Chappe 1824" "pp. 54-56, Belloc 1888" "p. 64, Hennig 1906" "pp. 27-28

Hood. De Courrejolles had a simple optical telegraph erected at a mountain top on the coast of one of the islands, and used it to monitor the enemy's movements. Every change in position was reported by the telegraph. Using this information DeCourrejolles was able to overrun a squadron commanded by the then Captain(later Admiral) Nelson, and force the English fleet to retreat.[13] Inspired by this success, De Courrejolles submitted a proposal to the French Minister of War to have the army adopt optical telegraphs for signaling purposes. Though De Courrejolles was unsuccessful at that time, he may well have paved the way for Chappe.

No precise information has survived on the type of semaphore used by Courrejolles. An indication that it may have resembled one of Chappe's later designs is that Courrejolles later accused Chappe of plagiarism, as we shall see below.

THE SYNCHRONIZED SYSTEM

The brothers Chappe spent the winter of 1790-1791 experimenting with telegraph designs. In March 1791, they were ready for a first public demonstration of the telegraph they had constructed. The telegraph design used in this first experiment was described by the Chappes as a "pendulum system." It is usually referred to as the *Synchronized System*.

For the first experiments, two telegraphs were used, possibly merely two modified pendulum clocks. One was placed on a terrace at the former location of a castle in Chappe's hometown Brûlon, and the other at the window of a private house in Parcé, a little town at a distance of roughly 16 km (10 miles), and about halfway between Brûlon and La Flèche. The Brûlon location, referred to in most documents as "the castle," was in reality a regular house, built on the spot where a larger castle used to stand. The castle was destroyed in 1774.[14] The house that replaced it, and where the experiment took place, was itself also destroyed by fire in 1793.

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13 Nelson (1758-1805) became Captain in 1778 and Admiral in 1797.
14 Coudreuse 1991" "p. 4

Figure 2.2 **Dubious Representation of the Synchronized System**.
(Source: Figuier 1868)

Unfortunately, we do not have an accurate description of the working of the pendulums that were used in the first experiment, and the information we have leaves many questions unanswered. The most reliable record that has survived is a description given by Ignace Chappe, which reads as follows.[15]

> The first telegraphic correspondence that we performed was done with two pendulum clocks, that were kept in perfect synchrony; the face of the clocks was divided into ten parts, each part designating a different numeral [French: *un chiffre de la numération ordinaire*]. When the pointer of one clock passed over the number one wanted to indicate, a sound was made, announcing to the correspondent that the number which also his pointer indicated at the moment that the sound was heard, was significant. By representing the words in a dictionary with successive numbers one could thus transmit any thought.

An illustration of the telegraph that was supposedly used in this first experiment (Figure 2.2) is reproduced in virtually every source, with the notable exception of Chappe's book. Ignace Chappe does not present drawings for any of the early designs, and it appears that his verbal description is at odds with the ones that others used.

The most popular illustration shows not 10 but 16 divisions of the clock face, each one indicated not with a number but with a symbolic code that very closely resembles the symbols used by Robert Hooke in his experiments in 1684.[16] Probably based on this

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15 Chappe 1824" "pp. 123-124
16 Chapter One, p. _tag1_C.

illustration, many later writers have suggested that Chappe borrowed some of his ideas from Hooke. It is not known with certainty where the dubious illustration first originated.[17]

As Chappe indicated, to operate correctly, the hands of the clocks of neighboring stations had to be synchronized. The Chappes had an original solution to this problem:[18]

> To transmit a phrase, the two clocks (separated by 400 meters in the first experiments) were set in motion, at the same instant. A sound was made, by striking a casserole [stew pan], at the moment that the pointer was over that part of the clock-face that corresponded with the number of the code one wished to signal.

The two pointers rotated by the pull of falling weights. We can imagine that a first sound signal at the sending station was used to indicate to the telegraph operators at what precise moment the weights had to be released to start the pointers rotating. Each new signal could then be used to transmit a single code symbol, until either the message was completed or the weights would hit the floor and the pointers stopped.

The initial experiments were held over distances up to ca. 400 meters (1300 feet), behind the parental house in Brûlon.[19] At this distance, the sound signals could still easily be heard, but it was clear also at that time that it would eventually have to be replaced if longer distances were to be covered. Abraham Chappe later wrote that Claude performed many experiments to find a good alternative, including the use of electrical signals traveling through conducting wires. He records that an optical method was only chosen[20][

> …after having tried, unsuccessfully, electricity, various acoustical methods, the use of smoke produced by different types of combustible materials, etc.

The idea to use an electrical signal had to be abandoned when no adequate insulators could be found for the wires. Ignace Chappe wrote in 1824 that the signals could also be given visually, with the help of large black and white surfaces that could be flipped at the moment that otherwise the sound signal would have been given. Of course, a proper application of any of these alternative synchronization methods could have replaced the whole telegraph, but the Chappes did not realize it at the time.

> Today, 2 March 1791, at 11, we, the undersigned municipal officers from Parcé, district Sablé, département of Sarthe, in the presence of MM. Francois Delauney de Fresney, Julien Delauney de la Motte, Léon Delauney, Prosper Delauney, René Taillay, Jean-André Tellot, royal notary and elected representative of the département de la Mayenne, all inhabitants of Laval; Etienne Eutrope Brossard, royal notary at Avoise, Jean-Baptiste-Joseph Gillier de la Chererollais, curator of Saint-Pierre de Parcé.

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17 The oldest source known to us is [Figuier 1868] It is reproduced without mention of an origin in Belloc 1888" "p. 69

18 Jacquez 1893" "p. 7-8

19 The parental house in Brûlon still exists at No. 1 of what is now called Rue Claude Chappe.

20 In his letter to Journal de Paris from 1805, reproduced in Jacquez 1893""pp. 72-73 See also Fahie 1884" "p. 94, and Appleyard 1930" "p. 265 Ithad been known for almost fifty years that it was possible to transmit anelectrical signal through a wire (cf. p. _tag5_4).

At the invitation of Mr. Claude Chappe, we have gone to the house of Mr. Ambroise Perrotin, in the aforementioned city of Parcé, to observe the result of an invention intended to communicate and correspond in the shortest amount of time.

First, we were led into a room of the said house, by the said Mr. Claude Chappe, and we found there a pendulum clock, and a telescope pointing in the direction of Brûlon, 4 leagues distant from Parcé.

Next, the said Mr. Claude Chappe aimed the telescope directly at Brûlon, announcing that even though the weather was rainy, his correspondent at Brûlon would proceed by initiating a transmission that would be dictated to him by the municipal officers at that site; and while continuously keeping his eye at the telescope, he successively, within the space of four minutes, dictated to Mr. Pierre Francois Chappe, his brother, various characters, unknown to us. By translating these characters, the following phrase was produced: Si vous réussissez vous serez bientôt couvert de gloire [If you succeed you will soon bask in glory].

Done and attested to in Parcé, at the house of the said Mr. Perrotin, before midday, at said day and year. [Followed by a list of signatures.]

It is curious that the affidavit mentions that the message was encoded in "characters, unknown to us" (French: *caractères, à nous inconnus*), although Ignace Chappe indicates that the encoding was done in numerals. It could also be that the phrase indicated unknown "encodings" rather than unknown "symbols," but it isn't clear from the text.

The matching affidavit from the eyewitnesses at Brûlon is also preserved. It gives some extra clues about the method of signaling used in this test.

Today 2 March 1791, at 11, we, municipal officers at Brûlon, district Sablé, département of Sarthe, have accompanied MM. Avenant, vicar, and Jean Audruger de la Maisonneuve, doctor, from Brûlon, to the castle of said Brûlon, at the invitation that was given us for the purpose of witnessing, and confirming the authenticity of an invention of Mr. Claude Chappe, nephew of the celebrated Abbé of the same name, intended to correspond and transmit news in a very short period of time.

First, we went with Mr. René Chappe, brother of Mr. Claude Chappe, to the terrace at the castle, and there we found a pendulum clock and a movable tableau, with two sides, one being white and one black.

Next, Mr. René Chappe informed us that Mr. Claude Chappe was at that time at Parcé, at a distance from Brûlon of 4 leagues, to receive what he was about to transmit. He asked us to dictate a phrase to him, or any series of phrases of our choosing. In response, Mr. Chenou, doctor, proposed the following phrase: *Si vous réussissez vous serez bientôt couvert de gloire.* Immediately, said Mr. René Chappe, after pointing out to us that the weather was rainy, and that the atmosphere was obscured by a light mist, contemplated said phrase, and proceeded to transmit it while moving the tableau in various ways, which lasted four minutes. He then told us that the said phrase had actually been transmitted to Parcé; as an inspection of the notary report, drafted by the municipal officers at that location would demonstrate.

Done and attested to in Brûlon, at said castle, at midday, at said day and year.

Since the phrase of nine words, or 55 letters, was transmitted in just four minutes, it can be ruled out that the pendulum ran at a normal speed.[21] In that case the second hand of the clock could have indicated no more than one code per minute. If a dictionary of, say, 1000 words was used, every word would have been required one, two, or three digits to encode. This would mean that between 9 and 27 (3 ◊ 9) codes were transmitted in 240 seconds. If this is correct, the pointer on the clock rotated through the code space of the 10 available numbers once every 10 to 30 seconds.

Interesting also is the mention of the movable tableau that was being manipulated by René Chappe during the experiment. It means that synchronization was no longer done by striking a stew pan, but was given visually with black and white surfaces. Abraham Chappe wrote in 1840 that the tableau was 1.66 ◊ 1.33 meter, and mounted on an axis 4 meters above the ground.[22]

The experiment was repeated, with the same witnesses, at 3 of the same day, and a third time at 10:30 the next day, 3 March 1791. The phrase from the second test, transmitted by Claude Chappe in Parcé to his brother Pierre-Francois at Brûlon, was: *L'Assembleé nationale récompensera les experiences utiles au public.* [The national assembly will reward experiments that are useful to the public.] This time the phrase took 6 minutes and 20 seconds to transmit. Though the phrase was probably not made up by Chappe himself, it perfectly illustrates what his ultimate ambition was, even at this early stage. From the third test we only know that the phrase that was transmitted contained 25 words; it was not recorded how long it took to transmit it.

THE POLITICS OF INVENTION

Claude Chappe used the affidavits within a few months to support a first request to the Legislative Assembly to permit and support the construction of a true telegraph line. The request specifically asked for permission to perform further experiments at the Barrière de l'Etoile in Paris. This is where the hard road to success really began for Chappe. Understandably, it was much harder to secure government funding for the construction of a telegraph network than it was to develop a working telegraph in the first place. What sets Chappe apart from his many contemporary inventors was his stamina in solving this part of the problem adequately. He simply refused to give up until the network was a fact.

Even the request to perform experiments in Paris, rather than to continue experiments in Brûlon, was probably, and appropriately, pursued more for its political than for its technical merits. In another astute political move, the same year that the first experiments were held Claude's brother Ignace volunteered for, and was elected to, the new Legislative Assembly in Paris. He became a Deputy to the Assembly on 1 October 1791, representing Sarthe. He also became a member of the Committee for Public Instruction, which had an important advisory role in the consideration of new inventions. Through Ignace, and the Committee of Public Instruction, Claude Chappe would be able to gain access to the Legislative Assembly to defend his proposals personally. The first request, however, just like De Courrejolles's earlier attempt, was unsuccessful. Chappe succeeded only in obtaining permission from the local commune near the *Etoile* to erect his telegraph.

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21 Chappe 1824" "pp. 234-237

22 The speed of a pendulum can be adjusted over a wide range by changing theposition of the weights.

It is not certain what type of telegraph Chappe was planning to build at this site. According to Abraham Chappe, writing in 1840, the materials for its construction were stolen before any tests could be done.[23]

Not in the least discouraged by these experiences, on 22 March 1792 Claude Chappe submitted a new proposal to the Legislative Assembly. He wanted to have his design evaluated in a serious experiment. With help from his brother Ignace, Claude obtained permission to address the Assembly in Parison 24 March 1792 to explain his plan. The text of his address has been preserved.[24]

> Mr. President,
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> I have come to offer to the National Assembly the tribute of a discovery that I believe to be useful to the public cause. This discovery provides a simple method for rapidly communicating over great distances, anything that could be the subject of a correspondence. The report of an event or an occurrence could be transmitted, by night or by day, over more than 40 miles in under 46 minutes. This transmission takes place almost as rapidly over a much larger distance (the time required for the communication does not increase proportionally with the distance). I can, in 20 minutes, transmit over a distance of 8 to 10 miles, the following, or any other similar phrase: "Lukner has left for Mons to besiege that city. Bender is advancing for its defense. The two generals are present. Tomorrow the battle will start." These same phrases are communicated in 24 minutes over a distance twice that of before; in 33 minutes they cover 50 miles. The transmission over a distance of 100 miles requires just 12 minutes more. Among the many useful applications for which this discovery can be used, there is one that, under the present circumstances, is of the greatest importance. It offers a reliable way of establishing a correspondence by which the legislative branch of the government could send its orders to our frontiers, and receive a response from there while still in session.
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> My assertions are not just based on a simple theory. Many successful experiments, held at a distance of 10 miles, in the Sarthe department, are for me a certain guarantee that this can be accomplished. The attached affidavits, drawn up at two municipalities, in the presence of a range of witnesses, attest to its authenticity. The obstacle that seems to me to be the most difficult to overcome is the popular suspicion that usually confronts those who pursue projects such as these. I could never have escaped from the fear that has overtaken them, if I was not sustained by the conviction that I should, as every French citizen, today more than ever, contribute to his country what he can.
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> I ask, Sirs, that the Assembly submit to one of its committees the examination of this project that I have the honor to announce to you, so that they can appoint delegates to observe the results of an experiment readily performed at a distance of 8 to 10 miles, and convince themselves that the same can be accomplished at any distance. I will perform this experiment, and in addition, at any distance that is requested, and I ask only, in case of success, to be reimbursed for the expenses that are made.

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23 Chappe 1824, in the revised edition published by Abraham Chappe in 1840, p. xiv.

24 Jacquez 1893" "pp. 14-15 Bertho 1981" "p. 10, notes that Chappe's speech was given in an evening session of the Legislative Assembly, which was usually devoted to topics of no immediate political urgency.

[Image Not Included in Original]

Figure 2.3 **Destruction of the Panel Telegraph**
(Source: Figuier 1868)

Curiously, the proposal does not detail a specific method, nor does it contain any mention of the word *telegraph*. It is said, that at this time Chappe called his device a *tachygraphe*, i.e., a "rapid writer," although also that term is not used here.[25]

As requested, the proposal was promptly delegated to a committee. About six months passed in which Chappe worked feverishly to make certain that he would be ready when called upon to perform the experiment.

THE PANEL TELEGRAPH

Not satisfied with the use of the pendulum system, Chappe had started experimenting with a different design. He built a rectangular wooden frame with five sliding panels (in French persiennes) that could be displayed or obscured individually with pulleys. The five panels trivially produced a five-bit binary code, with $2^5 = 32$ possible combinations, more than three times as many codes as used in the first design.

To avoid further mishaps, Chappe also moved from the *Etoile* to the quieter park of *Ménilmontant* in the town of Belleville, just to the northeast of Paris. But it was to no avail. Before any tests could be performed, the telegraphs were destroyed by an angry mob. The system was suspected to be a subversive instrument, meant to send signals to the enemy, which at this time included royalists, Austrians, Prussians, and Englishmen. Ignace Chappe described the events as follows:[26]

> This new experiment carried some risks for those involved: a crowd had formed in the Parc Saint-Fargeau [at Ménilmontant]; the telegraph was set on fire, and when the workers returned to the park to continue their work, the crowd had to be prevented from throwing them into the fire as well. The experiment could not be continued . . .

It is intriguing to see how close Chappe came to the shutter systems that the Swedes and the British later adopted. In 1794, Abraham Edelcrantz would perform virtually the same experiments as Chappe, comparing semaphore arms to tilting shutters, and arrived at different conclusions. Still, Ignace Chappe, describing Edelcrantz's system in 1824, considered his shutter system an independent invention. He wrote:[27]

> M. Endelecrantz [the name is misspelled consistently by Chappe], author of the Swedish telegraph, felt the correctness of these observations [i.e., about the necessity of tests]; he has made a large number of experiments to develop an idea that was entirely unknown before him: the usage of shutters that can either block light or permit it to pass through.

There is not even a mention in Ignace's account that the shutter system resembles the original panel system.

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25 The term tachygraphe had been used earlier by Henri Linguet, see p. _tag5_J.
26 Chappe 1824" "p. 125
27 Ibid., p. 166.

On 12 September, shortly after the destruction of the panel telegraphs, Chappe wrote another letter to the Legislative Assembly, describing his difficulties, but also announcing that he could be ready to perform a demonstration within two weeks. But his timing was poor. The Legislative Assembly was disbanded that month, and replaced with a National Convention. Ignace Chappe was not re-elected to the new body, so part of Claude's influence was lost in the transition.

The National Convention temporarily had more important things on its agenda than new proposals for telegraphs. On 10 August 1792, a mob had stormed the royal palace at the Tuileries, where the king and his family had, in effect, been kept hostage since their eviction from the Versailles palace three years earlier. After a short scuffle, King Louis XVI and Marie Antoinette were then imprisoned at the ominous "Temple" dungeon on 13 August. In its first session, on 21 September 1792, the National Convention sanctioned these decisions and it voted unanimously to abolish the monarchy and to establish a French Republic.

Apparently Claude Chappe was not too impressed with all this upheaval. He was not one to keep a low profile. On 9 October he resubmitted his proposal to the National Convention, which decided to delegate it to a fresh new committee. Then, on 15 October 1792 Chappe sent another letter to the convention, asking for official authorization to rebuild his telegraphs. Also that request was delegated to a committee.

The story again did not end there. The infamous "Reign of Terror" was about to begin. On 21 January 1793 King Louis XVI was beheaded, and in April of that year the Committee of Public Safety started its persecution of all those suspected of opposing the revolution. On 1 February war was declared on Britain and the Netherlands, and on 7 March also on Spain. Miraculously, the telegraph study was not discarded as utterly irrelevant under those circumstances.

THE SEMAPHORE TELEGRAPH

Around this time Claude Chappe concluded that the panel telegraph had been a false start, and he changed designs once more. As Ignace noted:[28]

> Some time later [we] established with certainty that elongated objects were better visible than the sliding panels adopted before.

The semaphore telegraph that Chappe designed next consisted of a large horizontal beam, called a *regulator*, with two smaller wings, called *indicators*, mounted at the ends, seemingly mimicking a person with wide-outstretched arms, holding a signal flag in each hand. The angles of the indicators, and independently also the position of the large regulator beam, could be varied in increments of 45 degrees, sufficient for the encoding of hundreds of symbols, as we will see shortly (see p. _sec 2.7_).

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28 Ibid., p. 125.

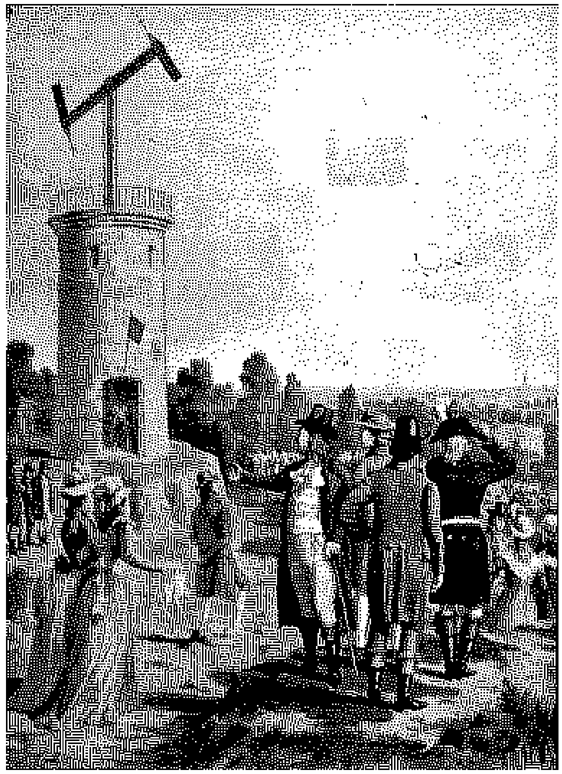

Figure 2.4 **The Semaphore Telegraph**.
(Coll. Musée de la Poste, Paris)

Chappe had found a few allies in the legislative bodies, the most prominent of whom was deputy Charles-Gilbert Romme (1750-1795).[29] On 1 April 1793 Romme intervened at the Convention on Chappe's behalf. He gave a speech that strongly supported Chappe's proposals, saying:[30]

> Many memoranda on this subject [i.e., telegraph proposals] have been presented to the Legislative Assembly, and have been delegated to the Committee for Public Instruction; just one of those truly merits attention. Citizen Chappe offers an ingenious method to write in the air, using a small number of symbols, simply formed from straight line segments, easily distinguished from one another, that can be executed rapidly and clearly over great distances.

Romme duly noted the potential importance of the invention for military purposes in this revolutionary period, and proposed to allocate 6,000 francs immediately to fund the construction of the telegraphs for the proposed experiments. This time the proposal was not delegated, but simply accepted. Two deputies, Joseph Lakanal and Pierre Claude Francois Daunou, were appointed official observers for the Convention on 6 April. A few days later a third observer, Louis Arbogast, was added. As it turned out, Joseph Lakanal, a

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29 Also known for proposing the abolishment of the Christian calendar on 5October 1793, and the adoption of a Revolutionary calendar, taking the founding of the French Republic on 22 September 1792 as year zero. Romme fell from favor in 1795 and committed suicide to escape the guillotine. The new calendar was abandoned at the end of 1805.

30 Jacquez 1893" "pp. 29-30

well-respected scientist at the time, was also a strong ally of Chappe. Arbogast, a professor of mathematics, and Daunou, a jurist and historian, were more conservative, but also somewhat less influential than Lakanal.[31]

Ignace Chappe, though no longer an elected representative, was still actively involved in the lobby to have the proposal approved. It is recorded that at this moment the term *tachygraphe* was first replaced with the term *télégraphe*, or "far writer," as a result of a conversation between Ignace Chappe and Count André Francois Miot de Mélito, who was then *Chèf deDivision à l'Interieur*.[32]

The danger of having telegraphs demolished by mobs still existed. On 2 July 1793 Joseph Lakanal filed a report to the Convention on Chappe's behalf, requesting officially that the mayors of the three communities where the first telegraphs were being erected would be ordered to take measures for the protection of the telegraphs. The proposal was accepted. The three locations that had been selected were the park Ménilmontant in Belleville, the heights of Ecouen at 15 km north of Belleville, and the town of Saint-Martin-du-Tertre, another 11 km further north.

THE CRITICAL TEST

On 12 July 1793 the official test was held, with all three observers from the committee present. Daunou was at the Belleville station with Claude Chappe; Lakanal and Arbogast were at Saint-Martin-du-Tertre, which was operated by Abraham Chappe. At 4:26 the first signals were exchanged, and within 11 minutes thereafter Daunou completed the transmission of the following message:

> Daunou has arrived here. He announces that the National Convention has just authorized his Committee of General Security to put seals on the papers of the deputies.

The answer from Lakanal arrived 9 minutes later. It was probably the result of some painstaking earlier deliberations between Lakanal and Arbogast, since it didn't really respond much to Daunou's enthusiasm for the new seals. It said:

> The inhabitants of this beautiful region are worthy of liberty by their respect for the National Convention and its laws.

Communication continued a while longer, until the intermediate station at Ecouen signaled that it was unable to dispatch any further messages.

Things moved quickly from here on. On 26 July 1793 the decision was made to establish a French state telegraph. On 4 August 1793 the Convention appropriated 58,400 francs for the construction of a first line of fifteen stations from Paris to Lille, at the frontier with the Austrian Netherlands (now part of Belgium), about 190 km (120 miles) north of Paris. On 24 September 1793, the Convention gave blanket permission to the Chappes to place telegraphs in any belfries, towers, or emplacements of their choosing. They also had permission to remove any trees that interfered with the line of vision between the stations. Permission was also granted for Chappe to hire personnel, and to draft the first rules and regulations for the French telegraph.

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31 Bertho 1981" "p. 16

32 The event is also recalled in the Mémoires of Miot de Mélito (i.38), which were published posthumously in 1858. Mélito was a count before the french revolution.

Claude Chappe was given the title of *Ingénieur Télégraphe*,[33] with the military rank of an engineering lieutenant,[34] a salary of 600 francs per month, and the permanent use of a government horse. The name *stationaire* was introduced for the telegraph attendants, a name that would continue to be used until 1862. At Chappe's request, his brothers Ignace, Abraham, and Pierre Francois were appointed as administrators of the line to Lille, at 500 francs per month each.

[Image Not Included in Original]

Figure 2.5 **The First Line from Paris to Lille (1794)**.

Success

The Chappes now started working on the design of the mechanics of the stations. To construct the controls of the telegraph, an intricate system of pulleys and ropes, Claude Chappe consulted Abraham Louis Bréguet (1747-1823), a well-known watchmaker at the time. For the design of the all-important code tables, it is often said that he relied on Léon Delauney, a cousin of the Chappes who had been a staff member of the French Consulatein Lisbon, and was experienced in diplomatic ciphers and codes.[35] According to the affidavits from the first experiments in 1791, Léon Delauney and his brother Prosper had been involved in the experiments from the very start in Brûlon.

To make sure that a communication with Lille could be established, even if that city were to fall under a siege by the enemy while the work was in progress, Claude Chappe sent his brother Abraham to Lille with instructions to remain there until the line was completed. The conditions under which Abraham Chappe had to work in the year that followed are recorded in letters he sent to Claude.[36] Funds appropriated by the Convention were always slow in coming, and the Chappes understandably had a hard time convincing workers to stay on the job without pay, sometimes for weeks on end. Abraham noted in one of his letters that the people in Lille were starting to avoid him, and were treating him with increasing hostility.

[Image Not Included in Original]

Figure 2.6 **Construction of a Telegraph Station**.
(Source: Belloc 1888, p. 91)
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33 The formal act of the National Convention from this date states that Chappe is accorded the title of Ingénieur Thélégraphe. This slip of the pen returns in many subsequent documents.

34 The telegraph was originally considered an exclusively military device, and the Telegraph Administration reported to the Ministry of War. Within five years, however, that changed, and the administration was moved to the Ministry of the Interior.

35 Others state that it would have been unlikely that Léon Delauney would risk his career by revealing diplomatic codes or cyphering methods. It is known from letters that Léon's brother, Prosper, was a lifelong friend of Claude's. In the correspondence between the brothers Chappe Contant 1993, in the year preceding the completion of the first line to Lille, there is frequent reference to the design of the new code for the semaphore telegraph. No reference to Delauney's involvement in this project can be found though.

36 A number of these letters appears in [Belloc 1888] A larger set is reproduced in [Contant 1993]

On 30 April 1794 all stations along the line to Lille were manned and preparations for the first trial transmissions began. An early logbook reveals that the telegraph line was routinely transmitting texts of decrees from the National Convention from Paris to Lille, at least as early as 17 May 1794.[37]

On 16 July 1794, less than one year after the decision of the Convention to build a line, the connection between Paris and Lille was formally declared open. There were two stations in the city of Paris itself, the first at the Louvre, and the second at the St. Pierre tower on the MontMartre. The next three stations along the line were the ones from the experiment: Belleville, Ecouen, and Saint-Martin-du-Tertre. The remaining stations were Ercuis, Clermont de l'Oise, Fouilleuse, Belloy, Boulogne la Grasse, Parvillers, Lihons, Dompierre, Guinchy, Hamelincourt/Brévillers, Théluch, Carvin, and Lille (tour Saint-Pierre).

On 15 August 1794 the first official message passed along this line from Lille to Paris, reporting the recapture of the city of LeQuesnoy from the Austrians and Prussians by the French generals Sherer and Marescot. The message arrived in Paris within a few hours after the recapture had taken place, and, of course, the delegates were impressed.[38] Two days later, delegate Bertrand Barère de Vieuzac described the sentiment in a speech to the Convention, as follows:

> Modern peoples by printing, gunpowder, the compass and the language of telegraph signs, have made vanish the greatest obstacles which have opposed the civilization of men, and made possible their union in great republics. It is thus that the arts and sciences serve liberty.

Two weeks later, on 30 August 1794, the telegraph was used again to report happy news: the recapture of Condé.[39] The message read as follows, being restricted to the words that occurred in the vocabulary:

> *Condé être restituer à la Republique. Reddition avoir eu lieu ce matin à six heures.* [Condé is restored to the Republic. Surrender took place this morning at six o'clock.]

These first two messages firmly established the reputation of both the optical telegraph and of its creator. More reports of victories followed in 1794 and 1795 as the French advanced north into Holland, and Chappe looked better with every piece of good news that arrived in Paris. Soon Claude Chappe was being hailed as a "benefactor of the motherland." The future of the French telegraph network was virtually guaranteed. On 3 October 1794 a decision was made to build a second line, originally intended to connect Paris to Landau via Metz and Strasbourg.[40] Construction on the new line started the same year, but incurred many delays. It took four years before the connection with Strasbourg was established, and by that time it was decided not to extend the line further.

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37 Parts of this log were reproduced in Amis 1968" "p. 45 and p. 57 A message from 18 May 1794, for instance, contained the text of a decree of the National Convention, announcing the withdrawal of five-livre banknotes.

38 Abraham Chappe started transmitting the message at 5:45 and completed it at 7:30 , as noted in FNARH 1993" "p. 24 This message therefore could not have arrived until at least two hours after the recapture had taken place.

39 The modern name is Condé-sur-l'Escault. It is about 11 km (7 miles) northeast of Valenciennes. The message was sent at 3 , and had to be terminated, still incomplete, 30 minutes later. Claude Chappe delivered the message without waiting for a retransmission.

40 Landau is about 270 km (170 miles) east of Paris.

In December 1794 Chappe moved his workshop from No. 23 Quai d'Orsay to No. 9 Rue de l'Université, the new headquarters for the Telegraph Administration, known as l'Hôtel Villeroy.

[Image Not Included in Original]

Figure 2.7 **Gaspard Monge's Design**.
(Source: Chappe 1824)

MONGE'S DESIGN

Despite the success, Chappe still was not satisfied with the performance of the semaphore telegraph. The time to transmit messages was longer than he had expected, and the relatively poor visibility of the stations caused too many transmission errors. There is a note from Abraham Chappe written just two days after the first message was successfully transmitted, announcing the recapture of LeQuesnoy, in which he complains to Claude that far too many service interruptions occur, making effective use of the telegraph almost impossible. According to the logbooks, the transmission of the second important message, about the recapture of Condé, was also hit by an unscheduled interruption lasting one hour. Fortunately, enough of the message had arrived at the time of the interruption that Claude Chappe decided to deliver it to the Convention immediately, without waiting for its completion.

A number of ways were considered to alleviate the problems. First, Claude Chappe decided to have extra stations built along the line from Paris to Lille. These auxiliary stations could be included in the transmission chain when visibility was low, for instance, in early morning fog. Second, he proposed to enlarge the regulator from roughly 4 meters to close to 15 meters to improve its visibility. Third, he consulted French mathematician Gaspard Monge (1746-1818) about the problem. Monge recommended increasing the number of arms (often also called "wings" or "indicators") from two to seven to increase the code space and hence the speed of transmission (Figure 2.7).

Monge designed a code for a seven-indicator semaphore, and several sources report that many telegraphs of this type were built for the Paris to Strasbourg line. But neither Monge's seven-indicator telegraphs, nor the enlarged two-indicator semaphores would ever be used.[41] Chappe finally came to the conclusion that the problem with the semaphore telegraph was not its size or the number of indicators, but an inadequate signaling code. Between 1794 and 1795 he developed a new coding system that alleviated much of the problem.

Despite the early successes, there was little that the Chappes could take for granted. Especially the first lines were constructed to establish communication with cities that were at risk of being besieged by the enemy, which meant that they lead close to enemy territory. During the construction of the station at Brévillers, on the line to Lille, Prosper Delauney wrote to Claude Chappe on 22 April 1794, almost casually:[42][

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41 See also Chapter Two, p. _tag2_3. Claude Chappe long continued to support Monge's design, though. In a letter to Le Moniteur Universel of 10 November 1797 he still described the seven-indicator telegraph as the best possible design.

42 Contant 1993" "letter A.N. F 90/1427-1428, B 34

Until yesterday, every afternoon and all morning yesterday, the cannons fired constantly; we can hear them clearly because the attack, we have been told, comes from Cambrai, which is no more than 6 leagues from here.

Ignace Chappe also described the atmosphere during this construction in gloomy terms.[43]

It is remarkable how difficult it was to survive the second phase of our efforts, the establishment and the organization of the line from Paris to Lille; how much energy, exhaustion, and resources we had to spend to overcome the unforeseen obstacles, returning endlessly, in a project of a kind that had never been attempted before; the fear and the worries caused by the uncertainty if the project could succeed at all: the death of the project could always be read on everyone's face!

This aspect of the work would never change. In 1798, for instance, the funds for payment to workers on a new line from Paris to Brest, commissioned by the French Navy, were repeatedly delayed. Attempts were made to pay in kind, instead of in cash, but that also failed. Claude Chappe made desperate pleas for money, as recorded in a series of notes sent to Paris (cf. Figure 2.8):[44]

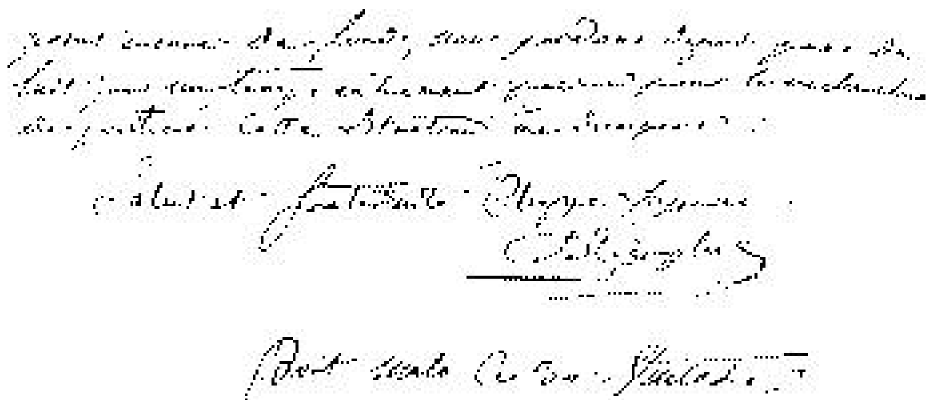

Figure 2.8 **Claude Chappe's Appeal for Funds, 21 March 1798**.
(Source: Belloc 1888)
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18 Ventôse An VI -- Des fonds, des fonds, encore une fois, des fonds, autrement nous ne pouvons rien faire. Adressez-les à Port-Malo…
[9 March 1798 -- Funds, funds, once more, funds, or we cannot do anything. Send them to Port-Malo …]

30 Ventôse An VI--Point encore de fonds, nous perdons depuis près de huit jours un temps extrêmement précieux … cette situation me désespère …
[21 March 1798 -- No more funds, we have lost almost eight days at an extremely important time … this situation makes me desperate …]

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43 Chappe 1824" "p. 200

44 As reproduced in Jacquez 1893" "p. 66, and in Appleyard 1930" "p. 271 "An VI" was the sixth year of the French revolutionary calendar (1798). Ventôse was the sixth month, from 19 February to 20 March, and Prairiàl was the ninth month, from 20 May to 18 June. One of the telegrams is reproduced in Figure 2.8, which is from [Belloc 1888]

14 Prairiàl An VI -- Je fais tout pour assurer le prompt succès de l'établissement que je dirige; de l'argent, ou point de ligne de Brest. [3 June 1798 -- I do everything to assure the prompt success of the organization I direct; money or there will be no line to Brest.]

The line to Brest was nonetheless completed in seven months.

Beginnings of a Network

The beginnings of a network became visible around 1800. Telegraph stations were built roughly 10 km (6 miles) apart. To simplify the administration and the reliability, each line was divided into short, autonomous segments called divisions. At the start and end of every division all messages were to be completely decoded and recorded in logbooks by an inspector, before being passed on. The operators at intermediate stations were allowed to know only a small subset of the telegraph code: the control codes that preceded and followed the actual messages, and the occasional error codes that could be inserted into them. They did not know the code used for enciphering the actual messages. That authority rested solely with the inspectors of the lines, and the director and assistant directors of the Telegraph Administration.

[Image Not Included in Original]

Figure 2.9 **The Semaphore Telegraph Network, ca. 1805**

At the start of 1805 there were four main branches, stretching out into the north, south, east, and west of France. The main lines constructed in this period are given below. The distances given are map distances, and most likely underestimate the actual distances along the trajectories of the lines as they were built. The dates in the leftmost column of the table indicate when construction began. The last column gives the period the lines in active use. Some of the longer lines took several years to be completed. Note, for instance, that the line from Lyon to Turin was built directly across the Alps, and took three years to complete.

1794	Paris to Lille	190 km	(1794-1847)
	Paris to Landau/Strasbourg	128	(1798-1852)
1798	Lille to Dunkerque	64	(1798-1801)
	Paris to Brest	210	(1798-1853)
1799	Strasbourg to Huningue	96	(1799-1800)
1803	Lille to Brussels	96	(1803-1814)
	Lille to Boulogne	80	(1803-1816)
1804	Paris to Dijon to Lyon	370	(1804-1852)
1804	Lyon to Turin	250	(1807-1814)
	Turin to Milan	100	(1809-1814)
1805	Lyon to Toulon	305	(replaced in 1821)

For a short period after the treaty Amiens from March 1802, most lines of the network, except the line from Paris to Brest, were shut down for lack of both the motivation and the funds to operate them. The line to Brest, by virtue of being funded through the navy, was spared this fate, and remained in operation as the only remaining line for more then one year. In May 1803, however, England resumed its war with France, and the telegraph network was quickly restored to its original size.

Figure 2.10 **Claude Chappe, ca. 1804**.
(Source: Koenig 1944, p. 432)

The Chappes were now arguably at the peak of their success. The construction on the line to Milan, for example, was begun at the explicit request of Napoleon Bonaparte, who had seized power in 1799 and declared himself emperor in 1804. Between 1800 and 1804, however, Claude Chappe became increasingly despondent. He was especially upset when others started attacking his designs, claiming credit for having invented the telegraph earlier. These critics included Bréguet, who had helped with the mechanics of the first stations in 1794, and Bétancourt, who together with Bréguet had made an unsuccessful attempt in 1797 to have Chappe's design replaced with their own.[45] A third critic was Captain De Courrejolles, who we met earlier, and who had also been unsuccessful in promoting his own design for an optical telegraph in 1783.

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45 Bréguet and Bétancourt's design used a single semaphore arm that was rotated in 10-degree increments, giving 36 different codes. To distinguish the smaller angles, they used telescopes with the 36 positions engraved into the glass of the eyepiece. To encode messages, Bréguet and Bétancourt assigned a single letter or numeral to each semaphore position, and used a simple spelling method. Clearly, this method was simpler, but also slower than Chappe's. The challenge of Chappe's design lead to a curious exchange of angry letters in the French newspapers between November 1797 and April 1798 by A. M. Eymar, a spokesperson for Bréguet and Bétancourt, and Claude Chappe, which was in part republished as [Chappe 1798] See also FNARH 1993" "pp. 325-331

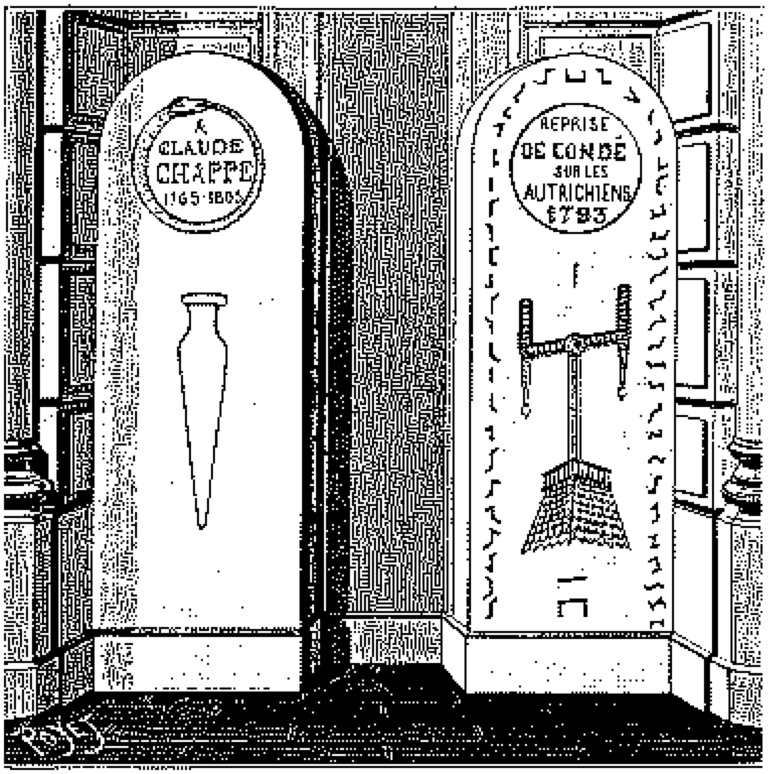

Figure 2.11 **Chappe's Tombstone from Vaugirard**.
(Source: Belloc 1888, p. 135)

Despair

Towards the end of 1804, Claude Chappe fell ill during a routine inspection tour of some of the new lines that were under construction. He suspected food poisoning, and pointed an accusing finger at his adversaries. When Chappe returned to Paris after a sickness of several months, he sank into a depression from which he did not recover. On Wednesday 23 January 1805 he committed suicide by jumping into a well outside the Telegraph Administration at l'Hôtel Villeroy in Paris.[46][According to some newspapers, a short note was found, written in a quivering hand:[47]

> *Je me donne la mort pour éviter l'ennui de la vie qui m'accable; je n'ai point de reproches à me faire.* [I give myself to death to avoid life's worries that weigh me down; I'll have no reproaches to make myself.]

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46 A newspaper reported that the employees of the Telegraph Administration searched for their missing director for several hours. When his hat was found close to a well in the yard, the well was dredged, and Chappe's body was recovered. It is possible that Chappe had been in the well since the prior evening. Hôtel Villeroy no longer exists. It was located at no. 9, Rue de l'Université in Paris.

47 Bulletin of Les Amis de Paris Central Télégraphe, No. 20, July 1993, p. 3, wrote that only few newspapers mentioned the existence of this note. The note apparently has not been preserved.

Five days later, on 28 January 1805, Chappe's death was reported in the French newspaper *Le Moniteur* as follows:[48]

> Mr. Claude Chappe, the inventor and administrator of the telegraph, died Wednesday last, at the age of forty-two; a true loss for the arts. It has been said, with reason, that the art of signaling existed long before him. But, in fairness, what he added was to expand this art into an application so simple, so methodical, so certain, and so universally adopted, that he can be regarded its true inventor.

Abraham Chappe commemorated the accomplishments of his brother in a letter to the editor of the *Journal de Paris*. The letter was dated 7 Pluviòse AnXIII (27 January 1805), and was published six days later. It ended ambiguously:[49][Note 49]

> He is dead, like his uncle the Abbé Chappe, a victim of his passion for the sciences and for his country. May their successors learn to imitate their example, and not to fear the fate of those who went before them!

In the letter, Abraham also referred to the accusations of Bréguet, Bétancourt, and De Courrejolles, that had driven Claude to such despair. It seems that at least De Courrejolles's accusation was unfounded. Claude's other brother Ignace later wrote in his book:[50]

> … two different types of telegraph have been experimented with. One was placed at the Louvre, the other at the pavilion in the middle of the Tuileries. This last one, of which Mr. De Courrejolles claims that it resembles his own design, was designed by Monge; it was, however, never used. Mr. De Courrejolles has acquired too much fame at the Turkish isles to have any need to claim the paternal rights to a child that died at birth.

Chappe was buried in a cemetery at Vaugirard, near Paris. The front of the tombstone that was placed at his grave shows a snake eating its tail (a symbol of eternity), encircling the words *Claude Chappe 1765-1805*. The back has a small vertical semaphore sign in the middle (the code for "idle"), and a picture of a telegraph below it showing the station sign of Lille. At the top is a reference to one of the first messages sent: *Reprise de Condésur les Autrichiens 1793.* The tombstone seems to have been made in haste: Claude Chappe was not born in 1765, but in 1763, and Condé was not retaken in 1793, but in 1794.

The Network Expands

After Claude Chappe's death the remaining brothers continued working for the Telegraph Administration, with the strong support of the government. Napoleon Bonaparte understood the potential of Chappe's system. Immediately after seizing power in 1799, he used the telegraph network to send the reassuring message:[51]

> *Paris est tranquille et les bons citoyens sont contents.* [Paris is quiet and the good citizens are content.]

He later also made use of the telegraph in his campaigns, in attempts to outwit the enemy by having fast notification of their intentions.

48 Quoted in Belloc 1888" "p. 133
49 As reproduced in Jacquez 1893" "pp. 72-73
50 Chappe 1824" "pp. 54-56
51 Bertho 1981" "p. 39 and p. 42

Figure 2.12 **Button from Claude Chappe's Uniform**.
(Coll. Musée de la Poste, Paris)
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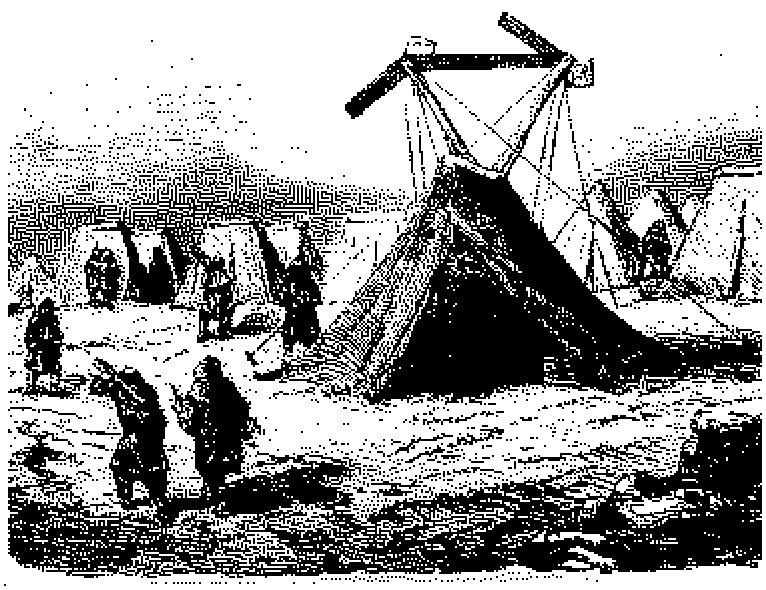

Figure 2.13 **Mobile Semaphore Telegraph.**
Used in the Crimean War 1853-1856.
(Source: Belloc 1888)

In 1801 Napoleon commissioned Abraham Chappe to develop a telegraph that could signal across the English Channel, to facilitate a possible invasion of England. In preparation for this, he ordered the line to Calais extended to Boulogne. Abraham designed a large semaphore with two arms. It was tested in June and July of 1801 between Belleville and Saint-Martin-du-Tertre, the two terminal stations on the first experimental line from 1793. The distance between these two stations roughly matches the shortest distance across the English Channel. The test proved to be successful. A telegraph of this design was installed for a short time in Boulogne, around 1804, but since Napoleon changed his mind about the invasion of England, it was never used as intended.

In 1808, Napoleon requested a report from the Minister of the French Navy, Vice-Admiral Decrès, which reads as follows:[52]

> Send me a memo on the establishment of signals and telegraphs similar to those near Spain and Cadix [Cadiz], so that I can learn within moments what happens at Toulon on the channel, at Cape Finistère, and at Cape Saint-Vincent. Make the memo short and clear, so that it tells me which new telegraphs you will have erected. Are they [based on] combinations of the letters of the alphabet, as in the land telegraph, or [flag] signals? Can one send, via these telegraphs, an order to the squadron in Cadix [Cadiz] to perform a manoeuvre, or to prevent an squadron from leaving Toulon or Brest?

A year later Napoleon became impatient with the slow progress in the construction of the line to Milan. The following angry note, directed at Minister of Interior Mr. Crétet, was written on 16 March 1809:[53][

> Mr. Crétet, I wish that you complete without delay the establishment of the telegraphic line from here to Milan, and that in fifteen days one can communicate with that capital.

The emperor promptly received his guarantee from Crétet that the line would be completed within weeks. Of course, it took another few months before it could actually be done.[54]

In 1812 Abraham Chappe was commissioned again by Napoleon, this time to develop a mobile version of Chappe's telegraph that could be deployed during the invasion of Russia in that year. His design was still in use in 1853 when the Crimean War took place.

The brothers Chappe had achieved a position of power and relative independence in the administration and operation of the telegraph network. When Louis XVIII was restored to the throne in 1814, the three brothers Ignace, Pierre, and Abraham were given the rank of *Chevaliers de Légiond 'Honneur*.[55]

[Image Not Included in Original]

Figure 2.14 **The Semaphore Telegraph Network Overview of Lines Constructed between 1794 and 1846**.

[Image Not Included in Original]

Figure 2.15 **Message Traffic between Paris and Bayonne**

(Data from: Massie 1979)

1809	Brussels to Antwerp	40 km	(1809-1813)
	Antwerp to Vlissingen	72	(1809-1811)
1810	Antwerp to Amsterdam	128	(1810-1813)
	Milan via Turin to Venice	241	(1810-1814)
1813	Metz to Mainz	225	(1813-1814)

52 Correspondance de Napoleon I, XVII, 1808, p. 288.
53 Ibid., XVIII, p. 416
54 Belloc 1888" "p. 140
55 King Louis XVI had been beheaded, and his son Louis XVII had died as a youngster.

1816	Lille to Calais	80	(1816-1852)
1821	Lyon to Toulon	305	(1821-1852)
1823	Paris to Bordeaux	507	(1823-1853)
	Bordeaux to Bayonne	160	(1823-1853)
	Avranches to Nantes	157	(1823-1853)
1825	Paris to Lille	190	(expanded)
1828	Avignon to Perpignan	209	(1828-1853)
1833	Avranches to Cherbourg	108	(1833-1853)
1834	Bordeaux to Toulouse	205	(1834-1853)
	Toulouse to Narbonne	127	(1834-1853)
	Narbonne to Montpellier	84	(1834-1853)
	Montpellier to Avignon	80	(1834-1853)
1840	Boulogne to Calais	32	(1840-1852)
	Narbonne to Perpignan	54	(1840-1853)
	Calais to Boulogne	40	(1840-1853)
	Dijon to Besancon	72	(1840-1852)
1844	Bordeaux to Agen	145	(replaced)
1845	Boulogne to Eu	100	(1845-1853)
1846	Bayonne to Behobie	30	(1846-1853)

The connection between Metz and Mainz was also established at Napoleon's request, and disappeared with his fall in 1814. The connection from Lille to Calais from 1816 replaced the earlier line from Lille to Boulogne, but only the last four or five stations along the line were affected by this switch. In 1840 the connection to Boulogne was restored with the construction of an extra line segment long the coast to Calais, and in 1845 that line was extended further south to the city Eu. The line from Dijon to Besancon, finally, was originally intended to reach Strasbourg via Huningue, to provide an alternate route through the network, but the full line was never completed.

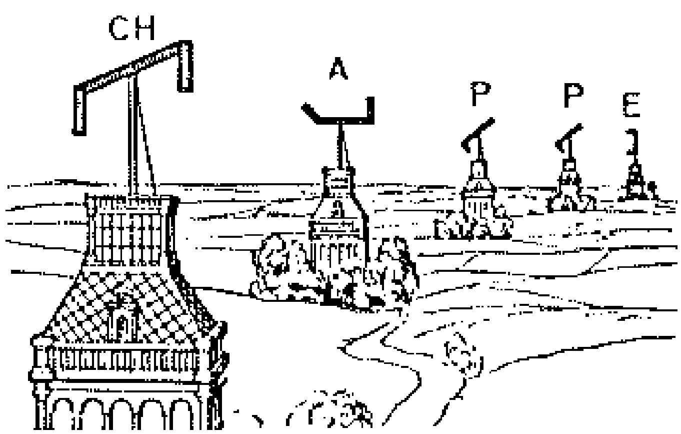

Figure 2.16 **Transmission Line**.
(Source: Koenig 1944, p. 435)

Figure 2.15 shows the amount of traffic carried on a typical line from this network, between Paris and Bayonne, over the 30-year period it was in use (9 April 1823 to 24 March 1853).[56][Traffic averaged a few hundred messages per year, with most traffic flowing towards Paris.

56 Massie 1979" "pp. 7-8, who also notes that the original transcripts of all telegrams sent on the Paris-Bayonne line between 1823 and 1853 are preserved in the French

FRAUD

Every attempt was made to guard the secrecy of transmissions on the telegraph network. There was clearly money to be made by speculators if, for instance, they could find a way to transmit news from the stock market in Paris to other parts of the country faster than the daily papers.

A curious case of fraud was discovered on the Paris to Bordeaux line.[57] Two bankers, the brothers Francois and Joseph Blanc, had bribed the telegraph operators at a station just behind Tours to introduce a specific pattern of errors into the transmissions, to signal the direction in which the stock market was moving in Paris to an accomplice in Bordeaux. The telegraph operators near Tours received their instructions from Paris by ordinary (stage-coach) mail, in the form of packages wrapped in either white or grey paper, indicating whether the stock market in Paris had gone up or down. The fraud had been in operation for two years when it was discovered in August of 1836.

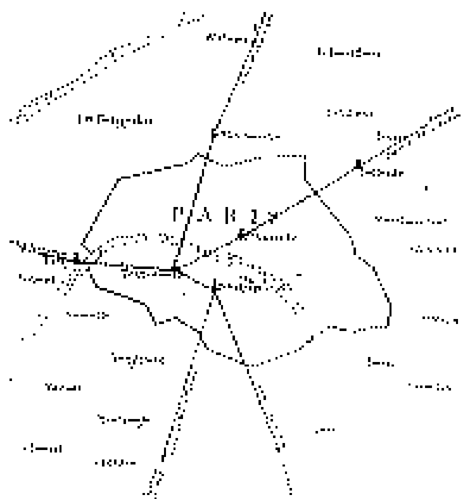

Figure 2.17 **Telegraph Lines in Paris, ca. 1852**.
(Coll. Musée de la Poste, Paris)

The reason that the telegraph station at Tours was chosen for this fraud lies in the administration of the telegraph network itself. At each division station, such as Tours, all incoming messages were decoded by a telegraph director. The messages were purged of transmission errors, and then re-encoded and passed on. On the French telegraph network only the directors and inspectors were allowed to know the code for message signals. The operators, or *stationaires*, knew only the limited set of control codes used for error corrections, clock synchronizations and the like (see also Chapter Six).

National Archives under register numbers F90/541-569, and F90/754-776. The data for message traffic after 1847 towards Paris was not included in Massie's study.

[57] Bertho 1981" "pp. 43-44, Saint Denis 1979" "pp. 2-4, FNARH 1993" "pp. 367-371 The operators involved in the fraud were tried in 1836, but acquitted on 14 March 1837. Their attorneys successfully argued that their actions had not violated any explicit law.

NETWORK NODES

Avranches in Bretagne was another division station where four lines met at a single network node. Each line was terminated at a separate telegraph, and each message received was decoded before it was passed on, by hand, to the operators of the appropriate connecting line. The same method was also adopted in Paris where four telegraph lines terminated at the headquarters of the Telegraph Administration, located at 103 Rue de Grenelle since 1840. The four faces of the telegraph tower on this building each carried a separate telegraph, mounted on the outside walls.

In 1823 Ignace Chappe retired at a pension of 4,255 francs per year. Pierre-Francois Chappe also retired and received 2,252 francs. They were succeeded by their younger brothers, René and Abraham, though nominally placed under the supervision of a new general administrator appointed by King Louis XVIII, Count Kerespertz. Ignace died on 25 January 1829, 66 years old. Claude Chappe was then reburied next to his brother on 19 June 1829 at the cemetery Père Lachaise in Paris.[58]

René and Abraham remained in charge of the Telegraph Administration until 1830. During the July revolution of that year, René Chappe refused to transmit messages on the optical telegraph network for the new government, considering himself bound by his oath to the king.[59][Note 59] The refusal made it painfully clear to the government how much power the two remaining Chappe brothers still had over the telegraph network. Shortly thereafter, that power was eliminated when both Réne and Abraham were forced to retire.

Figure 2.18 **Statue by M. Damé -- Destroyed in 1942**.
(Photo: Agence Roger-Viollet, Paris)

58 The tombstone is formed as a pile of rocks with a replica of the Chappe telegraph on top. The telegraph lost one of its indicators around 1890. The missing indicator was replaced and the tomb restored to its original state in January 1993.

59 FNARH 1991" "p. 29

Pierre-Francois died 20 February 1834 in Allonnes near Le Mans at the age of 64. Abraham died 26 July 1849, 76 years old, and was buried in Brûlon. René, the longest surviving Chappe brother, died in Brûlon on 6 November 1854. He was 85 years old.

Only two of the five Chappe brothers ever married. Pierre-Francois married Marie Blondel de Manneville and had three children, only one of whom survived: a daughter named Cornélie Emilie born in 1800. Abraham Chappe married the same Cornélie Emilie, his niece, in 1825, and had one child, Pierre-Emile, in 1826. Pierre-Emile, in turn, married in 1855 and had two daughters and two sons. These two sons, Pierre and Francois, each also married and had six children in all (two for Pierre, and four for Francois).The two male descendants of the Chappe brothers among these, named Christian and Claude, were both killed in World War I, leaving no male descendants alive today.[60]

Figure 2.19 **The Letterhead Used for Telegrams**.
(Source: Belloc 1888, p. 177)

By 1852 the French network of optical telegraphs had grown to 556 telegraph stations, covering roughly 4800 km (3000 miles). The network connected 29 of France's largest cities to Paris. With two operators on duty at each station, the network employed well over 1,000 people, including nearly forty telegraph inspectors and twenty directors.[61]

In 1859 Claude Chappe's dubious tombstone was removed from Vaugirard and presented to the Telegraph Administration, which had it cut into two slabs. The two halves of the stone, front and back, were placed in the entrance hall of the new headquarters at No. 103 Rue Grenelle in Paris, where they remain today.

In 1893, at the first centennial of the telegraph, a copper statue of Claude Chappe by M. Damé was erected in Paris, at the intersection of Boulevard Saint-Germain and Boulevard Raspail, near the Rue du Bac where Chappe had his first workshop. Alas, the statue did not survive long enough for a bicentennial celebration. It was melted down for ammunition during World War II, and was never replaced.

60 In 1990 close to 300 other descendants of the Chappes were alive, as reported in FNARH 1991" "p. 41

61 See also Field 1994" "p. 342, who gives the approximate numbers of people employed by the telegraph administration in 1833.

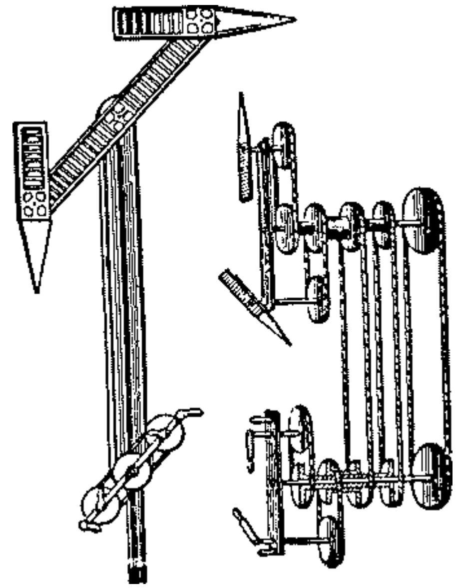

Figure 2.20 **Semaphore Telegraph Mechanics**.
(Source: Koenig 1944, p. 434)

How the Telegraph Worked

The mechanical construction of the telegraph was thoroughly studied by the Chappes before a final design was chosen. In Ignace Chappe's words:[62]

> … a telegraph appears to be such a simple device to construct hat few people have studied it seriously.

Several authors have given detailed information on the design, although the measurements given are rarely in precise accordance.[63] The measurements below are taken from Shaffner, as the earliest source. The telegraph consisted of an iron support column, 4.55 m (15 ft) high, with a movable wooden regulator of 4.25 x 0.35 x 0.05 m attached to the top. At the ends of the regulator beam were two movable indicators, each 1.80 x 0.30 x 0.025 m, counterbalanced with lead weights on steel rods. The indicators we remounted asymmetrically on the regulator beam, the longest end measuring 1.65 m. The distance from the center of the regulator to the center of each indicator was set at 2 m, so that when both indicators were turned inward they were 0.70 m apart.

A large control handle, about one meter long, was placed at the bottom of the support beam. The control handle exactly reproduced the position of the semaphore outside. It rotated the regulator with two cords, running across double pulleys to the beam. To allow the cords to be shortened and lengthened for proper tension, the cords were interrupted in the middle by iron bars with tension screws. The indicators were moved, also via pulleys and cords, in such a way that their angle with the regulator stayed fixed, and could be set independently of the position of the main regulator. The angles of the indicators were further secured with spring-loaded tooth-in-notch mechanisms. The regulator itself could be secured (at night or during storms) with a large bolt in the support beam.

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62 Chappe 1824" "p. 199

63 E.g. Shaffner 1859" "p. 34 ff, or Jacquez 1893" "p. 21 ff

To reduce both weight and wind resistance, the indicators were made from a brass grating with copper slats. Half the slats were set to the right, the other half to the left, to distribute the wind forces evenly, and to avoid reflections. Both the regulator and the indicators were painted black to produce a maximum contrast against the sky.

THE FIRST CODE

Much attention was also given to the definition of workable signaling codes and station instructions, to secure maximum visibility and a minimum number of operator errors.

Ignace Chappe noted that it was virtually impossible to prevent transmission errors when messages had to be passed down long chains of telegraphs. He ridiculed those who thought they could design new telegraphs without considering the subtleties of signaling across longer chains.[64]

> Those who think they have invented a telegraph that can be used without preliminary instructions for the telegraph operators, are mistaken; they have probably never performed experiments with more than two or three stations.

The original code for the synchronized system (the pendulum telegraph), possibly developed with the help of Léon Delauney in 1791, consisted of a code book of 9,999 entries.[65] The clock face of the pendulums had 10 divisions on them, leading naturally to a decimal encoding. Delauney placed the most frequently used words and phrases at the top of the encoding list, giving them the shortest encodings. The first nine entries, for instance, were the numerals from 1 to 9, which were encoded in one signal. The next 89 entries, numbered from 10 to 99, were encoded in two subsequent signals. Similarly, the entries from 100 to 999 required three, and the remaining entries, from 1,000 to 9,999, four subsequent signals.

[Image Not Included in Original]

Figure 2.21 **Basic Code for Numerals, ca. 1794**

According to the description later given by Ignace Chappe, and discussed also by Jacquez in 1893, the Chappes continued to use a code very similar to this on the semaphore telegraph until 1795. Several drastic variations were considered before the decision was made to adopt it though.

In an undated manuscript titled *Mémoire relatif à une découverte dontl'objet est de communiquer rapidement à de grandes distances, tout ce quipeut faire le sujet d'une correspondance* [Memorandum on an invention for communicating quickly over great distances, everything that could be the subject of a correspondence], Claude Chappe motivated the initial choice of signals for the semaphore system. The memoire was probably written in late 1793. It reads as follows:[66]

> With ten characteristic, and two secondary, signs, I will now introduce a system of combinations that reduces the language of signals to a very simple [method of] expression. One should consider these characters as a form of numerical shorthand, which aims to represent words in the smallest possible number of signs.

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64 Chappe 1824" "p. 111
65 Jacquez 1893" "p. 18
66 Amis 1968" "pp. 109-110, also discusses the manuscript and reviews the first codes.

The ten "characteristic" signs were formed with the regulator in either a horizontal or a vertical position, and at most one of the indicators tilted 90 degrees, leaving the other indicator idle.

Claude proposed to use these ten characteristic signs to encode numbers from one to 20, by prefixing each with one of two possible "secondary" signs. These secondary signs, also called the right and the left *oblique* position, were formed by placing the regulator at a 45 degree angle with the horizon. If the characteristic sign was preceded by a right oblique, the number was odd, if it was preceded by a left oblique, it was even. Compared to a purely decimal system, the base-20 system allowed for a smaller number of signals to be used per word or phrase from a numbered dictionary or code-book. It was, however, never adopted. The code used on the Paris to Lille line in 1794 was still based on a decimal encoding, as in the synchronized system, using the ten characteristic signs to represent the numbers from one to ten (see Figure 2.21).

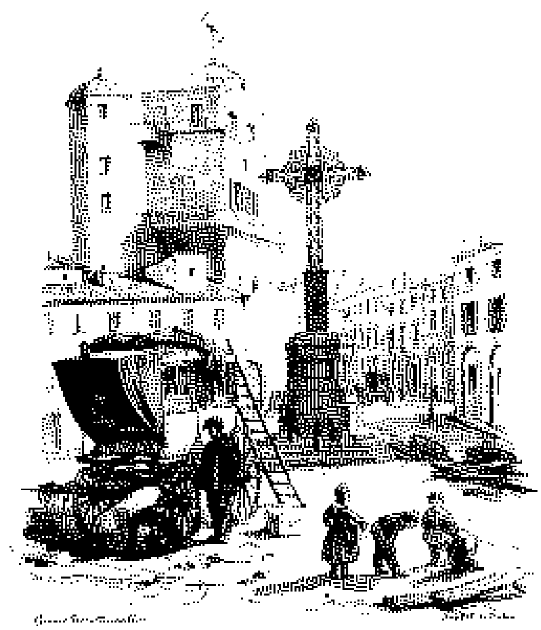

Figure 2.22 **The Telegraph at Montpellier**.
(Coll. Musée de la Poste, Paris)

To separate variable-length code groups from each other in a longer transmission, the last sign in each group was made with the unused indicator turned slightly away from the regulator. The undated manuscript gives the required angle as 22.5 degrees, rather than 45 degrees, to clearly distinguish this "termination" sign from other possible semaphore positions. It is not known if this smaller angle was also used in the code that was adopted in 1794.

Apart from these correspondence signals, of which the meaning -- other than the numeral value of the code -- was unknown to anyone below the level of telegraph inspector, there were fourteen service or *control* signals known to all operators. These signals were always set with both indicators turned, avoiding the codes that were used for the correspondence signals. They were used to signal the following conditions:

Start of transmission
End of transmission
Suspension of transmissions for one hour
Suspension of transmissions for two hours
Synchronization, meant to allow the stations along the telegraph line to resynchronize their clocks
Conflict, to indicate that two messages from opposite directions had arrived simultaneously at one station
Priority, to indicate the precedence of one of the conflicting messages
Acknowledgement, indicating the reception of a correctly deciphered message at the final destination
Error, to cancel the last transmitted sign
Idle, indicating the closing of the station or line
Minor failure, to indicate a small problem with the telegraph, or the temporary absence of the operator
Major failure, to indicate a more serious problem disabling the telegraph, requiring outside help
Rain or fog restricting visibility, and
Night transmission.

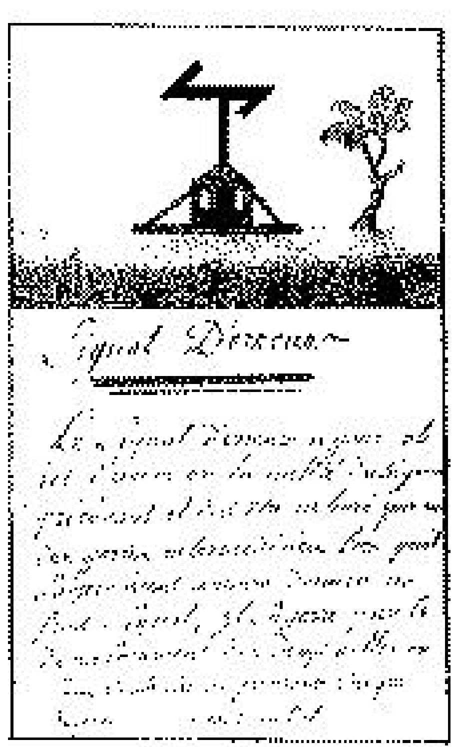

Figure 2.23 **Instructions for Use of the Error Signal**.
(Coll. Musée de la Poste, Paris)

The last signal was probably included only with an eye towards future extensions of the telegraph system on which transmissions at night were foreseen. As far as we know, no effective system of night signaling was ever used on the Chappe telegraphs.[67]

The precise signaling code that was used on the Paris to Lille line is still somewhat of a mystery. In a letter dated 5 July 1794 Claude Chappe writes that he just completed two code books regulating the correspondence on the new line, together with a set of detailed instructions on the use of the telegraph, which he delivered to the Committee for Public Safety.[68] No code books, however, have been preserved that completely match the descriptions. It is understandable that, to safeguard the secrecy of the correspondence signs, very few of such books would have been prepared.

In the Paris Postal Museum an undated code book has been preserved that could be either an adapted version of Delauney's first code, or a proposal for a new code that remained unused. It contains two sets of 88 pages, each with four columns of 88 entries, not all of which are defined. From the 2 ◊ 88 ◊ 4 ◊ 88, or 61,952, possible code combinations, only 45,056 were filled in. Possibly, this code required that the semaphore be set in one of 88 positions to form each sign. That number was increased to 92 or 94 in the code that Chappe adopted in 1795.

THE REVISED CODE

Based on the first year of experience with the Paris to Lille line, Claude Chappe developed a new code in 1795.

From the beginning, the regulator and the indicators of the telegraph were set only at angles that varied in increments of at least 45 degrees. This allowed for eight positions for each indicator and four for the regulator, giving 8 x 8 x 4 = 256 possible combinations. It was also realized from the beginning that the positions where the indicators either extended the position of the regulator, or were hidden behind it, were almost indistinguishable. By excluding the positions that extended the regulator beam, the number of indicator positions was reduced to seven each, leaving 7 x 7 x 4 = 196 possible combinations for the telegraph as a whole. Since the available code space was still large enough, the meaningful signs were further restricted to only those where the regulator beam was either placed horizontally or vertically. This limited the number of possible signs to 7 x 7 x 2 = 98. These 98 combinations were further reduced to either 92 or 94 signals. After retiring from the Telegraph Administration, Abraham Chappe summarized this signaling system in a letter dated 24 January 1844. He explained this last restriction as follows:[69]

> From these 98 signals 4 or 6 are reserved for special indications, so that 92 or 94 signals remain for the correspondence.

The code that was adopted in 1795 consisted of two parts, called *divisions*. According to Abraham Chappe's letter, the first division defined 94 different signs encoding the alphabet, the numbers from zero to nine, and some frequently used syllables. Each code from this division was set, following the rules for the formation of signals to be explained shortly, and

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67 A system of Dr. J. Guyot was tested around 1840 on a small number of lines, apparently with some success, but it was never extended to the whole network. Guyot's experiment is referred to, among others, in a letter sent by Abraham Chappe to the telegraph administration in 1844.

68 The letter is reproduced in [Perardel 1979] See also Contant 1993" "pp. 12-13, who adds that a second copy of this vocabulaire was delivered to Florent Guyot in Lille.

69 The original letter is preserved in the Musée de Poste of Nantes.

then confirmed, or *closed*, by folding in the two indicators. The resulting two double-closed positions (horizontal and vertical closed) were not counted among the 94 signals from the code books, but among those that were reserved for "special use," as indicated by Abraham Chappe.

The second division of the code consisted of a code book of 94 pages with 94 signs (called *series*) each, defining more syllables and commonly used words.[70] Each entry from this code table was again transmitted as a code pair. The first sign of the pair now gave a line number from the code book, and the second sign gave the page number. Care was taken that the second sign could never be a "double closed" sign, to make sure that the codes from the first and the second division were different.

The complete code of 94 + 94 ◊ 94 = 8,930 words and phrases comes close to the size of Delauney's original code with 9,999 entries, but was presumably somewhat simpler to use.

In 1799, four years after the new code was adopted, Chappe extended his code by adding a few extra divisions in separate code books. The extra divisions contained codes for additional words and phrases, names of places and people, etc. In his summary from 1844, Abraham Chappe described a total of five different divisions. The codes in the third division were preceded by a separate horizontal, double-closed signal; those in the fourth division were preceded by a vertical double-closed signal; and those in the fifth division by a signal that was borrowed from the first division. All codes from the first and second division, therefore, required two signs; those from the third and fourth division required three signs, and those from the fifth division four.

There are indications that the codes were revised once more in 1809, but remained stable thereafter.

FORMING A SIGNAL

By restricting the regulator beam to only a horizontal or vertical position potentially half of the code space remained unused. Diagonal semaphore positions did, however, occur during the formation of signals. From the first code on, in 1794, each sign was always set in two separate movements. The first step was used for the formation of the signal proper, the second step for its confirmation, or completion. To form a signal, the regulator beam was first tilted to the right or to the left, with both indicators folded in. Only then could the indicators be turned to assume their new position. Moving the regulator back into a horizontal or vertical position was called *carrying the signal to completion*. The tilted positions of the regulator were called the *right oblique* and the *left oblique*.

By definition, a signal was meaningless as long as the regulator beam was tilted -- a safeguard against the confusion caused by quickly changing arm positions during the formation of signals. With these rules, then, the transmission of a complete code from the fifth division of the code books required a total of eight movements of the telegraph. The more frequently occurring codes from the first division, however, required just three movements: (1) setting the signal on an oblique, (2) carrying the signal to completion, and (3) folding in the indicators to close the signal.

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[70] A fragment of the first page is reproduced in Belloc 1888" "p. 71

Figure 2.24 **Uniform of a Telegraph Inspector**.
(Coll. Musée de la Poste, Paris)

Correspondence (message) signals were always formed on the left oblique, and service (control) signals always on the right oblique. Of course, what was the "left" oblique to one operator, looked like the "right" oblique to another, thus providing a wonderful source of confusion.

All signals on the semaphore telegraph were passed one at a time, in strictly synchronous fashion. The operators were required to check their neighboring stations every few minutes for new signals, and reproduce them as quickly as possible. The operator then had to verify that the next station in line reproduced the signal correctly, and set an error signal if it failed to do so. Each signal received had to be recorded in a logbook, as soon as it was carried to completion. Since no symbolic or numeric code system for representing the semaphore positions was described, this was done in the form of little pictograms, displaying the relative positions of regulator and indicators. If the signal was a control signal, the hour and minute of its arrival was also recorded in the logs.

Figure 2.25 **Flocon's Design, Reconstructed Station near Narbonne**.
(Source: Galfano 1990, p. 13)

The instructions that were given to the operators of the semaphore telegraphs have been preserved. They detail precisely what the operator had to do to detect and recover from transmission errors, how to resolve conflicts between messages traveling in opposite directions, and how to deal with low visibility and unscheduled delays. Translations of the original texts are reproduced in Appendix B. The instructions are also discussed in Chapter Six.

In 1837 Gabriel Flocon, an administrator of the French telegraph network, introduced a new coding method, where the heavy regulator beam always remained fixed in a horizontal position.[71] A separate, small, indicator wing was added in the middle to represent what would have been the position of the regulator. This version of the telegraph was called the *télégraphe horizontale*. Abraham Chappe wrote in his letter from 1844 that this variant had been installed on short line segments only, such as Perpignan to Bayonne and Dijon to Besancon. One of the Flocon stations near Narbonne, at Jonquières, was reconstructed in 1987, and can still be visited today (see Figure 2.25).

Table 2.1 Transmission Times.

Destination	Stations	Time (sec)	Time/Station (sec)
Calais	27	180	6.7
Brest	80	480	6
Lille	22	120	5.5
Strasbourg	45	390	8.7
Lyon	50	540	10.8
Total	224	1710	7.6

TRANSMISSION SPEED

Edelcrantz says in his treatise from 1796 that initial reports gave the speed of the French telegraph as 20 seconds per symbol.[72] Most other sources, however, rated the speed at 30

71 Jacquez 1893" "p. 27
72 Chapter Four, p. _tag4_A.

seconds per symbol, noting that at higher speeds the number of transmission errors increased too much.

The end-to-end speed of the telegraph lines is reported in various places, but not always consistently. In early 1819, John Macdonald quoted the following numbers from a "recent French paper," counting telegraphs on the lines from Paris to various destinations, and the time it took to send a first sign from Paris to five destinations:[73]

The line to Lille had been extended from 17 to 22 stations by the time these data were collected. Of course, the transmission times in the table above were not averages that could be sustained for all signs throughout a message. The overall average of 7.6 seconds per sign per station is therefore best interpreted as a lower bound. The usual quote of two to three symbols per minute, or 30 to 20 seconds per sign, also matches the clock-times recorded in logbooks from this period.[74]

Rollo Appleyard, most likely basing his report on figures from the earlier book written by Alexis Belloc, wrote:[75]

> At Paris, when this system had been perfected, they could receive communications from Lille in two minutes, from Calais in four minutes five seconds, from Strasbourg in five minutes fifty-two seconds, from Toulon in twelve minutes fifty seconds, from Bayonne in fourteen minutes, and from Brest in six minutes fifty seconds.

Shaffner reported somewhat better results, quoting roughly six seconds per station:[76]

> Chappe said that when the weather was fine, and the fogs and haziness of the atmosphere are not a hindrance to vision, the first signal of a communication ought not to occupy more than 10 or 12 minutes in passing from Toulon to Paris, cities situated 215 leagues or 475 miles [765 km] apart, and connected by a telegraph line of 120 stations; but Chappe added that if we suppose a continuous correspondence between Paris and Toulon, there would ordinarily arrive at Toulon but one signal a minute.

Of course, transmitting complete messages one signal at a time would take time. Whether or not a message would get through correctly on the first try depended on the weather, and thus on the time of year. M. Vasseur, studying the reliability of message transmissions over a four-year period (1836-1839) for a private optical telegraph line connecting Antwerp and Brussels, noted that messages would get through on the first try an average of 97 percent of the time in the month of August 1838 (the best month), but only 16 percent of the time in the month of December 1839 (the worst one).[77] In related studies it was found that during the winter messages could take up to three days to reach their destination.[78] Despite

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73 [Macdonald 1819]

74 Amis 1968" "pp. 53-54 According to the logs, during the first experiments in 1794 the time required per signal was often as high as 60 seconds.

75 Belloc 1888" "p. 202, Appleyard 1930" "p. 274

76 [Shaffner 1859]

77 Vasseur 1981" "p. 4

78 The statistics for all message traffic between Bayonne and Paris from January 1843 until January 1845 can be found in FNARH 1993" "p. 140 A total of 925 messages was sent in this two year period. Of these, 508 messages, or 55%, arrived on the first day. Another 263 (28%), arrived the second day; 99 (10%) on the third day, and the

all this, messages traveled faster on these networks than they had ever done before;after all, in the winter a rider on horseback also has trouble getting through. Macdonald reflected the excitement of the new phenomenon in the following note, written in 1819:

> It was lately stated, in their [the French] papers, that 3000 messages could be conveyed in one day from Paris to any extremity of France; and also that answers could be received to them.

The claim seems exaggerated. Even if one sign would have taken roughly eight seconds to traverse a station, in eight hours of daylight a maximum of only 3600 signs could have been given, with full-time operation. Each message surely consisted of more than just a single sign, requiring at least signals for identifying the sender and the receiver, and multiple signals for encoding the communication itself.

The Competition

In 1796, when the Chappe system was fairly well established, Gottfried Huth (1763-1818), a German professor, published a curious booklet titled *A treatise concerning some acoustic instruments and the use of the speaking tube in telegraphy*, which included a translation of a work on acoustical instruments from 1763 by the Frenchman J. H. Lambert.[79][In his own additions to the translation, Huth criticized the Chappe system for being obviously restricted to fair weather and day-time use. As an alternative, Huth proposed a system where men with so-called "speaking tubes," or megaphones, would be placed on towers, roughly five km apart, so that they could shout messages to each other. Huth's suggestion was based on the legend that Alexander the Great had used a megaphone of enormous proportions to shout messages to his troops during battles.[80]

Huth realized that he had to think of an original name for his system to set it apart from the Chappe system. He wrote:

> The fundamental difference therefore deserves, and will ultimately require, a different name for the telegraph based on speaking tubes. But what name would be more appropriate than the word derived from the Greek: "Telephon," or far-speaker [German: *Fernsprecher*].

The name would stick, though not to this invention. As far as we know, Huth's proposal was never put into practice.

In 1809 Napoleon decided to experiment with a quickly improvised communication line that consisted simply of men equipped with colored signal flags. It is possible, though, this was only a stop-gap measure to bridge the distance from his military headquarters in Vienna to the nearest optical telegraph station in Strasbourg. The flag signaling line was abandoned when Napoleon left Vienna.

A more serious challenge to Chappe's design would come in 1831 when a private citizen, Alexander Ferrier, opened a public telegraph line between Paris and Rouen, funded by

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remaining 55 messages arrived later still. The really long delays were all incurred in winter months.

79 [Huth 1796] See also Aschoff 1984" "p. 209

80 According to Aschoff 1984, this system was described in a work by Athanasius Kircher, titled Phonurgia Nova, which was published by Rudolph Dreher in Kempten in 1673.

stockholders. He charged 20 francs per 100 French miles (444 km). Ferrier's telegraph consisted of two rotating pointers, placed five meters (16 feet) apart, each pointer with a 30 cm (one foot), counterbalanced, disc mounted at the end.[81] Each pointer could be set in one of eight positions. At night, each pointer carried two lights, one in the center, one at the disc. Ferrier advertised that he could transmit at least 10 messages per hour over 100 French miles, allowing an average of 12-15 words per message. The first station of Ferrier's line was placed on the Boulevard MontMartre, another in a private house on the Mont Martre itself. The line failed to make a profit, though, and was abandoned within one year. Ferrier then moved to Brussels to try his luck there.

More private telegraph companies appeared and disappeared over the years. Fearing a proliferation of communications networks that would be hard to control in the long run, the French government soon moved to ban the establishment of private telegraphs.[82] A bill to that effect was passed on 14 March 1837 in the Chamber of Deputies (the lower house). It was confirmed by the Chamber of Peers (the upper house) and became law on 17 April 1837:

> Anyone performing unauthorized transmissions of signals from one place to another, with the aid of telegraphic machines or by any other means, will be punished with an imprisonment of one month to one year, and a fine of 1,000 to 10,000 Francs.

Virtually the same law is in effect today. In the current text the term *telegraphic machines* has been replaced with *telecommunications apparatus* and the fine has been increased to 3,600 to 36,000 Francs.[83]

The End

Even at the peak of their success, around 1824, the Chappes made it clear that they were not satisfied with the way the network was being used. Ignace Chappe wrote in the introduction to his book:[84]

> Why is its use restricted to the transmission between a relatively small number of cities, of news that is usually of little importance?

Instead, argued Chappe, the telegraph network could be exploited profitably, for instance, by quickly reporting market prices from all over Europe to Paris, so that traders could instantly buy goods at whichever location they were offered for the lowest price, and sell them where the price was highest. Such use, wrote Ignace, could establish Paris as the trade capital of Europe. Whatever the reasons may have been, it was never done. Perhaps, as Chappe noted somewhat bitterly, the reason was simply this:

> The use of novel methods that modify established habits, often hurts the interests of those who profit the most from the older methods. Few people, with the exception of the inventors, are truly interested in helping projects succeed while their ultimate impact is still uncertain. … Those in power will normally make no effort to support a new invention, unless it can help them to augment their power; and even when they do support it, their efforts are usually insufficient to allow the new ideas to be fully exploited.

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81 Herbarth 1978" "Fig. 15, p. 25
82 Bertho 1981" "pp. 45-46
83 Ibid., p. 51.
84 Chappe 1824" "pp. 12-13

A final, and, of course, for good reason fatal, competition to Chappe's optical semaphore network came from the electrical telegraph. It took many years, however, for the advocates of the electrical telegraph to prove its superiority. As early as in 1838 Samuel Morse visited France to demonstrate his telegraph to the French Academy of Sciences. Morse bid on a contract to install an electrical telegraph line along the railway from Paris toSaint-Germain. But, when Morse left France again in February 1839, he had not succeeded in winning that contract. The French government had decided that the installation and exploitation of the telegraph network was too important to be trusted to a private company, and the plan to install an electrical line was abandoned.[85]

In 1840, one of the staunchest defenders of optical telegraphy, Dr. Jules Guyot, traveled to England to study the electrical novelties. Upon his return he published an article in the *Courier Francais* that appeared 5 July 1841. It argues convincingly:

> … with the aerial telegraph you can transmit your dispatches from station to station; under no circumstances will the Government fail to receive news from scenes of conflagrations or the theater of war.

The electrical telegraph, on the other hand, was clearly less useful. Its reliance on the existence of an uninterrupted, physical connection between stations could prove to be a fatal flaw:

> Every sensible person will agree that a single man in a single day could, without interference, cut all the electrical wires terminating in Paris; it is obvious that a single man could sever, in ten places, in the course of a day, the electrical wires of a particular line of communication, without being stopped or even recognized.

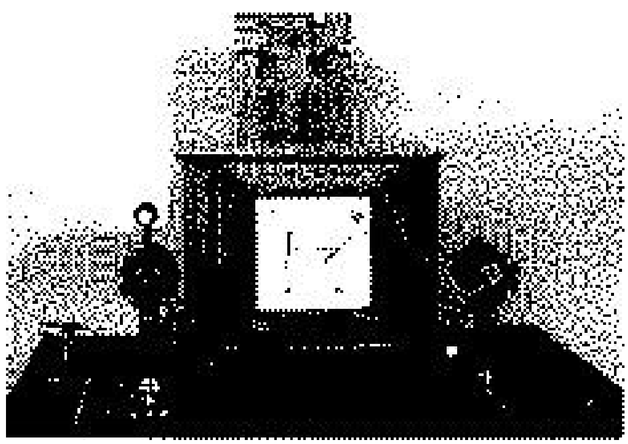

Figure 2.26 **Foy-Bréguet's Electrical Telegraph**.
(Coll. France Telecom CNET, Paris)

To settle the matter once and for all, Guyot concluded:

> … what can one expect of a few wretched wires under similar conditions? … Assuming that the electrical telegraph functions well in winter and poorly in summer, or that it functions well at all times, it cannot seriously be considered

[85] Bertho 1981" "pp. 67-68

suitable for the needs of the Government, and the day is not far distant when this truth will be clearly demonstrated.

Funds for the first experimental electro-magnetic telegraph line between Paris and Rouen were appropriated in 1844 and the line went into service on 18 May 1845.[86] The test proved successful, and on 3 July 1846 the French government made the historic decision to begin replacing optical telegraph lines with electrical ones. The first one chosen was the oldest line of the network, the line from Paris to Lille.

Alphonse Foy, the chief administrator of the telegraph network at this time, ordered the construction of a version of the electrical telegraph that would be backward compatible with the French optical telegraphs. The design was made by the engineer Louis Bréguet, grandson of the famed Abraham Louis Bréguet who had assisted Claude Chappe with the construction of his first telegraphs fifty years earlier. Bréguet designed a little wooden cabinet, displaying a Chappe regulator, with two indicator wings, that could transmit the familiar Chappe codes as electrical signals.[87] Curiously, the Foy-Bréguet telegraph duplicated only the Chappe indicators and not the regulator. A competing electrical telegraph design by Dr. Pierre-Antoine Joseph Dujardin did contain small replicas of both indicators and regulator, but, perhaps because it required an additional wire to control the regulator, it was not selected.

The attempt to duplicate part of Chappe's vocabulary on the Foy-Bréguet telegraph was quickly abandoned. By 1852 the same device was still in use, but with a much simplified character encoding, using one indicator combination for each letter of the alphabet. The telegraphs were finally replaced with Morse telegraphs in 1855.

One of the last messages transmitted over an optical telegraph line reported the fall of Sebastopol in 1855.

Bibliographic Notes

The first publications on Chappe's designs were newspaper articles. The telegraph was debated in 1794 in a series of letters sent to *Gentleman's Magazine*, reproduced in Appendix A. Chappe's design is also discussed in Edelcrantz's Treatise from 1796, see Chapter Four.

Claude Chappe himself published several papers in physics, []Chappe 1789a, 1789b,1790, 1791, 1792, 1793 On the optical telegraph, though, he left only some handwritten notes and letters. An undated manuscript written by Claude Chappe was preserved entitled *Mémoire relatif à une découverte dont l'objet est de communiquer rapidement à degrandes distances, tout ce qui peut faire le sujet d'une correspondance* [Memorandumon an invention for communicating quickly over great distances, everything that could be the subject of a correspondence]. The manuscript must have been written after 1792, since it discusses a code for the semaphore telegraph which was first used in that year, and before early 1794, since the proposed code differs from the one that was adopted at that time.

Many letters written by the Chappe brothers between 1792 and 1798 have been preserved. They provide a valuable source of information about the hardships that the Chappes had to

86 Belloc 1888" "p. 197

87 Bertho 1981" "p. 75 A copy of the Foy-Bréguet telegraph can be seen in the Historical Collection of the French Telecommunications Museum in Pleumeur Bodou, Bretagne.

endure, especially during the construction of the first line from Paris to Lille in 1793 and 1794. The letters were collected and annotated by Gérard Contant in [Contant 1993]

{Image Not Included in Original}

Figure 2.27 **Remains of a Chappe Tower at La Queue-les-Yvelines**.
(Photo: Gerard J. Holzmann, 1993)

In 1798 a letter by Claude Chappe appeared in several French newspapers, including *LeMoniteur Universel and Republicain*. In the letter Claude defended his semaphore design against a simplified variant that had been advanced starting in 1796 by Abraham Louis Bréguet (1747-1823) and Augustin Bétancourt (1760-1826). When the attempts of Bréguet and Bétancourt to get their alternative design adopted failed, their friend AngeMarie Eymar wrote a letter of complaint to the newspapers on their behalf. Chappe's letter was a response to this first letter of Eymar. The complete exchange contained three more letters, two by Eymar and one by Chappe. Three of the letters were later republished under the title *Lettres sur le nouveau télégraphe* [Chappe 1798]

The most detailed contemporary information on Chappe's designs is contained in a book by Claude's brother Ignace, *Histoire de la télégraphie*. It was published in 1824, a year after Ignace retired from the Telegraph Administration. In 1840, well after Ignace's death, Abraham Chappe had the book reprinted, and wrote a new long preface for it, comparing, among others, the advantages of the optical telegraphs to those of acoustical systems.

Reproductions of many original documents, including letters written by Abraham Chappe to his brother Claude during the construction of the first telegraph line from Paris to Lille, can be found in [Belloc 1888]

A first biography of Claude Chappe was written by Ernest Jacquez, at the time a librarian at the Post and Telegraph administration in Paris, and secretary of the committee preparing the celebrations for the first centennial of Chappe's system, [Jacquez 1893] Under the direction of Jacquez's committee, the Frenchman A. Kermabon also prepared a series of 49 maps, documenting the detailed trajectories of the lines of the optical telegraph network, [Kermabon 1892]. More biographical information on Claude Chappe and his uncle Abbé Jean Baptiste can be found in Brevost et al. 1959, Appleyard 1930, and [FNARH 1991].

A good description of the operation and construction of Chappe's telegraphs is given in [Shaffner 1859]. The general history of the French optical network is traced in many books, most notably Hennig 1908, Koenig 1944, Still 1946, Wilson 1976, Herbarth 1978, and, more recently, in Alexander Field's article [Field 1994]. A more dubious source, containing many inaccuracies that have left an unfortunate trail in later works, is Figuier 1868, published by the prolific writer of popular science books Louis Figuier. Numerous misleading copper engravings from [Figuier 1868] have been reproduced in later works, often without mention of the source.

At the bicentennial celebrations of the first experiments, in 1993, the FNARH or *Fédération Nationale des Associations de Personnel des Postes etTélécommunications pour la Recherche Historique* (National Federation ofOrganizations of PTT Personnel for Historical Research) published an excellent collection of articles on various aspects of the Chappe system, [FNARH 1993]. The FNARH is located in Nancy, France.

In 1968 a reconstruction of the Chappe telegraph that once stood at Haut-Barr in the Alsace was completed. It was once part of the line from Paris to Strasbourg. In 1987 the reconstruction was begun of a second station at Jonquières near Narbonne, originally on the line to Perpignan. This telegraph is of the type introduced by Gabriel Flocon in 1837, with a fixed regulator beam and three indicators, the third indicator taking the place of the movable regulator in the original version. The reconstruction was completed on 12 May 1989. A replica of a telegraph that was based on original construction drawings discovered in Holland in the 1980s can also be seen at the Telecommunications Museumin Pleumeur Bodou, near Lannion in Bretagne. The same museum also has on display one of the original Foy-Bréguet telegraphs.

An outstanding exhibit on the French optical telegraphs can be found in the Postal Museum of Paris. Other exhibits can be found in the Postal Museum of Nantes, and in the small museum dedicated to Claude Chappe in his birthplace, Brûlon. At the museum in Brûlon, the original eyewitness statements to the experiment from 1791 can be seen. At the Postal Museum in Nantes several original documents, letters, and manuscripts from the Chappe era have been preserved. Among them are notes from Claude Chappe from 1793 on the selection of the stations for the first line from Paris to Lille, and the letter from Abraham Chappe to the Telegraph Administration from 1844, detailing a proposal for a final revision of the signaling codes.