The Invention of the Communication Engine ‘Telegraph’

B. J. G. van der Kooij

In the Invention Series the following books have been published:

The Invention of the Steam Engine
The Invention of the Electromotive Engine
The Invention of the Communication Engine Telegraph
The Invention of the Electric Light

This case study is part of the research work in preparation for a doctorate-dissertation to be obtained from the University of Technology, Delft, The Netherlands (www.tudelft.nl). It is one of a series of case studies about "Innovation" under the title "*The Invention Series"*.

About the text: This is a scholarly case study describing the historic developments that resulted in the communication engine called the "telegraph". It is based on a large number of historic and contemporary sources. As we did not conduct any research into primary sources, we made use of the efforts of numerous others by citing them quite extensively to preserve the original character of their contributions. Where possible, we identified the individual authors of the citations. As some are not identifiable, we identified the source of the text. Facts and texts that are considered to be of a general character in the public domain are not cited.

About the pictures: Many of the pictures used in this case study were found at websites accessed through the Internet. Where possible, they were traced to their origins, which, when found, were indicated as the source. As most are out of copyright, we feel that the fair use we make of the pictures to illustrate the scholarly case is not an infringement of copyright.

Cover art is a line drawing of Cooke's five needle telegraph (GB Patent № 7,390, US-Patent № 1,622) and Morse's electro-magnet telegraph (US Patent № 1,647/RE 118) (courtesy USPTO).

Version 1.2 (October 2015)

ISBN-10: 1516811445
ISBN-13: 978-1516811445

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Preface

When everything is said and done,
and all our breath is gone.
The only thing that stays,
is history, to guide our future ways.

My lifelong intellectual fascination with technical innovation within the context of society started in Delft, the Netherlands. In the 1970s, I studied at the University of Technology, at both the electrical engineering school and the business school[1]. Having been educated as a technical student, I studied vacuum tubes, followed by transistors, and I found the change and novelty caused by the new technology of microelectronics to be mindboggling, not only from a technical point of view but because of all the opportunities it created for new products, new markets, and new organizations.

During my studies at both the school of electric engineering and the school of business administration[2], I was lucky enough to spend some time in Japan and California, noticing how cultures influence the context for technology-induced change and what is considered novel. In Japan, I explored the research environment; in Silicon Valley, I saw the business environment—from the nuances of the human interaction of the Japanese to the stimulating and raw capitalism of the United States. The technology forecasted by my engineering thesis made the coming technology push a little clearer: the personal computer was on the horizon. The implementation of innovation in small and medium enterprises and the

[1] At the present time, it is the Delft University of Technology Electrical Engineering School and the Erasmus University Rotterdam School of International Business Administration.
[2] The institutions' actual names were Afdeling Electro-techniek, Vakgroep Mikro-Electronica, and Interfaculteit Bedrijfskunde.

subject of my management thesis left me with a lot of questions. Could something like a Digital Delta be created in the Netherlands?

During my life's journey, innovation has been the theme. In the mid-1970s, I joined a mature electric company that manufactured electric motors, transformers and switching equipment. Business development was one of my major responsibilities. How could we change an aging corporation by picking up new business opportunities? Japan and California were again on the agenda, but now from a business point of view. I explored acquisition, cooperation and subcontracting. Could we create business activity in personal computers? The answer was no.

I entered politics and became a member of the Dutch Parliament (a quite innovative move for an engineer), and innovation on the national level became my theme. How could we prepare a society by creating new firms and industries to meet the new challenges that were coming and that would threaten the existing industrial base? What innovation policies could be applied? In the early 1980s, my introduction of the first personal computer in Parliament caused me to be known as "Mr. Innovation" within the small world of my fellow parliamentarians. Could we, as politicians, change Dutch society by picking up the new opportunities technology was offering? The answer was no.

The next phase on my journey brought me in touch with two extremes. A professorship in the Management of Innovation at the University of Technology in Eindhoven gave room for my scholarly interests. I was (part-time) looking at innovation at the macro level of science. The starting of a venture company making application software for personal computers satisfied my entrepreneurial obsession. Now it was about the (nearly full-time) implementation of innovation on the microscale of a start-up company. With both my head in the scientific clouds and my feet in the organizational mud, it was stretching my capabilities. At the end of the 1980s, I had to choose, and entrepreneurship won for the next eighteen years. Could I start and do something innovative with personal computers myself? The answer was yes.

When I reached retirement in the 2010s and reflected on my past experiences and the changes in our world since the 1970s, I wondered what made all this happen. Technological innovation was a phenomenon that had fascinated me along my entire life journey. What is the thing we call "innovation"? In many phases of the journey of my life, I tried to formulate an answer: with my first book, *Micro-computers, Innovation in Electronics* (1977, technology level), my second book, *The Management of Innovation* (1983, business level) and my third book, *Innovation, from Distress to Guts* (1988, society level). In the 2010s, I had time on my hands, so I decided to pick up where I left off and start studying the subject of innovation again. As a guest of my alma mater, working on my dissertation, I tried to find an answer to the question "What is innovation?"

It started in Delft. And seen from an intellectual point of view, *Deo volente*, it will end in Delft.

About the Invention Series

Our research into the phenomenon of innovation, focusing on technological innovation, covered quite a time span: from the late seventeenth century up to today. The case study of the steam engine marked the beginning of a series of case studies. That is not to say there was no technological innovation before that period of time. On the contrary, imitation, invention and innovation have been with us for a much longer time. But we had to limit ourselves, as we wanted to look at those technological innovations that were the result of a *general purpose technology* (GPT)—an expression that is not a part of everyone's vocabulary. As clearly some clarification is needed here, we will start with some definitions of the major elements of our research: innovation, technology, and GPT.

We define *innovation* as the creation of something new and applicable. It is a process over time that results in a new combination: a new artefact, a new service, a new structure or method. Whereas *invention* is the discovery of a new phenomenon that does not need a practical implementation, innovation brings the initial idea to the marketplace, where it can be used. We follow Alois Schumpeter's definition: "Innovation combines factors in a new way, or…it consists in carrying out New Combinations…" (Schumpeter, 1939, p. 84). Innovation is quite different from invention for Schumpeter: "Although most innovations can be traced to some conquest in the realm of either theoretical or practical knowledge, there are many which cannot. Innovation is possible without anything we should identify as invention, and invention does not necessarily induce innovation, but produces of itself…no economically relevant effect at all" (Schumpeter, 1939, p. 80). What about invention then? We follow here Abott Usher's interpretation, where the creative act is the new combination of the "Act of skills" and the "Act of insight": "Invention finds its distinctive feature in the constructive assimilation of pre-existing elements into new syntheses, new patterns, or new configurations of behaviour" (Usher, 1929, p. 11). Again the element of a combination is recognizable. By the way, one has to realize that these definitions arose in the early twentieth century, and their meaning has shifted over time.

We define *technology* as the knowhow (knowledge) and way (skill) of making things. So technology—knowing how to make things—is part of the before mentioned "Act of skills". Technology is more than the "technique"—ie a body of technical methods—from which it originates. "Technology is a recent human achievement that flourished conceptually in the 18th century, when technique was not more seen as skilled handwork, but has turned as the object of systematic human knowledge and a new 'Weltanschauung' (at that time purely mechanistic)" (Devezas, 2005, p. 1145). We follow Anna Bergek and associates here: "The concept of technology incorporates (at least) two interrelated meanings. First, technology refers to material and immaterial objects—both hardware (e.g. products, tools and machines) and software (e.g. procedures/processes and digital protocols)—that can be used to solve real-world technical problems. Second, it refers to technical knowledge, either in general terms or in terms of knowledge embodied in the physical artefact" (Bergek, Jacobsson, Carlsson, Lindmark, & Rickne, 2008, p. 407).

We define a *General Purpose Technology* (GPT) as a cluster of technologies of which the resulting new combinations, the innovations, have considerable impact on society: "the pervasive technologies that occasionally transform a society's entire set of economic, social and political structures" (Lipsey, Carlaw, & Bekar, 2005, p. 3). In popular terms it is the technology that results in—what we are identifying as—the Industrial Revolution, the Information Revolution, etc. It is the engine of economic growth but also the engine of technical, social and political change—the engine of creative destruction. We follow Richard Lipsey et al. when they define a GPT as "a technology that initially has much scope for improvement and eventually to be widely used, to have many uses and to have many spillover effects" (p. 133). The GPT is not a single-moment phenomenon; it develops over time: "they often start off as something we would never call a GPT (e.g. Papin's steam engine) and develop in something that transforms an entire economy (e.g. Trevithick's high pressure steam engine)" (p. 97).

The case studies are about observing phenomena as they occur in the real world—for example, the development of the steam engine, from which one can conclude it was a GPT according to the definition. The observation of what caused the Second Industrial Revolution shows its complexity. Is "electricity" the GPT, or are the electro-motor and the electric dynamo the GPT? Or can it be that the resulting development of the electric light, telegraph and telephone is a GPT on its own? The interpretation becomes more complex, the opinions diffused, especially when one looks at the present time, for example, at the phenomenon of the Internet, part of the Information Revolution.

About Our Research

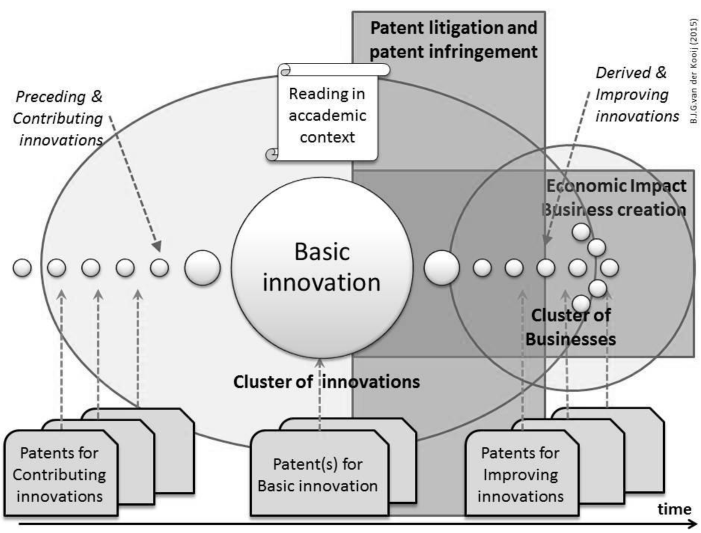
This book is the third manuscript in the *Invention Series*, a series of books on inventions that created the world we live in today. In the first manuscript, *The Invention of the Steam Engine*, we explored a methodology to observe and investigate the complex phenomena of technological innovation as part of a general purpose technology (GPT). In that case, it was about the steam technology that fuelled the Industrial Revolution. One could consider that case study as a trial to see if our methodology could be applied. It looked promising enough to try again. The result was another case study on electro-motive engines. Now, in this case study, we focus on the application of electricity in communication. So, let's start to describe the basic elements of our research approach.

Now, our *field of interest* in the GPT of electricity is, in particular, the area of application of electric telegraphy. To understand how this technology could fuel the next Industrial Revolution, we applied the method of the case study. The case-study method offers room for context and content. The context is the real-life context: the scientific, social, economic and political environment in which the observed phenomena occurred. The content is the technical, economic and human details of those phenomena. The reader will recognize this content and context approach in the structure of the manuscript.

The case study is based on a specific scholarly view to observe the phenomena as they occurred in the real world. Our *view* is based on the construct of clusters of innovations, as identified by early twentieth-century scholars active in the domain of innovation research. Among those economists we find Alois Schumpeter, who related the clusters of innovations to business cycles under the influence of creative destruction. He observed clusters: "because the new combinations are not, as one would expect according to general principles of probability, evenly distributed through time…but appear, if at all, discontinuously in groups or swarms" (Schumpeter & Opie, 1934, p. 223); and he observed "the business cycle is a direct consequence of the appearance of innovations" (pp. 227–230). For Schumpeter, it was the entrepreneur who realized the innovation and, as imitators were soon following in the entrepreneurial act, thus created the business cycles that are nested within the economic waves. Later, it was Gerhard Mensch and Jaap van Duijn who related the basic innovation within the clusters to the long waves in the economy with respect to industrial cycles. Mensch related the cyclic economic pattern to basic innovations: "The changing tides, the ebb and flow of the stream of basic innovations explain economic change, that is, the difference in growth and stagnation periods" (Mensch, 1979, p. 135). Duijn referred to innovation cycles (Duijn, 1983). More recently, it was scholars like Utterbach and Abernathy, Suarez, Dosi, Tushman, Anderson and O'Reilly who developed and used, as part of their view on technological revolutions and technological trajectories, the construct of the "dominant design" being the watershed in a technology cycle (Tushman, Anderson, & O'Reilly, 1997). It is the innovation that—at a given moment in time—has become the 'de facto' industry standard. This Dominant Design we considered to be the basic innovation.

Our *focus of analysis* is the cluster around the basic innovation with the preceding and derived innovations (Scheme 1). Our *unit of analysis* are the contributions made by individual people resulting in inventions and innovations. Then, for our *domain of analysis*, we first observed contributions in the GPT Steam technology (a collection of many mechanical, hydraulic, thermic and related technologies explored in the first study), followed by the observations in the GPT Electric technology (second study). Now, in this third study, we focus on the application area where communication technology based on electricity was used.

For our method, we chose the *embedded multiple case design*. The method is *multiple*, as we looked simultaneously at the scientific, technical, economic and human aspects. It is *embedded* because we looked simultaneously at the individuals (the inventors, the entrepreneurs), the organizations (their companies, the institutions) and societies, thus making the analysis multilevel and multidimensional. Our qualitative data originate from



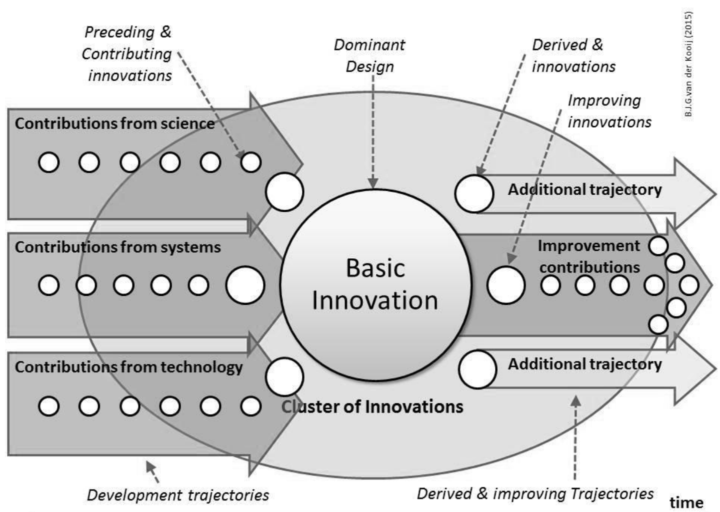
Scheme 1: The construct of the Cluster of Innovations and Cluster of Businesses.

general, autobiographic, and scholarly literature (see references), creating a mix of sources that are quoted extensively. Our quantitative data were sampled from primary sources like the United States Patent Office (USPTO) and British and French sources of patents.

Our *perspective* was the identification of patterns that are related to the cluster concept. Can coherent clusters of innovation be identified within a specific general purpose technology? If so, how are they related, and how are the clusters put together? The first pilot case showed that it could be done. So in this case study, our objective was to identify the basic innovations that played a dominant role in the GPT of electricity that created the *Era of Communication* in the Second Industrial Revolution. As we used patents as innovation identifiers and used patent wars (patent infringement and patent litigation) and economic booms (business creation, business and industry cycles) to identify basic innovations, this aspect is quite dominant in the study.

Considering our *unit of analysis*, in view of the earlier-mentioned aspect of innovation being the result of a combination, we tried to refine the cluster concept by detailing the contributing innovations into specific technological development trajectories (see Scheme 2):

Scientific contributions: Such as the trajectory of the "scientific contributions" concerning the basic laws of nature the curious and ingenious people in the eighteenth and nineteenth century were



Scheme 2: The construct of the trajectories leading towards and from the basic innovation in a cluster of innovations.

inquiring into. We use the definition of *science* as "The intellectual and practical activity encompassing the systematic study of the structure and behaviour of the physical and natural world through observation and experiment" (Oxford Dictionary). This incorporates the contributions of the electro-physicists who discovered the basic principles of electromagnetism, and the experimentalists who applied those principles.

Technology contributions: Next we distinguish the technological contributions and use—in addition to our earlier mentioned definition—the definition of *technology* as "The application of scientific knowledge for practical purposes" (Oxford Dictionary) and as the knowhow (knowledge) and way (skill) of making things. Or, as Giovani Dosi puts it, "[We] define technology as a set of pieces of knowledge, both directly 'practical' (related to concrete problems and devices) and 'theoretical' (but practically applicable although not necessarily already applied), know-how, methods, procedures, experience of successes and failures and also, of course, physical devices and equipment" (Dosi, 1982, p. 151). This incorporates the contributions of all those instrument-makers using their fine mechanical skills to create magnets, batteries, telegraph components and telegraphic instruments, which were so essential to the creation of electrical telegraphy.

System contributions: A third development trajectory consists of the contributions that resulted in earlier developed systems. The system-concept being quite general, we will be using the definition of a system as "A set of things working together as parts of a mechanism or an interconnecting network; a complex whole" (Oxford Dictionary). The keyword is "network", to which development so many creative minds contributed. However, these are contributions that are harder to classify. Let's, for example, consider our application area of communication (postal, optical or electrical). Communication is always realized in a structure of several elements (parts, components) connected by a structure (network). For the early postal system, it is the network of mail coaches, mail couriers and the inns to change horses: the postal network. For optical communication it is, as we will see, the semaphore network with its relay towers and the organization of telegraphists that used semaphore code: the semaphore network. For electric telegraphy, it is similar. The electrical components like the transmitter, the cabling and the receiver, the code used for the transmission and the structure of the telegraph offices created the network-infrastructure for electric telegraphy: the telegraph network. People who contributed to that totality created the system contributions.

Given the genesis of the *basic innovation*, it will be followed over time by new contributions leading to other innovations (Scheme 2). Such as:

Improvement contributions: This includes contributions that enhance and improve upon the basic invention. The increasing knowhow of the ever-developing technology will add to the original invention step by step in in an incremental way. These improvement contributions create a technological trajectory of incremental innovations.

Derived contributions: In addition to the improvements, there will be contributions of another nature. In those cases, either to circumvent the patent-protection or just by accident, the same functionality of the basic invention will be realized using a different concept, spinning off in a different trajectory. The example here is the development of the speaking telegraph (also known as the telephone) using undulatory electrical currents (ie alternating current) for the transmission, which resulted from the improvement efforts in electro-magnet based telegraphy using direct electrical current. Those derived innovations will create additional trajectories when the new development is applied in other ways and other fields of application, thus showing the pervasiveness of the general purpose technology of electricity.

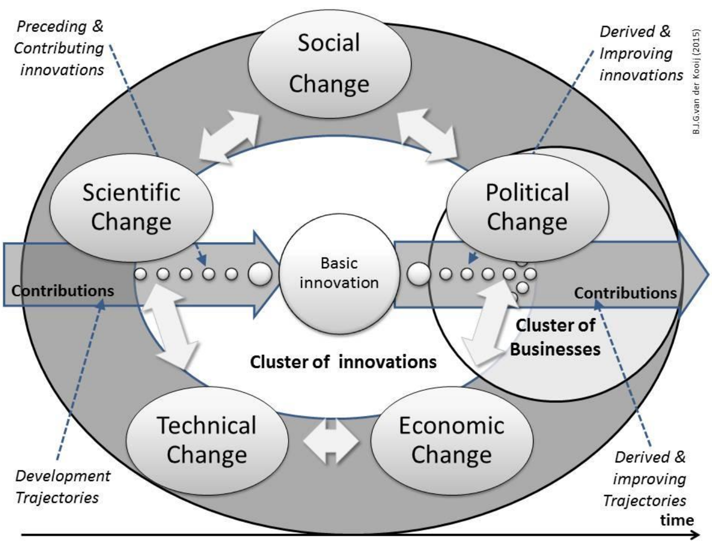
About the Context

As mentioned before, case studies are about content and context. Our specific case studies are about the *content* of Technical Change—they cover technological innovations—and we look at change from the perspective of the development of technological innovations themselves: the clusters of innovations. These innovations are the result of contributions of many individual persons: individuals who lived within their specific "spirit of time"—often even with its specific "madness of time"; people with personal hopes and fears, drives, ambitions and limitations; honest people and cheating people; extraverted and introverted people; people who lived in—and whose behaviour was influenced by—times of war, destruction and stagnation; and people who lived in times of peace, creation and progress.

Each case takes place in the society as it existed at that moment in time. That society defined the *context* for the individual inventor and his inventions at that given period of time—a society that itself changed constantly. Hence, we speak about Social Change; the autonomous changing of social structures, social behaviour and social relations in a society—as the result of social forces. When those changes are incremental, Social Change is incremental. But sometimes the changes are discontinuous and disruptive—even revolutionary. Then we talk about revolutions such as the American, French and Russian Revolutions as drastic—even dramatic—forms of Social Change. The same goes for Technical Change: the autonomous changing of technical structures, technical "behaviour" and technical relations in a society—as the result of scientific and technical forces. Technical change can be incremental or sometimes even disruptive. We talk about the Industrial Revolution as a drastic result of Technical Change.

For *content*, we used the perspective of the 'Clusters of Innovations" (Scheme 2). Now we want to include the context that influences the occurrence of those clusters of inventions more extensively (Scheme 3). Therefore, we borrow, from evolutionary biology, the concept of Darwinian "Fitness for survival" which encompasses the fitness of the organism and the fitness of the environment. It is a concept that—in short—refers to the mutual relation between organism and environment, between the properties of organisms to survive and the conditions of the environment in which the changes on a species level occur.

> *The fitness of the environment is one part of a reciprocal relationship of which the fitness of the organism is the other. This relationship is completely and perfectly reciprocal; the one fitness is not less important than the other, nor less invariably a constituent of a particular case of biological fitness.* (Henderson, 1914, p. 113)



Scheme 3: The cluster of innovations and the cluster of business in relation to Change in the relevant man made environment.

In terms of technological innovation, it refers of the fitness of a specific technology and its artefacts in relation to the fitness of the environment in which it appears. Some technologies "make it and prosper"; other technologies prove to be "a dead end". They were not fit enough[3]. When the environment proves to be fertile—for example in business terms—many technology-induced innovations and their artefacts will prosper[4].

As this is not the place to dwell on evolutionary biology, we focus dominantly on the fitness of the environment (Scheme 3) in relation to technological innovation for our analysis of the context for change and novelty. As the GPT Electricity was the catalyst of the Second Industrial Revolution, while early developments were the catalyst during the First Industrial Revolution, we will try and analyse the social revolutions that took place when the foundations for the Industrial Revolution were created.

Finally a word about the use of the words *invention* and *innovation* in the case study. We described before how we define them, but in the case study we follow our sources. They use the words in the context of their time—a use that can be different from our time. What would be called in the early nineteenth century an invention could be called an innovation today. There is quite a difference, and even our present day interpretation shows great variance, as we found in a survey of the word *innovation* as used by innovation scholars[5].

About this Case Study

This case study is the result of our quest to describe the Nature of Innovation. Where the other cases focused on energy—the power of steam and the power of electricity—in this case it is about the early forms of communication using electricity. Of the dual roles of electricity—on one side offering means for transporting power and on the other offering means for transporting information—the latter is explored. This case study about the telegraph focusses on communication, thus realizing "distant writing", and it is complemented by the case study on the telephone with its

[3] An example would be the reciprocating electromotor of the early days of the electro-motive engines. See: B.J.G. van der Kooij, *The Invention of the Electro-motive Engine* (2015, pp. 72-75). In this study it would be the electro-chemical telegraph and the electro-statical telegraph.
[4] Here the example is the availability of electricity when the electric dynamo came into existence. Then the electric light, the telegraph and telephone started to develop in force. See: B.J.G. van der Kooij, *The Invention of the Electro-motive Engine* (2015, pp.87-125).
[5] See: B.J.G. van der Kooij: Innovation Defined: a Survey. Source: http://repository.tudelft.nl/view/ir/uuid%3A6a5624c9-e64e-4426-98e9-f239f8aaba18/

characteristic of "distant speaking"[6].

The manuscript is divided into the following sections:

Context for discoveries: We will begin with a thorough look at the events that created the historical climate in Europe of the time: in this case the French revolution and its aftermath in the first half of the nineteenth century. Although these events are not directly related to the invention of electric telegraphy itself, the social, economic and political turmoil—followed by relative peace—created the European context for scientific discovery and technological development. We proceed describing the early efforts where curious people with inquiring minds started to try and apply the new phenomenon of electricity into the basic human need for communication. We describe how, originating from contributions of European scientific experimenters, "distant writing" using electricity proved—apart from some dead-end technologies—feasible.

The invention of the optical telegraph: This segment is about the early form of optical communication: the system of semaphores that transmitted information over a long distance. We analyse the individual contributions as well as how the military application in a time of constant war became the driving force behind its development. It describes the genesis of the system for long-distance communication.

The invention of the pointer telegraph: Here we describe those early efforts that resulted in the creation of electric telegraphs based on the galvanometer. We explore how in Britain the decade-long cooperation between an extraverted entrepreneurial inventor and an introverted engineering scientist resulted in the first telegraph systems. Although the resulting needle telegraph was limited in its performance, it proved that electric telegraphy fulfilled a need. We describe how the then following alphabetic telegraphs—simpler in use—resulted in a large telegraphic infrastructure: first in England, but soon crossing the channel into Europe. And we analyse the accompanying industrial bonanza of service providers and equipment manufacturers in Britain.

The invention of the electro-magnetic telegraph: Then we proceed with the development of a radical new artefact: the telegraph using the electro-magnet as the receiver of the incoming transmission. We describe the efforts of one particular dedicated creative man, who—

[6] To be published as: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telephone'* (2015)

with the help of other curious and inventive people—created the electro-magnetic telegraph in the United States—a device that was to become a dominant part of the Communication Revolution with its own industrial bonanza.

Basically, this is an exciting narrative about the people in the *General Purpose Technology* of electricity" with its "clusters of innovations" and "clusters of businesses". People that created the Era of Communication and changed the world we live in. I hope the reader will enjoy reading it, as much as I enjoined writing it.

B. J. G. van der Kooij

The Invention of the Communication Engine ‘Telegraph’

Context for the Discoveries

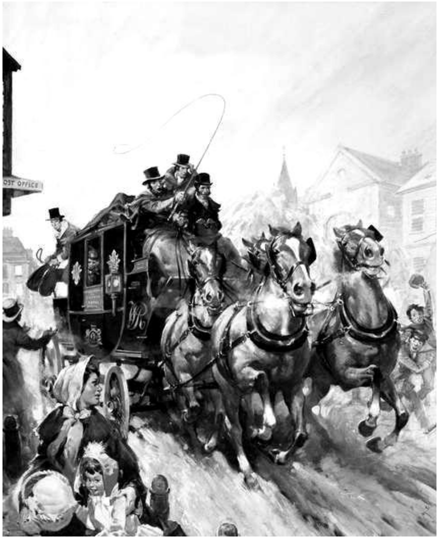


Figure 1: Delivering the post and passengers by coach.

Source: James Edwin McConnell, http://www.scholarsresource.com/browse/work/2144689165

For someone living in the pre-electric era, it is hard to image how one would communicate over longer distance the way we do today. In those times, person-to-person communication was with the written word. As the world was small, the written word was often transported locally, by the messenger boys. For communication over longer distances, one could send a letter by postal messenger, who transported it on horseback in a mail pouch with other written messages (eg the American Pony Express). Or, when available, one could use the mail-coach that was part of the network of royal postmasters (eg the British Royal Mail). A network for P-mail (ie postal mail) with *relays*: stations along the postal trajectory where fresh horses would be available to replace the exhausted ones (Figure 1). Whatever form the communication had, concerning communication over distance—also known as telecommunication—it all would take time. Nobody even was dreaming that one day there would exist communication engines, such as the telegraph, that would send the message at the speed of light.

Figure 2: Pony Express rider saluting the telegraph builders.

Source: Nebbraska State Historical Society (RG24090-144). http://www.blog-nebraskahistory.org/page/6/

Now, for a moment, step back in time and image the surprise when in the second half of the nineteenth century the common people discovered that they could send messages much faster than the traditional postal mail: the new phenomenon of telegrams (T-mail)—that it would be possible to write at a distance with lighting speed—that one could send private information (personal, business) or official information (military, governmental) over long distances or that one would be rapidly informed about the news in the world, when public information (newspaper, stock market, lotteries) was sent to distant places through a wire. It was so special that newspapers announced that their news was received by telegraph. Some even had the word, "telegraph", in their name (eg the Daily Telegraph). All this was possible through the rise of the communication engine telegraph with its cabled network. It was the equivalent of today's computer-based Internet, also called the "Victorian Internet" (Standage, 1998). The network of horse-powered telecommunication was replaced by network of cables transmitting the messages over distances (Figure 2). With the arrival of the telegraph, the age of communication by smart devices—communication engines—had started without people really realizing it.

In contrast, people living today can hardly imagine what it would be like to live without the communication engines of our time. Today, the most modern communication engine—the wireless smartphone and its mobile Internet—enables E-mail facilities and short message service (SMS) facilities. Electronic mail after the 1990s replaced paper-based mail more and more in such a drastic way that postal mail services had to slim down their facilities and discharge their employees. The SMS facilities are used for private use (*Will be home late, dear*), business use (*Accept your proposal, contract follows*) or public use (ie amber alerts, governmental emergency alerts). The modern person hardly knows we ever had something like the Pony Express and telegrams transported over the cables of the telegraphy networks that were delivered at home by the young Telegram messenger on a bicycle.

Figure 3: Perpetual Motion by Norman Rockwell (1920).

Source: www.wpclipart.com

In hindsight, the enormous impact of the introduction of electricity in society is obvious. The application of electricity and its engines had massive consequences, like its use in the fields of communication. That was already the case in the nineteenth century when telegraphy using communication engines revolutionized private and professional communications. In the twentieth century, the Communication Revolution continued and increased when modern electronic technologies where applied, up until today, where the massive effects of modern communication media are clearly visible in society. But it took some time, some curiosity leading to scientific discoveries, a lot of ingenuity and engineering effort (Figure 3) before this all came to happen.

Technical, Social, Political, Economic and Scientific Change

We used the word Communication Revolution to indicate the massive social changes that were the result of the development of the communication engines (eg the telegraph, the telephone). Their origin—as we will see further on in detail—lies in the nineteenth century. Then, in the first half of the century, the General Purpose Technology Electricity came into existence when the phenomenon of electricity was slowly unravelled by scientists and engineers. The efforts of many curious and ingenious people with the voltaic battery that was discovered around the turn of the nineteenth century resulted in the first applications of electricity (eg the electromagnet, DC electric motor, early spark lights). Over some decades, the secrets of the new phenomenon of electricity slowly became unearthed.

All those efforts took place in the societies of those days—societies with their own historic development in which the remains of earlier times still existed. The former absolute monarchical societies, with their feudal heritage[7] and medieval system of guilds[8], were followed by the more recent

[7] Feudalism: The political structure in a social system in which relations are derived from landownership. It included the concept of *manorialism,* where the landowning lord and the land-working peasants were interrelated.

empires (eg the British Empire, Spanish Empire, French Empire) with their imperialism, colonialism, mercantilism and protectionism. Societies saw mass disruption in their development over time caused by social revolutions: from the American Revolution to the French Revolution and the European revolutions of 1848. These societies all underwent the "madness of times": war, conflict and revolt at sea and on land. Sometimes they appeared locally in regional wars and revolts, sometimes as the result of conflicts in monarchic succession and sometimes on a broader scale, as wars between nations. But it always had to do with people.

Human society is about individual people living in a social cohesion of interpersonal relationships. And much of that relationship is about power, as the exercise of power is endemic to humans as social beings, resulting in societies based on inequality and privileges. From the Middle Ages, it resulted in societies in which specific groups (ie monarchy, aristocracy, and nobility) ruled over other groups (vassals, peasantry, and citizens). This exercise of power resulted in political conflicts as part of social conflicts. It was often a conflict between those that had a lot to lose and nothing to win and those who had nothing to lose and only could win. When an agreeable solution couldn't be found, it resulted in social revolution. It was these societal changes that created the context for the discoveries we are going to investigate and that resulted in the Second Industrial Revolution.

Technical Change and Economic Change

As we have seen before[9], the new ways to apply mechanical rotative power—the technologies of steam engines—resulted in a societal change in the seventeenth century. Labelled as the (first) Industrial Revolution (1780+), the early technological developments of that time heralded formidable change in the society. *Industrialization* became the word for new processes of mass-production (eg textiles). The factory system of mass manufacturing of goods came into use. Urbanization was the result of the massive migration into cities, people looking for work, fleeing away from the impoverished country sides. The effect of the availability of electricity to create mechanical rotative power was even more drastic[10]. The new technology of electricity proved to be very pervasive, especially as we are considering the application of electricity in communication—in this

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[8] Guild (French: *corps de métiers*): A form of organization of merchants (merchant guild) and artisans (craft guild)—societies that held the exclusive rights to do business in a specific town or city all over Europe.
[9] See: B.J.G. van der Kooij: *The Invention of the Steam Engine* (2015).
[10] See: B.J.G. van der Kooij: *The Invention of the Electromotive Engine* (2015).

volume—and (electric) lighting[11].

The economic consequences of the Industrial Revolution were enormous. But the Industrial Revolution was about more than—as many economists evangelized in their theories—the rise in productivity and increasing real incomes. It was also about the results of freeing mankind from physical labour as its "prime mover" to create mechanical energy. Now wood and coal could be used to fire the steam engines—like the early highly energy inefficient Newcomen's steam engine—replacing the animal powered, wind powered and water-wheel powered mills.

The Industrial Revolution started in Britain in those areas with an abundance of coal and a newly developed infrastructure—the canals—, the areas around Manchester (nicknamed later the Cottonopolis[12]), Birmingham, Leeds and Sheffield. There the first steam-powered engine—Savery's pump known as the "Miner's Friend" followed by Newcomen's engine—solved the water and foul air problem in mining. Then—when the technology advanced with Watt's steam engine—the application was spread over larger areas, changing the way people worked in the manufacturing industries: the wood, textile and grain mills. And finally, Trevithick's steam engine was available, finding its way in mobile applications: steam ships, steam locomotives and steam carriages. Changing the way goods and materials were transported, the way people travelled. It created the infrastructure of the railways. So, to cut a long story short, changes in the technical systems in the First Industrial Revolution started to induce changes in the socio-economic system we call society[13]. It was Britain of the eighteenth century, the cradle of the technologies that created the Industrial Revolution, that started it and that profited enormously from it. (Mokyr, 2011)

This mechanism is called *Technical Change* (change in the technical system), which induces *Economic Change* (change in the socio-economic system).

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[11] See: B.J.G. van der Kooij: *The Invention of the Electric Light* (2015).
[12] In 1781 Richard Arkwright opened the world's first steam-driven textile mill on Miller Street in Manchester. Although initially inefficient, the arrival of steam power signified the beginning of the mechanization that was to enhance the burgeoning textile industries in Manchester into the world's first centre of mass production. As textile manufacture switched from the home to factories, Manchester and towns in south and east Lancashire became the largest and most productive cotton spinning centre in the world.
[13] We recommend reading the case study of the "Invention of the Steam Engine" to get a better understanding of the here mentioned topics. B.J.G. van der Kooij: *The Invention of the Steam Engine* (2015).

From Climate Change to Social Change

It was not only a change in the technological systems that resulted in the changing the socio-economic systems. Society itself is under the influence of continuous or periodic change—change induced by non-technical factors—factors that contribute to the changes in society constantly.

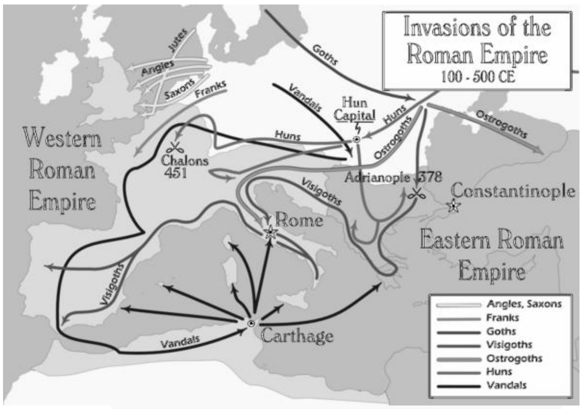

Figure 4: Map of the "barbarian" invasions of the Roman Empire showing the major incursions from 100 to 500 CE.

Source: Wikimedia Commons

Just take the climate and the affairs of men. In periods of bad harvests, those people already living on the brink of existence faced with worsening conditions have to act just to physically survive. They migrate, like they did in historic times. Individual and collective migrations induced changes, like the overthrowing of the existing cultures by the newly arriving barbarians (eg the Roman culture being overthrown by Visigoths during the migration period) (Figure 4).

> *Bit by bit, the rough, tough nomadic people, the barbarians who won't play by the rules, encroach upon the civilizations and eventually seize them. The civilized people are always more numerous than the nomads, but they always lose during the bad times.* (Winkless & Browning, 1975, p. 149)

> *The Indo-European peoples in Southern Russia began a migration that saw them poring through the Caucasus, then spreading East and West. These people included the Hittites, who moved into central Turkey and established the beginning of an empire that vied with Egypt in the time of Tutankhamen. Others moved into the area of Iran, establishing themselves as the ancestors of the later Medes and Persians.* (Winkless & Browning, 1975, p. 173).

> *Between 304-535 AD various nomadic tribes invaded and dominated province in North China. …Between 320-330 AD nomadic invader destroyed the African Sudanic civilization of the Kush. … The Huns and Germanic tribes moved from Northern Europe and from the Steppes into Southern Europe continuously between 375-450 AD. The Vandal even made it all the way from*

> *somewhere around Poland down through Spain, across the Straits of Gibraltar into Africa, then eastward to Carthage … In the fifth century, northern tribes (Jutes, Picts, Irish, Frisians, Angles and Saxons) invaded England. British tribes fled these invaders into France, becoming the Bretons* (Winkless & Browning, 1975, pp. 179-181).

Nature also has its effects in another way. As a consequence of continental drift, large segments of the earth surface—the tectonic plates—move and collide; creating rifts and rises, such as the well-known Pacific Ring of Fire with the San Andreas Fault in California, the Mid-Atlantic Ridge and the East-Pacific Rise. The drift results in earthquakes, volcanic eruptions and mountains building as the plates collide and sub duct each other. When those volcanos erupt, they spew enormous amounts of ash into the atmosphere (the pyroclastic flows). The eruptions result in a layer of volcanic cloud covering the earth and causing two effects: less daylight from the sun and a drop in temperature on the surface of the earth.

In April of 1815, the cataclysmic eruption of the Tambora Volcano in Indonesia—the most powerful eruption in recorded history—created a volcanic cloud that lowered global temperatures by as much as 3°C. Even a year after the eruption, most of the northern hemisphere experienced sharply cooler temperatures during the summer months. In parts of Europe and in North America, 1816 was known as "the year without a summer" (Harington, 1992; Klingaman, 2013).

> *There is also abundant evidence for extreme weather in 1816, especially in the spring and summer in northeastern North America, and much of Europe. The folkloric memories of 'the year without a summer', 1816, still command popular interest in the northeastern USA. …On 4 June 1816, frosts were reported in Connecticut and, by the following day, most of New England was gripped by a cold front. On 6 June, snow fell in Albany, New York, and Dennysville, Maine, and there were killing frosts at Fairfield, Connecticut. Severe frosts had spread as far south as Trenton, New Jersey, the next day. Such conditions recurred over the next 3 months, drastically shortening the growing season … and resulting in almost total failure of main crops. … Summer temperatures across much of western and central Europe were 1–2°C cooler than the average for the period 1810–1819 and up to 3°C cooler than the mean during 1951–1970. Rainfall was also anomalously high across most of Europe except the eastern Mediterranean during the summer of 1816. … The northern hemisphere summers of 1817 and 1818 are also anomalously cold (5th and 22nd coldest in the 600-year record).* (Oppenheimer, 2003, p. 244)

People became hungry, their physical condition worsened, they felt weak and they became ill as they were more vulnerable to diseases. All this resulted in social unrest and hungry people rioting:

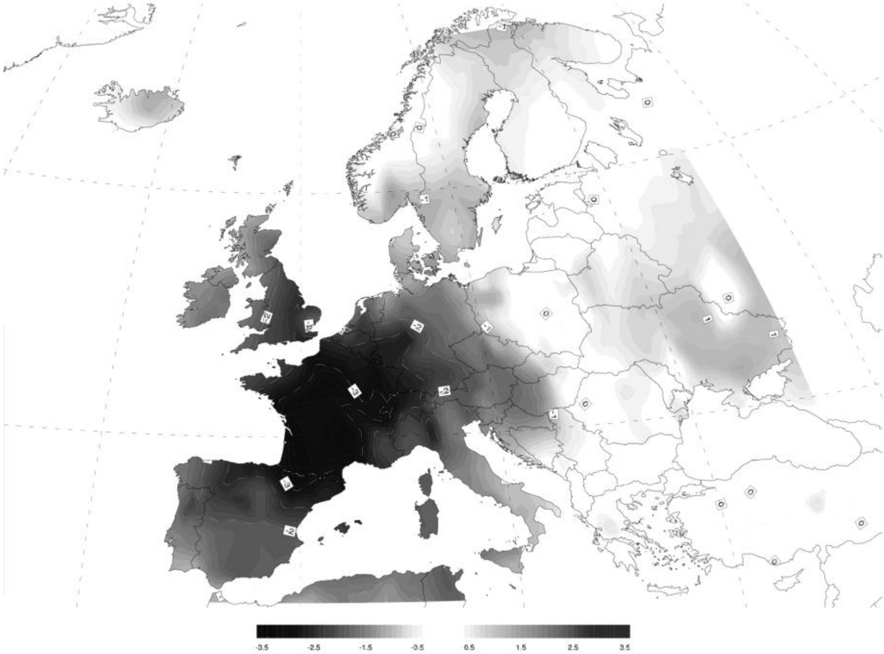

Figure 5: The European drop in temperature in 1816

Source: Wikimedia Commons. Reference: Luterbacher, J., D. Dietrich, E. Xoplaki, M. Grosjean, and H. Wanner: European seasonal and annual temperature variability, trends and extremes since 1500. Science, March 5th, 2004, Vol. 303 No 5663, pp 1499-1503.

> *Popular reaction to the dire circumstances included demonstrations in grain markets and in front of bakeries and, in some regions, riots, looting and arson … . In May 1816, riots broke out in various parts of East Anglia, including Norfolk, Suffolk, Huntingdon and Cambridge. Acts of protest included destruction of threshing machines, and torching of barns and grain sheds. The insurrection culminated in formation of marauding groups of rioters armed with heavy sticks studded with iron spikes and carrying flags proclaiming 'Bread or Blood'.* (Oppenheimer, 2003, p. 251)

The effects of climate changes can even be more dramatic when one realizes what the scarcity of food can lead to.

> *Far beyond Indonesia, the pattern of climatic anomalies has been blamed for the severity of a typhus epidemic, which raged through southeast Europe and the eastern Mediterranean between 1816 and 1819. The first great epidemic of cholera broke out in Bengal in 1816–17. … concluded that taking account of these epidemics and the famines of 1816–17, this period witnessed one of the greatest world disasters associated with climate change. Post characterized the*

> *period 1816–19 as the last great subsistence crisis to affect the Western world—1816-17 witnessed the worst famine in over a century.* (Oppenheimer, 2003, p. 250; John D Post & Post, 1977)

Social Change and Economic Change

Next to those changes related to human's basic needs (physical survival and safety), there exist also other changes in the social system of an independent, non-technical-nature. Like the social movement of *democratization* where the old social structure of absolutism[14]—with many ups and downs over a long period of time—was replaced by a new structure: democracy (ie the parliamentary democracy[15]). It was a transition where the old societal powers (nobility, aristocracy and clergy), over a considerable stretch of time, lost their dominant position, and the balance of power in society shifted from a few to many. From historic times, only a few (ie the so called "landed class" of landowners[16]) had decided on taxation, created legislation (eg labour laws), who had realized the law enforcement, distributed royal charters[17] and established monopolies[18]. They had maintained their powerbase on the foundations of the feudal system in an agrarian society in different forms and degrees all over the western world, up until the nineteenth century. And one of those societies was British society at the brink of the nineteenth century.

> *Parliament became in the 18th century the executive committee of the landed classes …, and this continued until past the middle of the 19th century. The revenues of the national government came largely from indirect taxes on staples such as salt, candles, beer, cider, soap, starch, leather, and malt. They were spent mostly on maintaining navies and armies that served the mercantile interests of a small, wealthy minority …. In 1855, public spending on civil government, excluding "law and justice," amounted to just under 1% of net national income, and public spending on education was negligible, about a tenth of that …. Patronage served for "the provisioning of younger sons of the gentry" … Restraints on grain imports under the Corn Laws benefited the landed few at the*

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[14] Absolutism: used for the monarchical form of government in which the monarch has absolute power among his or her people.

[15] Parliamentary democracy: a system of government in which all the people of a state are involved in making decisions about its affairs, typically by voting to elect representatives to a Parliament or similar assembly.

[16] The term *landed class* refers to the British social class of landowning individuals but has its equivalent in other countries, such as the "junkers" in Germany.

[17] A royal charter is a formal document issued by a monarch as letters patent, granting a right or power to an individual or a corporate body.

[18] Like the trading companies such as the East India Company, which ruled the Indian trade route of cotton, silk, slat, saltpeter, tea and opium from the seventeenth century.

> *expense of the hungry man. The Combination Laws of 1799–1800 limited the rights of labor to organize. Master and servant laws, under which unwilling laborers could be imprisoned for breach of contract, placed the machinery of the state at the service of harsh factory discipline.* (Justman & Gradstein, 1999, pp. 119-120)

That power base was about to change in the course of the nineteenth century. The economic importance of landownership was, now international trade and early industrialization slowly took effect, not any more the dominant factor. The British Agricultural Revolution[19] increased food production, leading to a drastic increase in populations. As more children survived—only one could inherit the farm—more adolescents had to create a living outside farming. Going into trade was one option. Colonial trade (including slave trade) gave employment not only to huge numbers of sailors, but it also spawned jobs in a host of local industrious activities—in the ports itself (London, Bristol, Liverpool) and also far into the hinterland. It made many merchants rich, often richer than the landed gentry. And that new class in society—the emerging middle class of industrialists, mercantile traders, businessmen and service professionals—demanded their place in society. The change from a society dominantly based on agricultural production to a society that was complemented by industrious[20] production—and its related Demographic Revolution[21]—also encompasses a societal change of its own—a change that involved many social classes, either the newly arising middle class of the *bourgeoisie*, or the former peasantry that over time emancipated into the working class. Having thus grown out from abject poverty and docility, their struggle was about their right to exercise their representation in the societal power structure of the evolving democratic system. And a big part of that struggle was about the so-called male suffrage[22].

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[19] The British Agricultural Revolution was the result of the complex interaction of social, economic and farming technology changes: social changes like the enclosure of common lands into private lands; economic changes like markets free of tariffs, toll and custom barriers; farming changes like the application of the Dutch plow, crop rotation and selective breeding. The resulting increase in the food supply allowed the population of England and Wales to increase from 5.5 million in 1700 to over 9 million by 1800.

[20] By using the word *industrious* we refer to the proto-industrialization of artisans producing goods. This was independent of the industrial changes caused by the technological developments themselves (eg the factory system).

[21] Eighteenth century England went through a Demographic Revolution: a period of rapid population growth as the result of demographic transition. Demographic transition refers to the transition from high birth and death rates to low birth and death rates as a country develops from a pre-industrial to an industrialized economic system.

[22] A development that was influenced by the earlier American Revolution: a revolution that would result in the *Declaration of Independence* (1776). There, the old Irish slogan of "No

Political Change and Social Change

Next to these autonomous developments, there was the Enlightenment movement and its consequent Liberalism that was based on liberty and equality of people under the credo "all men are created equal". It was about the freedom of thought, freedom of speech, freedom of press, freedom of religion, freedom to associate and organize, and the freedom from fear of reprisal. Early English philosophers like John Locke (1631-1704) had already developed their views that each man has its "natural rights to life, liberty and property". And in this view, government was obliged to facilitate and safeguard those rights. It was the direct opposite of absolutism, where the people were the king's subjects. The new role of government was to remove obstacles that prevented individuals from living freely: obstacles like poverty, disease, discrimination and ignorance. Liberalism stood for the emancipation of the individual and was concerned with the scope of governmental activity. However, proclaiming these views was not going to be unchallenged by the ruling powers of those times.

> *Locke's ideas on freedom of religion and the rights of citizens were considered a challenge to the King's authority by the English government and in 1682 Locke went into exile in Holland. It was here that he completed An Essay Concerning Human Understanding, and published Epistola de Tolerantia in Latin. The English government tried to have Locke, along with a group of English revolutionaries with whom he was associated, extradited to England. Locke's position at Oxford was taken from him in 1684. In 1685, while Locke was still in Holland, Charles II died and was succeeded by James II who was eventually overthrown by rebels (after more than one attempt). William of Orange was invited to bring a Dutch force to England, while James II went into exile in France. Known as the Glorious Revolution of 1688, this event marks the change in the dominant power in English government from King to Parliament. In 1688 Locke took the opportunity to return to England on the same ship that carried Princess Mary to join her husband William.*[23]

Locke exercised a profound influence on political philosophy, particularly on liberalism. His writings influenced Voltaire and Rousseau, many Scottish Enlightenment thinkers, as well as the American revolutionaries.

In nineteenth-century Britain, the liberals generally formed the party of

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taxation without representation" was used as "Taxation without representation is tyranny"—taxation being one of the tensions between Britain and its American colonies.

[23] Source: Biography John Locke. The European Graduate School. http://www.egs.edu/library/john-locke/biography/

the entrepreneurial middle class. They were the ones who toppled the former powers of the earlier feudal-based social system. They initiated the rupture from the Old World with the absolute monarch and powerful aristocrats. But they did more than just that. In practice, liberalists applied the system of separation of powers—ie the distribution of power between such functionally differentiated agencies of government as the legislative, the executive and the judiciary branches—within a system of checks and balances. It also resulted in the *laissez faire, laissez passer* (let it be, leave it alone) doctrine that advocated free trade. It would lead to the abolishment of numerous feudal and mercantilist restrictions on countries' manufacturing and internal commerce, and it would put an end to tariffs and restriction on imports to protect domestic producers. As a consequence, it fit liberal thinking that government must provide education, sanitation, law enforcement, a postal system, and other public services that were beyond the capacity of any private agency. But liberals generally believed that, apart from these functions, government must not try to do for the individual what he is able to do for himself.

We explored some aspects of democratization and liberalization. Obviously these two societal developments can be complemented by others, but they illustrate that societal change manifested itself independently of technical change. They are part of the complex process of Enlightenment (French: *illumination*, German: *Aufklärung*) from the 1650s up to the 1780s, in which the old power structures were be challenged. Enlightment that, next to new arising ideas about the "social contract[24]", saw the encouragement of arts and sciences[25]. Although at different moments in time and in different forms at different places.

Scientific Change and Technical Change

Over time, into the nineteenth century, traditional thinking about nature and society—often referred to as *Aristolean philosophy*—changed into the more *natural philosophy*. The original construct of earth, air, water and fire

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[24] A social contract or political contract is a theory, originating during Enlightenment, that typically addresses the questions of the origin of society and the legitimacy of the authority of the state over the individual. Both John Locke and Jean-Jacques Rousseau developed their own social contract theories in *Two Treatises of Government* and *Discourse on Inequality*, respectively.

[25] The social contract doctrine leads to the right of intellectual property. Thus individual persons could ask for protection of the fruits of their intellectual efforts (inventions). This protection was realized by a patent, originally called a "grant of privilege". It is a constitutional right created in the US Constitution:" [The Congress shall have the power…] *To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries."* US Constitution, Article 1, Section 8.

(the so-called Aristotelian physics) was abandoned. Based on the observations of the physical world, curious and inquiring people—later called scientists—wondered about the nature of heat, the nature of lightning, the nature of sound, etc. These "natural philosophers" observed phenomena like steam produced by heat, thunderous sparks as the result of friction produced in the air (lightning), glowing light produced by burning wood and sound they observed everywhere as created by nature and living beings (eg by vibrating strings). They created their views on nature as they observed and analysed it, both on earth (the *mechanists*) and its surrounding universe (the *astronomists*). They developed their views of mechanical and astronomical properties of the world. In the meantime, they changed the old "alchemy" into the modern "chemistry"—views that conflicted with the religion based views of those days. Originating from the constructs of "Gods", powers that created unknown phenomena (eg Wodan throwing his hammer to create thunder and lightning), the Christian religions had a totally different view on the world, such as the dogma that "God created the world in seven days".

A breakthrough in the thinking about our world was made by Nicolaus Copernicus (1473–1543) with his heliocentric model of the solar system (Kuhn, 1957), stating that the Sun, not the Earth, was the centre of our universe, as published in his *De Revolutionibus Orbium Coelestium* (On the Revolutions of the Heavenly Spheres). It was a concept that brought him in conflict with one of the existing powers of those days: the Catholic Church, with its dominant grip on societies. The same happened with Galileo Galilei (1564–1642), who expanded the astronomical part of the Copernican model and contributed with his *Dialogo sopra i due massimi sistemi del mondo* (Dialogue Concerning the Two Chief World Systems) in 1632 to the concepts of gravity and time (the Galilean relativity). His work was opposed by astronomers, philosophers and—surprise—clerics. It resulted in the Catholic Church condemning heliocentrism as "false" and "altogether contrary to the Holy Scripture" in a decree by the Congregation of the Index in February 1616. Galilei was placed under perpetual house arrest (Sharratt, 1996, pp. 127-131). It took a while before the Catholic Church reflected on his work:

> *In 1979, Urban's successor several times removed, Pope John Paul II, appointed a committee to re-examine the merits of the case against Galileo. Their report, issued a decade later, blamed and exonerated both parties: the Inquisition had understood the scientific issues at stake, but not the principles of exegesis; Galileo had employed a sound hermeneutics, but not an acceptable standard of scientific proof. Their no-fault collision arose from a "tragic mutual misunderstanding." People restricted to ordinary modes of thought may have trouble accepting this*

> *resolution and the associated assurance that there is no essential opposition between science and religion.* [26]

Sometime later, Isaac Newton (1642-1727) expanded on this thinking and created the laws of gravity. His Newtonian mechanics as published in his *Philosophiæ Naturalis Principia Mathematica* ("Mathematical Principles of Natural Philosophy") marked the beginning of the modern period of mechanics and astronomy. The invention of the telescope (opening up the macro-cosmos of the universe) and the microscope (opening up the micro-cosmos) by people such as the Dutchmen Hans Lippershey, Zacharias Janssen, Christian Huygens and Antoni van Leeuwenhoek, contributed to the development of his views.

This change over time in thinking about the natural world, often referred to as the Scientific Revolution, had great consequences. Its study of the nature of heat resulted in the mastering of the power of heat (the mechanical force). Its study of the nature of lightning resulted in the mastering of the power of electricity (the electromagnetic force). The latter created the insight into the phenomenon of electromagnetism (Oersted et al.) and electrodynamics (Faraday et al.)[27].

It was the discontinuity in the scientific thinking between the Aristotelian physics and Newtonian mechanics that characterized the Scientific Revolution. Not the continuation along the existing views of those times, but the creation of totally new views created the change that characterizes a revolution in scientific thinking. It would result in a wealth of discoveries and inventions that created the world we are living in today.

Social Change and Scientific Change

The Scientific Revolution was closely related to another development in society. In the same period of time new views about the "natural rights" of people, and the role of government developed. It was philosophers like Francis Bacon (1562–1626), René Descartes (1596–1650), John Locke (1632–1704), Baruch Spinoza (1632–1677), Pierre Bayle (1647–1706), Giambattista Vico (1668–1744), Voltaire (1694–1778), David Hume (1711–1776), Immanuel Kant (1724–1804), Cesare Beccaria (1738–1794), Francesco Mario Pagano (1748–1799) who created their views on society. Views that contrasted with the then-dominating *feudalism* (the dependence of people on the powers of aristocracy), the *religious dominance*

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[26] Source: Heilbron, J.: http://blog.oup.com/2011/01/galileo/ #sthash.hqrXe7A1.dpuf. (Accessed June 2015)

[27] See: B.J.G. van der Kooij: *The invention of the Electro-motive Engine* (2015).

(the power of the religious institutions over society) and *absolutism* (the absolute powers of the crown). This period of enlightenment—the Age of Enlightenment—resulted in conflicts with the institutional powers in the seventeenth, eighteenth and early nineteenth centuries. It created the social revolutions known as the Dutch Revolt (1568-1648), the English Revolution (1642-1651, 1688) and, sometime later, the American Revolution (1765-1783) and the French Revolution (1789-1799).

The Dutch Revolt was the conflict of the Protestant Seven Provinces of the Low Countries (today's Netherlands) with the rule of the Roman Catholic King Philip II of Spain. The religious clash of cultures had been building up gradually but inexorably into outbursts of violence against the perceived repression of the Habsburg Crown. These tensions led to the formation of the independent Dutch Republic that rapidly grew to become a world power through its merchant shipping and experienced a period of economic, scientific and cultural growth: the Dutch "Golden Age". A period of tolerance that attracted many scientists to the Low Countries: people like the French philosopher and mathematician René Descartes (1596-1650), the English philosopher and physician John Locke (1632-1704), the philosopher of Portuguese origin Baruch Spinoza (1632–1677), and the French philosopher Pierre Bayle (1647–1706). They all took refuge in the Netherlands and published their views.

The English Revolution, with its civil wars, was a violent conflict over the governing powers in Britain: it was the clash between the Royalists supporting the absolute monarchy and the Parliamentarians supporting the parliamentary democracy. The clash resulted in the abolishment of monarchy and the creation of the Commonwealth of England, a republic under Oliver Cromwell until the restoration of the, then parliamentary, monarchy in 1661. This lasted until the Glorious Revolution of 1688, a bloodless, negotiated compromise that ended any chance of Catholicism becoming re-established in England. The totality of these changes would create the foundations the first British Empire. Seen from an economic perspective, it was a most lucrative enterprise.

The American Revolution was a political conflict between the thirteen American colonies and the rule of monarchy and aristocracy as exercised by its motherland, Britain. It created the United States of America[28], which would end the British mercantilist practices and start the economic development of America. The development would be supported by the scientific discoveries of a technical nature that we are going to explore.

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[28] This development will be covered in another case study. : B.J.G. van der Kooij, *The Invention of the Communication Engine 'Telephone'* (2015).

The French Revolution was a social conflict between the feudal powers of monarchy, aristocracy and clergy and the third estate of the peasantry and emerging *bourgeoisie*. Further on, this social conflict will be analysed extensively.

These were the social developments that—painted in rough brushstrokes—prepared the world of the early nineteenth century for massive, science-induced changes.

The First Half of the Nineteenth Century

We described some of the socio-political, socio-economic and socio-technic developments in the societies of that period in time that occurred independently from the technological innovations that characterize the First Industrial Revolution. These social developments would set the context for the next (technological) developments that took place in the nineteenth century: the emergence of electricity as a source of power and the use of electricity in specific fields ultimately creating the Second Industrial Revolution. It was a range of developments resulting in technical changes that cannot be seen in isolation from the context in which they took place.

As this is not the place to analyse the historical regional social developments in relation to technical change—other scholars have done an excellent job already[29], we will try to paint two pictures of societies at the brink of the nineteenth century: the society of the United States of America and the society of France. In the United States we will focus on the American Revolution and its aftermath, resulting in a new

Figure 6: British redcoats at the Battle of Bunker Hill, 1775.

Source: Wikimedia Commons, E.Pierce Moran

[29] Mokyr, Joel: *Industrialization in the Low Countries, 1795–1850* (1976, New Haven, Yale University Press); Mokyr, Joel: *The Enlightened Economy: An Economic History of Britain 1700-1850 (Mokyr, 2009);* Nye, David: *Electrifying America (1990);* Noble, David: *America by Design: Science, Technology, and the Rise of Corporate Capitalism* (1977).

nation[30]. In France, we will focus on the French Revolution and its aftermath, resulting in a changed nation. Both are the result of quite different societal developments, but they also have much in common: one of them being the need to finance warfare-a rather vulgar and mundane trigger for historic change.

Imagine the last part of the eighteenth century. Everybody seemed to be at war with everybody, but two large nations were constantly at each other's throat: England and France. And in between them, those irritating Dutch merchants were spoiling—and enabling—the ambitions of the British and French monarchs. We are talking here about the *Seven Year W*ar (1754-1763), with its different theatres where these three "players" each played their own game.

In the North-American theatre of war, the French were expanding their territorial claims. This resulted in local fights with the British, who already had considerable colonies. Both countries sent reinforcements; Britain had in 1758 an army of some 50.000 "redcoats" in the American colonies, a number that would increase when the revolts leading to the American Revolution broke out (Figure 6). In the meantime, although opposed by the Brits, Dutch merchants traded intensively and profitably with the British colonies.

In the European theatre, the British Navy harassed French shipping, seizing hundreds of ships and capturing thousands of merchant seamen. Naval battles like the Battle of Quiberon Bay were fought, destroying ships and crippling the French Navy for decades to come (Figure 7). On more than one occasion, the French even planned to invade Britain. But at the end of the Seven Year War, the Brits were victorious.

Figure 7: The Battle of Quiberon Bay, 20 November 1759.

Source: Wikimedia Commons, Nicholas Pocock

[30] To be published in: B.J.G. van der Kooij: The invention of the Communication Engine 'Telephone'.

Although the Brits depended on Dutch financing, they were furious about the Dutch financing—through French loans—the American Revolution. So their navy was soon blocking trade for the Netherlands. It might have crippled the Dutch economy, but for the British it did not solve the problems at home.

> *But a steep price accompanied the fruits of total victory. The British Government had borrowed heavily from British and Dutch bankers to finance the war, and as a consequence the national debt almost doubled from £75 million in 1754 to £133 million in 1763*[31]*. In order to address this onerous liability, British officials turned to larger import duties on enumerated goods like sugar and tobacco, along with a series of high excise (sales) taxes on goods such as salt, beer, and spirits. This taxation strategy tended to burden consumers disproportionately. In addition, government bureaucracy expanded in order to collect the needed revenue. As the number of royal officials more than doubled, Parliament delegated new legal and administrative authority to them. Thus, even as British subjects lauded their preeminent position in the world, they chafed under the weight of increased debts and tightened government controls.*[32]

So, the governments were faced with —among others—a financial problem. For a government to raise more money—generally speaking—different instruments are available: raising taxes, broadening the base of taxpayers, creating new taxes, improving the tax-collecting system and discouraging tax bribery, evasion and fraud.

Obviously, the English King Charles II (1630-1685) and his ministers (such as Charles Townshend and William Pitt), supported by the House of Lords representing the aristocracy, would have looked for ways to raise money. In this case they—next to measures related to other fields—looked for ways to broaden the base for taxation. Then an idea popped up: why not let those colonists in the new American colonies pay for the protection of the British Army and Navy? Everybody—that is, everybody in the British Parliament (which did not include representation from the colonies)—thought that was a good idea, and swiftly, some bureaucrat was ordered to design the Stamp[33] Act of 1765;

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[31] Equivalent to £ 18,000 million in 2013-based historic opportunity costs. Source: http://www.measuringworth.com/

[32] Source: http://www.taxhistory.org/www/website.nsf/Web/THM1756?OpenDocument (accessed April 2015)

[33] Originally, this was a tax required to legalize certain documents: "For every skin or piece of vellum or parchment, or sheet or piece of paper, on which shall be ingrossed, written or printed, any declaration, plea, replication, rejoinder, demurrer, or other pleading, or any copy thereof, in any court of law within the British colonies and plantations in America, a stamp

> *An act for granting and applying certain stamp duties, and other duties, in the British colonies and plantations in America, towards further defraying the expences of defending, protecting, and securing the same; and for amending such parts of the several acts of parliament relating to the trade and revenues of the said colonies and plantations, as direct the manner of determining and recovering the penalties and forfeitures therein mentioned.* ("Stamp Act," 1765)

Nothing was wrong with this idea, one would observe, but soon there appeared to be quite an obstacle, as the Brits forgot to include the ones who had to pay the taxes in the legislative process—an omission that would have serious consequences. As we will see[34], it resulted in the American Revolution.

The same happened in France with King Louis XIV. The French war contributions to the American Revolution[35], and the costs of general warfare and colonial expansion had drained the public treasury considerably. Also, all the expenditures of the monarchy itself were quite a burden on the treasury. Here, the choice to raising money by taxation also resulted—as the taxation levels for existing taxes such as the Taille and Head Tax were already maxed out—in an idea to broaden the tax base.

> *When lenders showed themselves recalcitrant, in 1786, Calonne was obliged to notify the king that fiscal reform was absolutely inevitable. … Expenses were set down at 629,000,000 livres and revenues at 503,000,000, leaving a deficit of 126,000,000, or 20 per cent of expenses, which it was now proposed should be made up by another recourse to borrowing. … It was the debt that was crushing the royal fiancées, for debt service required 318,000,000, or more than 50% of the expenditures.* (Lefebvre & Palmer, 1947, pp. 20-22)

So here the idea popped up to include in the taxation those societal groups that had always been—in different degrees—exempted from taxation: the nobility and clergy. The then active minister of finance, Charles Alexandre, Vicomte de Callone (1734-1802), proposed—next to other measures such as the sale of church property and the equalization of the salt and tobacco taxes—a new land value tax, the *subvention territoriale*, that would sweep away the fiscal exemptions of the privileged orders. This

duty of three pence.", "For every pack of such cards, the sum of one shilling.", "And for and upon every paper, commonly called a pamphlet, and upon every newspaper, containing public news, intelligence, or occurrences, which shall be printed, dispersed, and made public, within any of the said colonies and plantations, and for and upon such advertisements as are herein after mentioned…" (text of law).

[34] This topic is covered in the book: B.J.G. van der Kooij, *The Invention of the Communication Engine 'Telephone'.* (2015)

[35] Amounting to a total of over 1,000 million livres (Eugene N. White, 1989, p. 560)

approach might not have been unrealistic, given the extent of the state's financial problem. But—surprise—the nobles revolted, and after that, things got completely out of hand: the "madness of times" struck, as we will see more in detail further on.

Now back to the Dutch. Located in the lowlands at the sea in the Rhine Delta, it was the geographical focal point between the powers from the south (Spain, France), the east (Prussia, Austria) and the west (Britain). The lowlands at the sea had been an occupied country governed either by the Spanish, Austrians, or French for a long time. Foreign armies roamed across Dutch country side several times. At the end of the eighteenth century, the Netherlands were confronted by the British Empire, who ruled the waves, and the French republican expansionism who ruled the lands. The Dutch did not like either. As merchants used to negotiating the oceans, taking part in the wave of colonialism of those days, they captured the East-Indies (today's Indonesia) and the West Indies (today's Surinam, Curacao); the Dutch were everywhere. Their Dutch India Companies were operating in the east and the west, creating settlements that grew into colonies: settlements like New Amsterdam in America, later taken by the Americans, and Cape of Good Hope in South Africa, later taken from them by the Brits.

Figure 8: The Dutch Republic of the Seventeen Provinces.

Source: Wikimedia Commons

The Republic of the United Provinces at the lowlands (Figure 8) became rich and prosperous, ruled by the social class of the Regenten, consisting of capitalistic merchants. Those rich merchants and their banks financed sovereign debt: from the Glorious Revolution of 1688 to the public debt of England to the Dutch merchant banks financing the French royal lifestyle in the 1750s.

As their merchant fleet grew, roaming the seas, their home front became a tolerant republic: tolerant in religion and tolerant in social interaction. Nevertheless, it was a society that needed defence, both at land and also at sea, protecting the merchant fleet. As a small country often in conflict with other nations their solution was diplomacy, and—often—neutrality, like in the Seven Years' War (1756-1763). But sometimes that approach failed and they had to fight, like in the Anglo-Dutch Wars and especially the Fourth Anglo-Dutch War (1780-1784), when the British Navy blockaded the Netherlands. This threatened the interests of the rich Dutch merchants, who by then were dominating the international capital market. Soon they also financed monarchy—ie the sovereign debt—in France. Over time the Dutch became the third player—although a small player next to the Brits and the French—in the social reform that swept the European scene at the end of the eighteenth century.

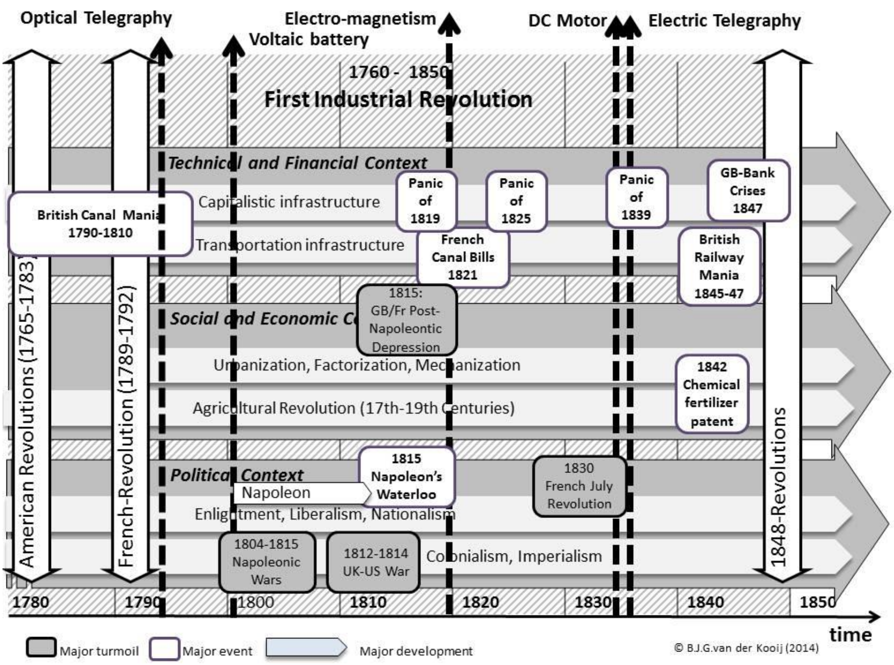

Figure 9: The context for the development of telegraphy.

Source: Figure created by author

These three players did, each within its own realm and limitations—especially the small Dutch society—play a role in the social changes that were going to occur in the begin of the nineteenth century, thus setting the scene for the emergence of the Second Industrial Revolution (Figure 9)—a scene characterized by many separate contexts. Like the *financial and mobility context* created by the emerging capitalistic infrastructure and by the transportation infrastructure of roads, canals and railway. Or like the changing *social and economic context* due to urbanization, factorization and early mechanization. Agricultural changes were also contributing to a more prosperous situation to feed a growing population. The same goes for the *political context* with its own developments like enlightenment, liberalism, nationalism, colonialism and imperialism.

Assumption: Social Change Precedes Technical Change

Our assumption is that social change can provoke and facilitate, stimulate and induce—but also limit and restrict—technical change by setting the "scene". A scene that consists of the specific society at a given moment in time (the "fitness of the environment" that evolutionary biologists talk about) and the individual people living in that society (similarly, realizing the "fitness of the organism"). Or, as has often been noted, the time seems to be ripe for a specific development. Like the times were ripe for the development of the telegraph.

For the development of telegraphy we will explore further on, this scene was created by the American and French Revolutions with their individual political, social, technical and financial context. In a way, one could say that the social revolutions set the stage for the Industrial Revolution to come.

To get a feeling for that assumption, we will explore here more in depth a social evolution in the late eighteenth century that set the stage for early nineteenth century Europe: the *French Revolution*[36]. A revolution that marked the dawn of the modern times. Times where the concepts of liberalism, republicanism and nationalism, as well as democratization and de-Christianization, would have their societal impacts.

[36] The American Revolution will be explored in B.J.G. van der Kooij, *The Invention of the Communication Engine 'Telephone'* (2015).

France under the Ancien Régime [37]

The French Revolution that started in 1789, although it seemed a failure at first, it was a marker in the development of many European countries. It was a transformation in the shape, values and politics in a society on a scale and impact never seen before. It was a departure from the *Ancien Régime* (the old regime): the old society with its century old establishments, institutions, culture and politics under an absolute monarchy.

This remaking of the society, based on the doctrines of "natural right" (ie the rights of man that are universal)[38] and "general will" (ie the idea that sovereignty lies in the people)[39] was the result of a revolutionary socio-political change within a decade (1789-1799) that found its roots in the preceding period. And it was a change that would echo throughout nineteenth century Europe—a change with a massive impact as it…

> … *would eradicate all hereditary nobility, venality of office, purchase of noble titles for money, hereditary privilege, monopolies, arbitrary arrests, seigneurial jurisdiction and illicit decrees. … The revolutionaries would establish liberty of commerce, liberty of conscience, liberty to write, liberty of expression.* (Israel, 2014, p. 25)

The Revolution became a massive change, certainly for France itself, but the other countries of Europe also felt its effects. It created the European context for political, cultural and social innovation and set the scene for technological innovations to come.

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[37] This introductory part is based on multiple sources of a general nature (ie Wikipedia and other encyclopedias).These are not identified individually. Where functional, additional sources will be identified. Some historic analyses are dominantly used (Israel, 2014; Mignet, 1888; Sée & Zeydel, 1927). See also Jeremy D. Popkin, *A Short History of the French Revolution, 2nd ed.* (1998); William Doyle, *The Oxford History of the French Revolution* (1989, reprinted 1992); David Andress, *French Society in Revolution*, 1789–1799 (1999); Samuel F. Scott and Barry Rothaus (eds.), *Historical Dictionary of the French Revolution*, 1789–1799, 2 vol. (1985).

[38] As a result of the philosopher's political thinking in the period of Enlightenment, the Declaration of the Rights of Man and of the Citizen formulates a set of individual and collective rights for all men that are universal and valid in all times and places. It can be found in the first two articles of the declaration: "*(1) Men are born and remain free and equal in rights. Social distinctions may be founded only upon the general good. (2) The aim of all political association is the preservation of the natural and imprescriptible rights of man. These rights are liberty, property, security, and resistance to oppression."*

[39] Originating from the ideas of Jean-Jacques Rousseau. It can be found in the in Sixth Article of the Declaration of the Rights of Man and the Citizen (French: *Déclaration des droits de l'Homme et du citoyen*): "*The law is the expression of the general will. All citizens have the right to contribute personally, or through their representatives, to its formation. It must be the same for all, whether it protects or punishes. All citizens, being equal in its eyes, are equally admissible to all public dignities, positions, and employments, according to their capacities, and without any other distinction than that of their virtues and their talents."*

> *History has witnessed few moments of creative destruction so encompassing as the French Revolution. From its very outset the National Assembly sought to eliminate the intermediary bodies of the old regime. Parlements were dismissed; local assemblies (Etats) abolished along with all feudal privilege; the Church was dispossessed of its wealth and most of its educational and welfare functions; and almost all guilds were dissolved. The National Assembly envisioned the creation of central bureaucracies staffed by civil servants as key to improving the essential functions of government. The Revolutionaries, however, were soon fighting for their lives, and their fortunes waxed and waned with the progresses and setbacks of French armies in the battlefield. The forces that had so completely wiped out all vestiges of the patrimonial regime eventually found themselves unable to give France a stable political order, a task that fell to Napoleon and that involved the re-emergence of an autocratic empire in Europe.* (Bogart, Drelichman, Gelderblom, & Rosenthal, 2010, p. 9)

Thus, what is today called the French Revolution is a complicated affair—an affair with many different aspects:

On the one hand, it is an *economic conflict*: a conflict between the "have's" (the landowning nobility, aristocracy and clergy) and the "have not's" (peasants and plebs). A conflict between the rich, who lived in abundance with all their privileges, and the poor, who were living under terrible circumstances supplying for the rich by heavy taxation. Basically, it was nature and its agriculture that created wealth, strongly influenced by climatic conditions. That wealth of the country, created and labored for by the poor, was confiscated by the rich in a repressive feudal system under the absolute monarchy—a system that had often to rely on brutal force to keep the masses in check.

On the other hand, it is a *social conflict*—a conflict between the social classes of the rulers (nobility, aristocracy and clergy) and those who were being ruled (the peasants, the bourgeoisie and the plebs). It is about social hierarchy and social dominance, where a few people ruled over many people. It is about a social structure that was held in place for centuries but which came under pressure from several social developments—developments such as the mechanization of work and the subsequent urbanization and the growth of the middle class of citizens that demanded liberalization. But it also was a social conflict that resulted from endogenous societal developments: cultural and social change in the Era of Enlightenment—developments that challenged authority and advocated individuality and appeared in coincidence with the scientific revolution[40].

Then, as politics[41] is about the representation of interest of specific social groups, the social conflict and the economic conflict resulted in a *political conflict*. A conflict between social classes in which one class had much to lose—its privileged position—and another class had much to win—their liberal rights. It was a political conflict in which the interests were so large, the consequences of the structural change and the dismissal of the former powers were so far-reaching for the structure of the society and for individual personal life that it had to become radical, extreme and violent.

The French Revolution can be considered as a turning point between the old social structures based on absolute monarchism and the new social structure based on the civil rights of men. So, let's begin our analysis with a look at the existing structures at the end on the eighteenth century.

French Economy up to the Nineteenth Century [42]

France at the end of the eighteenth century was, like the rest of Europe, a country dominated by agriculture, peasantry working the land and limited artisan activity of masters and their journeymen. There were the small villages, some bigger towns and one dominant city: Paris, with some 600,000 inhabitants in the 1780s. From Paris, the centralized state ruled under the absolute monarchy. From Paris radiated a network of royal roads into the extremities of the kingdom. It was the time of horse-powered coaches—both the private coaches of nobility and the stage coaches for public transportation (Figure 10). They were traveling on roads and bridges maintained by the Corvée Royale, the unpaid labour imposed by the state/king on the peasantry.

[40] The Scientific Revolution marks the period of the seventeenth and eighteenth century when the views of the classical world gave way to different views on nature (ie Copernicus, Newton).

[41] The word *politics* can have different interpretations. It can be the process of the representation of group interests (national politics). It can also relate to the different political groups and their particular views themselves (the liberals, socialists, etc.). Or it can be the individual behavior related to social processes (as in political maneuvering). Oxford Dictionaries defines politics as "The activities associated with the governance of a country or area, especially the debate between parties having power". But politics is more than a debate; it is also about the prevailing ideology—about the power to dominate and conserve one's station in society.

[42] Throughout this chapter extensive use will be made of sources from Wikipedia. As this concerns information available to the general public, further reference to the authors is not made. Sometimes (partially edited) text parts are used.

To travel from Paris to Lyon (a distance of 465 km) took 5 days, to Bordeaux (583 km) 6 days and Marseilles (776 km) 11 days.[43] The mail service was slow. Goods were transported by draymen on their horse-pulled flat-bed wagons. Transportation was expensive, hindered by tolls for road charges and taxation and theft.

Figure 10: Traveling in France; the departure of the mail coach.

Source: Wikimedia Commons, George Cruickshank (1818).

Guild Dominated Economic Structure

European societies had a guild-dominated economy in which the manufacturing of goods was controlled. Enterprise was small scale: the master and his apprentice, sometimes employing a few journeymen. Every trade had its own guild, from the guilds of the metalworkers, shoemakers and weavers to the guilds of the bakers, fishmongers and butchers. The inter-personal relations within the guilds were all quite regulated and aimed at creating a monopoly for the masters of the same trade. As the guilds were powerful institutions in the communities, the social-economic structure was often dominated by the guilds. They forged useful political

[43] Just to compare with our present time. The fast-speed train system TGV covers in 2015 these distances in hours. Paris-Lyon: 1 hour 56 minutes for €57; Paris-Bordeaux: 3 hours 17 minutes for €64; and Paris-Marseille: 19 trains a day, travel time 3 hours, 17 minutes for €73 (Data December 2014, SNFC, best fares).

alliances in a society governed by privilege. In addition, the monarchy controlled this institution as they were based on a "letters patent"[44] issued by the monarch.

> *The respective rights and duties of master and apprentice were fixed. The apprentice had to pay board for his maintenance, and he bound himself not to desert his master. The master, on his part, had to teach the apprentice his trade "without concealing anything from him," give him suitable lodging and board, and treat him decently. The number of apprentices was limited by statute, usually to one or two. … The journeyman was hired to his master by a contract, which was often verbal but which he was compelled to respect in any case. Discipline was often harsh; the workman had to finish the task he began and could not leave his master without giving two weeks' notice. … In the eighteenth century, more so than in previous ages, it was impossible for the majority of journeymen to rise above their station. It was due mainly to the legal organization of the trades that they were doomed to remain journeymen all their lives. (Sée & Zeydel, 1927, p. 71)*

The manufacturers were all small-scale operations under royal control. Take for example the urban areas with industrial-like production, such as silk-manufacturing in Lyon and St. Etienne nearby. There also were rural areas with their rural industry: the cloth industry of the Languedoc in the South-West of France and the cotton industry in Normandy. The King ruled them all from Paris.

> *The manufacturing establishment always depended on the royal administration. Beside the state factories, such as the Government Tapestry Works, the Soap Works and the porcelain works at Sèvres, of which the king was the patron, there were a great number of royal establishments, for the creation of which a government authorization was necessary. The royal establishments were encouraged by subventions, loans without interest, and direct and indirect bounties. Often they received also pecuniary aid from the provincial estates or the city municipalities.* (Sée & Zeydel, 1927, p. 87)

Or take the mining of coal, metals and salt. Mining that was forbidden except by royal concession, especially salt, a very important mineral used for conserving food; the mining of salt was the prerogative of the king. He controlled the mining, for example the mining in the royal salt mines located in the Franche-Comté region (Salins les Bains, Arc-et-Senans).

[44] Letters patent are a type of legal instrument in the form of a published written order issued by a monarch, generally granting an office, right, monopoly, title, or status to a person or corporation.

The guilds were a conservative lot and innovation—being the equivalent to change and novelty—was not their objective. Take the following example of a French situation in 1666.

> *The question has come up whether a guild master of the weaving industry should be allowed to try an innovation in his product. The verdict: 'If a cloth weaver intends to process a piece according to his own invention, he must not set it on the loom, but should obtain permission from the judges of the town to employ the number and length of threads that he desires, after the question has been considered by four of the oldest merchants and four of the oldest weavers of the guild.' One can imagine how many suggestions for change were tolerated.*
>
> *Shortly after the matter of cloth weaving has been disposed of, the button makers guild raises a cry of outrage; the tailors are beginning to make buttons out of cloth, an unheard-of thing. The government, indignant that an innovation should threaten a settled industry, imposes a fine on the cloth-button makers. But the wardens of the button guild are not yet satisfied. They demand the right to search people's homes and wardrobes and fine and even arrest them on the streets if they are seen wearing these subversive goods.* (Heilbroner, 2011, p. 30)

This illustrates that "innovation" was not only seen as undesirable but was just actively combatted. This approach certainly had—for some—its advantages, but it also had—for many—its drawbacks. All over France, manufacturing was done by small masters, working alone or employing some journeymen and/or apprentices who produced goods that were sold by the merchants. It was a closed system with great social differences.

> *As a matter of fact, the price paid for work by the merchants was not enough to afford the masters a decent livelihood. Many of them were reduced to misery and clamored in vain for an equitable schedule. Their budget always showed a deficit, even when business was good. The working hours were excessively long. … Revolts, too, broke out frequently. They were repressed harshly and did not serve to improve the lot of the workmen." … Among the guilds of merchants some members, by virtue of their economic condition, belonged to the high bourgeoisie. These were the apothecaries, the printers and book dealers, the goldsmiths, the haberdashers, and the cloth and silk merchants. But in other guilds very diverse conditions were found. This was true of the grocers. Furthermore, there were very many merchants on a small scale, among them the old-clothes merchants, particularly the retailers, the hucksters, etc. Among the commercial bourgeoisie the highest place was held by the wholesale merchants, who escaped the guild organization. … Since there were great differences between the condition of the simple tradesmen and that of the merchants, their mode of life was also quite different. The tradesmen, even when they were in easy circumstances, lived very simply. They had no living room and ate their meals in the kitchen. On the other*

> *hand, the merchants led a life that was often more luxurious than that of the nobility.* (Sée & Zeydel, 1927, pp. 96-97)

Industrial activity was limited, as in the eighteenth-century, machinery in France had been introduced only in a few industries. The textile industry was influenced by developments in England. The nobility played an important role in it.

> *Between 1775 and 1780 the inventions of Arkwright and Cartwright began to be introduced in France. Important concentrated factories for cotton spinning were established, for example those of Lecler at Brives, those of Martin and Flesselles at Amiens, and those of the Duke of Orléans—that great captain of industry—at Orléans and Montargis. To be sure, France was employing only 900 jennies at the time, while there were 20,000 in use in England. Only a beginning had been made. … But in 1789 the era of machinery and industrial concentration was only in its infancy. The predominant system in all France was that of petty enterprises employing only a few workmen.* (Sée & Zeydel, 1927, pp. 92, 93)

Institutionalized Public Structure

In Ancien-Régime France, almost all posts of public responsibility had to be bought or inherited. Rather than tax their richer subjects directly, French kings preferred to sell the privileged public offices. It was the "venal system", in which the right of a public office was bought from the crown. By the eighteenth century, there were 70,000 venal offices, comprising the entire judiciary, most of the legal profession, officers in the army, and a wide range of other professions—from financiers handling the king's revenues down to auctioneers and even wigmakers.

> *Venality permeated every sphere of public life, from government ministers downwards. The finances of the state were largely managed by receivers, payers and accountants who bought their positions. Military commissions were subject to purchase. So were many municipal dignities. The entire judiciary, from the presidents of sovereign courts down to the humblest attorneys, clerks and ushers, was made up of venal offices. A number of key services were also venal monopolies, such as those of notaries, brokers, surveyors, auctioneers, and even, as we have seen, wigmakers. … Offices tended to be bought for profit, for prestige, and for posterity.* (Doyle, 1984, p. 833)

For those who held venal offices (2-3% of the French adult males), there were different motives. Certainly there were the financial motives, but there was also social status that came with the office:

> *They bought them for reasons of prestige and social standing. The return on the investment came not in financial terms, but in social recognition.… Ennoblement was the greatest incentive to buy an office that the crown could offer, and in the*

seventeenth and eighteenth centuries this was the way most families entered the nobility. (Doyle, 1984, p. 834)

For the right to a venal office, one had to pay, in the form of a down payment combined with mutation fees called *le Centième dernier* (in the case of inheritance, marriage) or *marc de noblesse* (incomplete nobility offices). In other cases, the venal right was obtained for an annual fee, such as the lease of the right on tax collecting by the farmers-general (*Fermiers Généraux*—also called farmers). This office was quite important to the monarchy. By paying in advance, they became the financers of the state debt, and as the average financial returns were high (18%), theirs became the wealthy offices.

> *Farmers typically forwarded several years' worth of tax receipts to the government on the signing of a lease. Anticipations increased in importance, rising from an average of 1.27 million livres tournois in the 1620s to 4.29 million in the 1840s. … French kings drew on short-run and long-run debt to finance their eighteenth-century wars. James Riley estimates that between 1750 and 1768 long-term borrowing amounted to some 872.3 million livres tournois. During that time the Company of General Farms loaned the king 244 million livres tournois' —about a quarter of long-term Royal debt. …. Historians know that during some years the General Farmers earned profits as high as 37 percent on their investment, well above the return on comparable investments.* (Johnson, 2012, pp. 17, 19, 20)[45]

Centralized Political Structure

The *Ancien Régime* was based on the absolute monarchy, where a centralized power ruled the country. After five hundred years of struggle between king and nobles, between central and local powers, in the eighteenth century one finds a centralized France.

> *The history of centralisation in France, as everywhere else, goes parallel to that of absolutism. … As long as absolutism lasted only Paris profited by it, the*

[45] How much would that amount be worth today? Converting French *livres d'Or* or *livres tournois* into present value is complicated. No tools similar to the dollar and pound conversion (other than Measuring Worth) could be found. The value of the *livres d'Or* fluctuated between 10-30 *livres tournois* (later to be called *livres/franc*). The *livre* and the franc around 1800 contained 290mg of pure gold. Taking the 2015 price of gold to be around €34/gram, the *livres/franc* would have a present day value of about €10. So the reader could use a multiplication factor of 10 to have a rough estimate of the present day equivalent in euro. In the treaty of the Louisiana Land purchase (1803) the then actual conversion rate of the franc against the dollar was set as 0.225 (1 franc = $0.225). Deriving from this, the reader could use a multiplication factor of 0.225 to have a rough estimate of the present day equivalent in dollars. But one has to realize that these multiplication factors are quite a rough method.

> *provinces had to put up with the costs of the state and His Majesty's arbitrariness. All culture, all esprit, all science from the whole of France was concentrated in Paris, existed for Paris; the press operated only in and for Paris; the money of the provinces, which the court drew towards itself, was squandered in and for Paris. This gave rise to that great disproportion in culture between Paris and the rest of the country which, with the fall of absolutism, developed in a form extremely disadvantageous for France. Centralisation alone made the revolution possible, in the way in which it eventually happened; but centralisation also had made the gulf between Paris and the rest of the country so great that Paris felt little concern for the welfare of the provinces as long as it itself was not affected by the general oppression.* (Engels, 1842)

That movement over time towards centralization had created a situation in which Paris had become the head and heart of France, both before and after the revolution. And the centre of the power was the royal court that, as we will see further on, was not located in Paris but in nearby Versailles. Although the royalty might have slighted Paris and resided there—in the Tuileries—as little as possible, this absenteeism was not followed by the nobility. They created their freestanding mansions (the *hôtel particulier*—"the private houses") and lead a life of splendid grandeur that dominated a period of national decadence.

Daily Life in Paris

Paris is those days was—for someone used to today's metropolis with roads, trains, metro and functioning public services for waste and water—quite astonishing. It was crowded, filthy, smelly and noisy. All those carriages, camions, diligences and carts were horse (and dog) powered. All leaving their manure on the streets which were also used by the population to empty their toilet bowls. Obviously, what was coming out had to be consumed first. An enormous amount to feed the population was entering Paris: live cattle to be sold on the cattle markets and slaughtered on the quays of the River Gauche de la Seine, milk from the farms, flour from the hundreds of mills outside the city, wine from the wine regions, chickens and turkeys from the farms near Paris. Food that was taxed by a tax called "octroi". Around Paris, the 24-km tax wall, or the *mur d'octroi des Fermiers generaux,* with 64 toll-gates, started to be built in 1784 to ensure the payment of toll on goods entering Paris (Figure 11). It were these 64 toll gates that would later be used as barricades by the revolutionists to prevent the royal troops from entering inner Paris.

Already in that time, Paris was a beehive of economic activity. The earlier-mentioned guilds were well organized and powerful entities in the social structure. Next to the building guilds that shaped the cities, there were the guilds that brightened up the city:—the Seamstresses' Guild and the Goldsmiths' Guild—and the ones that fed the city—the guilds of the bakers, millers and the merchants of the grain and flour trade.

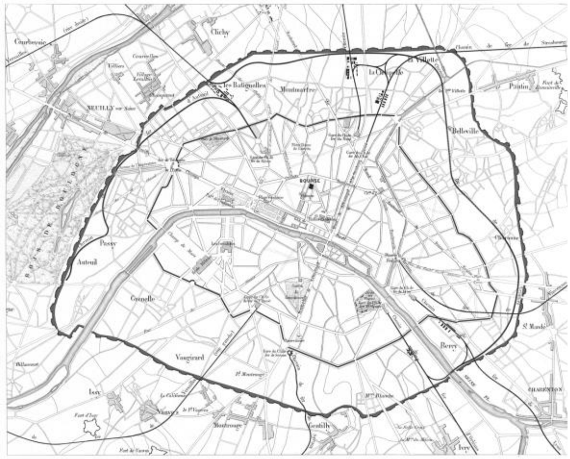

Figure 11: Tax-wall around Paris.

The map shows the wall and fortifications of the defence wall made under the government of prime minister Adolphe Thiers (outer wall, dark line) build in 1841-1844, and the 'Mur d'Octroi' (inner wall, lighter line) build between 1784 and 1791.

Source: Wikimedia Commons

There was one specific profession that was playing an important role in that time: the bankers who operated in the capital: "At Paris the number of bankers increased during the eighteenth century, especially in the second half of the century, but they were more interested in making loans to the state than they were in industrial and commercial affairs. … The bankers of the court were particularly important" (Sée & Zeydel, 1927, p. 103).

French Society under the Ancien Régime

France was, like so many European countries, a hollowed-out feudal society under the Ancien Régime. From a collection of independent feudal territories wielding its own power (eg the Duchy of Brittany in the west, the Duchy and County of Burgundy in the east, and the County of Provence in the south), it had become a centralized country under an absolute monarchy. As illustrated by the words *L'Etat c'est moi* ("I am the State"), reportedly said by King Louis XIV (1638-1715) when he addressed the Parliament of Paris on April 13, 1655.

Absolutism and Royalty

France was ruled in that time by members of the House of Bourbon, a branch of the Capetian dynasty. The history of the Capetian monarchy had in fact been largely the story of its struggle against the aristocracy. King Louis XIV (1638-1715), the Sun King (*le Roi-Soleil*), was one of the most powerful kings in French history; he reigned for 72 years and had consolidated the absolute monarchical rule in France. His most well-known mistress was Madame de Pompadour, who—although not from aristocratic descend as was the norm for mistresses—had considerable influence on his reign. His son, Louis XV (1710-1774), known as Louis the Well-Beloved (*Louis le Bien Aimé*), succeeded him at the age of five in 1715. Till 1723 his kingdom was ruled by the Regent Phillippe II, Duke of Orleans, after 1723 he ruled for over fifty years. He in turn was succeeded by his son, Louis XVI, (1754-1793) in 1774, who would later face the consequences of the French Revolution as "Citizen Louis Capet".

The French royalty was closely related by family ties to the other monarchies in southern Europe (Spain, Naples, Sicily, Parma), like the Spanish branch of the House of Bourbon that was founded by Philip V, born in 1683 in Versailles as the second son of the Grand Dauphin, son of Louis XIV. His rise to power came after the War of the Spanish Succession (1710-1714), in which French, Bavarian and Austrian royalty claimed the Spanish throne. There were also historic ties with the House of Bourbon of the two Sicilies (that was the result of the unification of the Kingdom of Naples and the Kingdom of Sicily in 1442).

The King of France had military, legislative, executive, and judicial powers. He was the commander of the Royal Army that was originally the collector of the taxes, but later his tool to enforce his centralized power. He also held the supreme judicial authority. He could condemn men to death without the right to appeal. It was both his duty to punish offenses and stop them from being committed. From his judicial authority followed his power both to make laws and to annul them. In other words, he was the absolute power. Power that was executed, at the end of the eighteenth century, by administrative institutions under the rule of the "Intendants", the royal civil servants in the financial, juridical and administrative system of the monarchy. Spiritually, it was governed by the Catholic clergy, who were not only interested in practicing their religion devoutly, but were also interested in more worldly affairs. The basic principles in the French society of that time were *Inequality* and *Privilege*.

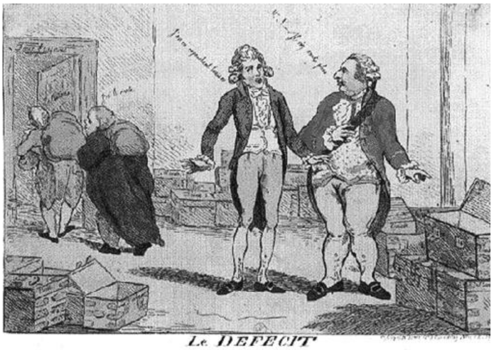

Figure 12: Cartoon 'Where is the Tax money' showing the King Louis XVI looking at the empty chests (1789).

Source: Collection Banque Nationale de Paris (Paris: Editions Hervas, 1988)

Bankruptcy of the State

At the end of the eighteenth century, the French state was in financial trouble due to the looming bankruptcy of the king, and thus the state (Figure 12). This financial crisis was partly caused by the expenditures for fighting major wars, like the Seven Year's War (1756-1763), in essence a conflict between France and England, and the American Revolutionary War (1775-1783), where France intervened on the side of the new nation against England.

It was not only the funding of wars that caused the crisis. The severe financial situation was also aggravated by the luxurious spending of royalty. Take, for example, the luxuriously furnished Palais de Versailles with its extravagance gardens (Figure 13). This immense complex was built by Louis XIV, who invited—as a part of his policy to weaken the power of the regional nobility—nobles to come and live at the court. It was an opulent extravagant affair; the fountains were supplied with the same volume of water (pumped by the *Machine de Marly*) as the whole city of Paris used (some 650,000 people) at that time. It was a complex capable of holding up to 20,000 people, which had 700 rooms, more than 2,000 windows, 1,250 chimneys and 67 staircases. Up to 3,000 princes, courtesans, ministers, and servants lived there at any given time. Some estimates say that maintaining the palace, including caring for and feeding the royal family and their massive staff, consumed anywhere from 6-25% of the entire French government income[46].

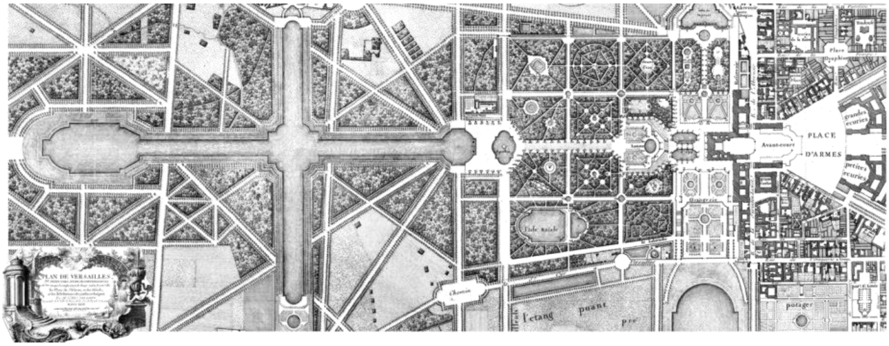

Figure 13: Plan of the Palais de Versailles with its gardens (1746).

The Palace itself is located right next to the Place d'Armes.

Source: Wikimedia Commons, by Delagrive

46 Source: http://www.pbs.org/marieantoinette/life/. (Accessed January 2015)

The state had a financial problem, that is clear, and it was soon resulting in considerable social discontent, fuelled by several additional causes. One was the behaviour of the monarchy and aristocracy, not only in Versailles but all over Paris. At the top of the nobility were some forty families, including that of the Duc d'Orléans, who spent two million livres a year. Below them were about a hundred families with incomes between 10,000 and 50,000 livres a year. The bulk of that money spent by the *grande noblesse* came from heavy taxation of the people living and working on their domains (from castle to manor) as the nobles owned—next to the church—the majority of the land. The way that was done, by the harsh methods of the *Fermiers generaux*, added to the social discontent:

> *"Contemporaries ascribed the trouble to the shameless waste of the ministers and the Court, to the monstrous profits of the private concessionaires who collected the indirect taxes and to similar profits made by the innumerable official collectors who channeled the direct taxes into the Treasury."* (Lefebvre & Palmer, 1947, p. 20)

Zeitgeist of the Enlightenment

The social discontent was also fuelled in other ways. Members of the intellectual class exposed more and more the problems of society, as expressed in the works of the philosophers of that time: Montesquieu (1689-1755), Voltaire (1694-1778), Rousseau (1712-1778), and Diderot (1713-1784) (Figure 14). These philosophers not only criticized the existing societal structure but also created alternatives to the existing situation, such as the Charles-Louis de Secondat, Baron de La Brède et de Montesquieu, who published in his *Spirit of Law* (De l'Esprit du Lois) his ideas about separation of powers (*trias politca*).

It was François-Marie Arouet, known as Voltaire, who strongly opposed the Ancien Régime and advocated freedom of religion, freedom of expression and separation of state and church. The Genevean philosopher Jaen Jacques Rousseau argued that private property was conventional and the beginning of true civil society in his *Discourse on the Origin of Inequality Among Men* (1755). He wrote *Of The Social Contract, Or Principles of Political Right* (Du Contrat Social ou Principes du Droit Politique) in 1762. And there was Denis Diderot, the author of the controversial *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers* (ca. 1750) that represented the thought of the Lumières movement (the Enlightenment)[47]. It was the

[47] Enlightenment: A philosophy that emphasized the shift of the origin of political authority from divinity or heritage to the people. Coinciding with the Age of Enlightenment was the Scientific Revolution.

phylosophie that both rejected Christianity and the principle of monarchy. It influenced the people who led the revolution: "The philosophique revolutionary leadership as a group was overwhelmingly republican from the outset" (Israel, 2014, p. 29). Later, the *philosophes-revolutionaires* would expand on their concepts and each played a role in the different phases of the French Revolution.

> *The first phase of the French Revolution was the one in which the dominant ideas were those of Montesquieu, notably those expounded in his masterpiece, L'Esprit des loix, first published in 1753. Montesquieu claimed that a liberal constitutional monarchy was the best system of government for a people who prized freedom, on the grounds that by dividing the sovereignty of the nation between several centers of power, it provided a permanent check on any one of them becoming despotic.* (Cranston, 1989)

In a later phase, Rousseau's ideas about the social contract between monarch and people would highly influence republican thinking. And even later, it was Voltaire whose doctrine of *Enlightenment absolutism* influenced Napoleon—and many other empires of that time.

In another way, people's discontent was expressed by intellectuals of that time, for example, by means of theatrical play, as with the work of Pierre-Augustin Caron de Beaumarchais (1732-1799), who himself became a revolutionary, supporting the American and French Revolution. He wrote the play *The Marriage of Figa*ro (Le Mariage di Figaro) in 1778, part of the three Figaro plays that are indicative of the change in social attitudes before,

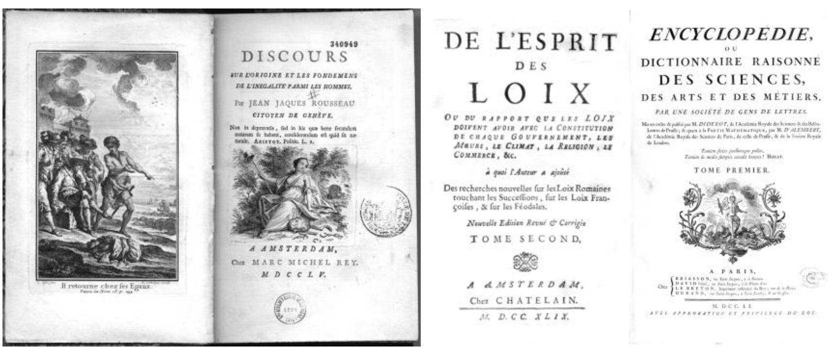

Figure 14: The work of the philopsphers.

Title pages of Rousseau's *Discours sur l'origine et les fondemens de l'inégalité parmi les hommes* (left, 1755), the *L'esprit des Lois* by Montesquieu (middle, 1753), and the *Encyclopedie* edited by Diderot (right, 1751-1772).

Source : Collection Bibliothèque municipale de Lyon, cote Rés 340949. Encyclopedie, L'Esprit : Wikimedia Commons.

during and after the French Revolution. The play of *The Marriage of Figaro* was a satire on the aristocracy, especially the seigneurial right of the *droit de cuissage* or *droit du seigneur*; the right of defloration of their serfs' daughters (also known as *Jus pimae noctis*). After his play was first banned by Louis XVI in 1781, in 1784 the adapted version passed the censor. Based on his play, Mozart composed his comic opera *La Nozze di Figaro* in 1784, seeing it banned by the Austrian Emperor Joseph II. Only when the political content was suppressed was he allowed to stage it.

Class Conflict in France

Underlying to the obvious financial problem related to the bankruptcy of the state versus the zeitgeist of the Enlightenment, however, were other causes that fuelled revolutionary developments. Basically, it was a social conflict between classes. The overburdened bourgeois and peasantry wanted liberalization. In a world of *inequality and privileges*, they wanted reforms based on *equality without privileges* for the few—a demand that has to be seen in relation to their actual living conditions: partly a result of historic developments (feudalism), partly poverty caused by climatic conditions. Poverty due to bad harvests resulted in a scarcity of food in the 1780s. The Little Ice Age had its effect on grain production, the main staple crop in France. Combined with an increasing urbanization in which more and more people moved into French cities seeking employment, this led to starvation among the poorest: the peasants and the urban poor. The cities became overcrowded with the hungry, destitute and disaffected, an ideal environment and breeding ground for a revolution.

The First Estate

French society at the end of the eighteenth century was divided into, aside from the monarchy, three estates, each with its own characteristics and dynamics. The First Estate of the Catholic clergy, organized in 135 bishoprics and archbishoprics, comprised of about 70,000 priests and 60,000 monks (Figure 15). The clergy, owning 5-10% of the lands in France, was heterogeneous and consisted of the high clergy and the regular clergy. All the bishops and abbots were noblemen who took the profitable positions and lead a pompous lifestyle.

> *The abbots, almost all nominated by the king, were chosen well-nigh exclusively from among the nobility. Moreover 840 abbeys out of 1100 were granted in commendam, as the expression was, that is to a beneficed clergyman who merely exercised the function and took for himself one-half or two-thirds of the revenue of the abbey. In short, the majority of the old lucrative abbeys were granted to favorities …*

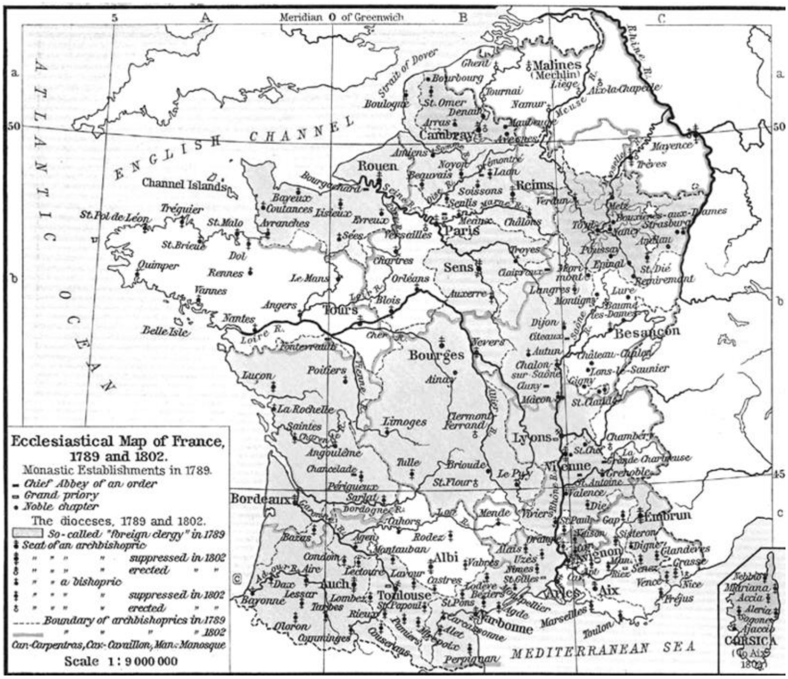

Figure 15: Ecclesiastical map of France with monastic establishment (1789).

The map shows the seats of archbishops and bishops.

Source: http://www.emersonkent.com/map_archive/ france_eccles_1789_1802.htm

In 1789, as the abbot Sicard says, not a single bishop from the ranks of the common people could be found. If we peruse the lists of bishops and archbishops of this time we are confronted with the names of the highest and oldest families of France, …

If a man belonged to the high nobility, his career was as a matter of course rapid and triumphant. Between the ages of thirty and forty he became archbishop or bishop. … These were lucrative benefices reserved for the younger sons of the great families. …

A rather large number of bishops and archbishops had a great train of retainers, an open table, a residence at Paris and a luxurious country home. … Often they preferred to reside at Paris, rather than in their dioceses. In 1764 it was found that more than forty bishops lived in the capital, and rarely there were less than a score there. … They were little concerned about the maintenance of religion and even less about their charitable duties. The great tithe-owners hardly helped the

> *poor. This fact was often affirmed and deplored by the parish clergy.* (Sée & Zeydel, 1927, pp. 40-41, 43)

On the other hand, there was the regular clergy. In a beehive of corporations (like the Sisters of Calvary, the Gray Friars, etc.) they devoted to caring for sick, teaching and supporting the poor. In some cities, like Dyon in Bourgogne, there were a score of religious orders.

> *But in the eighteenth century, especially during the second half, there was a growing decadence, particularly from the point of view of morality. In the old contemplative or mendicant orders there was a marked relaxation of discipline, and the discredit into which the orders fell made it difficult to fill their ranks. The prelates themselves took a severe attitude toward the monks. Thus Conzié, the archbishop of Tours, wrote in 1778: "The Gray Friars are in a state of degradation in this province. The bishops are complaining of the debauched, disorderly conduct of these friars. …*
>
> *The decadence was less felt among the new corporations, especially among those composed of women, such as the Sisters of Charity, of Wisdom, and of the Good Shepherd, who were engaged in the work of instruction and charity.* (Sée & Zeydel, 1927, pp. 41-42)

In contrast to the lifestyle of the high clergy, there were the members of the low clergy. These vicars, curates, and priest were poorly remunerated. Some were supported by their family; others shared the shabby lifestyle of the faithful. Not too surprisingly, they opposed the attitudes of the high clergy: "At the end of the ancient régime the vicars began to revolt against this attitude of their bishops and to compare their miserable lot with the opulence of their superiors"(Sée & Zeydel, 1927, p. 47).

So there was to be found a great distinction between the high clergy and the low clergy. But, speaking in general terms, the clergy was well organized, powerful, and wealthy and, as an institution, did not pay taxes to the crown. They just collected the *tithe*, a tenth's tax often paid in kind[48] by the peasants.

> *The clergy, besides its honorific preeminence, possessed very great privileges. It was an organized body, represented by a periodical Assembly, equipped with its own administration (agents-general of the clergy, diocesan chambers, etc.) and provided with its own courts of law, called officialities. It was subject to none of the ordinary direct taxes but instead determined on its own authority a "free donation" to the king. …*

[48] With a payment in kind, no money is involved.

Materially it depended neither on the state nor on the generosity of the faithful. It collected the tithe on all products of the soil, and its own landed property, very extensive in the north, somewhat less so as one went west and south, comprised probably a tenth of the kingdom. Bishops, abbots and chapters were lords over many villages, and as such received manorial dues. Closely allied with the monarchy, whose divine right was symbolized by the religious ceremony of coronation, the clergy exercised a control over thought in the interests of both Church and king, possessed a monopoly in education and poor relief and shared in the censorship of everything that was lawfully printed. …

Without Catholic sacraments the king's subject had no legal existence; his children were reputed bastards and had no rights of inheritance. Not until the beginning of 1788 did the authorities reluctantly concede the continued existence of Protestants and make exceptions in their favor. (Lefebvre & Palmer, 1947, pp. 7-8)

The Second Estate

The Second Estate was the nobility (*la noblesse*), the closed social group of landowners, often by inheritance or by appointment of the monarch (about 400,000-500,000 persons in some 80,000 noble families in 1800). They owned 30-40% of the land, depending on the region, and had their manorial privileges. The *seigneur du manoir* (lordship of the manor) especially had its rights, from the earlier mentioned medieval *droit du seigneur* of deflowering his serf's daughter before her wedding to more material privileges such as the *honorary pre-eminences*: the right to have a coat of arms, a lord's bench in the parish church, and special vaults.

The power of the lord of the manor over his fief also showed in the obligatory contributions from his peasant underlings: either in labour (*corvée*) or in kind. Next, he collected from the peasants working and living on his lands (feudal dues). And there was the *droit de banalite*: the obligation for his underlings to make use (pay for) of the facilities of the lord, such as the mill or his winepress. This manorialism characterized the relations between the lord and his peasantry. And, of course, the nobility themselves did not have to pay taxes to the state either.

The nobility as a class was les and les homogeneous. Some were very rich, like La Fayette, who inherited 140.000 livres a year at the death of his father. They lived at court or in sumptuous chateaux, like Rohan at Saverne and Briene at Brunoy. Their manner of life often lacked balance and seriousness, and many ended up greatly in debt, for example the Guemene family, which went bankrupt on the eve of the Revolution. The provincial nobles led a les dissipated existence; many were scarcely comfortable and some were even poor, especially in the hilly regions. The large class of needy gentry were of all the nobility the most wedded to tradition and

> *the least inclined to concessions, for they feared that to give up their feudal rights or even to pay more taxes would consummate their ruin.* (Lefebvre & Palmer, 1947, p. 11)

Originally, the Nobles of the Sword (*Noblesse d'Épée*), who came from the oldest nobility of France for over four generations, constituted the aristocracy of France. But their group was expanded by the Nobles of the Robe (*Noblesse de Robe*): bourgeoisie who by merit rose to power and were knighted by the king or who had bought, inherited or otherwise obtained certain administrative posts like the membership of the provincial parlements[49] (the appellate courts). Although they were not allowed to carry a sword, their position gave them enormous prestige and power[50]. That right to obtain a venal office had to be paid for to the king, and for the right to hold a hereditary office, they paid an annual fee to the king (*la paulette*): 1/60th of the price of the office originally paid for.

Among the higher-ranking nobility there where those who were presented at the court. To secure one's place in the ranks of nobility, it was essential to be presented.

> *Toward the end of the ancien régime there were 4000 families that had been presented, representing about 20.000 persons. [...] Indeed under Louis XVI there were more presentations than ever. Many provincial noblemen coveted this honor. […] The presentation was not only an honor. It conferred considerable advantages, especially in the army. It made it easy to intrigue for high military offices. With all the merit and efficiency in the world, one could not pass beyond the rank of colonel, unless one had been presented at court.* (Sée & Zeydel, 1927, p. 53)

One of those presented to the king was Marie-Joseph Paul Yves Roch Gilbert du Motier de Lafayette, Marquis de Lafayette (1757-1834). Born in a wealthy, land-owning family in the province of Auvergne, he was commissioned an officer at the age of 14. At that age he already had a yearly income of 150,000 livres (somewhat equivalent to $1.5 million today). In 1774, he married the wealthy daughter of the Duc d'Ayen, an aristocrat close to the royal family. As a member of the Assembly of the Notables and

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[49] Parlements were the court of final appeal of the judicial system and typically wielded much power over a wide range of subject matter, especially taxation. The parlement had the duty to record all royal edicts and laws. Some, especially the Parlement of Paris, gradually acquired the habit of refusing to register legislation with which they disagreed until the king held a *lit de justice* or sent a *lettre de jussion* to force them to act.

[50] Their power originated from the juridical system in which they had the possibility to order torture and pronounce death sentences (even for mere theft) by hanging, decapitation, the breaking wheel or burning at the stake. The system continued until the eighteenth century.

the Estates-General of 1789, he would become a key figure in the French Revolution (Figure 16).

> *This enormously wealthy young nobleman, enamored of the ideals of the American Revolution, traveled to the [American] colonies in the summer of 1777 where he volunteered to join the cause. Soon thereafter, at age 20, he received his commission as a major general in George Washington's Continental Army. Lafayette developed close friendships with a panoply of American Revolutionary War era icons, including five future presidents: Washington, Thomas Jefferson, James Madison, James Monroe and John Quincy Adams. …*
>
> *Lafayette served on Washington's staff for six weeks, then was given command of his own division and fought boldly and with distinction in New Jersey and Pennsylvania. He returned to France in 1778 where, working with Benjamin Franklin, the young Marquis accomplished what was arguably an even more important mission: helping secure full French support for the American cause. Lafayette came back to U.S. shores in 1780 and immediately and enthusiastically returned to fighting the British.*[51]

Before the revolution, his house in Paris, the Hôtel de La Fayette in Paris's rue de Bourbon, became the headquarters of Americans there. Benjamin Franklin, John and Sarah Jay, and John and Abigail Adams met there every Monday and dined in company with Lafayette's family and the liberal nobility. In 1825, when the Marquis was on a visit to the United States, it was the young painter Samuel F.B. Morse who was commissioned to paint a portrait of him (Figure 16).

Figure 16: The Marquis de LaFayette (1825-1826).

Painting by Samuel F.B Morse

Source: The Atheneum, www.the-athenaeum.org/art/full.php?ID=49066#

Next to the presented nobility, there was the Court Nobility (*Noblesse du Cour*) that had greatest privileges and most lucrative offices and pensions. These were the extremely rich nobility with enormous incomes and owners of great fortunes. They lived in the great castels such as the châteaux along the river Loire (Figure 17): Château De Chenonceau, Château d'Azay-Le-Rideau, Château de Chambord, Château de Chaumont, Château d'Usse, Château De

[51] Source: Leepson, M. Lafayette, Lessons in Leadership from the Idealistic General: http://www.marcleepson.com/lafayette/thebook.html

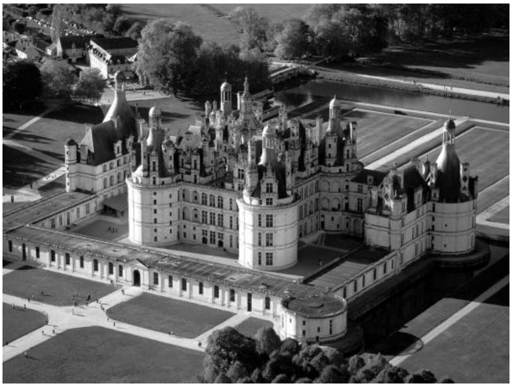

Figure 17: Chateau de Chambord (top) and Château de Villandry with gardens (bottom).
Source: Wikimedia Commons

Villandry, Château de Blois, Château de Cheverny, Château d'Amboise, etc. In all the residencies, there were endless feasts, theatrical performances and magnificent hunts.

> *Many members of the high nobility led a very pompous, ruinous life. The memoirs of the time reveal the luxury in garments and robes, for the clothing of the men rivaled that of the women in costly ornaments. … The court nobility boasted of having the finest horses and the most elegant carriages, often upholstered in velvet and decorated with painted panels. Luxury at table was particularly striven for by the magistrates and financiers. An army of servants was employed. It was nothing unusual to find in a nobleman's house from 30 to 40 men-servants, not to mention the chambermaids and stewards. Finally it was fashionable to support mistresses, who received sumptuous pensions, not to mention presents. … The receptions in high society were no less expensive, regardless of whether they were given in conjunction with balls, dinners, theatrical performances or hunts.* (Sée & Zeydel, 1927, p. 55)

Monarchs very often expected the more important nobles to spend much of the year in attendance at court[52], where they were joined by other courtiers. Not all courtiers were noble, as they included clergy, soldiers, clerks, secretaries, and agents and middlemen of all sorts with regular

[52] A famous member of the *nobles du court* was Louis Rohan, Cardinal de Rohan (1734-1803), descendant from the kings of Brittany. He inherited important clerical positions, becoming bishop of Strasbourg, and was ambassador to the Austrian court.

business at court. Those personal favourites without business around the monarch, sometimes called the *camarilla*, were also considered courtiers. And naturally, there were those female courtesans that were quite close to the king: his mistresses[53].

Well, obviously all those expenditures had to be paid for. So the nobles needed income, in form of pensions drawn from the treasury. The sums where enormous: for example in the case of the pensions given by Madame de Pompadour to the members of her family and to her friends (Sée & Zeydel, 1927, p. 97).

But also the king needed to finance his expenditures, like granting rich endowments to the daughters of favourites at the time of their marriage or giving presents to his mistresses. Take the example the scandal of the diamond necklace[54]. This 2800-carat[55] necklace was originally commissioned for 1,600,000 livres by Louis XV for his mistress Madame de Barry. As he died before it was paid for, it became, as part of the numerous court intrigues, an affair that would tarnish the reputation of Queen Marie-Antoinette (Figure 18).

> *When at the time of the Revolution the Red Book[56] revealed the startling sum of pensions granted to the favorites of the court, the hatred against the ancien régime naturally increased, and cries of anger arose against this useless aristocracy, against these parasites, for whose foolish extravagances the royal treasury had to pay.* (Sée & Zeydel, 1927, pp. 97-98)

Marie-Antoinette, as the wife of Louis XVI, had nearly 300 dresses made annually for her various social engagements at the court of Versailles,

53 A famous *courtesaine* was Jeanne Antoinette Poisson, known as Madame de Pompadour (1721-1764). She was the official chief mistress of King Louis XV, a notorious womaniser. Jeanne was from common background (although her biological father is suspected to be the tax collector Le Normant de Tournehem). Next to being beautiful and intelligent, she was well educated and an accomplished actress and singer who, being married into nobility of the robe, was in 1745 introduced to the king. Soon she became his mistress and wielded considerable power and control behind the scenes.

54 More details at: http://www.marie-antoinette.org/articles/diamondnecklace/#more-1121 (Accessed January 2015).

55 In our present time, a 1-carat diamond at wholesale price would cost $3,080-26,950. So the necklace had a value equivalent to tens of millions of dollars—or even $100 million—in our present time.

56 The Red Book is a register of all the pensions, donations and every kind of expenditure of public money by the court of the twenty years before the French Revolution (de Moleville, 1800).

her private parties at Petit Trianon[57] and for the stage of her jewel-box theatre. She contributed greatly in this way to the economy of the silk city of Lyon.

All the money for the extravagant lifestyle directly came out of the treasury. Speaking more in general terms, the conclusion is clear that the aristocracy put the burden of their lifestyle on the peasantry one way or the other.

So, there was the extravagant rich nobility. On the other hand, the provincial nobility, living in manors, lived in varying conditions. Among these the poor nobility of the country were gentlemen living in manors that were falling into ruins who were in constant need of money.

Figure 18: Queen Marie-Antoinette, wife of Louis XVI in a court dress.

Source: Wikimedia Commons, painting by Louise Élisabeth Vigée Le Brun

> *The noble proprietors suffered reverses as the result of bad crops and were hardly better off than the farmers themselves. … In 1789 seven noblemen dressed as peasants appeared before the provincial assembly of Poitou. They could not even pay their own expenses at the inn, and they confessed that their daughters worked in the farm-yard and herded the sheep in the fields. … Accordingly it is easy to understand the hostility felt by the poor, petty nobility toward the court nobility in 1789, for the latter garnered all the favors, the lucrative sinecures and the military positions.* (Sée & Zeydel, 1927, pp. 59-60)

Some of the not-too-poor nobility became industrious in salt mining, manufacturing, iron melting and glass making, while others speculated in real estate. Some bought shares in the tax concession, which collected custom duties, and managed the sale of salt, the government monopoly. But most relied on demanding their feudal rights:

> *They [the aristocracy] farmed out their rights to bourgeois agents who were relentless in collection of dues; they had minutely detailed manor-rolls drawn up,*

[57] A small chateau located on the grounds of the Palais de Versailles. It was A house of intimacy and of pleasure. The building was designed to require as little interaction between guests and servants as possible.

putting into effect dues which had become obsolete; they prevailed upon the king to issue edicts allowing them to appropriate a third of the common lands or to enclose their own fields and forbid the peasants to pasture their animals in them; they made use of the 'planting right' to set out trees along the roads on land belonging to the peasants; they expelled the peasants from the forests. (Lefebvre & Palmer, 1947, pp. 13-14)

Then there was the nobility, which can be labelled as the parliamentary[58] nobility and the administrative nobility. They were in a position halfway between the bourgeoisie and the nobility, occupied as judges of sovereign court and regional parlements, important positions in the regional structure of France (Figure 19). In the eighteenth century, it was a complete fusion between the nobility of the sword (*noblesse d'épée*) and that of the gown *(noblesse de robe).* It was dominantly a conservative lot, as they had much to lose in case of social change.

… *the members of the parliaments claimed to adhere to the old customs. They frowned upon the diminution of the cost of justice, the abolition of the judges' fees and the unification of practises. They did not wish to change the ancient criminal procedure, which was so unjust and involved so many errors of justice, and they adhered to the barbaric system of torture. Not until the eve of the Revolution (1780–1788) were the forms of torture known as question préalable and question préliminaire abolished.* (Sée & Zeydel, 1927, p. 66)

The administrative nobility were those high dignitaries, the members of the council of state and the provincial governors, or intendants[59], that had bought venal offices and formed a genuine caste.

To an increasing extent, toward the end of the ancien regime, they dealt with economic questions, and often happily. If they were unpopular, it was due to the fact that they showed themselves hostile to experiments in self-government, especially to the institution of the provincial assemblies. They came to be looked upon as the principal agents of "despotism." (Sée & Zeydel, 1927, p. 68)

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[58] Keep in mind that the meaning of the word *parliamentary* here is different from our present meaning. Parlements were in the Ancien Régime the provincial appellate courts. In that time there were 13 parlements in France. They were not legislative bodies but rather provincial high courts that heard appeals from the lower courts of record. Each was composed of a dozen or more appellate judges, or about 1,100 nationwide.

[59] These civil servants were the result of centralization policies of the French crown. Intendants were sent to supervise and enforce the king's will in the provinces and had jurisdiction over three areas: finances, policing and justice.

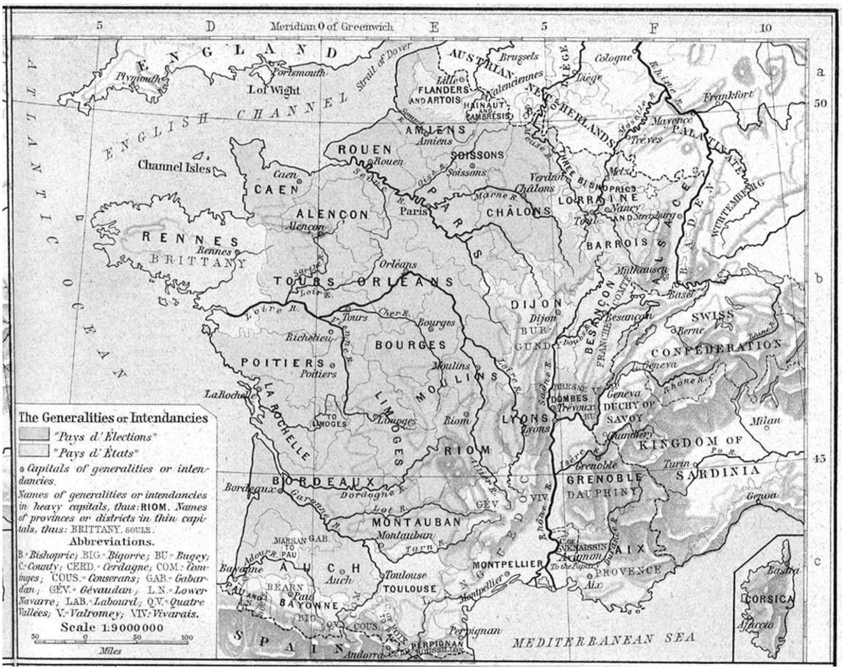

Figure 19: The Generalities and Intendancies (1789).

The 36 regions with their administrative divisions in France under the Ancien Régime.

Source: www.lib.utexas.edu/maps/historical/ shepherd/france_generalities_1789.jpg

To conclude this short overview, the nobility, although divided along lines of wealth and income, in general was a very powerful social class, especially the high-nobility, as it occupied the positions at the court, the institutions of state and the positions in the church. As a class they were in a constant conflict of interest with the monarchy.

The Third Estate

Next to the clergy and the aristocracy there was the Third Estate. It consisted of bourgeois and peasantry, the bourgeoisie being the middle classes (doctors, lawyers, shopkeepers), the wage labourers and the artisans living in the villages. The bourgeoisie was the collective of many professions, like the industrially active people who employed others:

> *Everywhere in France the tanneries, glass-works and paper-mills, with the exception of a few large establishments, as well as the dyeing establishments and laundries, were small concerns that employed only a few workmen. In most of the cities the small artisans who worked alone or employed but a single assistant were in the majority.* (Sée & Zeydel, 1927, p. 69)

There also were the artisans (printers, apothecaries, goldsmiths, card makers, button makers, bakers, butchers, builders, cobblers, hat makers, etc.) organized in guilds (*corps de métiers*) that had a specific role. Those guilds were also a conservative and protectionist lot:

> *They [the guilds] aimed to maintain the collective monopoly of the masters of the same trade. They tried also to diminish the effects of competition, forbidding masters to have more than one shop, opposing the monopolies and endeavoring to assure to all the necessary raw material. Each of the trades formed a closed body, in opposition to the rest of the guilds. Each tried to maintain its privileges and monopoly and to defend itself against the encroachments of a neighboring guild, but at the same time to encroach upon others. Hence there were interminable lawsuits everywhere—between shoemakers and cobblers, and between tailors and old clothes dealers. The haberdashers were always in conflict with all sorts of other guilds, precisely because they claimed the right to sell all kinds of goods. The clothes merchants tried constantly to defend themselves against the competition of the haberdashers, wholesale clothiers, tailors and jewelers, who did not hesitate to sell clothing to their customers. …The spirit of routine in the guilds was increased. They were hostile to every innovation. In 1736 the button makers tried to oppose the manufacture of trade-buttons. … Thus, at the very time when the requirements of production were increasing, the trades guilds formed an obstacle in the path of industrial progress.* (Sée & Zeydel, 1927, pp. 72-74)

The crown, always in need of money, tried to levy license fees upon the guilds. This was one of the causes that made the guilds come into problems, and soon it became clear reforms were needed. In spite of the limited improvements in the system, it did not work out, and the conservative forces of the economy contributed to increasing tension in French society.

> *In 1775 they published a memorial of Bigot de Sainte-Croix entitled "Essai sur la liberté du commerce et de l'industrie" (Essay on the Freedom of Commerce and Industry), which revealed clearly all the defects of the guild system and demanded the complete freedom of commerce and industry. … in spite of certain improvements in the system, the question of the guilds was still a burning one when the Revolution broke out. In 1789 many of the memorials urged their abolition. These memorials reflected the feelings of the high bourgeoisie, the free*

Figure 20: The Third Estate carrying the Clergy and the Nobility on its back (1789).
Source: Wikimedi Commons

> *professions and the merchants. On the other hand, the masters of the trades demanded their retention.* (Sée & Zeydel, 1927, p. 75)

The peasantry was the largest group, being peasants living in rural areas, sometimes owning small plots of land, more often leasing the land of clergy and nobility and often working as day labourers or servants. This rural proletariat could hardly sustain life, and many became beggars and vagabonds. Of the 23 million people, most of which lived in the countryside, whereas the population of the cities hardly exceeded two million.

> *The peasants, although they enjoyed complete liberty, did not, however, form a single class, for they did not all possess the same amount of property. There were some who could live exclusively from the cultivation of their fields, and who constituted a sort of peasant aristocracy, the class of laborers. They were the ones who increased their holdings, profited by clearings, and during the Revolution took advantage of the sale of the national property. But most of the peasants did not own enough land to permit them to live thereby. If they had some capital they became farmers or métayers (co-operative farmers). The poorest hired themselves out as day-laborers or servants. Many of the proprietor peasants conducted a gainful trade on the side, being merchants, millers, innkeepers or artisans (masons, carpenters, tailors, weavers). Thus the extension of rural industry is explained.* (Sée & Zeydel, 1927, p. 18)

That was in rough brushstrokes an overview of the structure of the French society at the dawn of the revolution. Seen from a different perspective—in short—the Third Estate consisted of the people who paid the taxes to the state, the church and the feudal lords (Figure 20): taxes needed to fund clerical, nobility and court's luxury expenses and for warfarin and the national debt. Obviously, there were many taxes, such as the *taille*, a land tax on the landowning peasantry and the *gabelle*[60], a tax on salt that differed from region to region. And there was the *corvee*: unpaid labour for a limited number of days. There were also the *taillon* (tax for military expenditure), the *vingttieme* (5% on net earnings from land, property, commerce), the *aides* (tariffs on products like tobacco and wine); the *douane* tax (on specialty products) and the *octroi* (local tax on products entering towns). The salt tax was one of the most hated and most grossly unequal taxes in the country (Figure 21). And the people who collected the taxes, the farmers general, were equally hated.

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[60] Salt was a state monopoly that had a massive impact on the common people. People older than eight years were obliged to purchase a minimum amount of salt at a fixed price (the *sel de devoir*).

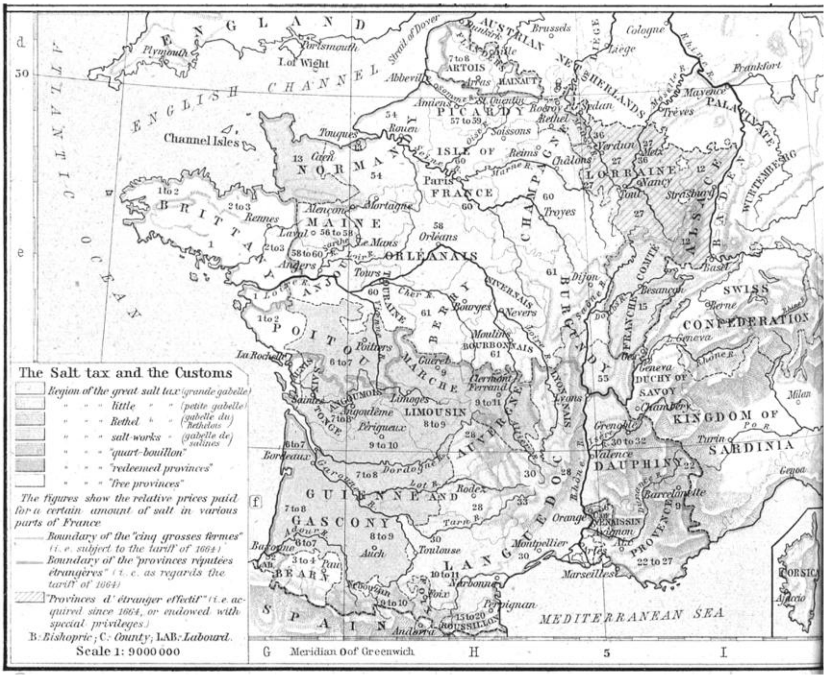


Figure 21: The regions with different tariffs for the salt tax (1789).

The 'pays' (regions) with their different taxation (*gabelle*) for salt: from *pays de grandes gabelles* to the *pays exempts.* Figures show relative prices.

Source: http://www.lib.utexas.edu/maps/historical/shepherd/ france_salt_tax_1789.jpg

For the transfer of wealth from the countryside to the towns, all those taxes had to be collected, and it was the *Fermiers generaux*, organized in the *Ferme generale*, who did that on behalf of the king. The partners in the Company of the General Farms, a cartel of venal offices, committed to paying the royal treasury the amount of the lease and received in return any surplus. Thus they were becoming very rich themselves. The Compagny Ferme Générale had its headquarters in Paris. In its central offices it employed nearly 700 people, including two chaplains. Its local operations included up to 42 provincial offices and nearly 25,000 agents distributed in two branches of activity: the offices that checked, liquidated and charged the fees and the guards' brigades, which sought and suppressed smuggling with very severe punishments (such as hard labour or hanging). They also created a postal system that employed 12,000 agents in 1,284 post offices and 3,000 relay stations.

The *Fermiers general* became rich, sometimes enormously rich, and they showed it.

> *The farmers general became notorious also for their pompous display. At Paris they built splendid mansions; …. In the country they had superb residences, not to mention the "small houses" or folies in the suburbs. In the immediate vicinity of Paris, in Passy, Auteuil, Vanves, Ivry, Puteaux and Neuilly, the rich financiers had splendid country homes. They had the richest furnishings and the works of art that revealed the best taste. The most skilled artisans and artists were in their employ. The memoirs and correspondence of the time reveal also the fact that the financiers squandered much money foolishly upon their mistresses and upon actresses and operatic singers.* (Sée & Zeydel, 1927, p. 105)

All their wealth came from the Third Estate, among which the peasantry, living in conditions that were dominated by economic misery aggregated by food shortage, causing famine, and pestered by diseases and epidemics caused by the climatic conditions in that time. By the end of the eighteenth century, the *Ferme générale* system became a symbol of an unequal society. The *Ferme générale*, with its colossal fortune, was seen as encapsulating all the perversions of the political and social system. People blamed the injustices and the annoyances—which actually arose from the complexity of the tax system—on the company itself, including the brutality of tax collecting troops and the brutal repression of smuggling.

Climate and the Affair of Man

The peasants, often already living under marginal conditions, were the first to feel the consequences of the often-recurring changes in the weather conditions. In extremely warm summers, the harvest failed of draught; in winter, prolonged frosts and snow damaged vines and wrecked chestnut and olive orchards. Whatever the local situation, it often left people that were dependent on the whims of nature with food shortages.

Take, for example, the aftermath of the eruption of Laki Volcano in Iceland in 1783-1784 that hit large parts of Europe (Figure 22):

> *The summer of the year 1783 was an amazing and portentous one, and full of horrible phenomena; for besides the alarming meteors and tremendous thunder-storms that affrighted and distressed the different counties of this kingdom [England], the peculiar haze, or smokey fog, that prevailed for many weeks in this island, and in every part of Europe, and even beyond its limits, was a most extraordinary appearance, unlike anything known within the memory of man.* (C. A. Wood, 1984)

> *The consequences of Laki make it one of the greatest natural disasters of the past millennium. In Britain, ~23,000 died from gas fumes, placing the event among the greatest disasters in British history. There were heat waves in northern and western Europe, while in France a priest performed an exorcism of the Laki dust*

cloud. Laki may even have contributed to the onset of the French Revolution, due to destruction of crops and livestock …

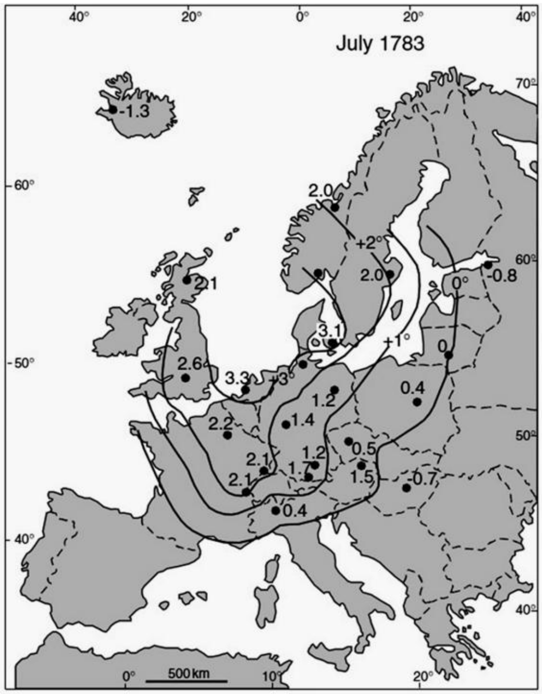


Figure 22: Temperature effect from the eruption of the Laki Volcano at Iceland (1783-1784).

Deviation of the 1783 July surface temperatures from the 1768–1798 mean. Numbers are given in degrees centigrade and the distribution of the anomaly is indicated by isotherms, drawn at 1ºC intervals

Source: (Thordarson & Self, 2003), Figure 8.

Following closely on the heels of this anomalous summer, the 1783–1784 winter was extremely cold and snowy around the circum-North Atlantic. European temperatures were ~2°C below average for the late 1700s, and it was among the coldest winters in central England. Iceland was ~5°C colder than normal, with the longest period of sea ice ever recorded. Cold, frozen soils, icebound watercourses and high snow levels were documented across Europe. (D'Arrigo, Seager, Smerdon, LeGrande, & Cook, 2011, p. 1)

As the peasantry was such a large part of society, in the prelude of the revolution of 1789, the "peasant question" became dominant:

The peasant question was bound to be of importance in a country in which the rural population was numerically so important, where industry on a large scale was only in its infancy, and where agricultural production was more important than all other branches. (Sée & Zeydel, 1927, p. 36)

The picure that emerges from the preceding rough brush strokes of the social situation in the late eighteenth century shows that in the period before the actual start of the revolution in 1789 there were already strong tensions between the social groups. On one hand, there were tensions between royalty and nobility that would lead to the *Aristocratic Revolution*. On the other hand were the protests from the Third Estate: tensions where social and demographical developments resulted in the *Bourgeois Revolution*, caused in part by the democratic wishes of the Third Estate. The nobility rose against the monarchy, and the bourgeoisie revolted against the nobility: "… the century also witnessed the last offensive of the aristocracy, of which the beginnings of the Revolution were merely the crowning effort" (Lefebvre & Palmer, 1947, p. 15). The situation was aggravated by the severe climate conditions at the time, which contributed to the *Peasant Revolution.*

The Changing Social Context

In the following, we will investigate the changes that occurred in France in the first half of the nineteenth century—a period that can be divided into distinct phases, starting with the period known as the French Revolution at the end of the eighteenth century.

The French Revolution (1787-1792)

France was approaching the end of the eighteenth century when French society was confronted with a dramatic period of change, later called the French Revolution. It was a period of societal change that would leave its traces throughout Europe for decades to come in the next century. It was the first phase of a range of distinctive periods in the first half of nineteenth-century France, and it seemed that one of its triggers was the financial problems of the state—problems that were the pinnacle of the underlying societal problem earlier described.

Financial Problems for the State [61]

It started with financial crises, as the state had accumulated huge debts and could not obtain loans to finance it, resulting in total chaos. But there was more to it.

> *By 1787, the French Crown was on the verge of collapse. Financially ruined by the ballooning of an immense state debt, the monarchy's prestige lay shattered by defeat in Europe and vast colonial losses. … At this point the monarchy found itself without the resources to the status it had consistently enjoyed for centuries in international, maritime and colonial affairs. … the French Crown had also been humiliated in European great power rivalry, most recently in the Dutch political crisis of 1787 when …Prussia's new king … invaded the United Provinces. Crushing the Dutch democratic Revolution, Prussia had restored the House of Orange, a firm ally of Britain and Prussia.* (Israel, 2014, p. 30)

[61] Much of the following text originates from Wikipedia sources such as Jacques Necker; Parlement, Louis XVIII ; Estates of 1789 ; Tennis Court Oath; Great Fear.

As indicated before, the collection of taxes was farmed out to a large number of venal offices of *fermes*, *regies* and *receveurs*. These corporate entities contracted with the crown to collect taxes for either a fixed price or a share of the total receipts. After deduction of costs (mostly interest payment on debts) they turned the remainder over to the royal treasury. When faced with a deficit, the crown issued a variety of debt instruments. Over the years, the rising debt caused a problem: "From a banker's viewpoint French public loans after 1777 should have appeared as bad risks. By paying excessive returns the state was behaving like a near-bankrupt merchant" (Eugene N. White, 1989, p. 547).

It was Jacques Necker, a Swiss (and protestant) banker, who published in 1781 the *Compte Rendu au Roi* (Financial Summary for the King), summarizing government's income and expenses. There were no concerns, was his message, as the report stated—incorrectly—that ordinary revenues in France were exceeding expenditure by over 10 million livres. The health of the accounts as reported in the *Compte rendu* boosted confidence among lenders and ordinary people, who saw Necker as a strong financial manager due to his prior experience as a banker. The report bolstered his reputation further. However, to reduce costs, he decided to eliminate more and more venal offices: "He abolished the Intendants of Finances and many of the numerous treasurers and controllers for the military and royal households, who had enjoyed considerable autonomy" (Eugene N. White, 1989, p. 558). A couple of years later, as it became clear that Necker had been forgetting to include some costs and as his optimism was disputed, he was dismissed and exiled. His reforms were reversed.

> *Necker's successor, Jean-Francois Joly de Fleury, was no parvenu banker but an established member of a noblesse de robe family. During his tenure as financial minister, the reform of the financial administration ended and many venal offices were recreated. These changes raised the costs of tax collection by decreasing efficiency and increased expenditures because of the interest paid on the officials' security bonds.* (Eugene N. White, 1989, p. 560)

De Fleury was facing the same problem and resigned in 1783. His successor as Minister of Finance, Charles-Alexandre Vicomte de Calonnne (a nobleman like all his other dignitaries) came to a different conclusion than the optimistic report made by Necker:

> *When lenders showed themselves recalcitrant, in 1786, Calonne was obliged to notify the king that fiscal reform was absolutely inevitable. … Expenses were set down at 629,000,000 livres and revenues at 503,000,000, leaving a deficit of 126,000,000, or 20 per cent of expenses, which it was now proposed should be made up by another recourse to borrowing. …. It was the debt that was crushing*

the royal fiancées, for debt service required 318,000,000, or more than 50% of the expenditures. (Lefebvre & Palmer, 1947, pp. 20-22)

Calonne then proposed to establish the *subvention territorial*, a new tax collected in kind on all landed income with no exemption for the privileged classes. As to be expected, in 1787, nobles consisting of the princes of the blood, the higher clergy and magistrate raised a storm of protest. It was again about the question of the 1781 deficit, but when Calonne was discovered to have hidden some vital evidence, the king also dismissed him in 1787 (Eugene N. White, 1989, p. 565).

The expenditures of the state were indeed quite unbalanced. In 1789-1790, the tax collections were used for military and colonial affairs, expenses for the court, interest and unspecified expenditures (Figure 23). The 1789-1790 budgets showed a total tax collection of 384.1 million livres, a deficit of 116.1 million livres. In modern terms the state deficit would be 30%![62]

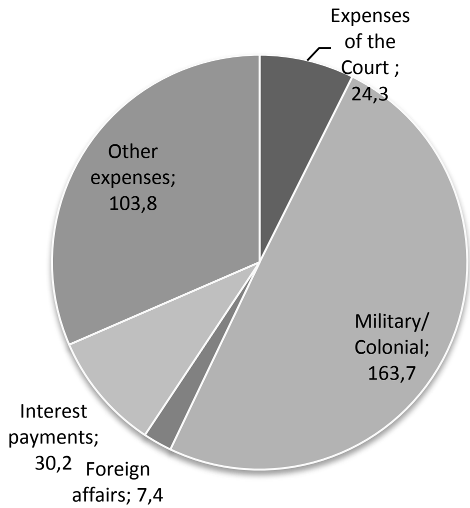


Figure 23: Expenditures by major category (Necker 1789-1790, Millions of livres).

Source: White p. 552. Table 2: Retrospective budgets of the Ancient Régime

So, again, a reform with new taxes was proposed. Raising the existing taxes was not an option. Neither was bankruptcy, as it would injure and enrage the huge creditor class in France that included not only the rich but also artisans and domestics. The solution was making taxation uniform all over the country (for example the salt and tobacco monopolies). And the tax base had to be enlarged. Technically, the crisis was easy to meet: all that was necessary was to make everybody pay. And it was exactly that measure that was threatening the tax privileges so

[62] Just to compare the state deficit to our present time, the French budget deficit in 2015 was 4% after an all-time high deficit of 2010 of 7.5%. Source: http://www.tradingeconomics.com/france/government-budget. (Accessed August 2015)

many enjoyed. A solution for repaying all the accumulated debts was the selling of the manorial properties of the church, thus eliminating the huge debt. Both were suggested at some time.

Revolt of the Nobles

The first problems arose when the nobles saw their privileges threatened when the land tax would also be imposed on their holdings. It would become the *Revolt of the Nobles*, a power struggle in 1787 between the monarchy and the nobility that could not be resolved within the existing legislative structure. Part of that structure was the Assembly of Notables, a group of high ranking nobles consulting the king. Calonne offered the assembly a choice. They could either agree to impose new taxes on the nobility or consent to force the nobles to give up their exempt status and pay the taxes currently in place. The nobles insisted on concessions in return, for they wished to share in control of the government. It did not work out, and the result was the abolition of the assembly. This resulted in the dismissal of Charles Alexandre de Calonne, who was replaced as minister of finance by the Archbishop of Toulouse, Étienne Charles de Loménie de Bienne (1727-1794).

Part of the legislative structure was the Parlement of Paris, the most important of the thirteen parlements in France. They were not legislative bodies but rather provincial high courts that heard appeals from the lower courts of record. Each was composed of a dozen or more appellate judges, or about 1,100 nationwide. They were the court of final appeal of the judicial system and typically wielded much power over a wide range of subject matter, especially taxation. It was this Parlement of Paris that challenged the king when he wanted reforms that would remove the aristocratic privileges, notably the exemption from taxes (they especially objected to the land tax). Only the Estates-General, they said, could register taxes. So, the issue of legislative power became another element of the Revolt of the Nobles.

Then, Louis XVI declared the reform to be law without any consent by implementing a "bed of justice" (*lit de justice*), which automatically registered an edict in the Parlement of Paris to ratify the desired reforms. The result was turmoil, rioting in Bourgondy, Provence and Britany, engineered by the local magistrates and nobility.

> *The aristocracy had formed a common front against the royal power. The intendants acted indecisively against such a coalition of courts, estates and upper clergy. Bertrand de Molevile, intendant of Britany, excused himself from using force against the Parliament of Rennes. Army officers declined to obey orders. The aristocratic class developed an organization for political action, exchanging*

> *correspondence and passing instructions from town to town. The Committee of Thirty, which was soon to take over the leadership of the Third Estate, seems to have originated as a center of parliamentary resistance. In Britany the nobility of the sword and of the robe, acting together, created committees in all the important cities, to which they dispatched delegates to stimulate action and give instructions. The aristocracy did not hesitate to appeal to the bourgeoisie to gain its ends. Lawyers lent their support, and shopkeepers who lived by service to the parliamentary and noble families were aroused to make demonstrations.* (Lefebvre & Palmer, 1947, pp. 30-31)

Archbishop Bienne conceded his defeat in July 1788 and it was decided there was to be held an assembly called the Estates-General: a general assembly representing the French estates of the realm: the clergy (First Estate), the nobles (Second Estate), and the common people (Third Estate). It was planned to assemble on January 24, 1789, the first meeting of the non-functioning system since 1614. It was the first large-scale response to the prolonged political and financial crisis. Elections for the deputies were to be held in the spring of 1789 by the members of the estates all over the country the same way as in 1614. By reviving them as much as possible like they had been, the aristocracy intended to control the authority of the people (the previous estates had *voted by order*; that is, the nobles and the clergy could together outvote the commons by 2 to 1). Each tax district (cities, boroughs, and parishes) would elect their own delegates to the Third Estate. The *bailliages*, or judicial districts, would elect delegates to the First and Second Estates in separate ballots.

> *The point at issue comes … when the Paris Parlement on September 23, 1788, ruled that the Estates-General should be constituted according to the precedent set in 1614. Up to this point the "aristocratic revolution" was proceeding without intervention from other social sectors and appeared to be successful in accomplishing its purpose. The Bourbon monarchy had been forced to concede constitutional limitations upon royal power, and, crippled by bankruptcy, forced to act in accordance with this concession: by reinstating, the Paris Parlement and agreeing to convoke an Estates-General to determine fiscal policy.* (Eisenstein, 1965, p. 79)

> *The first act of the Revolution, in 1788, consisted in a triumph of the aristocracy, which, taking advantage of the government crisis, hoped to reasert itself and win back the political authority of which the Capetian dynasty had despoiled it. But, after having paralyzed the royal power which upheld its own social preminence, the aristocracy opened the way to the bourgeois revolution, then to the popular revolution in the cities and finally to the revolution of the peasants—and found itself buried under the ruins of the Old Regime.* (Lefebvre & Palmer, 1947, p. 5)

Figure 24: The Cahier de Doléances de Scaer (1789).

Source: Wikimedia Commons. www.culture.gouv.fr/Wave/image/archim/0003/dafanch01_pc45003459_2.jpg

Part of the election process was that the estates could express their grievances. They were noted in the *Cahiers de Doléance* (Figure 24) and were explicitly discussed at a special meeting of the Estates-General held on May 5, 1789. In the cahiers of the First Estate, the clergy wanted internal changes but held on to their position in society. Surprisingly, in the cahiers of the Second Estate, the nobility took a more liberal position, 89% voting that they were willing to give up their financial privileges. Not surprisingly, the cahiers of the Third Estate spoke out mainly against the financial privileges held by the two other estates. The cahiers expressed the desire for change directed to the rooting out of inadequacies in the present system but not the eradication of monarchy.

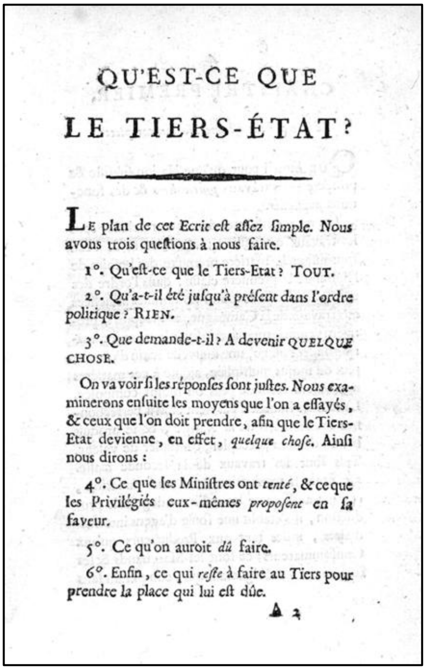
> *At the heart of the problem were perceived arbitrary abuses which were not held in check. … Another urgent issue frequently addressed was the taxation system and taxes on necessities like salt, which all three Estates identified as excessive. On this issue the three estates were of the same mind. …The cahiers reveal that, by 1789, the ideas of the enlightened thinkers had embedded themselves in the general populace, resulting in certain core principles, such as the Rights of Man, equality and freedom of thought, being integrated into the documents. These modern ideas which, in many ways contradicted the values of the ancien regime, are present in cahiers from all three estates. …*
>
> *However, the cahiers also express support for the monarchical system of the day. Although critical changes were called for, the cahiers reveal that at this stage the old regime was still widely respected and ultimately valued as an appropriate form of government. The Estates represent their grievances and reforms simply as inadequacies in the present system and did not question the monarchy itself.* [63]

[63] Source: Vancea, S.: The Cahiers de Doléances of 1789. http://cliojournal.wikispaces.com/The+Cahiers+de+Doleances+of+1789. (Accessed January 2015)

The Third Estate Protests

The Third Estate consisted of everybody outside clergy and nobility. It was a heterogeneous group of bourgeoisie (emerging industrialist and merchants, bankers, academia's, jurists and writers, often quite wealthy) and peasants (mainly poor land-working people). Many of the bourgeoisies were involved in finance, one way or the other:

> *The financiers had grown up in the service of the king. They included the bankers to the Court, the purveyors and contractors who supplied the army and navy with all kinds of transport and provisions, and above all the 'farmers-general'. These were wealthy men who formed companies to operate the "farm" or concession by which the government "farmed out" the indirect taxes, receiving an assured fixed sum, and leaving the farmers to make collections and retain the proceeds. …*
>
> *Financiers were grand personages, allied by marriage with the aristocracy, cultivated men, sometimes learned, sometimes writers or patrons of the arts—for example Lavoisier, Helvetius, Dupin de Francueil, La Popeliniere, Laborde. With them may be classified Treasury officials not yet raised to the nobility. In addition, toward the end of the Old Regime, Paris saw a great increase in the number of bankers. They were foreigners and Protestants for the most part. … For all of them the making of government loans was their main business.* (Lefebvre & Palmer, 1947, pp. 36-37)


QU'EST-CE QUE
LE TIERS-ÉTAT?

Le plan de cet Ecrit eſt aſſez ſimple. Nous avons trois queſtions à nous faire.

1°. Qu'eſt-ce que le Tiers-Etat? TOUT.

2°. Qu'a-t-il été juſqu'à préſent dans l'ordre politique? RIEN.

3°. Que demande-t-il? A devenir QUELQUE CHOSE.

On va voir ſi les réponſes ſont juſtes. Nous examinerons enſuite les moyens que l'on a eſſayés, & ceux que l'on doit prendre, afin que le Tiers-Etat devienne, en effet, *quelque choſe*. Ainſi nous dirons:

4°. Ce que les Miniſtres ont *tenté*, & ce que les Privilégiés eux-mêmes *propoſent* en ſa faveur.

5°. Ce qu'on auroit *dû* faire.

6°. Enfin, ce qui *reſte* à faire au Tiers pour prendre la place qui lui eſt dûe.

A 2

Figure 25: Abbe Sieyes: "What Is the Third Estate?" (1789).

Source: Wikimedia Commons. www.culture.gouv.fr/Wave/image/archim/0003/dafanch01_pc45003459_2.jpg

What all the different groups in the Third Estate had in common was that they all wanted to get rid of the dominance of the First and Second Estates and be treated more fairly. As analysed in a political pamphlet of clergyman, Abbé Emmanuel Joseph Sieyès said, "What Is the Third Estate? Everything. What has it been until now? Nothing. What does it ask? To be something" (Figure 25).

Sieyès stated that the people (the *tiers-état*) wanted genuine representatives in the Estates-General, equal representation to the other two Estates, and votes taken by heads and not by orders. Sieyès outlined the desires and frustrations of the alienated class of people that made up the Third Estate. He set out to reveal the perceived fraudulent nature of the nobility and the suffering of the overburdened and despondent French people, who he saw as victims of aristocratic parasitism. The pamphlet was essentially the rallying cry for the Third Estate, who came to outline and clearly state grievances that, for the first time, were not to be overlooked in the convocation of the Estates-General.

For months, preparations for the great gathering dominated politics in Paris and the provinces. A major topic was the representation, fuelled by the new phenomenon of pamphlets that created a new political culture and heralded the important influence of the press to come. When the elections for the deputies in early 1789 were concluded, the Estates-General assembled on May 4, 1789 in Versailles[64]. (Figure 26)

> *The deputies of the Third on the opening day marched directly behind the guard, at the head of the procession, modestly clad in the historic black costume of the French bourgeois, and followed by the nobility gilded and beplumed. Similarly the*

Figure 26: The opening of the Estates-General (May 4, 1789).

Source: Painting by Auguste Couder, Wikimedi Commons.

[64] Why was the assembly to be held in Versailles, not in Paris as one might expect? One reason was certainly the turmoil in the city that would interrupt the deliberations by popular interference. And another reason was that the king did not want interference with his hunting habits.

parish priests, in black habit, were grouped before the bishops and cardinals. When the deputies went to pay their respects at the chateau the king took pains to express special regard for "his" clergy and 'his" nobility. Nor were similar embarrassments avoided at the opening session on May 5. The three orders installed themselves in a newly built hall in the Rue des Chantiers, behind the Hotel des Menus Plaisirs, which ran along the Avenue de Paris. (Lefebvre & Palmer, 1947, p. 66)

However, due to the issue of representation, the Estates-General soon reached an impasse. The Third Estate (then called the Commons) wanted a numerical representation (one man one vote) instead of the former estate representation. On June 17, 1789 the Commons created their own National Assembly and granted itself control over taxation. When they were locked out of a meeting of the Estates-General on June 20 1789, they assembled on a nearby indoor *jeu de paume* court (early version of tennis) and took an oath that was a pledge signed by 576 of the 577 members from the Third Estate (Figure 27): the Oath of the Tennis Court*:* "We swear not to separate and to reassemble wherever circumstances require, until the Constitution of the Kingdom is established and built on solid foundations". The oath was both a revolutionary act and an assertion that political authority derived from the people and their representatives rather than from the monarch himself. This solemn oath, taken on June 20, in the

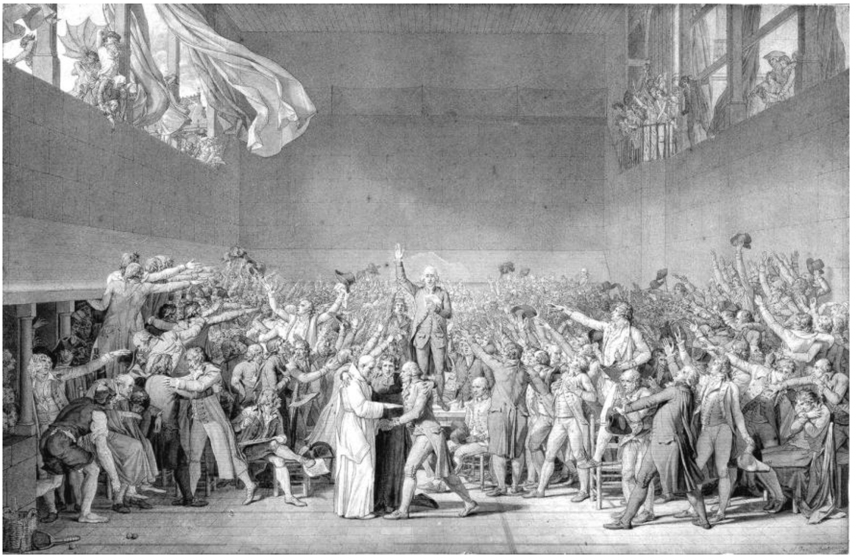


Figure 27: The Oath of the Tennis Court (1789).

Source: Wikimedia Commons, Jacques-Louis David presence of the nation, was followed on June 22 by an important triumph. The assembly met in the church of Saint Louis.

> *A numerous guard surrounded the hall of the states-general, the door of which was opened to the deputies, but closed to the public. The king came surrounded with the pomp of power; he was received, contrary to the usual custom, in profound silence. His speech completed the measure of discontent by the tone of authority with which he dictated measures rejected by public opinion and by the assembly. The king complained of a want of union, excited by the court itself; he censured the conduct of the assembly, regarding it only as the order of the third estate; he annulled its decrees, enjoined the continuance of the orders, imposed reforms, and determined their limits; enjoined the states-general to adopt them, and threatened to dissolve them and to provide alone for the welfare of the kingdom, if he met with more opposition on their part. After this scene of authority, so ill-suited to the occasion, and at variance with his heart, Louis XVI. withdrew, having commanded the deputies to disperse. The clergy and nobility obeyed. The deputies of the people, motionless, silent, and indignant, remained seated. They continued in that attitude some time, when Mirabeau suddenly breaking silence, said: "Gentlemen, I admit that what you have just heard might be for the welfare of the country, were it not that the presents of despotism are always dangerous. What is this insulting dictatorship? The pomp of arms, the violation of the national temple, are resorted to—to command you to be happy! Who gives this command? Your mandatary. Who makes these imperious laws for you? Your mandatary; he who should rather receive them from you, gentlemen—from us, who are invested with a political and inviolable priesthood; from us, in a word, to whom alone twenty-five millions of men are looking for certain happiness, because it is to be consented to, and given and received by all. But the liberty of your discussions is enchained; a military force surrounds the assembly! Where are the enemies of the nation? Is Catiline at our gates? I demand, investing yourselves with your dignity, with your legislative power, you inclose yourselves within the religion of your oath. It does not permit you to separate till you have formed a constitution.* (Mignet, 1888)

On that day, the royal authority was lost. The initiative in law and moral power passed from the monarch to the assembly. The solidarity of the Third Estate forced Louis XVI to order the clergy and the nobility to join with the Third Estate in the National Assembly in order to give the illusion that he controlled the National Assembly.

> *Hence was effected the bourgeois revolution, or what may be called a juridical revolution, realized without recourse to violence, by methods taken over from the Parliaments by men trained in the law. On July 7 the Assembly appointed a committee on the constitution, whose first report was presented by Mounier on July*

> *9. Henceforward, and for history, the Assembly was the "National Constituent Assembly."* (Lefebvre & Palmer, 1947, pp. 77-78)

The new National Constituent Assembly created the historic and influential document *The Declaration of the Rights of Man*, which stated the principle that all men had equal rights under the law. "Men are born free and equal in their rights. ...These rights are liberty, property, security and resistance to oppression. The fundamental source of all sovereignty resides in the nation. The law is the expression of the general will. All citizens have the right to take part personally, or through representatives, in the making of the law." It resulted of the abolishment of the feudal rights on August 13, 1789: both the seigneurial rights and the tithes gathered by the clergy.

In the same period, the National Constituent Assembly tried to resolve the immediate financial crisis by seizing (nationalizing) all the church lands and putting the church under control of the state. In the law of July 12, 1790, the Civil Constitution of the Clergy, it was formalized. On November 27, 1790, it was complemented by the Oath of Alliance, an oath of loyalty to the constitution required of the clergy, and the juridical system based on the parlements was suspended in November 1789. In a short period, the old powers of the Ancien Régime lost their privileged position (with the Declaration of the Rights of Man as the death certificate of the old regime). At least in theory, as in reality, it was not so easy to implement the changes, as the assembly did not create the necessary laws.

The Popular Revolution

The tensions between the social classes and the political causes, combined with the continuing food scarcity, resulted in the *Popular Revolution*. In the countryside, many peasant communities believed that the nobles were deliberately sabotaging the reform work of the assembly. In the preceding month, Paris had already been consumed by riots, chaos and widespread looting. The food shortages made food expensive, reducing the purchasing power of the masses.

> *… it has been calculated that between 1726-1741 and 1785-1789 prices rose 65 per cent while wages went up only 22 per cent. In 1789 a Paris workman earned on the average some 30 to 40 sous a day. For him to live, it was. estimated that bread should cost no more than 2 sous a pound. In the first half of July the price was twice this figure. In the provinces it was much higher, reaching 8 sous or more, because the government, fearing disturbances in Paris, had no hesitation in selling there, well below the current price, the grain which it imported from abroad. …*
>
> *The small people never resigned themselves to explaining scarcity and high prices simply by the weather. They knew that tithe owners and manorial lords who*

> *collected dues in kind had considerable stores of grain, which they withheld from sale while waiting calmly for higher prices. Even more bitterly they blamed the dealers in grain - the small merchants who went from one market to another, the millers and bakers to whom trade in grain was forbidden but who engaged in it fraudulently. All were suspected of withholding, or hoarding, to precipitate or encourage a price increase. …*
>
> *It is not surprising that want and high prices were frequent causes of rioting. Sometimes the attack fell on those thought to possess stores of grain or be trading in it; their establishments were pillaged or they themselves were put 'to the lantern," ie, hanged by the cord from which a street lamp usually swung.* (Lefebvre & Palmer, 1947, pp. 93-94)

In July 1789 Louis XVI, in dispute with the Estates-General on his reform plans assembled 18,000 troops around Paris, which caused tension among the Parisians. The liberal Parisians were further enraged by the fear that a concentration of royal troops brought to Versailles from frontier garrisons would attempt to shut down the National Constituent Assembly, which was meeting in Versailles. And the dismissal on July 11, 1789 of Minister Necker, who was quite popular because he wanted to take measures against the grain shortages, was the fuse that ignited the powder keg.

> *The deserted city fell prey to tumult and disorder. The poorer classes, remembering their own hatreds, rushed to the "barriers' and burned them. These were toll-gates in the wall built around the city in 1786 by the tax concession. On the next day a mob pillaged Saint-Lazare, which was thought to be a storage place for grain. The police having disappeared, security of person and property was in peril. Apprehension descended upon Paris. … The king's troops seemed to have the city surrounded. On the north they might occupy the hill of Montmartre and set up batteries there. On the west they could join Besenval and his Swiss. On the south they could threaten the Left Bank. On the east was the Bastille, where the governor, dc Launay, had moved cannon into the embrasures, bringing the whole Saint-Antoine area into his field of fire. Attacked and bombarded from all sides, the capital would be taken by assault and turned over to pillage. … Panic was continuous. … These days in Paris were simply the first act of the Great Fear. … The people, not content with guarding the city gates and carefully watching all entrance and egress, began to build barricades and arm themselves as best they could, soon emptying the shops of the armorers. The bourgeoisie took over leadership of the movement and tried to organize it, both to restore order and to make resistance more effective.* (Sée & Zeydel, 1927, pp. 97-98)

Then things got out of hand on July 14, 1789. The crowds stormed the Bastille, a medieval fortress and prison that represented the royal authority in the centre of Paris (Figure 28). It was captured, and the crowds swarmed the city; riots broke out everywhere. The king had to do something; it was flight or submission.

> *On July 15 he appeared before the Assembly, protested his good intentions and announced the removal of the troops. On the following day he recalled Necker. On the seventeenth, with fifty deputies, he went to Paris. He met with a dignified but cool reception. At the Hotel de Ville, Bailly expressed satisfaction that that people had "reconquered" their king. Louis XVI, presented with a national cockade, fastened it to his hat. On his return to Versailles his acceptance of the situation seemed final, and the popular joy burst out in wild acclaim.* (Sée & Zeydel, 1927, p. 103)

The news spread fast into the country. It produced an explosion of enthusiasm and delight. In many cities, the municipal revolution proceeded without violence, but in some it came to turmoil. All over the country castles and manors were attacked and property records burned. It was a protest against the feudal system, and again it was the taxation and food shortages that fuelled the situation.

Figure 28: Storming of the Bastille and arrest of the Governor M. de Launay (July 14, 1789).

Source: Wikimedia Commons, Jaen-Baptiste Lallemand

> *But in some places the bulk of the people were unwilling merely to associate themselves with the bourgeoisie. They called on the city authorities to reduce the price of bread, or besieged the town hall with cries of "Bread at two sous!" The town officers might hesitate, or take flight when threatened; riots would then break out, and the homes of officials, grain merchants and wealthy citizens would be pillaged or at least attacked; the militia, or sometimes the garrison, would arrive belatedly and put an end to the disorder.* (Sée & Zeydel, 1927, p. 109)

It was a time that the first wave of *émigrés*, the most prominent members of the counterrevolutionary conspiracy, left the country.

The Peasant Revolt

The peasantry was the largest body of people in France, and their social-economic situation was the worst. They had no political power, and their meagre economic power was decimated by taxes.

> *The taxes levied by the royal treasury were very instrumental in aggravating the condition of the peasants. It was the peasants alone who paid the taille, and even the new imposts (capitation and twentieth-tax) that were aimed at the nobles, fell almost entirely upon the rural population. We must also take into account the very defective, unjust system of assessment of the taxes, as well as the evils of the manner of collecting them.* (Sée & Zeydel, 1927, p. 23)

Next to that situation, there was the pathetic agricultural situation. The methods of cultivation were primitive and backwards; the fields of property-owning peasants were often too small to sustain the families. The peasants, prompted by the spirit of routine and having but little capital, devoted no great care to cultivation.

> *Carelessness on the part of the great proprietors, the indolence of the peasants, who were discouraged by the overwhelming taxes, insufficiency of the ways of communication and particularly of the main highways, in addition to obstacles placed in the path of the trade in agricultural commodities and in the path of free cultivation—all these things explain the slow development of agriculture.* (Sée & Zeydel, 1927, p. 25)

And there were all those property-less peasants who were at the grace of nobility and clergy. When there was no work, there was no money, and subsequently there was no food.

> *Yet everywhere there were property less peasants. Rarely was the number of these rural proletarians negligible: it has been estimated that about a fifth of family heads in Limousin, 30 to 40 per cent in the Norman woodlands, 70 per cent around Versailles and as high as 75 per cent in maritime Flanders. Some of these unpropertied peasants found land to rent. Ecclesiastics, noblemen and bourgeois seldom exploited their own lands, except in the wine country and in*

some parts of the South. Instead, they put them in the hands of farmers, or more often of sharecroppers with whom they divided the produce. Moreover, their estates consisted in many small unconnected parcels, which they were glad to lease out separately bit by bit. (Sée & Zeydel, 1927, p. 115)

It was those day labourers that were contributing in great number to the beggars and vagabonds. The peasantry was at the bottom of the social structure and paid the bill, not only in monetary terms but also in social terms:

The peasant was almost alone in paying the taille and drawing lots for militia service. He alone was held for road work and for aid in military transportation. From him came most of the proceeds of the poll-tax and the twentieth-taxes. Yet it was the indirect taxes that he detested the most, especially the government salt monopoly. Which held the price of salt as high as thirteen sous a pound in a large part of the kingdom. (Sée & Zeydel, 1927, pp. 117-118)

Clearly there was an agrarian crisis, and it is not surprising that in this climate, the revolutionary actions in the cities came to the countryside. The convocation of the Estates-General stimulated the peasants to voice their grievances. It became an agrarian revolt of the peasants.

On hearing of it [the convocation] the peasants concluded that, if the king invited them to set forth their grievances, it was because he meant to give them satisfaction—and that, if things were going badly, it was because they had too much to pay, to the king himself of course, but above all to the tithe owner and the manorial lord. … Cries of alarm rose everywhere in the kingdom in the course of the spring: the peasants were declaring their intention to make no payments at the coming harvest. … The agrarian insurrections, more even than those of the cities, were genuine mass movements. (Sée & Zeydel, 1927, pp. 124-125)

Figure 29: Farmers burn the feudal titles, so often denounced in the notebooks of grievances (1789).

Source: esaix.unblog.fr/2007/11/11/la-chouannerie-et-les-guerres-de-vendee-en-images/

After July 14, 1789, everywhere in the countryside disturbances took place, some quite violently directed at the local nobility as their manors were burned (Figure 29).

> *These disturbances were all aimed against the aristocracy. One of the chief concerns of the peasants was to force a renunciation of the manorial dues, and above all to bum the archives which authorized their payment. Violence against persons was rare, and though writers have talked of murders the documents reveal none. Very apparent, on the other hand, is the peasant's hostility to all the innovations that threatened his existence.* (Sée & Zeydel, 1927, p. 128)

The countryside was the domain of brigands and vagrants, often the land-less peasants with no income. People that had no other choice than to revert to beggary and stealing. It caused the Great Fear of 1789 (*la Grande Peur*), which spread around the countryside. It was supposed to be a famine plot organized by the aristocracy to starve or burn out the population. In response to these rumours, fearful peasants armed themselves, ringing church bells to warn of danger. As a result of the Great Fear, on August 4, 1789, in an effort to appease the peasants and to forestall further rural disorders, the National Assembly formally abolished the feudal regime, including seigneurial rights.

> *The carriers of the panic were people of all conditions. Fugitives explained their fright by enlarging on each other's stories, and these included bourgeois, priests and monks; postal couriers added to the confusion; then many people sent servants to warn their friends; and village curates, local officials and gentry put one another on guard. Even the government sub delegates and mounted constabulary were no exception; they too took the same initiative. The terrors spread because there was no means of verification and because unbelievers easily became suspects.* (Sée & Zeydel, 1927, p. 130)

The First Societal Reforms

So, there we are in the second half of 1789: the aristocratic revolution had failed and the bourgeois revolution was not too successful. The king played a double game: "in public acquiescing in his role as the servant of the people and the Revolution, while secretly writing to fellow monarchs. … In a panic, a fresh wave of courtiers and grandees departed, as also did a considerable number of rightist deputees defecting from the Assembly" (Israel, 2014, p. 92). As the stream of fugitive *émigrés* increased, in the meantime, the masses of the common people were still discontent.

> *The popular uprising was perplexing to many patriots. It had saved them and they could not dream of condemning it. On the contrary, they justified it, arguing that after the juridical revolution had restored the people to its sovereignty, and after the king and aristocracy had tried to rob them of their gains by violence, the*

> *intervention of the masses and the use of force against force had secured the triumph of right and law. Hence the fourteenth of July was already a sacred revolution. But, thought the patriots, since the Assembly represented the people, the people should restrict themselves to making sure that the Assembly was respected, and should then quietly await such reforms and lawful procedures as the Assembly might judge suitable to decree. But this was far from being the actual state of affairs.* (Sée & Zeydel, 1927, p. 136)

On July 14 of 1789, next to the storming of the Bastille, a constitutional committee was created to prepare the articles of the new constitution. It consisted of two members of the Fist Estate, two of the Second Estate and four of the Third Estate. The assembly was trying to find its place in the structuring of the legal anarchy: how should the assembly represent the different groups in society? Should the nobles have their own upper house? What was the position of the king? Should he have a veto? Soon a range of constitutional affairs occupied the constitutional assembly. But there were also other questions to consider: How should the country administratively be organized? What about the problems the peasantry faced as the consequence of the feudal system, the seigniorial rights and its manorialism[65]? Obviously there were some important decisions to be made.

Abolition of feudalism: One of their first decisions was about the abolition of feudalism. This meant that the seigneurial rights of the Second Estate (based on manorialism) were abolished, as well as the right to tithes (the ten percent tax in produce) by the First Estate. But there was more. It meant the abolishment of game laws, seigneurial courts, the purchase and sale of posts in the magistracy, of pecuniary immunities, favoritism in taxation, first-fruits, pluralities and unmerited pensions. It was the end of the *venality*[66]. Towns, provinces, companies and cities also sacrificed their special privileges; the road tax (*le peage*) was annulled. It was the end of the system of venality (and the beginning of the problems of the valuation of the venal offices).

The abolishment of the institutions that were part of the taxation system meant that taxation halted; exactly what the people wanted. But it aggravated the state's financial crisis. And the reform into a new tax system (based on property: the *contribution foncière* as it still exists today) was hindered by the problems of land registration. Thus tax reform did not take

[65] The power of the lord of the manor over his fief resulting in obligatory contributions from his peasant underlings: either in labor (*corvée*) or in kind.
[66] Venality is a term often used with reference to pre-revolutionary France, where it describes the then-widespread practice of selling administrative positions within the government to the highest bidder, especially regarding the Nobles of the Robe.

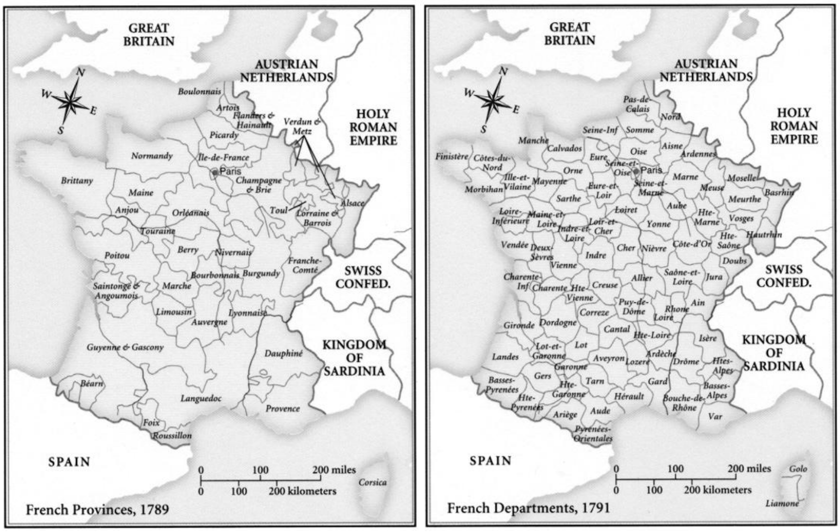


Figure 30: The administrative reforms from Regions to Departments (1791).

Source: Source: http://www.edmaps.com

effect rapidly enough to solve the debt problem.

Departments replacing provinces: Another decision was about the administrative structure of the country. In November 1789, in an effort to weaken the old political structure, the old provinces and their parlements were abolished, and France was divided in thirteen departments (Figure 30). Boundaries were deliberately chosen to break up France's historical regions in an attempt to erase cultural differences and build a more homogeneous nation. Boundaries were set so that any settlement in the country was within a day's ride of the capital of the department. This was a security measure, intended to keep the entire national territory under close control.

Paper money created: As there still was the financial crisis, something had to be done. The assembly decided to issue paper currency: the *assignats* (Figure 31). For its backing they confiscated all clerical possessions.

> *By mid-1790, members of the National Assembly had agreed to sell the National Estates and to use the proceeds to service the debt in a "tax-backed money" scheme. The government would issue securities with which it would reimburse debt. The securities were acceptable as payment for National Estates purchased at auctions; once received in payment, they were to be burned.* (Sargent & Velde, 1995, p. 496).

The *assignats* were not to exist long, though. Their value fluctuated and inflated; the actions of the *caisses patriotiques* (money-issuing private banks), and the outbreak of the 1792 war with Prussia and Austria were complicating matters. In October 1790, they started to sell the lands to the highest bidder to raise revenue.

Figure 31: The *assignats*, paper money issued by the Assemblee National in 1789.

Source: Wikimedia Commons,

Church position attacked: But as there was massive resentment against the Catholic Church, soon more measures were taken. In autumn 1789, legislation abolished monastic vows, and on February 13, 1790, all religious orders were dissolved. Monks and nuns were encouraged to return to private life. Later, on July 12, 1790, the *Civil Constitution of the Clergy* would require an oath of loyalty from all members of the clergy, making the choice between the pope and the state. The widespread refusal led to legislation against the clergy.

Nobility stripped of titles: The edict of June 18, 1790 prohibited the use of any title of nobility (Duke, Marquis, Vicomte, Baron, etc.) and the display of any coats of arms and liveries in public domain. This ban outraged the royalist press and provoked a long and furious quarrel. (Israel, 2014, pp. 104-105). In March 1793, the *émigrés* were declared stripped of all civil and family rights. In April, the nobles were barred from holding passports; by September they were confined to their places of domicile.

Fall of the guilds: Although strongly opposed by the guilds themselves, it was the Chapelier Law of 1791 that abolished the guilds in France, taking away the last remnant of the feudal system: "Article 1. In that the abolition of any kind of citizen's guild in the same trade or of the same profession is one of the fundamental bases of the French Constitution, it is forbidden to reestablish them under any pretext or in any form whatsoever" (Stewart, 1951, pp. 165-166)[67]. It was a major reform that would herald a new period for industrious France.

[67] Also to be found in source: https://chnm.gmu.edu/revolution/d/370/ (Accessed May 2015).

The Assembly did not examine the potential uses of the guild system. It swept away an outdated institution, which it associated with disgraceful privileges, and it did so not in order to create heaven on earth, but to align itself to economic realities. This is the essential point which brings us full circle to the original description of French industry. The guilds represented an outmoded organization, propped up by a political system which had now been revamped. Their disappearance was linked to the rationalization of the economy and polity, but this process was not merely imposed from the outside. The guilds had formed bothersome monopolies which had been attacked and undermined in the ancien regime. What is more, conflicts between masters and journeymen as well as between dependent and independent artisans caused the system to totter within the first weeks of the Revolution. (Vardi, 1988, p. 717)

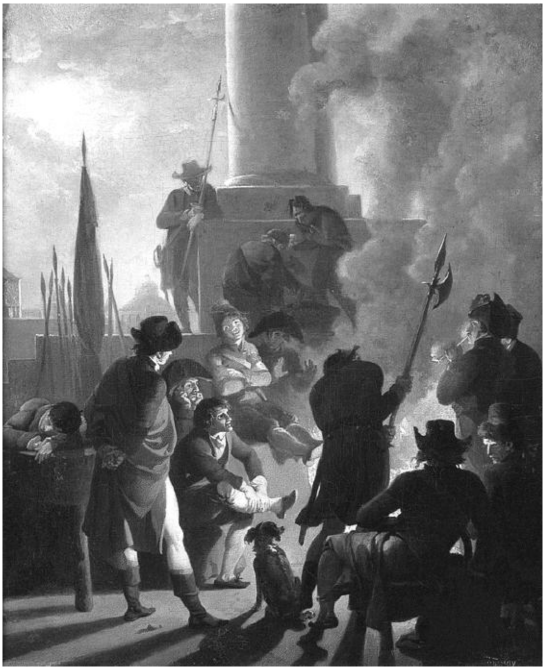


Figure 32: The waiting, people staying vigilant as show in 'Le bivouac des sans-coulottes' by Taunay (1790).

Source: Wikimedia Commons, Nicolas-Antoine Taunay (1790)

The totality of these measures certainly had an impact, but for the rest, the committee did not succeed in addressing the problems of the legislature and the dominant financial problem of the state. Among the revolutionists, there still was a wide rift between the parties at the left (the republicans) and the parties at the right (the monarchists, ultra-royalists and pro-aristocratics). A new committee was formed with different members. One of the controversies was the basic issue of citizenship. It was about the right to vote, to work, to live, to own private property and to inherit. It was about the freedom of speech and assembly. Quit obviously different views on the subject were competing in the debate.

In the meantime, the common people were waiting to see what was going to happen (Figure 32). That waiting was needed as the assembly was creating a constitution—trying to have the king to consent to the constitution and thus creating a constitutional monarchy[68], and they wanted the king to take up residence in Paris. These were important issues, but there were also dominant issues in the daily life of the people, like the failing economy with rising unemployment, the food shortages and rising food prices. The revolution was a catastrophe for the artisans and the poor no less than it was for the aristocracy. Whole towns (like Lyon, which depended on the manufacturing of luxury silk goods) had withered under the collapse of luxury trades and the continuing flight of the *émigrés*. For example, they fled to the Austrian Netherlands (today's Belgium), where the Habsburg monarch Joseph II had been facing a church-inspired revolt in 1789. Or they went to England—quite a few of them—and even to America.

In October 1789, Paris was in a state of turmoil. People were discontent; there were still bread protests of woman in the marketplaces objecting to the price and scarcity of bread. Then, on October 3, a welcoming banquet was given by the king's bodyguards for new troops—the Flanders Regiment—which the king and queen briefly attended. The press reported on it in their newspapers as a gluttonous orgy. Worst of all, the papers all dwelt scornfully on the reputed desecration of the tri-colour cockade; drunken officers were said to have stamped upon this symbol of the nation and professed their allegiance solely to the white cockade of the House of Bourbon. This embellished tale of the royal banquet became a source of intense public outrage.

On October 5, 1789, thousands of women marched to Versailles, first to the Hall of the Menus Plaisirs where the assembly gathered, then to the Chateaux de

Figure 33: The woman march on Versailles (October 5, 1789).

Source: Wikimedia Commons, Bibliothèque nationale de France

[68] Constitutional monarchy is a form of government in which a monarch is legally restricted within the boundaries of a constitution.

Versailles, where the king resided (Figure 33).

> *At about five thirty the women reached the gates of the palace, where they were stopped by the Bodyguard. Some were allowed to come in with Mounier and his colleagues to speak with the king, who received them graciously and promised grain for Paris, along with all the bread that could be found in Versailles. They withdrew delighted, but since they had nothing in writing the main body of women were annoyed and greeted them with threats, so that they were obliged to return and implore a note written in the king's hand.* (Sée & Zeydel, 1927, p. 171)

The bread issue solved, that evening the king also consented and accepted the constitution.

> *Orders having been given to provision Paris, and the constitutional decrees having been accepted, the commissioners had no more to ask except the king's removal to the capital. It was the first time during the whole day that this matter had been mentioned to Louis XVI. He gave no reply. …*
>
> *Since many of the demonstrators had found no place to spend the night, several hundred milled at six in the morning of October 6 about the palace gates. One was found open. The courtyard was invaded and fighting broke out. A soldier of the Bodyguard was put to death; a young workman was killed by a shot; a second guard was massacred. The mob reached the staircase leading to the queen's apartments and got as far as the anteroom, where they were pushed back by the Bodyguard, several being killed or wounded. The queen took refuge with the king. …*
>
> *La Fayette showed himself on a balcony with the royal family. The crowd, at first undecided, finally broke into applause, but cried, "To Paris!" without budging an inch. There could be no more illusions: after a few minutes the king yielded. At the same time he asked the advice of the Assembly, which replied simply that it was inseparable from the king's person, which in turn amounted to a vote for transfer to Paris.* (Sée & Zeydel, 1927, pp. 172-173)

Next, the royal family[69] set off to Paris with a delegation of deputies from the National Assembly, soldiers, and wagons full of wheat and flour and, in the rear the crowd, a mass of sixty thousand people. That night the royal family entered the Tuileries Palace, where they became prisoners of the revolution.

[69] Part of the royal family was the brother of Louis XVI, the Count of Provence and the later king Louis XVII, who was relocated at the Luxembourg Palace. They fled to the Austrian Netherlands in conjunction with the royal family's failed flight to Varennes in June 1791. After proclaiming himself as the regent of France, he sent emissaries to various European courts asking for financial aid, soldiers and munitions. Thus he became the focal point of the *émigrés*.

These events ended the king's independence and signified the change of power and reforms about to overtake France. The march symbolized a new balance of power that displaced the ancient privileged orders of the French nobility and favoured the nation's common people. But it would take almost two full years until the first French constitution was signed on September 3, 1791, and it required another popular intervention to make it happen.

The royal family stayed in the Tuileries, robbed of its grandeur, the diners and the royal activities like the king's favourite activity: hunting. In the meantime, the National Assembly was trying to forge and agree on a constitution. They debated also about their own legislative structure. Should the ministers of the king have a voice and seat in the assembly? To get a perspective on the financial affairs and the expenditures of the state, an analysis was made and published in the Red Book: "The revolutionaries were astonished by the thousands of names on the pension lists, as well as by the multiple secret favours consigned in the Red Book and indignantly published by the Assembly" (Sargent & Velde, 1995, p. 485). It created additional hostility towards the king.

In the summer of 1790, the state pensions were scrutinized to eliminate rank and royal favour from the main body of state pensions. Numerous nobles were crossed off the list or had their pensions drastically curtailed, as the assembly was to be the sole authority assigning grants from the public purse, even if these were paid in the king's name. It affected many court, administrative and military pensions, but—surprisingly enough—not the pensions of scientists (the *savants*), artists and writers (the *littérateurs*) (Israel, 2014, p. 119).

Radicalization and Upheaval [70]

As continued efforts were underway to create a constitution, many proposals were floated—some based on the American and British bicameral parliaments[71]. The main issue though was the position of the king. And there was the fundamental issue of citizenship: would every person have the same rights? Or should there be active citizens with political rights and passive citizens with only civil rights?

[70] Much of the following text originates from Wikipedia-sources, such as Flight to Varennes; Champs de Mars Massacre; Jacobins. Paul Marat

[71] Using the word *Parliament* in the present meaning, the bicameral system has two chambres or houses': the first house and the second house. The author has been a member of the Tweede Kamer der Staten Generaal (Second Chambre of the Estates-General) in the Netherlands.

Then something happened that would have grave consequences. On the night of June 20/21, 1791, the royal family decided to leave Paris and escape to Montmedy (northern France, close to the Belgium border) in order to initiate a counter-revolution. At Montmédy, General François Claude de Bouillé—the Marquise de Bouillé—had concentrated a force of 10,000 regulars of the old royal army who were considered to still be loyal to the monarchy. That loyalty was not obvious, as in general, the French army was in disarray. As the military officer corps was largely composed of noblemen, it became increasingly difficult to maintain order within the ranks composed from the common people. In some cases, soldiers (drawn from the lower classes) had turned against their aristocratic commanders and attacked them.

The flight itself, however, became a disaster. The royal family was recognized by a postmaster in Caintrix (who proved loyal), followed by the recognition of the postmaster in Sainte-Menehould, and finally arrested in the town of Varennes (Figure 34). When the royal family finally returned on June 25 under guard to Paris, the revolutionary crowd met the royal carriage with uncharacteristic silence and, consequently, complete shock rippled throughout the crowd at the sight of their now-loathed king.

> *It was a crushing, insulting silence, a hundred times worse, perhaps, than the insults in the forest of Bondy. The National Guard lined the road, with reversed muskets as for a funeral. Behind the soldiers were the people, "calm, but somber," their hats firmly on their heads. Many of the men were "armed with pikes, sabers and knives." The berlin, still laden with its groups of "patriots" reached the Etoile barrier and went down the Champs-Elysees. "There was an immense crowd of people," wrote Petion, "and it seemed as though the whole of Paris and its surroundings were gathered in the Champs-Elysees. No more imposing*

Figure 34: The Arrest of Louis Capet at his flight to Varennes (June 20-21, 1791).

Source: Wikimedia Commons, Bibliothèque nationale de France

> *spectacle has ever been presented to men's eyes. The roofs of the houses were covered with men, women and children.* (Castelot, 1962, p. 38)

The royal family was confined to the Tuileries Palace. From this point forward, the abolition of the monarchy and the establishment of a republic became an ever-increasing possibility. The credibility of the king as a constitutional monarch had been seriously undermined by the escape attempt. Under these circumstances, the constitutional debate resulted in the Constitution of September 1791. France was to be a constitutional monarchy with a separation of powers (based on Montesguieu's *Trias Politica*). The National Assembly was to be the legislative body, the king and royal ministers made up the executive branch and the judiciary was independent of the other two branches.

Politics Galore

The flight considerably influenced the political climate and the discussions in the assembly. The debates on the political future of the nation were already numerous from the beginning of the revolution. Opinions differed wildly, and groups sharing the same views gathered and created parties and clubs. In the present time, these would be called political parties. Although their importance, influence and composition changed over time, in the early 1790s, one could distinguish the following political movements.

Jacobins: The Society of the Friends of the Constitution was the most famous and influential political movement in the French Revolution throughout France. In the assembly the Jacobins supported more left-wing revolutionary opinions and wanted a democratic republic, spreading the ideals of the revolution. The club originated as the Club Breton, formed at Versailles from a group of Breton (west-coast of France) representatives attending the Estates-General of 1789. Later it became known as the Jacobin Club, a political movement of importance with more than half a million followers, mainly from the well-to-do bourgeoisie. The club ostensibly supported the monarchy up until the very eve of the republic; it took no part in the petition of July 17, 1791 for the king's dethronement. Nor had it any official share even in the insurrections of June 10 and August 10 of 1792.

Girondins: The republican deputies who came from the southwestern Bordeaux region (around the river Gironde), who originally dominated the Jacobin Club, became known as the Girondins. They were basically in favor of ending the absolute monarchy, not so much as revolutionaries (who were absolutely against any monarchy), but more as democrats (possibly under a constitutional democracy). Their ideology was based on order created by a strong government, protecting property and guarding the interests of the middle classes of society. As they were very strongly oriented in spreading the revolution across Europe, they supported an aggressive foreign policy. It was Jacques Pierre Brissot who called for a protective ring around France with vassal/sister states like the Netherlands, the Rhinelands, Swiss and northern Italy.

Montagnards: Also evolving from the Jacobin Club were the Montagnard deputies, who were in favor of abolishing monarchy. They were radical and ultra-democratic, and they completely supported the new republic and the abolition of the monarchy. The Montagnards wanted to abolish the last vestiges of feudalism and then to equalize property, to destroy the great landed estates, and to give the land to all, even to the poorest laborers. They favored the execution of Louis XVI. It was Maximilian Robespierre who consolidated his power over the Montagnards with the involvement of the Committee of Public Safety, created in March 1793, that had succeeded the previous Committee of General Defence.

Monarchiens (*émigrés*): There were also those people who wanted to continue the monarchy in one form or the other (as the absolute monarchy was not what they were looking for). They were part of the institution of the Ancien Régime and had nothing to gain and everything to lose. They were found outside France as they had fled the country: the *émigrés*. In the course of the revolution, they were an important political factor outside the assembly.

At a given moment in time, there were several other political groups, such as the Cordeliers[72], who had created the Société des Amis des Droits de l'Homme et du Citoyen*;* the Enrages[73] and the Hébertists[74], both supported by the Sans-Coulottes[75]; the Feuillants[76] and the

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72 This society held its meetings in the Cordeliers Convent, and quickly became known as the Club des Cordeliers. It took as its motto the phrase, "*Liberté, égalité, fraternité"*.

73 A group of extreme revolutionaries who advocated social and economic measures in favour of the lower classes. Concerned primarily with the problem of a critical food shortage, the Enragés supported a program of price controls over commodities, requisitioning of grain, and government assistance to the poor.

74 The Hébertists were ardent supporters of the dechristianization of France and of extreme measures in service of the Reign ofTerror, including the Law of Suspects enacted in 1793. They favored the direct intervention of the state in economic matters in order to ensure the adequate supply of commodities, advocating the national requisition of wine and grain.

75 The Sans-culottes, most of them peasants and urban laborers, served as the driving popular force behind the revolution. Their most fundamental political ideals were social equality, economic equality, and popular democracy.

76 The group held meetings in a former monastery of the Feuillant monks on the Rue Saint-Honoré near the Tuileries, in Paris and came to be popularly called the *Club des*

Thermodoarians[77]. Each of these clubs had different followers: from the poor plebs in the countryside and the cities to the bourgeois and the royalists. From these clubs came the different (informal) leaders, often deputies in the representative bodies. They were the core of the assembly during the French Revolution, as they are today in the democratic parliaments. As all these different views, opinion and interests conflicted, often strongly opposed each other, they resulted in intrigues, plots and increasing radicalism, both in the assembly trying to create a constitution, and on the streets of Paris. Each political movement had its own ideology, agenda and interest. Basically it was a difference in ideologies:

> *On the one side were those [the Montagnards] who understood that for the destruction of the ancient feudal system, it was not enough to register a beginning of its abolition in the laws; and that, to bring the reign of absolutism to an end, it was not enough to dethrone a King, set up the emblem of the Republic on the public buildings, and print its name upon the headings official papers; that this was only a beginning, nothing the creation of certain conditions which would perhaps permit remodelling of the institutions. And those who thus understood the Revolution were supported by all who wished the great mass of the people to come forth at last from the hideous poverty, so degrading and brutalising, into which the régime had plunged them -- all who sought, who strove to discover in the lessons of the Revolution the true means of elevating these masses, both physically and morally.*
>
> *And opposed to them were the Girondins—a party formidable in its numbers: for the Girondins were not only the two hundred members grouped around Vergniaud, Brissot and Roland. They were an immense portion of the French nation; most all the well-to-do middle class; all the constitutionalists whom the force of circumstances had made republicans, but who feared the Republic because they feared the domination of masses. And behind them, ready to support them, while waiting for the moment to crush them too, for re-establishing royalty, were all those who trembled for their wealth, as well as for their educational privileges -- all those whom the Revolution had deprived of their old privileges, and who were sighing for the return of the old régime.* (Kropotkin, 2009, p. Chapter XXXIX)

As the political climate became more radical, disturbances occurred more frequently in Paris. Sometimes they were minor; sometimes they were larger events, like the *Champs de Mars Massacre* on July 14, 1791 (Figure 35).

Feuillants. They sat on the right of the assembly (indicating their conservative attitude), opposed the democratic movement and upheld the constitutional monarchy.

[77] These were the members of the assembly that staged the Thermidorean Coup; the reaction against Robespierre's Reign of Terror.

Figure 35: The Fete de la Federation on the Champs de Mars (July 14, 1791).

In the figure below, a detail from the left corner is shown.

Source: Wikimedia Commons, Charles Thevenin

It was held a year after the storming of the Bastille and called *La Fête de la Féderation*, attracting thousands of people. On that same day, the National Constituent Assembly issued a decree that the king, Louis XVI, would remain king under a constitutional monarchy. Later that day, leaders of the republicans in France rallied against this decision. A petition was drawn up by the Cordeliers for the removal of the king, and a large crowd of thousands of people gathered to sign the petition. The National Guard, trying to disperse the crowd, opened fire and killed dozens of people.

So the radicalization not only took place in the National Assembly; the upheaval dispersed into the streets of Paris.

> *Radical political discourse directed hostility not only toward the King, but also toward the lawyers and other "bourgeois" who led the National Assembly, the Commune of Paris (that is, the new municipal government installed after the insurrection of 14 July), and the National Guard. By the summer of 1791, these bodies—formerly seen as instruments of the Revolution—had become the targets of ever more protests. After Louis XVI tried unsuccessfully to escape the country on 21–22 June 1791, Parisian radicals demanded a national referendum on*

> *what to do next, because the newly drafted constitution did not give the National Assembly the authority to depose the King. …*
>
> *The ensuing debate over the fate of the King and the constitution itself came to a head at the Federation Festival of 14 July 1791, when patriots demonstrating on the Champ de mars (parade ground) in favor of a republic were attacked by the Paris National Guard. The radical press issued an immediate call for aggressive action and in the following months continued to press the people of Paris to defend themselves and their revolution. The following summer, Parisian artisans demonstrated just such aggression in a series of demonstrations that culminated in an attack on the Tuileries Palace on 10 August 1792. It ended with the arrest of the royal family and the dispersal of the Legislative Assembly.* [78]

It was a battle between the three political factions in the new Legislative Assembly: the *royalists* (the Feuillants), the *moderates* (the Cordeliers) and the *republicans* (the Jacobins). The Feuillants, calling themselves the *Amis de la Constitution* (Friends of the Constitution), supported a constitutional monarchy, the Cordeliers a radical democratic constitution, and the Jacobin supported a radical democracy. The Feuillant Revolution was an attempt to capture the revolution in support of the monarchy. After the Massacre on the Champs of Mars on July 17th, 1791, a mass exodus of moderate deputies abandoned the Jacobin club in favour of a new organization: the Feuillant Club. For a long time, Parisian politics were in turmoil; the republicans (also called the patriots) losing terrain to the royalist counter-revolutionaries.

> *Insisting they alone correctly represented the Revolution's principles, the Feuillants strove to consolidate their hegemony, plastering their foes wit accusations of foreign plots and street protests arranged by paid 'agents'. Paris seethed with reports of suspicious foreigners who perverted public opinion. … Exploiting every popular prejudice, Feuillants also spend heavily, printing and posting up in the streets at night a daily newssheet, Le Chant du Cog' … Virulent political ideological rivalry also seeped into the theaters whenever they staged anything of a serious nature. … Nevertheless, politicization of the theatres gradually advances.* (Israel, 2014, pp. 210-211)

The new liberal monarchist constitution was, after heated debate, finalized on September 2, 1791 and presented to King Louis XVI, at that time forced to live as a prisoner in the Tuileries Palace after his capture in Varennes on June 21, 1791. On September 14, 1791, the king accepted the constitution.

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[78] Source: Liberty, Equality and Fraternity. http://chnm.gmu.edu/revolution/. Essay: Paris and the politics of rebellion. (Accessed December 2014)

> *Royal ascent was the signal for jubilant festivities throughout France. To a rousing chorus 'Vive le Roi' the whole Assembly accompanied Louis triumphantly back to the Tuileries. Bells were ringing throughout the capital. Public illuminations lit up the Tuileries and Champs Elysees. The Paris theatres put on special performances, some gratis, to celebrate the occasion. All the towns in France erupted in celebration. …*
>
> *The Constitution accepted, the democratic republican Left, despite their considerable reservations, promised to abide by it.… During early 1792, well-founded suspicion that the Feuillant leadership was actually in League with the court, and conspiring against the Revolution, scheming to revive aristocracy, further discredited the Feuillants in the public eye. … That a new major constitutional crisis was brewing, if obvious since November 1791, looked particularly threatening by late spring 1792 due to military setbacks suffered during early 1792. … As the military situation deteriorated further, yet another key measure was vetoed by Louis. … Use of the royal veto to block the Assembly emergency measures was turning the 'bons citoyens' against the king, and turning the Crown into the abettor of 'conspiracy against the people'.* (Israel, 2014, pp. 212-229)

The First Republic (1792-1804)

After this first phase of all the societal changes that took place in France in the first half of the nineteenth century resulting in a constitutional monarchy, we are now about to enter the second phase in which the republic would start to find its shape. Now the revolutionary action was turning in a different direction, that of a republic without any monarch.

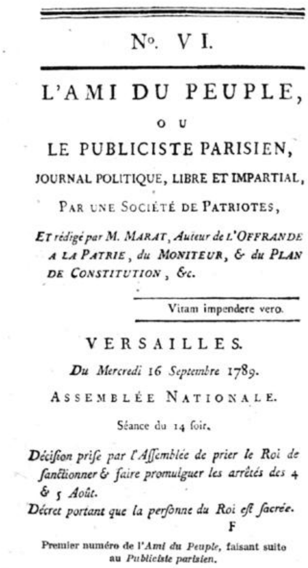
In March 1792, in retaliation for their opposition to war with Austria, the Feuillant ministers were forced out by the Girondins. Labelled by their opponents as royalists, they were targeted after the fall of the monarchy. The summer months of 1792 brought a heady blend of excitement, alarm and escalating violence. Republicanism now burst out of the coffee houses and became a dominating philosophy of the rapidly radicalized revolution. With insurrections in Paris and in the countryside and turmoil related to the war with the king of Bohemia and Hungry (the Austrians), the regular troops became and more involved by the supporters of the throne. Also there were constant exchanges between the king and the assembly; the assembly produced petition after petition, followed by heated discussions between monarchists and republicans. It was left (ie the Jacobinists) against right (the Feuillant party); the middle ground was the Girondists. And in that debate, one side wanted to minimize the role of the parish municipality in the country's transformation from constitutional monarchy to republic; the other sought to maximize it. It was not only the monarchists versus the republicans; it was also a power struggle of the assembly against the Paris commune.

Some Individual Participants

It is obvious that many people were involved in the revolution, either as initiators, as contributors or just followers; others were attacked as they belonged to a social class and yet others were victims of the events—the collateral damage of the innocent bystanders. The passive people were the victims just because they were part of a social class—the peasants as well as the clergy and the nobility—but also the active participants wanted change, liberation and a new social fabric. All these participants, from the nobility to the socially lower backgrounds, more or less played their own role within the institutions they were involved in.

Take the example of those who published in the newspapers and pamphlets, those who acted on the theatrical stage and those who acted in the political arena—an arena where they became heroes, rose to power to be defeated next; it was about "the revolution devouring its own children"[79].

As under the Ancien Régime, the few newspapers were heavily censored; the meetings of the Estates-General in 1789 had created an enormous demand for news. Over 130 newspaper appeared by the end of the year. Later on, as the discussions were not only among politically engaged people in and around the assembly and their clubs, the increasing number of newspapers and pamphlets were becoming a tool of the revolution, like the radical newspaper *l'Ami du People*: 700 issues were written by Jaen-Paul Marat from 1789-1792 (Figure 36).


N°. V I.

L'AMI DU PEUPLE,

OU

LE PUBLICISTE PARISIEN,

JOURNAL POLITIQUE, LIBRE ET IMPARTIAL,

PAR UNE SOCIÉTÉ DE PATRIOTES,

Et rédigé par M. Marat, Auteur de l'Offrande à la Patrie, du Moniteur, & du Plan de Constitution, &c.

Vitam impendere vero.

VERSAILLES.

Du Mercredi 16 Septembre 1789.

ASSEMBLÉE NATIONALE.

Séance du 14 soir.

Décision prise par l'Assemblée de prier le Roi de sanctionner & faire promulguer les arrêtés des 4 & 5 Août.

Décret portant que la personne du Roi est sacrée.

F

Premier numéro de l'*Ami du Peuple*, faisant suite au *Publiciste parisien*.

Figure 36: L'Ami du Peuple; six edition (15 September 1789).

Source : http://classiques.uqac.ca/classiques/mitton_fernand/presse_francaise_t2/gravures/gravure_5.html

Jaen Paul Marat was born in 1743 in the Prussian principality of Neuchatel, now in Switzerland.

[79] Expression coined by Jaen-Louis Mallet in his widely circulated 1793 essay "*Considérations sur la nature de la Révolution de France, et sur les causes qui en prolongent la durée*" (1793).

After staying in Bordeaux, Paris and London, he became involved in medicine. Returning to Paris, he became physician and bodyguard of the Compte d'Artois, Louis XVI's youngest brother. Soon he was in great demand as a court doctor among the aristocracy. In 1786, he resigned his court appointment and devoted his energies full time to scientific research. His scientific interests resulted in works on fire and heat, electricity and light. Among his publication was a study on the effect of light on soap bubbles in his "*Mémoires académiques, ou nouvelles découvertes sur la lumière*" ("Academic memoirs, or new discoveries on light", 1788).

On the eve of the French Revolution, Marat placed his career as a scientist and doctor behind him and took up his pen on behalf of the Third Estate. After 1788, when the Parlement of Paris and other notables advised the assembling of the Estates-General for the first time in 175 years, Marat devoted himself entirely to politics. His publication "*Offrande à la Patrie*" ("Offering to the Nation") dwelt on many of the same points as Abbé Sieyès' famous "*Qu'est-ce que le Tiers État?*" ("What is the Third Estate?"). He often attacked the most influential and powerful groups in Paris and became member of Club des Cordeliers. Due to his fierce opposition, he had to go into hiding frequently from 1790-1792. In September 1792, he became a member of the National Convention as one of the 26 Paris deputies. There he fought the Girondins, whom he believed to be covert enemies of republicanism. The result was that they managed to get him tried before the Revolutionary Tribunal on April 24, 1793, but he was acquitted of all charges and participated in the defeat of the Girondins.

Figure 37: The murder on Paul Marat by Charlotte Corday in 1793.

Source: Wikimedia Commons, Paul-Jacques-Aime Baudry.

Not long after that, on July 13, 1793, he was murdered in his bathtub by Charlotte Corday, a Girondin sympathiser (Figure 37). She came from an impoverished royalist family of Norman descent, nobles of the land and the sword, owing their rank to their services, not to court favour (her brothers were *émigrés*; she herself saw her aspiration to become a nun blocked in 1791 by a decree that closed monasteries and convents). His funeral became an event and was attended by the entire National Convention. Marat was placed in a proper coffin, paraded through the streets of Paris to the sound of weeping citizens, and buried at the Pantheon.

> *In the Commune Hébert pronounced the funeral eulogy of Marat, and everywhere, before the town hall, the Tuileries, the Clubs, the prisons, the house of Marat, the sweating crowd pressed, cursed, shouted, wept; it seemed as if Charlotte de Corday had achieved her end and had indeed cast terror and dismay into the midst of the tyrants.* (Bowen, 2013)

On the day of the funeral, his embalmed body was put on display. The ceremony itself became a spectacle. A couple of days later, after a trial before the Revolutionary Tribunal, on July 17th, Charlotte Corday died on the guillotine.

In addition to the dynamics of the political stage mentioned before, there were the theatrical stages that were used to spread the principles of the revolution (*la propaganda revolutionaire*). Performances were supposed to have a strong effect on public morale. Dozens of theatre companies offered the population entertainment, actors becoming the heroes of the revolution. That was quite a change from the stigma actors had before the revolution. Then the *comédiens* were seen by the bourgeoisie as immoral, vagabonds roaming villages, presenting scandalous spectacle both on and off the stage. It is not too surprising then that some actors joined the cause when, in the summer of 1789, volunteer guard militia (later the National Guard) were formed to defend the nation against foreign invaders. Other actors became revolutionary play writers or directors of theatres themselves. And some rose to power using their oratory skills on the political stage.

The actor Jean-Marie Collot-d'Herbois' career undertook a drastic change during the revolution.

> *After his experiences in Bordeaux, where he had written of his ill-treatment at the hands of the provincial bourgeoisie, Collot-d'Herbois moved to the city of Lyon, where he worked as an actor at the Théâtre de Lyon, eventually becoming director of that theater in 1787. He had begun writing plays as well, and in 1789 he moved to Paris to continue his career as a dramatist. In December of 1789, Collot was fortunate enough to see one of his plays performed at the Théâtre Français. Over the next year or two Collot went on to achieve both critical and popular success as a Parisian playwright. Even while Collot was busy writing plays for the theatrical stage, he was becoming increasingly involved in political activities. He joined the Jacobin Club early in the Revolution, and quickly became a prominent member. In 1792, Collot was elected to the National Convention as a deputy of Paris. By March of 1793, Collot was*

> *named to the alternating honorary post of President of the Jacobin Club. And in September of 1793, Collot reached the pinnacle of his political career (and indeed the pinnacle of Revolutionary politics as a whole) when he was named to the all-powerful Committee of Public Safety.* (Friedland, 1999, p. 5; 2002)

As a member of the Committee of Public Safety, he masterminded the brutal suppression of the federalist rebellion that erupted in Lyon. This was part of a range of federalist revolts outside Paris in the provinces during June-September 1793. Lyon, the second largest city in France, was especially confronted with the effects of the revolution, as it destroyed its economy and created a crisis in the silk industry. The resulting opposition of the city's working class resulted in revolutionary societies, turmoil in the city and ultimately the bombardment in the Siege of Lyon in August 1793. It seemed Collot had something to settle in a personal vendetta, as the committee decided on October 12, 1793 on the destruction of Lyon. The committee ordered not only that all the properties occupied by rich people be demolished, leaving just the houses of the poor and the homes of duped or banished patriots, but also the execution of more than nineteen hundred rebels. The suppression and the ensuing massacres made Lyon one of the bloodiest sites of the Reign of Terror.

> *… the true motive for Collot's savage treatment of the Lyonnais had been his personal revenge for having been booed off the stage some six or seven years earlier, when he had been an actor at the Théâtre de Lyon. In fact, Collot was actually accused of taking the time, amidst the horrors of the rape of Lyon, to search out citizens of the city who had been in the parterre on that fateful day when he had been forced to endure the audience's whistles of disapproval; having found them, he lined them up before a cannon and exacted his revenge.* (Friedland, 1999, p. 5; 2002)

The management of theatres by their choice of plays thus spread the revolutionary ideas. Not only in France itself, but also in the occupied states like the Austrian Netherlands (present Belgium), the French Revolution was exported by theatrical propaganda. Individual people also played important roles. Such as the former high class courtesan Marquerite Brunet (later called Mademoiselle de la Montansier, 1730-1820), who was originally entrusted with organizing royal entertainment at the Palais de Versailles and Fontainebleau but now had become a revolutionary theatre director. After being invited to accompany the armies to the Austrain Netherlands over the winter of 1792-1793, she introduced with her company *Comédiens de la République Française* the republican theater in French occupied Brussels. But that was not long lasting when the Austrian troops occupied Brussels in March 1793, forcing the French—army and artists—into a hasty retreat.

After her return to Paris, she presented the final bill for the operation to the National Convention. "After spending some 53,000 assignats of the government's money, it was not clear that the first propaganda troupe of the modern world had enlightened anyone at all" (Friedland, 1999, p. 23; 2002). Then she fell from grace as the political climate had completely changed; she was imprisoned on the pretext of conspiracy with foreign powers. However, she survived after being declared innocent and, financially compensated, she organized anew troupe of Italian singers. Later, during Napoleon's reign, in 1807 she managed to show her *variétés* in a new theatre on the Boulevard Montmartre (Israel, 2014, p. 430).

These were some illustrations of the revolutionary influences on the popular revolution within the borders of France. They were not the only influences that played a role in the development of the revolution. Take, for example, all those people that had fled the country. These were the *émigrés*, mostly nobles in exile fearing the consequences of the popular revolution who had been fleeing the country to the Austrian Lowlands (ie Belgium), the Savoy (ie Italy) and even to America. Many were officers from the army, former noblemen in official positions or members of the clergy called *refractory clergy* that had not taken the oath of loyalty. All those persons formed La France Extérieur and were in majority supporting the monarchy/aristocracy.

Figure 38: Scandal sheet showing Charles Philippe at the background, engaged in sexual activity with Marie Antoinette.

Source: Collection de Vinck. Un siècle d'histoire de France par l'estampe, 1770-1870. Vol. 7 (pièces 1046-1231), Ancien Régime et Révolution. http://frda.stanford.edu/en/catalog/fr667hp3232

One of those *émigrés* was Charles Philippe of France, the Comte d'Artois, younger brother of Louis XVI.

Constant permissiveness on the part of his family, his governor, and the inept tutors who had unfortunately been entrusted with his upbringing had made of the adolescent Charles Philippe a self-centered, shallow, intellectually apathetic, morally weak, but altogether charming young fop. (Baillio, 1992, p. 150)

His youth was passed in scandalous dissipation and extravagance, which drew upon himself and his coterie the detestation of the people of Paris (Figure 38). Known as someone who could spend money lavishly, he did build as a pleasure palace (*maison de plaisance*): the new Chateau de Bagatelle. It was the result of a bet with his sister-in-law Marie-Antoinette—for the sum of one hundred thousand francs—that he could realize the project in two months. When the final costs were calculated, the project had cost more than three million livres (Baillio, 1992, pp. 152-153).

> *He felt much more at ease in a salon surrounded by a coterie of sycophantic courtiers than he did on maneuvers. A disreputable and sexually promiscuous older cousin of the Orleans branch of his family, the duc de Chartres, helped to debauch d'Artois further by introducing him to the gambling dens and fancy brothels of nocturnal Paris. …*
>
> *By the time his eldest brother had become king in 1774 as Louis XVI, he had resumed his libertine ways. He spent lavishly on his mistresses, among them several celebrated ladies of the stage-Anne Victoire Dervieux, Rosalie Duthe, and Louise Contat-and a liberated English woman, Laddy Barrymore.* (Baillio, 1992, p. 151)

At the age of sixteen, in 1773, he married Marie Thérèse of Savoy, sister-in-law of his brother, the Count of Provence. In a few years he had incurred a debt of 56 million francs, a burden assumed by the impoverished state. Prior to the revolution he took only a minor part in politics, but when it broke out, he soon became, with the queen, the chief of the reactionary party at court. In the first days of the revolution, he became politically involved, supporting the removal of the aristocracy's privileges (but not the social privileges enjoyed by either the church or the nobility). He was instrumental in Necker's dismissal. But apart from these activities, the Comte d'Artois became a symbol of the court's decadence and a prime target for the radical press, which launched blistering attacks against him.

After the revolution became a popular revolution with the storming of the Bastille in July 1789, he left France, became leader of the *émigrés* and visited several of the courts of Europe in the interest of the royalist cause. First he went to Turin (now in Italy, but then in the Duchy of the Savoy, which was his wife's native country), later to Trier and Koblenz (now Germany, then part of the Rhinelands). He became the leader of the *émigrés* who participated in the counter-revolution and he set up a court-in-exile in the Electorate of Trier. When the French republican army in 1792 started to occupy the Austrian Netherlands, he fled to England, where he stayed in Edinburgh. There, King George III of Great Britain gave him a generous allowance. Later—in 1825—he would become the French King Charles X after the first Bourbon Restoration of 1814. His former reactionary interests had changed by that time and been replaced by ultra-monarchical behaviour. In that capacity he passed a law that would give everyone whose lands had been confiscated a sort of compensation—at a cost of 998 million francs, an enormous amount today and even more in those days!

The European Coalitions Threatening the Revolution

The bellicose activities of the *émigrés* in the Rhinelands[80] raised concerns for the French republican government. Other European monarchies had concerns that the principles of the French revolution would also create turmoil in their countries and threatened the existing order there. So they created coalitions and raised armies, resulting in movements at the borders of France. For example the Prussians (seventy thousand soldiers) had joined forces with the Australian Empire (sixty-eight thousand soldiers) in the First Coalition. Soon, the former soldiers among the *émigrés* joined them.

On 27 August, 1791, the Holy Roman emperor Leopold II and the Prussian king Frederick William II issued a statement in support of Louis XIV—whose wife Marie Antionette was Austrian by birth. This Declaration of Pillnitz was meant to satisfy the French *émigrés* and clearly oppose the French Revolution. The allied armies had a goal as made clear by its commander, the Duke of Brunswick, on July 26th of 1792, who, in the Brunswick Manifesto', "…declared that the allied sovereigns were advancing to put an end to anarchy in France, to arrest the attacks made on the altar and the throne; to restore to the king the security and liberty he was deprived of, and to place him in a condition to exercise his legitimate authority" (Mignet, 1888, p. 164). As next the


LA NATION
LA LOI
LE ROI.

N° 161.

DÉCRET
DE L'ASSEMBLÉE NATIONALE.
Du Onze Juillet 1792.
L'AN QUATRIÈME DE LA LIBERTÉ.

Acte du Corps législatif

Citoyens, la Patrie est en danger.

Figure 39: Declaration of the National Assembly: The country is in danger (August 10th 1792).

Source: http://www.megapsy.net/

[80] The Rhinelands are the regions on the left bank of the Rhine.

Austrian and Hanoverian armies crossed the Rhine and the Prussian army passed the borders at Koblenz and started to march to Paris, the revolutionary spirit became heated to a fury.

The revolution was now entering its radical phase. The Legislative Assembly had declared on July 11, 1792 that *"la patrie est en danger"* (The country is in danger) (Figure 39). It resulted in the *levée en masse,* where thousands of young men were conscripted in the army to protect the country from the allied armies.

As the progression of the revolution came to produce friction between France and its European neighbours, these had become determined to invade France to restore the monarchical regime. It was to be the *First Coalition* between the Kingdom of Prussia and the Habsburg monarchy, later joined by the British. The invading forces were met in France by a mixture of what was left of the old professional army and volunteers. And they won the Battle of Valmy in September 1792, the first major victory! The news of the victory of Balmy reached the newly elected National Convention on September 22, 1792. On the same day, it was decreed that France was to be a republic. After the French army was successful in the east of France, where the Savoy and Nice in Italy had been occupied, the political attention switched inland again.

In the meantime, in Paris not everybody thought the danger came from over the borders, though. One of the deputies, Jacques Pierre Brissot, leader of the Girondists, expressed it as follows:

> *"Our peril," said he, "exceeds all that past ages have witnessed. The country is in danger, not because we are in want of troops, not because those troops want courage, or that our frontiers are badly fortified, and our resources scanty. No, it is in danger, because its force is paralysed. And who has paralysed it? A man—one man, the man whom the constitution has made its chief, and whom perfidious advisers have made its foe. You are told to fear the kings of Hungary and Prussia; I say, the chief force of these kings is at the court, and it is there that we must first conquer them. They tell you to strike the dissentient priests throughout the kingdom. I tell you to strike at the Tuileries, that is, to fell all the priests with a single blow; you are told to prosecute all factious and intriguing conspirators; they will all disappear if you once knock loud enough at the door of the cabinet of the Tuileries, for that cabinet is the point to which all these threads tend, where every scheme is plotted, and whence every impulse proceeds. The nation is the plaything of this cabinet. This is the secret of our position, this is the source of the evil, and here the remedy must be applied.*" (Mignet, 1888, p. 161)

France became in effect divided in two parties: the monarchists, attached or loyal to royalty, and the republicans, desiring a republic. The popular party, placed in the necessity of conquering a position, saw no other way than annihilating the power of the king and no other way to annihilate it than to dethrone him. The royalists were in favour of a constitutional monarchy where the king would hold considerable power.

Overview of the Early French Revolution

Like so many places in Europe, the French social structure originating over centuries was about the dominance of few over many. It was a society dominated by *inequality and privileges*. The political, social and economic dominance of the absolute monarchy and the institutions that came with it, combined with the religious dominance of the clergy, defined life for the majority of the people. And that minority did not have the intention to change anything fundamentally, while the majority became more and more cornered and wanted reform.

The ensuing revolution from its early beginning (at the end of the 1780s) was an *Aristocratic Revolution* with the revolt of the nobles against losing their privileges (Figure 40). It soon became a *Bourgeoisie Revolution* in which the position of the monarchy was up for discussion. It became even more a *Popular Revolution* when the Third Estate wanted liberalization: freedom of the former feudal regime—of the dominance of the Catholic

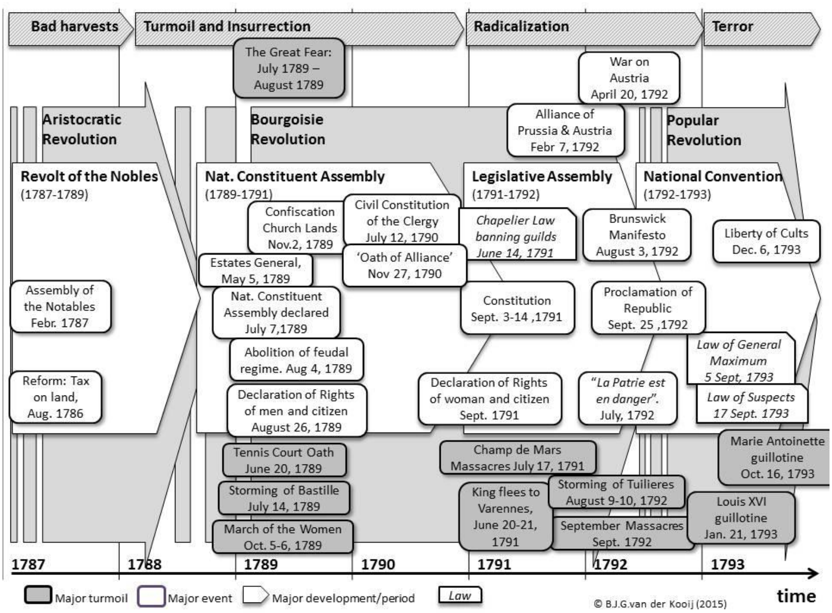


Figure 40: Overview French Revolution (1787-1793).

Figure created by author

Church and their subordinate position in general. It became a battle against the church, against feudalism and against the old guild system. Through all of this, the issues about the repressive taxation system and the representation of people were important issues. The slogan from the American Revolution, "No taxation without representation", was also applicable in France at that time.

The period from 1788-1792 was a period of turmoil in Paris, the French countryside and in Europe. In Paris, radicalization dominated the revolutionary actions. In the countryside, the peasantry and bourgeoisie revolted. In Europe, the French Revolution caused uproar and resulted in revolutionary wars and the creation of alliances to help restore monarchy in France. The revolution was underway; turmoil was its characteristic. But that was nothing compared to the Reign of Terror that devoured France soon after the bourgeois revolution became a *Popular Revolution*. Not only was there religious and political terror with its arbitrariness; there was also economic terror that ruled the country, plunging the nation into a state of disarray. As the guillotine was the dominant tool of justice in that period, the revolution took thousands of lives.

Reign of Terror [81]

The result was dramatic, as there was massive turmoil and heated frenzy, too many soldiers and troops, and too many agitated people with weapons. It was on August 10, 1792 that the dictatorial and arbitrary epoch of the revolution started with the assault on the Palais de Tuileries (Figure 41).

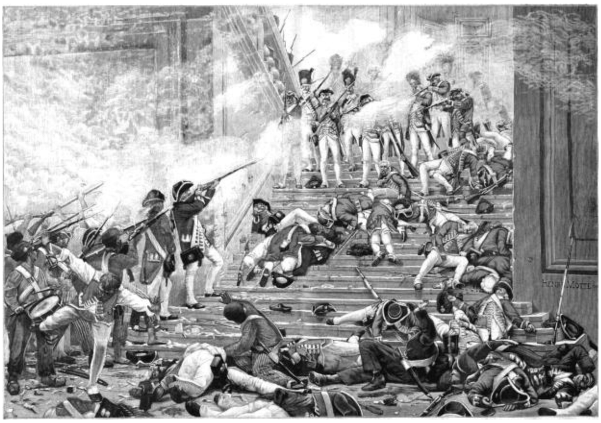


Figure 41: The assault at the Palais de Tuileries (August 10, 1792).

Source: Wikimedia Commons, Painting by Henri-Paul La Motte

The royal family had retreated for their safety to the assembly, while the mob slaughtered the Swiss guards guarding the palace and ransacked the royal apartments and wine cellars (Figure 42). On

[81] Much of the following text originates from Wikipedia-sources: such as National Convention; War in the Vendée; General Maximum; Jacques Pierre Brissot.

Figure 42: Plundering of the King's Cellar (August 10, 1792).

Source: Wikimedia Commons, Richard Earlom

August 11, the Legislative Assembly suspended the king's rule, and the king was imprisoned. It was decreed that the Legislative Assembly would be replaced by a newly elected National Convention in September. However, before that would happen, there were the September Massacres:

> *By 27 and 28 August, wild rumors of plots, spiriting away the king, and releasing all the political prisoners filled the streets, and, in turn, provoked talk of breaking into the prisons and slaughtering the interned "counterrevolutionaries" before they could escape. All this, coinciding with the open breach between the Assembly and the Commune, proved decisive for the Revolutions' subsequent history.* (Israel, 2014, p. 267)

> *The radical Paris commune is given the responsibility for tracking down those guilty of crimes against the state; citizens are encouraged to come forward and denounce the guilty. …Over a period of four days, from September 2, thugs enter the Paris prisons and drag the inmates out to summary execution. Most of the victims are priests and aristocrats, though many common criminals die as well. There is already a mood of public alarm, with foreign armies now on French soil, so it is easy for the commune to argue that the victims were dangerous royalist conspirators. About 1400 people die in Paris.*[82]

The way it worked is illustrated by the following eyewitness account of Pierre Nolet, a merchant writing to his family staying in the Ardennes (Figure 43):

> *The president the commissioner for the section sat down at the table, opened a register and sighed: "Let us begin." Two priests left the sacristy, where the prisoners had been assembled, not without difficulty. They came to the table,*

[82] Source: History of France. http://www.historyworld.net/. (Accessed December 2014)

Figure 43: The September Massacre, killings at Grand Châtelet de Paris (September 1793).

Source: Wikimedia Commons, unknown artist

carrying their breviaries. They were very pale, but seemed resolute. The commissioner made them state their name and profession and then asked them to take the oath of the civil constitution of the clergy. "That is impossible for us." The judge sighed and ordered them, with a gesture, to go into the garden. That simple gesture was a death sentence. One could hear cries of pain, the rattling of weapons, howls and then the inevitable cry of "Long live the nation!" The same scene was repeated. Notelet, overcome by the cries, "regretted having entered this hell and cursed his curiosity. At one moment he was able to glance into the garden." He perceived a pile of corpses in front of the short flight of steps and near the corpses the murderers who, "taking advantage of a pause, were calmly smoking their pipes. (Castelot, 1962, p. 52)

Without any form of justice, the systematic sentencing to death of the nobles, refractory priests and Swiss guards—on the pretext of saving the country from the enemy as claimed by Robespierre—was not just the result of a popular uprising.

> *There can not be serious doubt that the September massacres were closely linked to an organized conspiracy, part of a conquest of power, both condoned and organized by authoritarian, antidemocratic elements within the Commune.* (Israel, 2014, p. 273)

The King is Executed

The National Convention, that was to replace the Legislative Assembly, held its first session on September 20, 1792, with 749 elected deputies. It was a collection of radicals, opposing any form of government related to monarchy; the moderates, who just wanted change; and the conservatives, who were nobles supporting the king and their own interests. Their first decree was unanimously to abolish royalty from France. But what to do with the king, then called "Citizen Louis Capet?" The discovery in November 1792 of an iron chest containing correspondence apparently implicating him in treasonable correspondence with royalist enemies of France discredited the king even more.

On December 11, 1792, Louis XIV was charged with 33 crimes, which included complicity in "plots against the nation". The king was defended by lawyers like Raymond Romain and Comte Desèzem and the king also gave a declaration himself. Eventually, on January 14-15, 1793, the majority of the deputies vote for death without delay or referendum—a majority of just one. In view of the closeness of this result, a further vote was taken on the question of delay. There was again a majority for immediate action. As a result, on January 21, 1793, Louis XVI was guillotined (Figure 44). The memoirs of a priest, Henry Essex Edgeworth, an Englishman living in France tell us about his last moments in life:

> *The path leading to the scaffold was extremely rough and difficult to pass; the King was obliged to lean on my arm, and from the slowness with which he proceeded, I feared for a moment that his courage might fail; but what was my astonishment, when arrived at the last step, I felt that he suddenly let go my arm, and I saw him cross with a firm foot the breadth of the whole scaffold; silence, by his look alone, fifteen or twenty drums that were placed opposite to me; and in a voice so loud, that it must have been heard it the Pont Tournant, I heard him pronounce distinctly these memorable words: 'I die innocent of all the crimes laid*

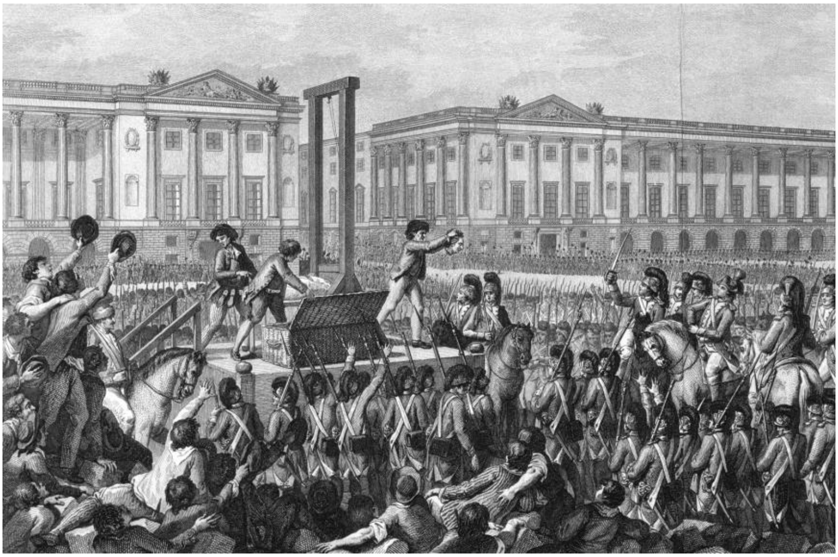


Figure 44: The beheading of King Louis XIV on the Place de la revolution (January 21, 1793).

Source: Wikimedia Commons, Bibliotheque Nationale de France *to my charge; I Pardon those who have occasioned my death; and I pray to God that the blood you are going to shed may never be visited on France.' He was proceeding, when a man on horseback, in the national uniform, and with a ferocious cry, ordered the drums to beat. Many voices were at the same time heard encouraging the executioners. They seemed reanimated themselves, in seizing with violence the most virtuous of Kings, they dragged him under the axe of the guillotine, which with one stroke severed his head from his body. All this passed in a moment. The youngest of the guards, who seemed about eighteen, immediately seized the head, and showed it to the people as he walked round the scaffold ...*[83]

The Revolutionary Tribunal

It was in early 1793 that the convention decided on March 10 to create an extraordinary criminal tribunal called the Revolutionary Tribunal. It was a reaction to a range of events: the military setbacks in the war against the coalition; the internal struggles like the war in the Vendee, Brittany and Normandy (Figure 45); and above all, the unrest in Paris as the result of the two opposing camps in the political arena.

The Girondins were convinced that their opponents aspired to a bloody dictatorship, while the Montagnards believed that Girondins were ready for any compromise with conservatives—and even with the royalists—that would guarantee they remained in power. The bitter enmity soon reduced the convention to a state of vociferous paralysis. Debate after debate degenerated into verbal brawl from which no decision emerged. The political deadlock, which had repercussions all over France, eventually drove

Figure 45: War in the Vendee (1793).
Source: Wikimedia Commons, Paul-Emile Boutigny

[83] Source: "The Execution of Louis XVI, 1793, Eye Witness to History", (1999) www.eyewitnesstohistory.com. (Accessed December 2014)

men to accept dangerous allies: royalists in the case of Girondins, *sans-coulottes* in that of the Montagnards.

Figure 46: The *sans-culottes*.
Culottes were the fashionable silk knee-breeches of the nobility and bourgeoisie (right). The sans-culottes wore trousers (left).
Source: Wikimedia Commons

The revolution was now—in the summer of 1793—under the dominance of the *sans-culottes* (Figure 46) in Paris, consisting of radical left wing partisans of the lower class. They came in different flavours: from the socially engaged to the anarchist. Take the example of the Society of Revolutionary Republican Women (*Société des Citoyennes Républicaines Révolutionnaires*), which complemented all those male revolutionary clubs at the time and demanded an equal place for the *citoyenne*, or the revolutionary firebrands such as the Enraged Ones (*Les Enragés*), who published in the *Manifesto of the Enragés* their views of how the rich—now it was the merchant aristocracy—still exploited the poor. Or, as they declared:

> *Freedom is nothing but a vain phantom when one class of men can starve another with impunity. Equality is nothing but a vain phantom when the rich, through monopoly, exercise the right of life or death over their like. The republic is nothing but a vain phantom when the counter-revolution can operate every day through the price of commodities, which three quarters of all citizens cannot afford without shedding tears. … For the last four years the rich alone have profited from the advantages of the Revolution. The merchant aristocracy, more terrible than that of the noble and sacerdotal aristocracy, has made a cruel game of invading individual fortunes and the treasury of the republic; we still don't know what will be the term of their exactions, for the price of merchandise rises in a frightful manner, from morning to evening.* (Roux, 1793)

They demanded price control, anti-speculation and anti-monopoly policies. It resulted in the Law of the Maximum (29 September 1793), an extension of the earlier Law of Suspects (*Loi des Suspects*) of 17 September 1793. The law set forth uniform price ceilings on grain, flour, meat, oil, onions, soap, firewood, leather and paper. The sales of these products were regulated at the maximum price set in 1790 value, plus one-third. But it did more than just a price regulation; it authorized a reign of terror to hold sway over both retailers and customers alike. The result was that there were still food shortages not only due to bad harvests but more importantly from the unwillingness of farmers to bring products to the market at prices below the cost of production. However, the shortages were widely blamed on speculators, hoarders and price gougers. It resulted in an economic terror in the cities.

On the countryside, peasants also revolted, but now because they objected to the persecution of the clergy and opposed the military conscription of young men into the army. It resulted in the War in the Vendee (1793-1796) (Figure 45). On August 1, 1793, the Committee of Public Safety ordered a pacification of the region by complete physical destruction. These orders were not carried out immediately, but a steady stream of demands for total destruction persisted. Under orders from the Committee of Public Safety in February 1794, the republican forces launched their final pacification effort. It resulted in the massacre of tens of thousands of civilians by the republican armies. Farms were destroyed, crops and forests burned and villages razed. There were many reported atrocities and a campaign of mass killing universally targeted at residents of the Vendée, regardless of combatant status, political affiliation, age or gender.

Figure 47: Towards the beheading of the Girondins (July 13, 1793).

The upper picture shows the painting *L'ultime adieu des Girondins le 31 Octobre 1793,* by Paul Delaroche. The lower picture shows the illustration *The Girondists on the way to Execution* by Karl Theodor von Piloty.

Source: Wikimedia Commons

In Paris, the revolution became a grim contest in the National Convention between the

Girondins (with their followers from the country, many from the Gironde) and the Jacobins (with their followers from Paris). Over time, the position of the Girondins weakened, and the Jacobins, under leadership of *Maximilien Robespierre*, forced the convention to arrest the Girondins on June 2 of 1793. Brissot was one of the first Girondins to try and escape but was also one of the first captured. First passing through his hometown of Chartres on his way to the city of Caen, the centre of anti-revolutionary forces in Normandy, he was caught traveling with false papers on June 10 and was taken back to Paris. On October 3, the trial of Brissot and the Girondins began. They were charged with being "agents of the counter-revolution and of the foreign powers, especially Britain". Brissot, who personally defended himself, brought up point by point the absurdities of the charges against him and his fellow Girondins. Regardless of their efforts, on October 30, the death sentence was delivered to Brissot and the other twenty-one Girondins by guillotine (Figure 47).

The Jacobins controlled the Committee of Public Safety, where Robespierre became the most radical member, which started a ruthless campaign to eliminate the enemies of the state: the *Reign of Political Terror*. It was—among other contributing factors—the result of the broad scope of the Law of Suspects of September 17, 1793 that defined when people were a suspect:

> *(i) Those who, either by their conduct or their relationships, by their remarks or by their writing, are shown to be partisans of tyranny and federalism and enemies of liberty; (ii) Those who cannot justify, tinder the provisions of the law of 21 March last, their means of existence and the performance of their civic duties; (iii) Those have been refused certificates of civic responsibility (certificats de civisme); (iv) Public officials suspended or deprived of their functions by the National Convention or its agents, and not since reinstated, especially those who have been, or ought to be, dismissed by the law of 14 August last; (v) Those former nobles, including husbands, wives, fathers, mothers, sons or daughters, brothers or sisters, and agents of émigrés, who have not constantly manifested their loyalty to the Revolution; (vi) Those who have emigrated during the interval between the 1 July 1789 and the publication of the law of 8 April 1792, although they may have returned to France during the period of delay fixed by the law or before.* (Text of Law of Suspects)

That description covered a lot of people, common people, nobles that were family of *émigrés*, as well as political opponents. Controlling the Revolutionary Tribunal, Robespierre could eliminate his political opponents.

During the winter of 1793, the Revolutionary Tribunal arrested hundreds of thousands people; tens of thousands of those were convicted and the number of victims of the guillotine in France's cities rose dramatically. The total number of executions in October (including the Girondin leaders), was 180, followed by 500 in November, 3,380 in December and 3,500 in January. In May 8, 1794 former farmers-general were paying the price at the scaffold: 28 former members of the consortium were guillotined, including the "father of modern chemistry", Antoine Laurent Lavoisier[84], whose laboratory experiments had been supported by income from his administration of the *Ferme générale*. Lavoisier was tried, convicted and guillotined on May 8, 1794 in Paris at the age of 50 together with 27 other co-defendants.

The reign of political terror was intense and brutal, but it was short lived. Even the radical Jacobins, the supporters of Robespierre, came to feel that the terror must be stopped. The people of Paris had experienced enough bloodshed.

> *As a matter of fact the Parisians had already begun to sicken at the smell of blood; the "national chopper" had lost its popularity. When the carts passed, shutters were dosed and it was even difficult to know where to erect the scaffold that had long since left the former Place Louis XV. Sanson's assistants, who were sent to set up the framework of the guillotine, had to flee from the Place de la Bastille as a result of protests from the surrounding inhabitants, and the sinister machine finally found its way to the present Place de la Nation.* (Castelot, 1962, p. 60)

When Robespierre called for a new purge in June 1794, he seemed to threaten the other members of the Committee of Public Safety (Figure 48).

> *On July 26, 1794, he mounted the tribune of the Convention. After protesting against the calumnies that showed him as a tyrant, he spoke of a new "purge" that had become necessary. But he named nobody. Having uttered his final phrase in which he called on the people "who are feared, who are flattered and who are despised," he left the tribune. The heat was appalling. The word "purge" brought out the sweat on the foreheads of the deputies. "The names . . . give the names!" cried several voices. Indifferent, Robespierre returned to his seat and did not deign to reply. This silence was to be his fall. There was panic among the enemies of the Incorruptible.* (Castelot, 1962, p. 61)

[84] In 1768 at the age of 26, around the time he was elected to the Academy of Sciences, Antoinne Lavoisier bought a share in the *Ferme générale*. For three years following his entry into the *Ferme générale*, Lavoisier's scientific activity diminished somewhat, for much of his time was taken up with official *Ferme générale* business.

Figure 48: Robespierre overthrown during a session of the National Convention (July 26, 1794).

Source: Wikimedia Commons, Max Adamo

The Jacobins had had enough. Cambon rose in the convention and said "It is time to tell the whole truth. One man alone is paralyzing the will of the Convention. And that man is Robespierre." Others quickly rallied to his support, among them the former actor Collot d'Herbois, who was one of those fearing for his life.

> *Collot, who happily for the conspirators was presiding over the session, rang his bell continuously, firmly decided to allow speech only to the attacking side and to refuse it to those who were already figuring as the accused. Three men were now dinging to the tribune: Maximilien, Billaud, who was yelling himself hoarse, and Tallien, who had taken out a dagger with which he was threatening Robespierre. But Billaud's vocal cords were beginning to thicken and Collot's arm to weary. Other partisans immediately replaced them. Thuriot, a former friend of Danton, took the bell from the President's failing hand and rang it with force, while Tallien and Barere, replacing the now speechless Billaud, delivered speech after speech. Robespierre, who had returned to his seat, tried in vain to get in a word. Yells, even from the center, answered him. There were cries of "Down with the tyrant!" Robespierre's breath was taken away. His pale complexion had turned yellow. The words stuck in his throat. It was then that Gamier, from Aube, hurled in his face the famous phrase: "The blood of Danton is choking you! Suddenly came the cry they had been awaiting for three hours: "I demand a decree*

of accusation against Robespierre." It was a certain Louchet who had found the ultimate courage. He was hardly known up to that time and was never to be heard of again. A terrible silence followed the shouting and weighed on the Assembly. The Convention, horrified at its own audacity, said nothing. For a few moments only the sounds of breathing could be heard. Finally the deputies plucked up courage. Applause, at first scattered, broke out. The proposal was accepted and voted by a show of hands. The case was heard. It was nearly four o'clock. Gendarmes entered the hall and arrested Robespierre, Saint- Just and Couthon. Robespierre's brother and Lebas joined them voluntarily, and the prisoners were taken away. (Castelot, 1962, p. 62)

Robespierre was, together with twenty-one of his allies, tried by the Revolutionary Tribunal the next day, July 27, 1794, and sent to the guillotine, the last victim of the Reign of Terror—but not the last victim of the revolution.[85]

It was not only Paris that was under the Reign of Terror. The turmoil had also spread to the countryside, as there followed a series of insurrections within the French cities of Lyon, Avignon, Nîmes and Marseille: the rebellion in Southern France (Figure 50). In Toulon, the revolutionaries evicted the existing Jacobin faction but were soon supplanted by the more numerous royalists. This port was a key naval arsenal, as 26 battle ships (30% of the fleet) were based here. If France were to lose this port, there was no hope for her naval ambitions. So the republican army, after restoring order in Avignon and Marseille, laid siege to Toulon on September 18, 1793. There they were faced with the armies and battle ships of the First Coalition, consisting of British, Spanish, and Neapolitan and Piedmontese troops.

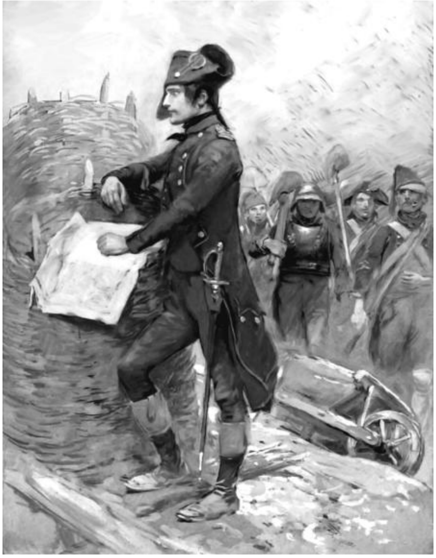


Figure 49: Napoleon Bonaparte at the siege of Toulon (September 1793).

Source: Wikimedia Commons, Edouard Detaille

Then a young artillery officer called Napoleon Bonaparte (Figure 49), well connected with the

[85] Source: Liberté, Egalité, Fraternité: The French Revolution Exhibit, www.historywiz.com/terror.htm. (Accessed December 2014)

republican cause as he knew Augustin Bon Joseph de Robespierre (brother of Maximillian Robespierre) quite well, and distinguished himself[86]. The siege resulted in the conquest of the city, the death of many, and the promotion of Bonaparte to brigadier general at the age of twenty-four.

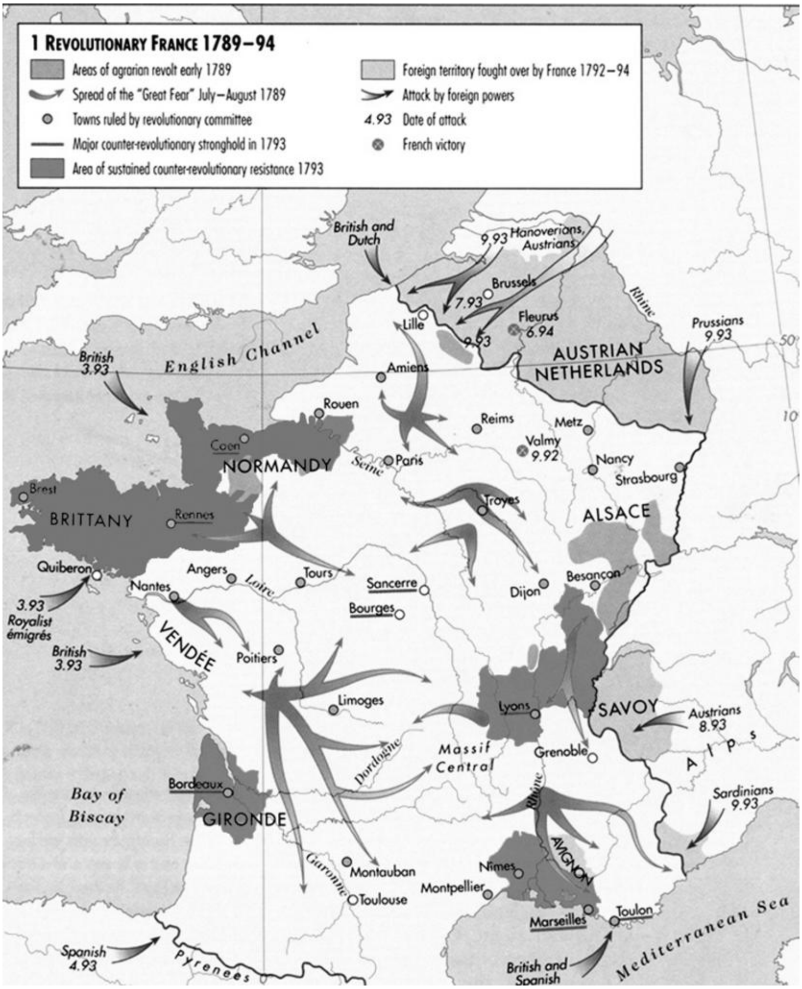


Figure 50: The internal/external wars of the French Revolution (1789-1794).

Map shows both the turmoil and revolts in the country (internal wars) and the wars with different members of the coalitions (external wars).

Source: Philips Atlas of the World (Octopus Publishing Group, 2005). Fair use is claimed.

[86] Augustin Robespierre had become his protector after reading Napoleon's pro-Jacobin pamphlet called "Le Souper de Beaucaire". The pamphlet is a story about a soldier meeting four merchants, discussing the revolution.

The end of Robespierre and the Reign of Terror marked a watershed in the French Revolution. In the period from 1789-1794, France had been in turmoil and overwhelmed with the madness of times (Figure 50). The events not only took place in Paris and Versailles; the countryside was also in turmoil. After the spreading of the *Great Fear*, counter-revolutionary movements dominated in areas such as Brittany, Normandy and the Vendee, Bordeaux, Nimes and Lyon. Although revolutionary committes had settled in important towns (eg Amiens, Reims, Dyon), other cities formed major counterrevolutionary strongholds (eg Lyon, Toulon).

The Directory

The aftermath of the Reign of Terror and the extremist behaviour of the Committee of Public Safety, called the Thermidorian Reaction, was a watershed in the French Revolution. Uprisings, turmoil and mass executions continued, but now it was royalists that attacked the revolutionary Jacobins in what became known as the *White Terror*. Throughout France, both real and suspected Jacobins were attacked and often murdered. "Bands of Jesus" dragged suspected terrorists from prisons and murdered them much as alleged royalists had been murdered in the September massacres of 1792. Just as during the Reign of Terror, trials were held with little regard for due process. In Paris, the *Muscadins*, gangs of dandyish youths from the bourgeoisie that were the street fighters (some 2,000-3,000), roamed the streets attacking Jacobins and *sans-culottes*. They formed a parallel militia that replaced the *sans-culottes*.

There was also another reaction to the horrors of that time, as not much later, the Incroyables/Merveilleuses appeared: young men and women originating from the fashionable aristocratic subculture that were the *nouveau riches* of that time (Figure 51). They dominated a city that erupted in a furore of pleasure-seeking and entertainment. They held parties (*bals de victims*), dancing in mourning dress, in memory of their guillotined loved ones. The Incroyables wore eccentric outfits: large earrings, green jackets, wide trousers, huge neckties, thick glasses, and hats topped by dog ears, their hair falling on their ears. The Merveilleuses scandalized Paris with dresses and tunics modelled after the ancient Greeks and Romans, cut of light or even transparent linen and gauze, sometimes so revealing they were termed "woven air"; many gowns displayed cleavage and were too tight to allow pockets.

Figure 51: Incroyable and merveilleuse (1794-1795).
Source: Wikimedia Commons,

In 1795, a new constitution was created and accepted by the bicameral legislative that consisted of the upper house (House of Ancients) and the lower house(Council of the 500). The new constitution went back to the constitution of 1791 for the dominant ideology of the country. Equality was certainly confirmed, but within the limits of civil equality. Many of the former ideals of the revolution were maintained: freedom of the press, freedom of religion and freedom of labour. However, numerous democratic rights of the constitution of 1793 were omitted. The convention wanted to define rights and simultaneously reject both the privilege of the old order and social levelling. This constitution of August 22, 1795 established the *Directory*, a government body of five directors. The Directory wanted to cater toward the growing number of royalists in France as well as the remaining Jacobins and sans-culottes who favoured the Republic.

Again the country was in shambles: economic depression, crop failures and famines, inflation reducing paper money to 1% of its face value, the army's uprisings and the government attacking its critics. Neither peasants nor merchants would accept anything but cash. The debacle was so swift that economic life seemed to come to standstill. The crisis was greatly aggravated by famine. Peasants, finally, stopped bringing any produce because they did not wish to accept paper money (*assignats*). The government continued to provision Paris but was unable to supply the promised rations. In provinces, local municipalities resorted to some sort of regulations, using force in obtaining provisions. The misery of rural day

Figure 52: Napoleon Bonaparte attacks the royalist uprising in Paris in the Rue Saint-Honore (October 5, 1795).

Source: Wikimedia Commons, Photothèque des Musées de la Ville de Paris/Habouzit for 1987 CAR 5607 NB labourers, abandoned by everyone, was often appalling. Inflation ruined creditors to the advantage of debtors. It unleashed an unprecedented speculation.

The Directory seemed to herald the end of the revolutionary period. People were tired of the terror, and there was disengagement, apathy, and cynicism about government among the common people. On the other hand, there was the rancorous, violent hostility between the politically engaged minorities of royalists and Jacobins, between whom the Directorial moderates vainly attempted to navigate. It was the battle of the monarchists against revolutionists that still created turmoil. On October 5, 1795, a battle between the revolutionary troops and the royalist forces in the streets of Paris started the rise of a 26-year-old army officer, Napoleon Bonaparte (Figure 52). With a few strategically placed canons, he scattered the rebels; the convention was saved and struggled on.

In the countryside, the Mass Drownings of Nantes from July 1793 to February 1794 took several thousand lives, among them many members of the clergy. They were drowned in the mouth of the river Loire. Many were killed by being thrown overboard, others by way of the "republican marriage", where a naked man and woman were tied together and drowned (Figure 53). The drownings were complemented by executions by firing squads at a quarry in the village of Gigant. There were also the Machecoul Massacres in March 1793, where in a gruesome revolt, hundreds of both republicans and counter-revolutionary suspects were murdered when they protested against mass-conscription, and the enforcement of the civil constitution of the clergy escalated.

Figure 53: Mass drowning at Nantes in the river Loire (October 5th, 1795).

Source: Wikimedia Commons, Photothèque des Musées de la Ville de Paris/Habouzit for 1987 CAR 5607 NB

On the other side of France, in the Siege de Lyon, a revolt was crushed in August 1793. Here many prisoners were collectively killed by grapeshot from a canon. In the coastal area of Brittany, a major landing of divisions of 3,500 French *émigrés* in June 1795 from English ships resulted in the Battle of Quiberon. It was part of the Chouannerie: a range of several revolts between 1794 and 1800 that killed thousands. In Provence, in the south of France, a counter-revolution broke out in 1793 in the cities of Avignon, Toulon and Marseille. All these civil wars (Figure 50) illustrated the madness of those times.

The revolutionary foreign policy was more successful. One reason was that it stimulated the economy by offering employment to young unemployed people, and it was financed by the considerable spoils and levies extracted from the conquered countries[87]. After the year 1794

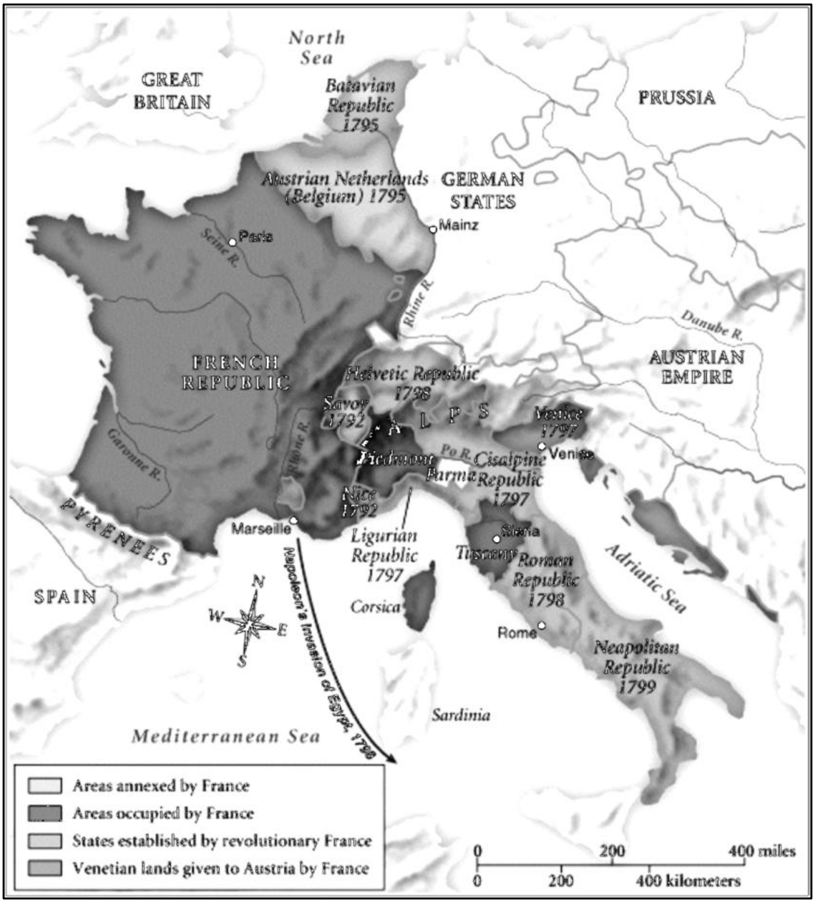


Figure 54: The sister republics of France during the First Republic (1792).
Source: Wikimedia Commons

[87] The Batavian Republic, for example, had to pay a war indemnity of 100 million Dutch guilders and annual maintenance costs of 12 million guilders for an army of occupation, amounting to 230 million Dutch guilders in total.

brought increased success to the revolutionary armies, the revolution was spread in a range of campaigns in the War of the First Coalition. In the south, it was the Italian Campaign, with the Battle of Lodi (Lombardy, Italy) on May 10, 1796 that brought northern Italy under control. In the north it was the Bavarian Campaign, where the army annexed the Austrian Netherlands (Belgium/ Luxembourg), and the Rhinelands on the western bank of the Rhine River. In the east, the republican armies "liberated" the Swiss people of feudalism. It resulted in a range of satellite regimes (sister republics) in Switzerland (The Helvetia Republic), Italy (the Ligurian Republic, the Cisalpine Republic) and the Netherlands (the Bavarian Republic), with institutions and a legislation similar as in France (Figure 54).

The military forces that realized this successful campaign were under the command of a general called Napoleon Bonaparte, a general who, as the winner of the Treaty of Campo Formio (October 18, 1797) returned to Paris as a hero, ready to prepare for the next campaigns, now against the English. As the British Royal Navy was too powerful in the English Channel, he had started the Mediterranean campaign in 1798 to seize Egypt and threaten the British interests in the Far East (India). It became a disaster, as at the Battle of the Nile (August 1-3, 1798), French ships were eliminated, trapping Bonaparte in Egypt and changing the balance of power in the Mediterranean.

On the home front, the economy was in shambles. State finances were in total disarray; the government could only cover its expenses through the plunder and the tribute of foreign countries. Commerce almost ground to a halt due to the decay of roads and the increase of bandits. The Directorate had lost control. In March-April 1797, new elections were held and the Directorials were defeated; pro-royalists and pro-Jacobins took control of the provincial assemblies. In reaction, the Directorate annulled the elections and removed the new deputies from their seats. It resulted again in revolt, this time on September 4, 1797, when Paris was placed under a military occupation. There was no resistance, and a decree stated that all those who wished to bring about the reestablishment of the monarchy would be shot on the spot. The elections were annulled in 49 departments, 177 deputies were removed and 65 were sentenced to *dry guillotine*—ie deportation to Guiana—42 newspapers were suppressed and repressive measures against *émigrés* and priests were re-implemented. The councils were purged, the elections in forty-nine departments were cancelled, and many deputies and other men of note were arrested. Then the government frankly returned to Jacobin methods. The law against the relatives of *émigrés* was re-enacted, and military tribunals were established to condemn any *émigrés* caught in France.

The combination of losses on the warfront, the political instability, and the economic downturn created the context for the next change: the Coup of 1799.

The Consulate

The Directorate struggled on, but not for too long, as on November 9, 1799, the army, under the promoted General Napoleon Bonaparte staged a coup d'état that overthrew the Directory (Figure 55). Napoleon Bonaparte became a member of a provisional trio of three consuls. The nation voted for the new constitution in a public referendum on February 7, 1800.

Figure 55: Napoleon Bonaparte in the coup d'état of 18 Brumaire in Saint-Cloud. (November 10, 1799).

Source: Wikimedia Commons, Francois Bouchot

> *After ten years of upheaval and terror the French are ready to accept dictatorial rule by a man who is decisive and undoctrinaire, professionally equipped to direct France's wars against her many enemies, sympathetic to the principles of the revolution (as his early career has proved) and yet inclined to safeguard people's resulting windfalls. Napoleon and the times are well suited to each other. The plebiscite of 1800 gives Napoleon the mandate to play a role for which he is well suited both in character and in terms of his 18th-century education - that of the enlightened despot.* [88]

The change of power was the result of many political struggles and personal rivalries. It was a bitter fight between Jacobin and Royalist, including plots and assignation attempts, such as the *Conspiration of the Swords* (October 1800) and the plot of the rue Saint-Nicaise (December 1800). The last plot was planned for by several royalist Breton Chouans on Christmas Eve. The plan was to explode a cart loaded with gunpowder as Napoleon passed by in his carriage on his way to the opera.

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[88] Source: www.historyworld.net/wrldhis/PlainTextHistories.asp?ParagraphID =mci#ixzz3LgYQzuLz. (Accessed December 2014)

It was three minutes past eight on a cold and misty Christmas Eve and the chief of state was late for a performance of Joseph Haydn's oratorium 'The Creation'. In order to make up time, his driver was proceeding at an even more reckless speed than usual and instead of following his usual route down the main road to the opera house, he turned early into a side street. A few seconds after vehicle and escort turned the corner, the air was filled by the roar of an enormous explosion which shattered the vehicle's windows, as well as those in the surrounding buildings, as a large vehicle borne improvised explosive device had been detonated on the main road. Fortunately, the chief of state was not injured by the blast. But as many as twenty-two civilians were reported killed and numerous others injured.[89]

The ensuing search for suspects gave Napoleon, with the help of one of the most powerful men of that time, the minister of police Joseph Fouché, the chance to eliminate the royalist opposition and the extreme left Jacobins. The executive power was now even more strongly in the hands of three consuls (Figure 56), among which Napoleon was the First Consul.

Now that Napoleon was solidly in power, he wanted to consolidate it by following the road of peace. As the majority of the French population was Catholic, he started to create religious peace by restoring ties to the papacy, as the clergy had been one of the main targets of the revolution. Under threat of death, imprisonment, military conscription and loss of income, about twenty thousand constitutional priests were forced to abdicate and hand over their letters of ordination; and six thousand to nine thousands of them were coerced to marry.

Figure 56: The three consuls of the executive power of the First French Republic: Napoleon Bonaparte, Cambaceres and Lebrun.

Source: Wikimedia Commons, Charles-Auguste Couder

[89] Source: http://terrorismanalysts.com/pt/index.php/pot/article/view/duncan-a-blast-from-the-past/html. (Accessed December 2014)

Many abandoned their pastoral duties altogether. Nonetheless, some of those who had abdicated continued covertly to minister to the people. By the end of the decade, approximately thirty thousand priests had been forced to leave France, and others who did not leave were executed. Most French parishes were left without the services of a priest and deprived of the sacraments. By Easter 1794, few of France's forty thousand churches remained open; many had been closed, sold, destroyed or converted to other uses. It was within this context that Napoleon signed on November 29, 1799 a decree ending the deportation of priests. In 1801, the de-Christianization more or less ended when Napoleon created in an agreement with Pope Pius VII, the *Concordat of 1801*, stating that the Catholic Church would be the majority church of France. In the Law of Organic Articles of 1802, the religion-based problems were addressed. Napoleon did not forget France's 680,000 Protestants, composed of 480,000 Calvinists and 200,000 Lutherans. By decree, he opened the chapels and decided that pastors would receive a salary from the state. And in 1806, he freed the Jews from their isolation by making Judaism the third official religion.

Next he wanted to create *political peace*. So at about the same time the Second Revolutionary War ended with the Treaty of Luneville, signed in February 1801 with Austria, he made overtures to create peace with Britain. It took a year of diplomatic ballet to realize the *Peace of Amiens* (March 25, 1802). In the treaty was stipulated that England would return colonies[90] and withdraw from Egypt, the Papal States, the Kingdom of Naples, the Maltese islands, and Minorca. In fact, it reduced Britain's rule in the eastern Mediterranean. It resulted in the *Amiens interlude*; a period of peace in which Paris was flocked by (aristocratic) visitors from Brittan, many of them "seeking pleasure". They went to the theatres with their plays and operas, visited the places of the revolution (eg the Bastille) and they wanted to see Napoleon himself as he appeared in public. Even a number of *émigrés* returned.

> *For the British government the experiment* [of the Treaty of Amiens] *was in living alongside a swollen French Republic controlled by a charismatic military dictator; for the military dictator the experiment was in expanding his power in times of peace rather than by conquest.* (Grainger, 2004, p. 210)

[90] Remarkably the conditions of the treaty were in favor of the Batavian Republic; Cape Colony and the West Indian Dutch colonies were to be returned, and the House of Orange-Nassau was to be compensated for its losses in the Netherlands. As the Batavian Republic's economy dependend on trade, they were willing to contribute financially to the peace process. But they still were under the control of France.

That peace did not last long, as the British did not honour the Maltese terms of the treaty when they became more and more concerned with Napoleon's growing imperialist policies in Europe and expansionists activities outside Europe. The resulting diplomatic and political conflict caused an exodus of foreigners—among those British on a Grand Tour like Maria Edgeworth and Amelia Opie—from France. Quite some faced even long time detention. However, on May 17, 1803 the British Royal Navy captured all the French and Dutch merchant ships stationed in Britain or sailing around, seizing more than two million pounds of commodities and taking their crews as prisoners. It was the start of another economic blockade of the French coast, crippling the French foreign trade. The French retaliated by ordering the arrest of British males between 18 and 60 in France and Italy, trapping travelling civilians[91].

But before that all happened, on August 2, 1802, a second national referendum was held, this time to confirm Napoleon as "First Consul for Life". With the peace of Amiens declared, the people of France, from Paris to the provinces, erupted in joy. For a month there was nothing but festivals, balls, fireworks and speeches by prefects and mayors, accompanied everywhere by "Long live the First Consul, long live Bonaparte!" For the first time since April 20, 1792, France was no longer at war. This peace lent the Consulate an allure and a splendour that radiated across the century, making this a blessed time, a golden age, one of these privileged moments that are so rare in a nation's history. The years 1801-1804 marked the high point of France's fortunes. France enjoyed a high level of peace and order under Napoleon that helped to raise the standard of comfort. Provisions in Paris, which had so often suffered from hunger and thirst and lacked fire and light, had become cheap and abundant; while trade prospered and wages ran high.

Overview of the First Republic

After the *Reign of Terror*, the time of the First French Republic—as it was created by the Directory in which a small group of men came to power—was still a period of (white) terror. The civil wars raged, especially on the countryside, killing thousands of people. Among those were the victims of the dechristianization, in which the clergy was stripped of its power (and wealth). The *émigrés* tried, with the help of the English, to come back and resize power. They failed, however, and the republicans established their reign with brutal force all over France: from Vendee in the west to

[91] During the renewed period of war, between 700 and 800 British civilians who had not been able to return to Britain before May 1803 became *détenus* at Verdun and other places in France for ten years (Wang, 2010).

Provence in the south (Figure 57).

France, being confronted by the coalition of the powers of those days (England and Prussia), was more successful in the Wars of the First and Second Coalition. It managed to secure its reign in the countries on its borders: the Austrian Netherlands, the Rhinelands, the Savoy and Nice. In a range of campaigns, it managed to establish vassal states (the sister republics of the Bavarian Republic, the Helvetic Republic and the Ligurian and Cisalpine Republics).

With Napoleon's coup in 1799, the Consulate under his leadership as First Consul managed to create peace both with the clergy and with the foreign nations. For the first time after the start of the revolution, France saw peace during the Amiens interlude. From the absolute monarchy, France was changed into a not-too-successful republic. Now it was about the transition from an exhausted republic to a dynamic despotism.

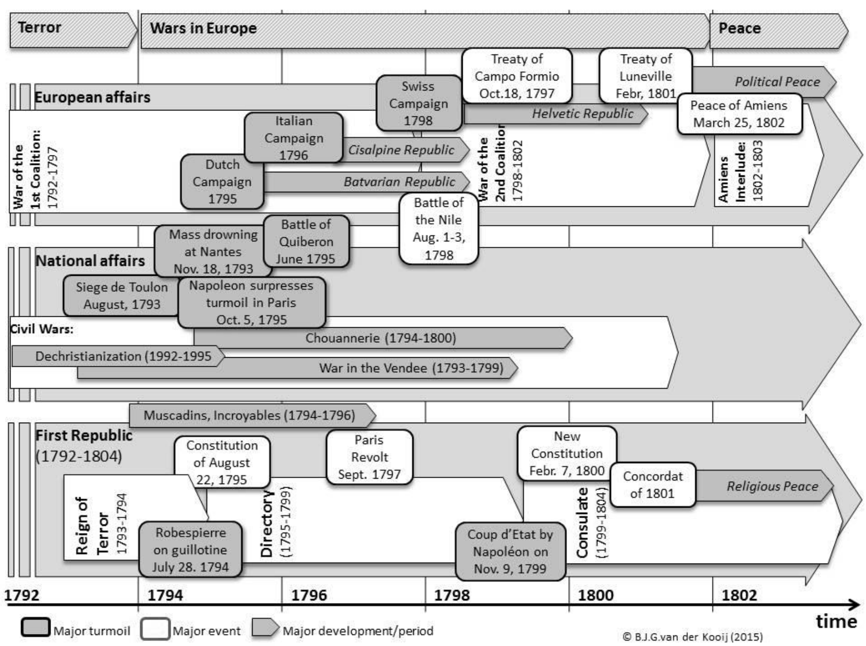


Figure 57: Overview of major events in the First French Republic (1792-1802).

Source: Figure created by author

The French Empire (1804-1814)

Europe was now in peace, but not for long. The common people may have been content, but the former royalists and Jacobins were not. And the other European countries certainly were not, where the old powers looked upon the French Revolution with suspicion. Throughout the revolution they were on the side of the monarchy and allied in the First and Second Revolutionary Wars; now they saw France getting more expansive ambitions under Napoleon. The peace was indeed short lived as the British gathered a Third Coalition against France and declared war on France on 18 May 18, 1803.

Notwithstanding the peace-efforts, during the Consulate the dissent with the government had grown, especially in the circles of the senators and republican generals. French royalists, financed by the British, devised a plot to kidnap and assassinate Napoleon in order to restore the Bourbon monarchy (the Cadoudal Plot). The plot failed, however, and only caused further irritation with the other European countries.

> *The plots were conceived by English ministers in collaboration with aristocratic French émigrés in London. They were then orchestrated by diplomats Sir Francis Drake in Munich and Spencer Smith, the brother of the admiral, in Stuttgart. The English agent Wickam had returned to Bern, from whence he played the role of corrupter, as he had done in 1795, 1796, 1797 to enrol Pichegru. Taylor did*

Figure 58: Coronation of Emperor Napoleon I and coronation of the Empress Josephine in the Notre-Dame de Paris, December 2, 1804.

Source: Wikimedia Commons, Jacques-Louis David

> *the same in Cassel." … The conspiracy by Cadoulal, which provoked justifiable outrage in the country (the Senate was shown coins found on the three English agents, Drake, Taylor and Smith, thereby substantiating the active participation of their country in the plot), had prepared public opinion for a change that seemed more and more essential for the survival of the state.* [92]

To strengthen Napoleon's political position, on May 18, 1804, the Senate passed a bill introducing the French Empire. Next, a referendum was held in France in November 1804. The officially announced result showed a nearly unanimous French electorate approving the change in Napoleon Bonaparte's status from First Consul to Emperor of the French. The ensuing coronation ceremony took place on December 2, 1804, where Napoleon crowned himself as Emperor of the French, establishing the First Empire (Figure 58), an empire that would grow within a decade into a large geopolitical force in Europe (Figure 62) that frightened the European nations of that time.

At War with the Coalitions

After his crowning, Napoleon continued fighting against successive coalitions of European allies. It was this military policy of the First Empire that influenced the geo-political development of Europe. Napoleon's way of preparing for battle, his strategies and tactics, his personal involvement and the loyalty and morale of his troops made him very successful and feared by the generals of the coalitions. Military morale was enhanced by the fact that out of the spoils of the war, every soldier would get his reward; being wounded or being involved in specific battles earned the soldier additional money. Also, promotion was open to anyone who proved capable. There was a saying in Napoleon's army: "Every one of you carries a marshal's baton in his knapsack; it is up to you to bring it out".

> *From 1796, when he assumed his first independent military command, until 1809, Napoleon displayed an astonishing near-invincibility in battle and an equally astounding ability to use that battlefield success to compel his enemies to grant him his political objectives. ... Napoleon knew how 'to speak to the soul' of his officers and men. Partly he used material rewards and incentives - titles, medals, awards; partly he resorted to deliberate theatrical measures to bend men to his will; but above all there was the sheer power of personality or charisma that*

[92] Source: http://www.napoleonicsociety.com/english/Life_Nap_Chap28.htm. See also: http://terrorismanalysts.com/pt/index.php/pot/article/view/duncan-a-blast-from-the-past/html

emanated from his large, grey eyes which so many of his contemporaries described.[93]

Third Coalition (1805): Fearful of an expanding France, Britain, Austria, and Russia formed the Third Coalition, but Austria and Russia were soundly beaten at the Battle of Austerlitz (December 2, 1805). Austerlitz and the preceding campaign profoundly altered the nature of European politics. Within three months, the French had occupied Vienna, decimated two armies and humbled the Austrian Empire. The ensuing Treaty of Pressbourg (December 26, 1805) ended hostilities for only a short time.

Fourth Coalition (1806–1807): Russia and Britain were still at war with France, and Prussia jumped into a new coalition (Figure 59). Prussia feared the rise in French power after the defeat of Austria and establishment of the French-sponsored Confederation of the Rhine. But the Prussians and Russians were soundly drubbed at the Battle of Friedland (June 14, 1807), effectively ending hostilities. By the Treaties of Tilsit in July 1807, France made peace with Russia. The treaty, however, was particularly harsh on Prussia, as Napoleon demanded much of Prussia's territory along the lower Rhine west of the Elbe. The end of the war saw Napoleon master of almost all of western and central continental Europe, except for Spain, Portugal, Austria and several smaller states.

Figure 59: Officers of the élite Prussian Garde du Corps, wishing to provoke war, sharpen their swords on the steps of the French embassy in Berlin in the autumn of 1806.

Source: Wikimedia Commons, F. de Myrbac

Fifth Coalition (1809): Once again, the Austrians and British joined forces to try to throw Napoleon out of France. And once again, Napoleon thumped the Austrians, this time at the Battle of Wagram

[93] Source : Napoleon's Strategy and Tactics ; Morale of Napoleon's Troops. http://www.napolun.com/mirror/web2.airmail.net/napoleon/Napoleon_tactics.htm#napoleonstrategymorale

Figure 60: The Battle of Aspern-Essling (May 1809).
Source: Wikimedia Commons, Fernand Cormon

(July 5–6, 1809), but not after he experienced the first major defeat in his military career: the Battle of Aspern-Essling (21–22 May 1809, (Figure 60). The ensuing Trea ty of Schönbrunn (October 14, 1809) was the harshest that France had imposed on Austria in recent memory. But the war was not over yet, as the Brits were getting active in Spain, and the handwriting was on the wall, as French military superiority and the Napoleonic image were getting undermined.

Napoleon was married in 1796 with his former mistress, the barren Joséphine de Beauharnais*,* widow of Alexandre de Beauharnais, who was guillotined during the Reign of Terror. But in 1810, Napoléon divorced her and married Marie-Louise of Austria, the daughter of the last Holy Roman Emperor Francis II, hoping to cement relations between the nations and also to give himself an heir.

By this marriage, he became the nephew of Louis XVI and Marie-Antoinette as well as the son-in-law of the old Habsburg dynasty. His son of this marriage succeeded him—being a four year old toddler—briefly as Napoleon II in 1815.

In 1812, Napoleon was at the height of his power. His sphere of direct influence covered a large part of Western Europe. The French Empire reached from Gibraltar in the South of Spain to the Donau regions in the east (Figure 62). His power was such that none of the European countries, except again Britain, dared to oppose his ruling. And then his fate turned when Russia withdrew from the Continental System.

Sixth Coalition (1812–1814): Russia betrayed Napoleon by trading with his enemy, Britain, thus undermining the economic blockade of Britain as foreseen by the Berlin Decree in 1806 (in the so-called

Continental System). As a result of the Industrial Revolution, Britain was Europe's manufacturing and business centre. To hurt their exports, Napoleon had decreed that all European nations should refrain from trading with Britain. But Russia refused to comply, and the resulting hostilities led to Napoleon's invasion of Russia. With an army of 650,000 men, he gained victory at the Battle of Borodino (September 7, 1812). After the occupation of an empty Moscow, without provisions and the winter approaching, Napoleon decided to retreat. It would become the disastrous Great Retreat (Figure 61). Confronted by partisan tactics from the Russians, the starving French troops had to eat their horses, abandon their canons, starve and face diseases; the French military position collapsed. The harsh winter conditions aggravated the situation as the army was supplied with summer clothing. Hypothermia coupled with starvation led to the loss of thousands. Out of an original force of 615,000, only 110,000 frostbitten and half-starved survivors stumbled back into France.

Figure 61: The Night Bivouac of the Napoleon Army during retreat from Russia in 1812.

Source: Wikimedia Commons, Vasily Verehchagin

Napoleon's withdrawal from Russia, opened the floodgates, and one by one his allies became former allies and members of the Sixth Coalition. Napoleon's defeat at the Battle of Leipzig (October 16–19, 1813), also known as the Battle of Nations, sealed his fate after the coalition troops invaded France and captured Paris (the Battle of Paris/Montmartre of March 30, 1814). Napoleon was exiled from France to the island of Elba (as Emperor of Elba) when the French Senate on April 2 agreed on the *Acte de déchéance de l'Empereur* (Emperor's Demise Act). In that same act, the Count of Provence (member of the House of Bourbon and brother of Louis XVI) was invited to the throne as King Louis XVIII. It was to be the *First Restoration* of the monarchy. And the victorious coalition eagerly sought to redraw the map of Europe at the Congress of Vienna.

Figure 62: The French Empire in 1812.

Source: Wikimedia Commons

This ended the first French Empire. Now the (first) *Bourbon Restauration* put the monarchy back in the driver's seat. But, in contrary to the absolute monarchy before the revolution, this was a constitutional monarchy, as the great powers occupying Paris demanded that Louis XVIII implement a constitution. So in the Charter of 1814, freedom of religion, freedom of press, and a two-chamber legislature consisting of the Chamber of Deputies and the Chamber of Peers was created. The peers were appointed by the king and the deputies would be elected every five years by citizens who paid taxes and were older than forty years (about 90,000 people were eligible to vote). His promises to abolish certain unpopular taxes (salt, tobacco, wine) were soon forgotten, and his treatment of the veterans of the Grande Armee was soon causing dissent among the troops. His monarchy was not to be unchallenged, as he had quite underestimated Napoleon.

Then Napoleon organized his escape from Elba with the help of troops still loyal to him (Figure 63). Landing in Golfe-Juan near Cannes, he followed the Route Napoleon to Grenoble, where he was met by the soldiers of the Fifth and Seventh Infantry Regiment.

> *On February 26, 1815, Napoleon managed to sneak past his guards and somehow escape from Elba, slip past interception by a British ship, and return to France. Immediately, people and troops began to rally to the returned Emperor. French police forces were sent to arrest him, but upon arriving in his presence, they*

Figure 63: Napoleon's return from Elba (1814).
Source: Wikimedia Commons, Charles Auguste Guillaume Steuben

kneeled before him. Triumphantly, Napoleon returned to Paris on March 20, 1815. Paris welcomed him with celebration, and Louis XVIII, the new king, fled to Belgium. With Louis only just gone, Napoleon moved back into the Tuileries. The period known as the Hundred Days had begun.... At the Congress of Vienna, where the European powers were meeting to discuss how to rearrange Europe in the aftermath of Napoleon's conquests, news of Napoleon's escape from Elba delivered an intense shock to all. On March 13, 1815, the nations represented there declared Napoleon an outlaw.[94]

Seventh Coalition (1815): Napoleon's return to France for a second reign as emperor (dubbed the Hundred Days to indicate its duration) caused all his old enemies to unite against him, with final defeat coming at the Battle of Waterloo (June 18, 1815), a carnage that took some 45,000 dead and wounded soldiers as well as 7,000 dead horses (Figure 64). After his defeat, he found the French politicians in the chambers quite hostile when he returned to Paris, now not as a conqueror but as a defeated man. He was forced to abdicate, thus

[94] Source: http://www.sparknotes.com/biography/napoleon/section9.rhtml. (Accessed June 2015)

> also losing his last battle at the home front.
>
> The following Second Treaty of Paris (November 1815) ended Napoleon's Hundred Days with some consequences. France's borders were retracted to their extent at 1790. France had to pay for an army to occupy her for at least five years at a cost of 180 million francs per year. France also had to pay a war indemnity of 320 million francs and war reparations of 700 million francs to the allies. All in all, the French actually paid 1.863 million francs, a considerable burden for French society (Eugene N White, 2001, pp. 5, 8). On top of that were the payments claimed by the royalist *émigrés* (one billion francs). The burden of these reparations, combined with the disastrous harvests and the destructions of the preceding wars, crippled the French economy for years.[95]

The question was what to do with the defeated emperor? He could not stay in France, and no country wanted to give him asylum. His plan to go to America, the land of freedom, failed. Facing execution by the Prussians

Figure 64: The Battle of Waterloo (May 1809).

Source: Wikimedia Commons : The storming of La Haye by Knötel

[95] The ones that profited exceptionally from Napoleon's defeat were the Rothschild bankers in London. They had used carrier pigeons to learn of Wellington's defeat of Napoleon at Waterloo before anyone else did; they bought British government bonds and realized a quick profit when their value rose once the victory became widely known. It resulted in their complete control of the British economy (Reeves, 1887, pp. 169-175).

(and even by the French), he ended up in England asking the Brits to protect him. Not too eager to repeat the Elba disaster, they did, on the most isolated place in the British dominated sea: St. Helena. So, with Napoleon sent off—in October 1815—to the totally isolated and strongly guarded island of St. Helena in the Southern Atlantic Ocean, 1,870 km from the west coast of Africa that was the end for Napoleon— politically but also physically, as soon as he died on May 5, 1821.

King Louis XVIII returned and was put on the throne by general Wellington in the *Second Bourbon Restoration*. With the foreign conquerors now demanding their spoils of war, France was also facing some severe additional problems, such as the economic situation, and the climatic conditions:

> *Throughout France, manufacturers fired workers or cut salaries and hours of work. The government responded to this crisis by importing grain from abroad, subsidizing the price of bread and providing some public works. Good harvests in 1817 and 1818 checked the rise in prices, but the depression continued through 1820. Part of the depression is be attributed to the restriction of credit by the Banque de France in response to a rapid drain in reserves, after the expansion of discounts in 1818, a part of the reparations funding.* (Eugene N White, 2001, p. 32)

> *The abnormally low temperatures in western and central Europe were accompanied by excessive precipitation during the growing season. Also, the agricultural dislocations occasioned by the recent wars reinforced the calamity. … Of more economic importance, the destructive weather exacted a high mortality among Europe's animal population. The excessive moisture proved especially injurious to cattle and sheep. Allegedly in Germany many landowners and peasants saw more than half of their flocks perish. Enormous mortality among the livestock during 1816-1817 was likewise reported in the United Kingdom, France, the Netherlands, Switzerland, and the Habsburg Monarchy.* (John D. Post, 1974, pp. 329, 341)

This totality of a disastrous economic situation, combined with severe climatic conditions, left a politically and socially unbalanced country—a country that was not in a position to participate wholeheartedly in the approaching development of the first Industrial Revolution. But one thing they did do was return Napoleon's remains from St. Helena to France in 1840. It was the *retour des cendres* (return of the ashes) under massive public interest. His remains were entombed at the Hôtel des Invalides in Paris.

Napoleon's Legacy

At that moment in time—mid 1815—France was back at the beginning of the revolution, certainly in terms of territory. France lost it annexations and was back to its borders of January 1790. The Napoleonic Wars had cost 2.5 million soldiers and a million civilians their lives. The monarchical aspects, however, had changed. France was now a constitutional monarchy; the Third Estate had conquered a place in the legislature, the citizens had gotten their liberal rights and the dominating role of the aristocracy and clergy was considerably diminished.

Napoleon's contribution to all this was based on his military capabilities. He changed the traditional military operations of that time and thus created a revolution in the conduct of warfare. It was Napoleon who exported the social revolution from France to Europe, with large effects on the respective societies. They had—during the wars—another noticeable effect for the French population: a recovering economy. For his armies he needed a massive volume of goods: from military supplies to fortifications. Financed with the spoils of the wars and the levies of the occupied countries, economic activity increased, only to collapse again with the 1815 defeat. These post-Napoleonic depressions had economic effects that were felt in France, but also in England.

> [In England] *Industrial stagnation in 1810-1812 led to widespread unemployment of both labor and industrial equipment, and, in this emergency, frame breaking by the Luddites became a common occurrence in the British textile industry. But 1812-1813 brought a revival of British trade and industry, which ripened into a speculative boom as the war came to an end in 1814 culminating in a great depression in 1815-1817. Despite some recovery in the last half of 1817, and notwithstanding a sharp revival in 1818, British industry once again fell into a depressed state in 1819. A gradual recovery occurred in 1821-1822.* (O'Leary, 1943, p. 186)

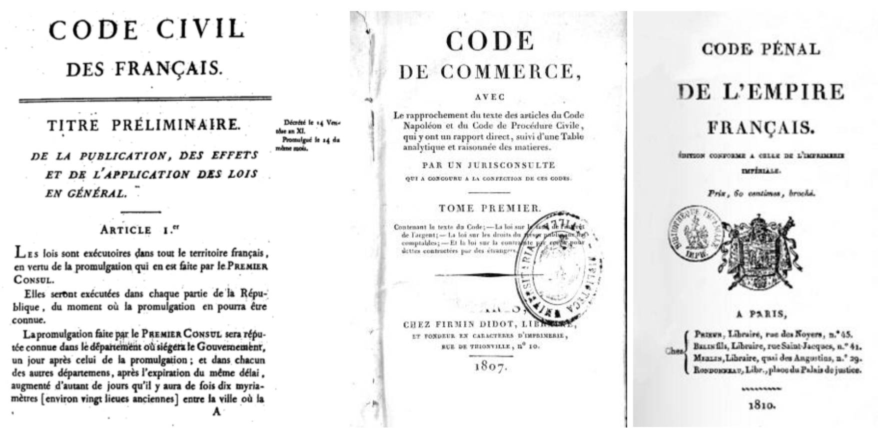
Under these more visible layers of the influence of Napoleon on France and Europe, there is another range of effects: his influence on civil development and administrative structure, his involvement in creating the country's transportation infrastructure and his interest in education and science. It resulted in a range of interwoven institutional developments important in creating the context for the first half of the nineteenth century: restoring the legal system, creating a transportation infrastructure and reorganizing the educational system.

Napoleon set to reform the French legal system in accordance with the ideas of the French Revolution: ideas that found their origin in the *Declaration of the Rights of Man and of the* Citizen of 1789, a core statement of the values of the French Revolution that had a major impact on the development of liberty and democracy in Europe—and even worldwide. It became known as the Napoleonic Code: a codification of law including civil, family and criminal law that Napoleon imposed on French-conquered territories (Figure 65).

Civil Code: Under his regime, the French created the civil part of the Napoleonic Code, which forbade privileges based on birth, allowed freedom of religion and specified that government jobs should go to the most qualified. It also established the rights of property, succession, freedom of servitudes and manorial services. By 1801, the code was complete but was not published until March 21, 1804. Promulgated as the Civil Code of the French, other European countries would adapt to this code over time.

Commercial Code: In 1807, the Code de Commerce was adopted. It regulated the creation of corporations and societies and the issue of shares in companies. It originated the law on bankruptcy and regulated foreign trade, navigation and the commercial courts.

Penal Code: To replace the former penal code of the revolution (1791), a new penal code was developed and implemented in 1810: the Code d'Instruction Criminelle (1808) and the Code Penal (1810). This code was concerned with the establishment of courts (eg the *tribunaux*



CODE CIVIL
DES FRANÇAIS.

TITRE PRÉLIMINAIRE.

DE LA PUBLICATION, DES EFFETS ET DE L'APPLICATION DES LOIS EN GÉNÉRAL.

Décrété le 14 Ventôse an XI.
Promulgué le 24 du même mois.

ARTICLE 1.er

LES lois sont exécutoires dans tout le territoire français, en vertu de la promulgation qui en est faite par le PREMIER CONSUL.

Elles seront exécutées dans chaque partie de la République, du moment où la promulgation en pourra être connue.

La promulgation faite par le PREMIER CONSUL sera réputée connue dans le département où siégera le Gouvernement, un jour après celui de la promulgation; et dans chacun des autres départemens, après l'expiration du même délai, augmenté d'autant de jours qu'il y aura de fois dix myriamètres [environ vingt lieues anciennes] entre la ville où la

A

CODE
DE COMMERCE,
AVEC
Le rapprochement du texte des articles du Code Napoléon et du Code de Procédure Civile, qui y ont un rapport direct, suivi d'une Table analytique et raisonnée des matieres.

PAR UN JURISCONSULTE
QUI A CONCOURU A LA CONFECTION DE CES CODES.

TOME PREMIER.

CHEZ FIRMIN DIDOT, LIB
ET FONDEUR EN CARACTERES D'IMPRIMERIE,
RUE DE THIONVILLE, n° 10.

1807.

CODE PÉNAL
DE L'EMPIRE
FRANÇAIS.

ÉDITION CONFORME A CELLE DE L'IMPRIMERIE IMPÉRIALE.

Prix, 60 centimes, broché.

A PARIS,

Chez Prieur, Libraire, rue des Noyers, n.° 45.
Belin fils, Libraire, rue Saint-Jacques, n.° 41.
Merlin, Libraire, quai des Augustins, n.° 29.
Rondonneau, Libr., place du Palais de justice.

1810.

Figure 65: The Code Civil (1804), the Code de Commerce (1807), and the Code Penal (1810).

Source: Wikimedia Commons

spéciaux) and reorganized the penal institutions of detention. This code served as a basis for criminal laws in many of the countries occupied at the time by the First French Empire.

As can be expected, in periods of such dramatic turmoil, during the early days of the revolution the postal service had fallen into chaos.

> *The army drafted men and took employees from the working sector. Some men fled the country as refugees or were jailed or executed. In the early 1790s, roads fell into disrepair, banditry increased, and rebels disrupted the mail service. Furthermore, postal surveillance became an issue, as conspiring and contentious authorities violated the privacy rules protecting postal correspondence. The postal service did not revive until the newly founded Directory restored it in 1795. Therefore, uninterrupted, quick communication across the country required a new system.* (Stathatos, 2013, p. 102)

The postal system needed renewal. Communication was crucial for the French military and the revolutionists, not only before and during military campaigns and operations but also to rule the dominated vassal states after they were occupied. So as soon an alternate communication system became available, it was soon broadly adapted. The former mounted courier (speed: 10 km/h) was replaced by a semaphore[96], an optical telegraph system designed by Claude Chapel (speed 500 km/h). A range of tower stations, each with semaphore and an operator, was erected in the 1790s and connected Paris with other parts of France and Europe (Figure 66).

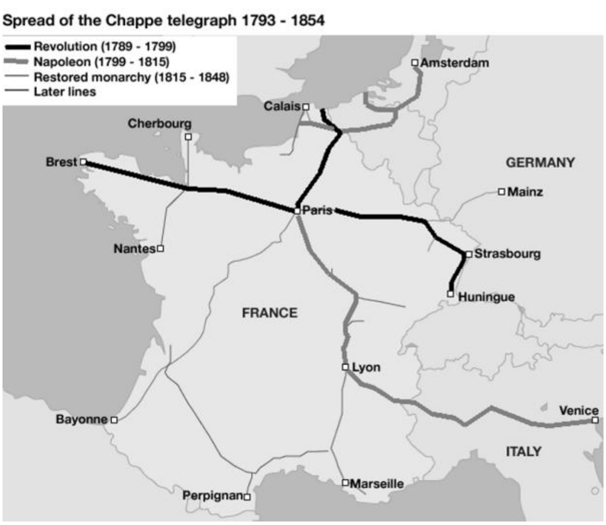


Figure 66: The map of stations of the Chappe optical telegraph (early 1800s).

Source: Wikimedia Commons

[96] A semaphore telegraph is a system of conveying information by means of visual signals, using towers with pivoting shutters, also known as blades or paddles. Information is encoded by the position of the mechanical elements.

Started during the French Revolution, the network grew to 556 stations covering 3000 miles of lines (5000 km), most of them in France. However, cities like Amsterdam, Brussels, Mainz, Milan, Turin, Venice were also connected. Small networks were also deployed in Algeria and Morocco, while a mobile network was used during the Crimea war. (Dilhac, 2001, p. 1)

The semaphore system was part hardware (the individual towers), part software (the code for transmitting the text) and operated only when a visual connection could be established (daylight, good weather) between the (human) operators of the semaphores. At first the lines were established to the warzones during the War of the First Coalition (1792-1797) and during the War of the Second Coalition (1798-1802).

The line of about 230 km between Paris and Lille was the first of its kind. It was completed in seven months and started operation in May 1794. The second line, from Paris to Strasbourg, was completed in 1798. In 1799 Napoleon Bonaparte seized power, and soon ordered the extension of the network, including a line across the Channel (using larger semaphores) in preparation of a later forgotten invasion of England. …Around the years 1800's, four lines were connecting Paris to major cities: that was the beginning of a real network. New lines will be constructed until 1846. (Dilhac, 2001, p. 5)

Napoleon limited the initial system to military use and administrative use. The government used the system to get a grip on the local officials in remote provinces of France. The military also used mobile stations that could be erected quickly near the war theatres. Their last use was in the Crimean War to transmit the news of the fall of Sevastepol (1855).

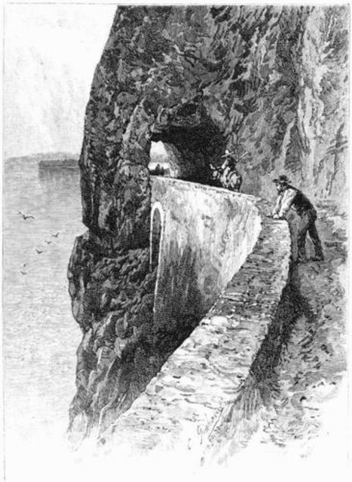


Figure 67: The Corniche Road at Menton connecting Nice into Italy.

Source: http://www.gutenberg.org/files/33367/33367-h/33367-h.htm

At the eve of the revolution, the road infrastructure of France was the result of the major administrative towns being connected by postal routes: "The road network had both a linear function, linking cities directly to Paris, and a hierarchical function, subordinating smaller towns to provincial capital" (Margadant, 1992, p. 432). At the end of the revolution, the roads also were in despair. As mobility was also important for military operations, Napoleon instigated a massive road construction project. It was characterized by linearity; it ran—where possible—from church to church in a straight line. He created the *Routes Imperiales* (Imperial Roads): in total 229 roads connecting from Paris to Europe, such as the *Road Imperiale No. 2*, connecting Amsterdam to Paris or the Corniche Road in the south of France to facilitate the Napoleon Italian Campaign of 1796. There, where the Alpine Mountains reach the Mediterranean Sea, from the original *chemin muletier* (mule track) of the old Roman road, the engineers of the Ponts et Chaussées made a viable aerial trunk road, audaciously clinging to rocks between sea and sky (Figure 67).

He also commissioned the building of roads to Mont Cenis (Italy), to Hamburg (Germany) and to Madrid (Spain). These great high roads were deliberately laid out in a linear fashion, like todays railways. In the period 1807-1812, millions of francs were invested in the later network of *routes departementales* (departemental roads). The roads were free of tolls. Canals, already planned before the revolution, were now realized. It resulted in one of the best transportation infrastructures in Europe.

> *In the area of public works, over 20,000 miles of imperial and 12,000 miles of regional roads were completed, almost a thousand miles of canals were build, the Great Cornice road was constructed along the Mediterranean coast, mountain roads were constructed across the Alps by ways of Simplon Pass and Mont. Cenis, and harbors were dredged and expanded at many ports, including Dunkerque and Cherbourg. … Monument buildings were constructed throughout the Empire and structures, such as the Imperial Cathedral of Speyer, made famous by Luther, were preserved while work on the spires of the great cathedral of Cologne were continued on Napoleon's orders. In fact, Napoleon's architectural handiwork can be found scattered across Europe, from Rome to Vienna.*[97]

This massive effort was the result of educational efforts that created the *Corps des Ingenieurs des Ponts et Chaussees* with their graduates from the *Ecole des Ponts et Chausses* in Paris. Here Napoleon linked science and engineering to military use.

> *The members of the Corps of Ponts et Chaussees Engineers received the most extensive formal education available in France at that time. Between the ages of seventeen and twenty, and after from one to four years of full-time cramming in mathematics, they had entered the national competition for entry to the Ecole Polytechnique. During their two years of barracks life at that militarized Parisian boarding school, elaborate rituals of initiation, frequent episodes of rebellion against the staff, a well-established, student-enforced code of solidarity,*

[97] Source: http://www.napoleon-series.org/ins/weider/c_jews.html. (Accessed december 2014)

> *and even a private, one-thousand word school argot had laid the foundation for a powerful esprit de corps. The Polytechnique's reputation as the world's leading institution of scientific education, the distinguished savants found on its faculty during this period (Monge, Ampere, Poisson, Gay-Lussac, J.-B. Dumas), and the special attention given to the students by the Parisian press, who considered them the flower of French youth, all contributed to the young Polytechniciens' sense that they were an intellectual and moral elite.* (Weiss, 1982, p. 5)

Before it came to this, something quite fundamental had to be changed during and after the revolution. Under the Ancien Régime, education was mostly in the hands of the church. As the French Revolution was quite a dramatic period without much social stability, one would expect that education was not an item on the revolutionary agendas. However, as it became clear from the expressed grievances before the Estates-General in 1788, educational issues resulted in the establishment of the Committee of Public Instruction in 1793. After the Reign of Terror more less had abated, the educational system was restructured with *écoles centrales*:

> *The Paris Normal school was created with a curriculum that included "republican morality and the public and private virtues, as well as the techniques of teaching reading, writing, arithmetic, practical geometry, French history and grammar;" and they were to use books which would be published and prescribed by the Convention. This latter requirement merely reflects what had by that time become a strong French tradition, namely the extreme centralization of educational policy.* (Markham, 2013)

As France needed academics, new schools were established, such as the Ecole Centrale des Travaux Publics that was to train civilian and military engineers in 1794. In 1795 it became the Ecole Polytechnique, still today one of the leading universities in sciences. Later, under Napoleon's influence, the system was refined: *École d'Application de l'Artillerie et du Génie* (School of Artillery and Engineering Applications), *École des Mines, and École Nationale des Ponts et Chausses* (National School of Bridges and Roadways).

The *Concordat of 1801* had already addressed educational issues and the role of the church in it. On May 1, 1802, a decree established what was to be a new system of education in France—a system with elementary schools (*écoles populaires*) and the establishment of thirty *lycées*, which provided educational opportunities beyond the secondary schools and replaced the *écoles centrales*. In 1808, Napoleon established the structure of the *Imperial University*, "a body charged exclusively with instruction and public education throughout the Empire... No school, no educational institution of any kind whatsoever, shall be permitted to be established outside the Imperial University, without the authorization of its chief. No one may open a school or teach publicly without being a member of the Imperial University and a graduate of one of its faculties" (Imperial Decree of 17 March 1808). Now education had become a state affair; for the first time, the state took responsibility, and control, of the elementary education of its citizens.

Another element in Napoleon reign was his relation to science. As a patron of science, he quickened scientific progress by means of education, prizes, research, exploration, and the recognition of scientists, native and foreign.

> *The period from roughly 1750 to 1830 was seeing many enhancements in the scientific thinking on mathematics and chemistry in France. The mathematicians Joseph Louis Lagrange (1736-1813), Gaspard Monge (1746-1818), Pierre Simon Laplace (1749-1847), Adrien-Marie Legendre (1752-1833), and Joseph Fourier (1769-1830), and the chemists Antoine Lavoisier (1743-1794) and Claude Berthollet flourished during this period.* (Weller, 1999, p. 61)

Monge and Berthollet were advisors to Napoleon. On his campaigns, he became interested in the cultural expressions of the countries he passed. So both the Italian campaign and the Egyptian campaign resulted in a large number of historic art objects being shipped to France, under the guidance of these scientists. As part of the Mediterranean campaign in Egypt and Syria (1798), a large contingent of scientists and scholars accompanied the army. These scholars included engineers and artists, members of the Commission des Sciences et des Arts, geologists and physicists. The explorations resulted in a scientific series of publications titled *Description de l'Égypte* and in the Rosetta Stone[98]. Also, foreign scientists were invited to Paris, such as the Italian Allessandro Volta, who gave lectures and demonstrations in November 7, 12 and 22, 1801, before the Institute de France in Paris, where Napoleon was present.

> *So impressed was Bonaparte by the novelty and promise of Volta's demonstrations that shortly after the session of the Paris Accademy he made the following announcement: "As encouragement to further experimentation and discovery, I wish give the sum of 60.000 francs to the one who will give to electricity and galvanism the advances in this field equivalent to those already given to these sciences by Franklin and Volta. My special aim is to encourage*

[98] The Rosetta Stone is a granodiorite stele inscribed with a decree issued at Memphis, Egypt, in 196 BC on behalf of King Ptolemy V. The decree appears in three scripts: the upper text is Ancient Egyptian hieroglyphs, the middle portion Demotic script, and the lowest Ancient Greek. Because it presents essentially the same text in all three scripts (with some minor differences among them), it provided the key to the modern understanding of Egyptian hieroglyphs.

> *and to fix the attention of physicists on this branch of physics which is, in my opinion, the road to great discoveries." This proposal, made on June 15, 1802, was enthusiastically received by the scientists of France.* [99]

Or take the Englishman Humphry Davy, who—on his grand tour through Europe where he studied volcanic heat in Italy—also visited Paris in 1813[100]. It was a time when England and France were at war, but in those days wars were solely the affair of soldiers and sailors; men of science continued to correspond with each other and remained constantly on good terms. As he had been awarded the Napoleon Prize by the *Institute de Paris* in 1807 for the best experiment on galvanism, Humphry Davy and his assistant Michael Faraday, with a passport issued by Napoleon, travelled into France, received the medal on November 2, 1813, and met other scientists like Ampere and Gay-Lussac, but did not meet the emperor. At the very moment the Davy party was arriving in the French port of Moraix, Napoleon was defeated at the Battle of Leipzig (October 16-19, 1813). On November 30, 1813, they met Napoleon's wife, the Empress Marie-Louise, daughter of Francis II, Emperor of Austria, in audience. Napoleon obviously had other things on his mind, as he was exiled to Elba a couple of months later.

After Napoleon's demise in 1815, during the Restoration where many of the old social values were re-established, science in France beheld a different position in society as compared with countries around France. It would influence the context for the mechanical arts that were to realize the technological innovations for the Industrial Revolution, in which France hardly played a prominent role.

> *Science in a vague and almost intangible way was somehow politically disreputable and revolutionary. …The experience of the Revolution, however, had shattered the ideal which had so captivated the Enlightenment, and the Empire had reduced the scientist from the rank of prophet to that of a useful and necessary technician. …*
>
> *Perhaps the most important effect of the Napoleonic reforms of education as far as the future of French science was concerned, was the close link forged during the Empire between science and the military. To the bourgeoisie, who were potentially the most receptive audience, science meant not an instrument for the increasing of production in manufactures and agriculture but a military career which, while*

[99] Source: "Alessandro Volta - Como e il bicentenario dell'invenzione della Pila 1799-1999, Como 1999" di Umberto Ferdinando Molteni (I2MS).
http://www.alessandrovolta.info/life_and_works_8.html

[100] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015)

> *glorious, might also be short. By making science the exclusive property of the armed forces, the Empire also deprived French industry and agriculture of one of their most important tools at a crucial period in their development. By the time this monopoly was broken, the old social values had been re-established, and the bourgeoisie looked upward to the aristocracy, not downward to the atelier. The chance to create a highly trained and technically competent middle-class had gone by, and France soon saw her industries surpassed, not only by those of England, which had always held the lead, but by those of Belgium and Germany, where it was not considered dishonorable to deal in the "mechanical arts."* (Williams, 1956, pp. 380, 381)

So the place of scientists in society, its domination by military affairs, and the lack of people with engineering capabilities might have contributed to the slowness and inertness in which France entered the first Industrial Revolution.

For Napoleon, more than science and education had required his attention. Under the monarchy, the French fiscal policy relied on the earlier-described taxation. But that had resulted in the financial crises under Louis XIV that fuelled the French Revolution. Hence, Napoleon was confronted with a problematic situation. How to finance the state and its war efforts? "The French Revolution's use of confiscation, capital levies, and an inflation tax destroyed its credibility and forced Napoleonic France to rely primarily on taxation" (Bordo & White, 1991, p. 304).

During the revolution and the period of hyperinflation (1795), several measures were taken, like creating paper money (*assignats* and *mandats*) and cancelling the debts of *émigrés* and convicts, which reduced interest payments considerably. But to finance the state and the war efforts, Napoleon had to take more drastic measures:

> *Napoleon's coup of November 1799 began sweeping changes in government finance that were built on the tough measures taken by the Directory. The system of taxation was reorganized, new taxes were imposed, payment on the debt in specie was resumed (1800), the nation returned to the bimetallic standard (1803), and institutions—the Banque de France (1800) and a sinking fund (1799)—were established, which served as additional guarantees of the government's commitment to fiscal prudence. …*
>
> *The fiscal discipline imposed on the empire because of France's lack of credibility was, however, partially eased by taxation of the conquered territories and its allies. Most of the taxation of conquered nations was to support French armies abroad. In 1805 Austria supplied 75 million and in 1809 164 million francs. Between 1806 and 1812 Prussia provided somewhere between 470 and 514*

> *million francs. These enormous revenues meant that French armies abroad were not a drain on the French treasury.* (Bordo & White, 1991, pp. 314, 315)

In the times leading up to the French Revolution, financial power in France was in the hands of about ten to fifteen banking houses, whose founders, in most cases, came from Switzerland. These bankers, mostly Protestants, were deeply involved in the agitations leading up to the French Revolution, supporting the rise of Napoleon, whom they regarded as the restorer of order. As a reward for their support, Napoleon, in 1800, gave the bankers a monopoly over French finance by giving them control of the new Bank of France, as the majority of the funding for the bank (30 million francs) came from private capital. For the first fifteen years, it was the sole issuer of bank notes in Paris. Among the shareholders was Napoleon Bonaparte himself and members of his family (Figure 68). Napoleon also reorganized the different locations for trading stocks in Paris by creating the Paris Stock Exchange (French Bourse). In 1807, he ordered the building of a permanent home for the Paris stock exchange called Palais Brongniart, also known as *Palais de la Bourse* (Stock Market Palace). Based on plans by the architect Alexandre Brongniart (1770-1847), it was completed nineteen years later and opened in 1826.

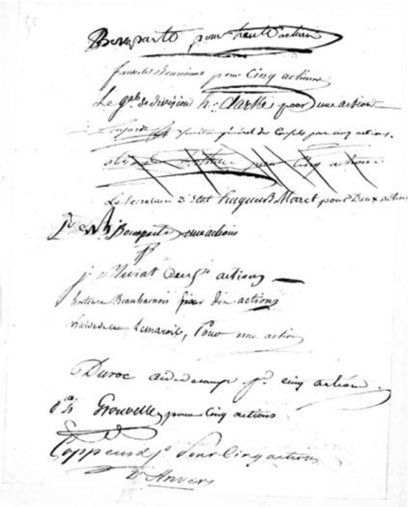


Figure 68: The book of shareholders of the Banque de France (January 1800).

The signature of Bonaparte appears on the first line, for 30 shares.

Source: http://www.citedeleconomie.fr/ Creation-of-the-Banque-de-France

The preceding shows that Napoleon played a role that was much broader than his military successes. He was the one that implemented the ideas of the revolution throughout Europe.

> *The ideas that underpin our modern world—meritocracy, equality before the law, property rights, religious toleration, modern secular education, sound finances, and so on—were championed, consolidated, codified and geographically extended by Napoleon. To them he added a rational and efficient local administration, an end to rural banditry, the encouragement of science and the arts, the abolition of*

> *feudalism and the greatest codification of laws since the fall of the Roman Empire.* (A. Roberts, 2014, p. p. xxxiii)

Overview Napoleonic Era

The period after the French Revolution that started with the Consulate was greatly influenced by one person: Napoleon Bonaparte. As a military officer, he contributed in many campaigns; wars inside France (The Siege of Toulon in 1793, War on the Vendee 1893-1896) and wars outside France (from the Dutch, Swiss and Italian campaigns to the Mediterranean campaign) (Figure 69). From the moment he became the First Consul in 1802, and the rise to emperor (1804), his powers became that of an enlightened despot. Creating stability within the country, he spread the principles of the revolution over Europe. The monarchies and clerical powers in Europe, feeling threatened by it, responded with a range of coalitions that unsuccessfully fought many battles against Napoleon. But his campaign against Russia was the turning point. After the disastrous Great Escape of 1812 from Moscow, he returned to Paris, losing the War of the Sixth Coalition with a decimated army. The last conflict with the Seventh Coalition resulted in the loss at the Battle of Leipzig (1814), which started the end of his reign. Then it was over after he lost the Battle of Waterloo (1815). With the Bourbon Restoration of 1814, the monarchy was back in France, although in a different form. France may have initiated the origins of the revolution, but Napoleon spread it over Europe.

France went through a metamorphosis in the period from 1789-1815. The Ancien Régime was dead, it seemed, as the civil rights of the citizens had been acknowledged, the legislation and the administration was changed, the feudal aristocratic and religious privileges had been eliminated and everybody was equal by law. In terms of economic life, much had changed; there was the right to have property, a liberal economic system and the dismantling of monopolies held by the guilds. As the sea blockade by the English caused the collapse of the French foreign and colonial trade, under Napoleon the only trade that flourished was the smuggling trade. Also, industrial development was held up by the French Revolution:

> *No doubt commercial capitalism began to influence industry in France on the eve of the Revolution. But the development was much slower than in England. We can detect only symptoms of an industrial revolution. The (industrial) revolution itself was not to take place until half a century later.* (Sée & Zeydel, 1927, p. 94).

It is questionable if the revolution can be considered successful, as the old powers of the nobility and clergy were not that defeated at all, as soon became clear during the oncoming Bourbon Restoration.

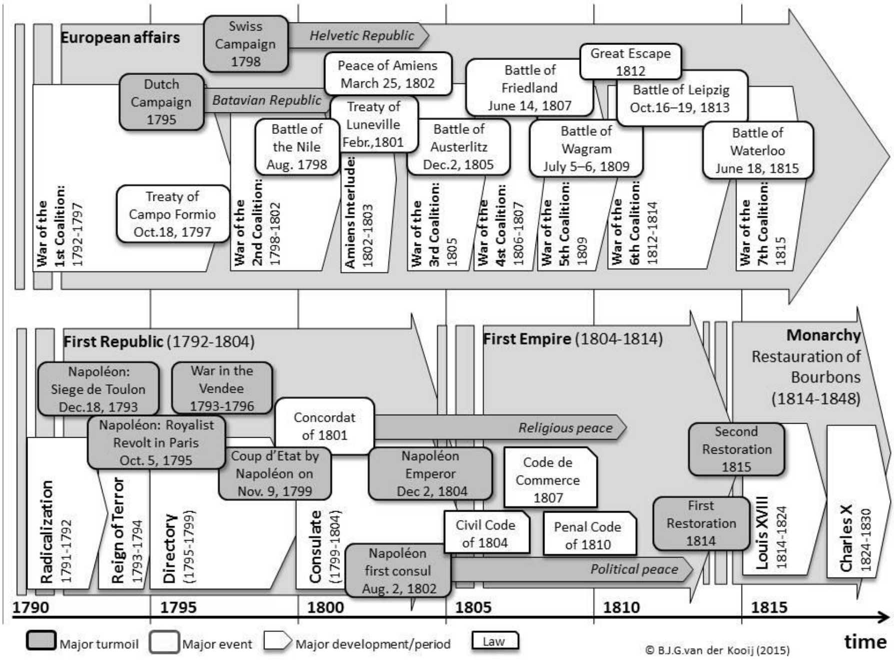


Figure 69: Overview of events during the Napoleonic Era (1790-1815).

Source: Figure created by author

The Bourbon Restorations (1814-1830)

After Napoleon's defeat, the *First French Empire* collapsed as the constitutional monarchy was restored in the *First Bourbon Restoration*. A brother of Louis XVI, the Comte de Provence, was put on the throne by the Allies and the French royalist as Louis XVIII.

> *On May 3, 1814, Louis XVIII, in his turn, made his "joyous entry" into Paris. The King, Madame Royale, now the Duchesse d'Angouleme, the Due de Bourbon and his father the old Prince de Conde, who was not quite sure what it was all about, had taken their seats in a barouche drawn by eight white horses from the imperial stables and driven by grooms wearing the Emperor's livery. The carriage was preceded, or followed witnesses do not agree on this point by the imperial guard. Some of the veterans had pulled their fur caps right over their eyes. They preferred not to see the spectacle. "Their jaws tightened with impotent rage." It was not the entry of Louis XVIII, but the funeral of Napoleon, who on that same day arrived in an English ship at the island of Elba, in sight of his "cabbage patch" of Portoferraio.* (Castelot, 1962, p. 146)

As a gift from the king to the people, a constitution called the Charter of 1814 was created: it ended with the words "Given at Paris, in the year of grace 1814, and of our reign the nineteenth". This indicated that the charter was presented as a gift from the king to the people, not as a constituent act of the rights of the people. This charter restored the position of the king as head of state and commander of the army and navy, who could declare war. He also appointed ministers, who exercised his power. It contained, next to freedom of religion, a bicameral legislature with a Chamber of Peers (appointed at the discretion of the king) and a Chamber of Deputies (with 90,000 citizens eligible to vote). The Napoleonic Code and many of the legal, administrative, and economic reforms of the revolutionary period were left intact. In that respect only, the constitutional monarchy was influenced by the legacy of the French Revolution.

However, most eager for the Bourbon Restoration were those who had lost most: the nobility in terms of possessions and the clergy in terms of influence. Louis XVI kept his promise, made in 1813 in the Declaration of Hartwell, to compensate the original owners of the *biens nationaux* (lands confiscated from the nobles and clergy during the revolution). However, soon, his efforts to slowly restore the pre-revolutionary rights of the aristocracy and the clergy created discontent. As he also inherited a considerable state debt, he forgot his promise to abolish the unpopular taxes on tobacco, wine and salt. Also, the decision of the Congress of Vienna to shrink French territory back to the pre-revolution situation contributed to discontent among the military, many of whom were still loyal to their former charismatic leader.

This was the opportunity for Napoleon to act and in resulted in his Hundred Days after his return from Elba on March 20, 1815 (Figure 63). Louis fled the country into the United Kingdom of the Netherlands when Napoleon was joined by his former troops. It was the start of a short reign for Napoleon. However, his following defeat at the Battle of Waterloo put an end to his power, and he was exiled to St. Helena. On that isolated island in the in the southern Atlantic Ocean, he died in 1821 as a prisoner of the British, a desolate man.

In the *Second Bourbon Restauration* Louis XVIII was again brought back on the throne after the Treaty of Paris in 1815. As described before, the treaty repudiated the revolutionary system as produced in France, consolidated royal authority and was geared towards a permanent balance of power in Europe. In this treaty, France was also forced to accept the payment of pecuniary indemnities for some 700 million francs: an enormous amount of money to be distributed over the participating countries and armies[101]. The

[101] General Wellington was rewarded with the title Prince of Waterloo, given by William I of the Netherlands. With it came an estate of 10.5 km^2, creating an annual income of about

French borders were reduced to their 1790 level and France had to pay for an enormous occupational force of 1.2 million foreign soldiers. The legacy of all this, the burden of taxation being again put on the population and the following (second) White Terror, created a formidable opposition for Louis XVIII. Again it became a period of political turmoil; people suspected of having ties with the governments of the French Revolution or Napoleon suffered arrest and execution (the second White Terror that purged the civil administration of some 70,000 revolutionary people). France went to war in favour of the Spanish Bourbon King Ferdinand VII against the liberal Spanish government.

When Louis XVIII died on 16 September 1824, he was succeeded by his 66-year-old brother, the Comte d'Artois, who took the title of Charles X and was crowned in the cathedral of Reims on May 29th, 1825 (Figure 70). It was a spectacular ceremony that was reminiscent of the royal pomp of the Ancien Régime. Charles supported the ultra-royalists in the Chamber of Deputies and raised the status of the Catholic Church once more. In 1824, the *Anti-Sacrilege Act* against blasphemy and sacrilege became law, introducing the death penalty. The bill that had passed due to the influence of the clergy in the Chambre of Peers irritated many as it seemed to be violating the equality of religious beliefs. Also, in the months preceding the ceremony, the chambers passed legislation that paid an indemnity to *émigrés* (the former enemies of the revolution), who had suffered by

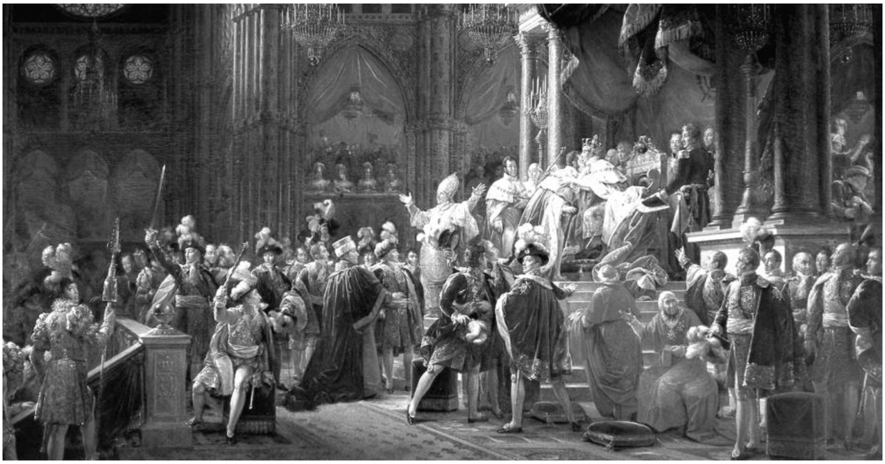


Figure 70: The coronation of Charles X (May 29, 1825).

Source: Wikimedia Commons, Francois Gerard.

£140.000 annually, a reward that is still endowed to his heirs until today. Source: Andrew Osborne, The Guardian, June 7th 2001. (Accessed December 2014) the confiscation of their lands during the revolution. It was this restoration of much of the old powers of the aristocracy and the clergy that infuriated the revolutionaries.

July Revolution of 1830

Because of what it perceived to be a growing, relentless and increasingly vitriolic criticism of both the government and the church, the government of Charles X introduced in 1830 to the Chamber of Deputies the *Four Ordinances*. These ordinances not only excluded the commercial middle class from future elections, it dissolved the lower house, and it also contained a proposal for a law tightening censorship, especially in regard to the newspapers. The chamber, for its part, objected so violently that the humiliated government had no choice but to withdraw its proposals. This all enhanced the discontent with the government under Minister Jules de Polignac, the ultra-royalist minister of foreign affairs and president of the King's Council, who was held responsible for the issue of the Four Ordinances.

Figure 71: July Revolution of 1830.

Louis-Philippe d'Orléans leaving the Palais-Royal to go to the city hall, 31 July 1830, two days after the July Revolution.

Source: Wikimedia Commons

Soon, not only the republicans but also the moderate royalists were beginning to turn against Charles, as did the business community due to the financial crisis of 1825[102]. In March 1830, the conflict resulted in a motion of no-confidence against the king and Polignac's

[102] Between 1827 and 1830, France faced an economic downturn, industrial and agricultural, that was possibly worse than the one that sparked the revolution of 1789. A series of progressively worsening grain harvests in the late 1820s pushed up the prices on various staple foods and cash crops.

ministry. When, after some delaying tactics, the king signed on July 25 the July Ordinances to become law, it ignited Paris. In three “glorious days” from July 26 to 29, the crowds revolted again; barricades were erected throughout Paris. Again people sacked the Palais de Tuileries and conquered the town hall (Hotel de Ville) (Figure 71). It was a renewed French Revolution. Again the rise of the liberal opposition and the economic downturns resulted in the regime’s downfall, and in July 30, 1830, the king abdicated and departed for Great Britain.

Under all this political turmoil, there was the “real economy” where the common people flocking into the cities, but unable to find a respectable place in the city’s life, they (the crowds of the *classes dangereuses*) had their own grievances.

> … *thousands of Parisian workingmen during the depression years of the late 1820's and early 1830's had specific grievances—lack of work, low wages, the high price of bread–that had nothing to do with the constitutional quarrel between king and deputies, nothing to do with the dispute over censorship that alienated printers and journalists from the Polignac ministry. … The composition of the crowd in 1830 was strikingly similar to that of the crowds in the Revolution of 1789. It was not made up of the scum of the capital or of the desperate and the dispossessed; nor did the substantial middle class of business, the professions, and public office have more than a small part in it.* (Pinkney, 1964, pp. 2, 3)

But the people of these *classes dangereuses* were not the only ones, as the *bourgeoisie* had its own motives—motives that fit in the spirit of the time.

> *In the records of combatants' professed motives, hostility to the Bourbons occupied the most prominent place. Almost half of those who stated why they took up arms said that they were moved by personal grievances against the governments of Louis XVIII and Charles X. … The combatants of 1830 were not men bowed down by the weight of misery. They were largely artisans from the city's established and respected crafts, shopkeepers, and employees… Rather they* [the protest] *were an expression of timeless economic complaints, of loyalties within traditional crafts, of popular resentments against symbols of the old regime, and of eighteenth-century ideas of liberty, equality, and fraternity.* (Pinkney, 1964, pp. 13, 16, 17)

Charles X was succeeded by—again—a constitutional monarch, in this case a cousin, *Louis-Philippe* from the House of Orleans. He was sworn in as King Louis-Philippe I on August 9, 1830. On August 7, 1830, the people had already adopted the Charter of 1830 that changed legislation by increasing the electorate, abolished the censorship of the press and declared Catholicism not to be the state religion anymore. It seemed Louis Phillippe had learned from earlier experiences in his life (he supported, as young man, the revolution as a member of the Jacobin Club and as an officer in Napoleon's army) and the recent events as he ruled in an unpretentious fashion. He soon became known as the Bourgeois Monarch and the Citizen King. Many of the earlier laws were repealed, and measures were taken to stimulate the economy. The political and administrative staffs were renewed as the Legitimist[103] supporters were expelled.

However, the trial of Charles' ministers became a major political issue between different political fractions. It ignited a strong social unrest in early 1831, resulting in a range of different governments that succeeded each other in a rapid pace. And it created turmoil and revolt in the provinces. It was about restoration of the former powers. In Paris, the anti-monarchist revolutionists tried to topple Louis Philippe's July Monarchy of 1830 in the June Rebellion of 1832. Now the Legitimists, supporting the House of Bourbon monarchy, and the Bonapartists, who wanted to restore the House of Bonaparte, were competing. All this turmoil was enforced by the outbreak of a cholera pandemic in early 1832 that provoked a panic among the population. It would last until September 1832, killing in total 100,000 in France, with 20,000 of that in Paris alone (a population of 650,000 people). Clearly, in the early 1830s Paris saw a lot of turmoil and social unrest.

The Canut Revolts: Rise of the Working Class

Sometimes the uprising was not political but had a different background. Take for example the revolts in the silk industry in Lyon, then already the second largest city in France with 134,000 inhabitants in 1789. Here the silk industry, originating from a monopoly granted by King Frances I in 1540, had created a chain of different

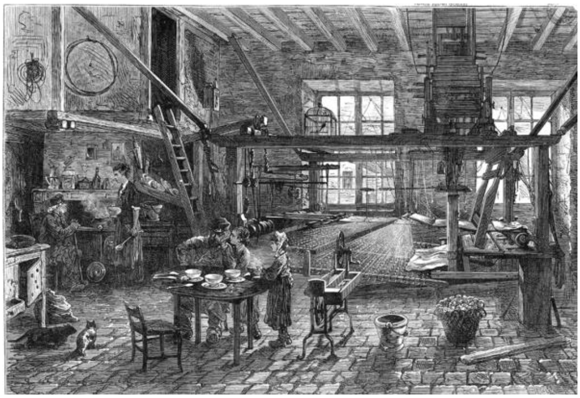


Figure 72: Workshop/living quarters of a weaver in Lyon (1877).

The figure shows a weaver's family having diner in their 'canut' where they worked and lived.

Source: Wikimedia Commons, Jules Férat

[103] Royalists who adhere to the rights of dynastic succession of the descendants of the elder branch of the Bourbon dynasty.

parties (merchants, drawers and weavers). There was a great interdependency: the merchants (*maitres marchands*) ordered and financed the production, supplied the raw materials and sold the end product; the manufacturer (*maitres-fabricants*, *maitres-ouvriers* or *canuts*[104]) weaved the textiles at his loom. It was a structure that stimulated cooperation but that also was a source of conflict, as the interests were opposite. The work was done in the typical workshops of that time that were also the living quarters for the weavers (Figure 72).

Obviously the time of the Revolution had its economic effect on silk manufacturing. But with Napoleon Bonaparte in power, the economy grew, and so did the silk industry. New methods of production, such as the invention in 1801 of the Jacquard loom using perforated cards to program the loom, were applied. However, in the mid-1820s, the economy was again in a crisis. And so Lyon had its revolts, not due to political reasons, but instigated by the economic situation.

The first Canut Revolt in 1831 was provoked by a bad economy and a resultant drop in silk prices, which caused a drop in workers' wages. In an effort to maintain their standard of living, the workers tried to see a minimum price imposed on silk. The refusal of the manufacturers to pay this price infuriated the workers, who went, on November 21, 1831, into open revolt, seizing the arsenal and repulsing the National Guard and military in a bloody battle, leaving the insurgents in control of the town (Figure 73). The government sent Marshal Soult, a veteran of the Napoleonic Wars, at the head of an army of 20,000, to restore order. Soult was able to retake the town without any bloodshed and also without making any compromises with the workers.

Figure 73: The First Canut Revolution in the streets of Lyon (1831).

Source: Wikimedia Commons, author unknown
Musée Gadagne (Gadagne Museum, Lyon)

[104] Canut were the independent weaving craftsmen of the silk industry. About 8,000 at the beginning of the nineteenth century employed about 30,000 apprentices. About 1,400 bankers and traders controlled and financed the industry.

Though some workers were arrested, all were eventually acquitted. The revolt ended with the minimum price abolished and with the workers no better off.

For the moment, the situation was back to normal in Lyon. But there was more to come, as again in 1834 in Lyon, a second Canut Revolt broke out, again caused by economic motives. This Canut Revolt occurred in a prosperous economy that had caused a surge in workers' wages. Owners saw these wages as too high, so they attempted to impose a wage decrease. This, combined with laws that oppressed republican groups, caused the workers to rebel. It resulted in the *sanglante semaine* (the bloody week) of April 11-15, 1834. The government crushed the rebellion in a bloody battle and deported or imprisoned 10,000 insurgents.

Although the French government was attacked from both ultra-loyalists as well as republicans, the period from 1832-1835 was a period of political consolidation of the regime. It was not without problems, though—problems like the return of insurrectionary troubles in various cities of France and troubles in Paris again. In 1834, new elections were held and again there were some short-lived governments, but in September 1835, three laws were passed that consolidated the king's regime, although the political situation stayed quite dynamic, as could be observed from the patriotic fever around the return of Napoleon's ashes from Elba to the *Hôtel National des Invalides*. But the regime stayed intact.

The Age of Transportation in France

Contributing to this governmental stability was the economic growth (3.5% annually between 1840-1846) when the (first) Industrial Revolution slowly reached France. It was noticeable in different ways. One was the transportation infrastructure that changed after the bureaucrat (and former tax collector) Jacques Becquey—general director of the Bureau of Bridges and Roads—had in 1820 written his report to the king. He assumed that the high cost of transportation was a bottleneck for the needed economic growth. The report gave a blueprint for the development of a large network of waterways through concession contracts (Geiger, 1994, pp. 113-115). It resulted in the Canal Bills of 1821 and 1822 as part of the modernizing of the transportation infrastructure of roads, railways and canals. It would lead to the rise of private enterprise in France. But that private involvement in infrastructure development was short lived.

Canals: Although Napoleon might have instigated the extending of the French canal system, it took a while before they were realized. Next to the older canals like the Briare Canal (connecting the 57 km between the

Loire and Seine valleys), the Burgundy Canal (242 km long connecting the Saonne and Yonne near Dyon), and the Canal du Midi (a 241 km long canal in southern France linking the Mediterranean sea with the Atlantic ocean) new constructions were started with the Becquay Program in 1820-1821. Originally, they were financed, exploited and operated by private enterprises, resulting in canals like Canal Saint Martin to supply Paris with water. But most projects were not feasible, and it never became a "canal mania" as it had been in England from 1790s-1810s.

> *The French central government was keen to develop the waterway network and so it devised a 'public-private partnership' to implement the Becquay plan. The state borrowed from private investors, mostly Parisian financiers, and agreed to split the profits once the debt was repaid. Relations with investors were often confrontational, especially regarding the tolls and the return paid on the bonds. The French state eventually bought out the companies interests in the 1870s and began financing many of its own canals. By the end of the 1870s, the French waterway network was largely government-owned.* (Bogart et al., 2010, p. 32)

Railways: The implementation of a railway network in France was late in time because it had invested heavily in water-borne transport. The opposition from local authorities, fearing the effects of on traditional way of life and the agriculture, was fierce. The involvements of the central government led to lengthy debates in Parliament, where liberals, conservatives, royalist and democrats were strongly divided. As there was no strong industrial base willing to pay for new railway projects, only small and scattered railways lines were constructed. So national railroads did not come to France till after 1842, when the exploitation of railways was regulated by law. Again, it never became a "railroad mania" as it had been in England in the 1840s. By 1855, the many original small railroad firms had coalesced into six large companies, each having a regional monopoly in one area of France. The Nord, Est, Ouest, Paris-Orléans, Paris-Lyon-Méditerranée (PLM), and the Midi lines divided the nation into strict corridors of control.

> *In France, the Ponts et Chaussées was responsible for planning and engineering. The state offered companies the right to lease the lines for 99 years and guaranteed the dividends on securities issued for new construction. Out of this system emerged six large railroad companies that owned most of the French railroad network. The policy was fairly successful in that Paris was connected by rail with all regions of France.* (Bogart et al., 2010, p. 35)

Paris was the hub of the wheel. However, when one would transfer goods outside this star-like network, there was a problem that was related to interconnections. To give an example: only separated by 120 kms, passengers and goods between Lyon and Clermont-Ferrand were to travel by Paris, a detour of seven hundred kilometers[105], in a time where horse power was the only alternative way to power the common means of transportation.

So, one could conclude that the Age of Transportation came late in France, compared to England and Germany: "France lagged behind Britain in the initiation of industrialization, and when industrialization occurred it was incomplete. In the second half of the nineteenth century Germany rapidly surpassed France in heavy industry" (Cameron & Freedeman, 1983, p. 3). That may be the case; France had its own approach that was followed by other European countries that did not have a large coal and mineral base: "[They] industrialized in much the same manner as the French: that is, more slowly, gradually, with each nation or region taking advantage of its own endowment of natural and human resources" (Cameron & Freedeman, 1983, p. 24).

The 1848 Revolutions

The renewed French Revolution, in the form of the *July Revolution of 1830*, had, next to the consequences for France itself, its effect in other European countries as well, as it sparked uprisings in Brussels, Italy, the German Confederation, Austria and Poland (Figure 74). The United Kingdom of the Netherlands (consisting of the Austrian Netherlands and the Republic of the Seven United Netherlands) collapsed after the 1830 Belgian Revolution. William I, King of the Netherlands, would refuse to recognize a Belgian State until 1839, when he had to yield under pressure by the Treaty of London. Ultimately, it would lead to the European revolutions of 1848: the Italian Revolution, the revolutions in the German lands and those in central Europe (Hungary)[106].

The French Revolution of 1848[107]

One of those 1848 revolutions took place in France. Again in Paris, turmoil erupted during the *June Days Uprisings*. After the financial crises and bad harvests of 1846, followed by an economic depression a year later, peasants rebelled. They were—like in 1830—to be joined by the working and middle class. In Paris, the protesters faced a problem. As political

[105] Later, during the Franco-Prussian War (1870-1871), this structure would prove to be a problem as the German railway network could supply the army faster and more efficiently than the French army could supply its army.

[106] See: B.J.G. van der Kooij: *The Invention of the Electric Light* (2015).

[107] Sources for this text are found in Wikipedia: French Revolution of 1848

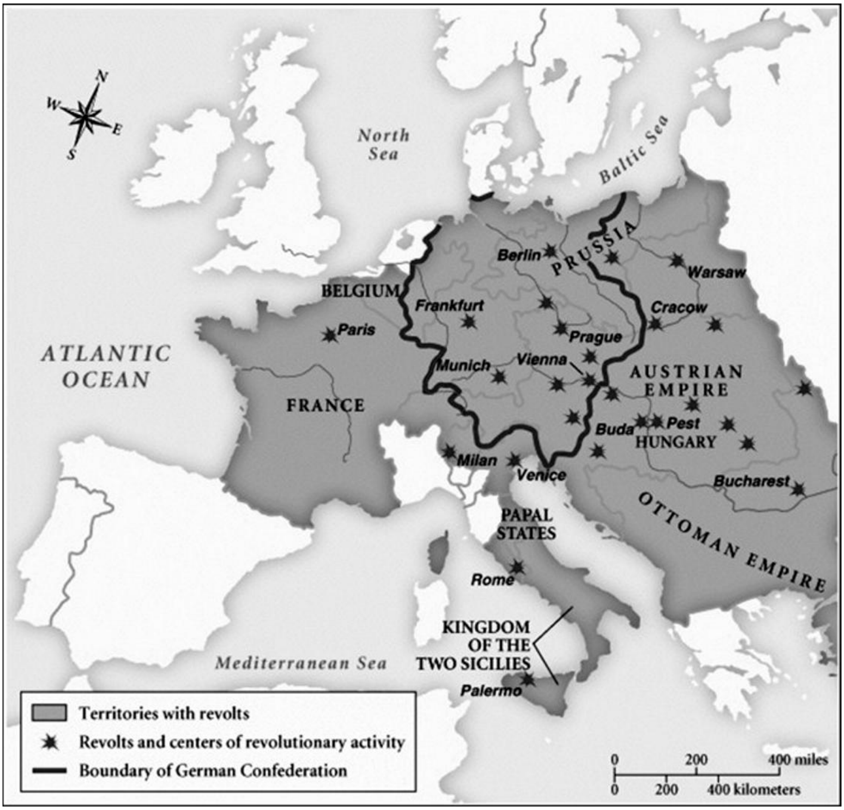


Figure 74: The major sites of the European Revolutions (1848).

Source: Wikimedia Commons, author unknown

gatherings and demonstrations were forbidden by law, the campaigns of the alternative fundraising banquets proved an outlet for popular criticism. The government reacted with outlawing the reform banquets in February 1848, which resulted in popular uprisings, making Paris a barricaded city (Figure 75). Soon King Louis Philippe abdicated and fled to Britain.

A provisional government was created that included established moderates, liberals, middle-class and republicans. They promised to create opportunities for paid work for all citizens. The National Workshops system was instituted on 26 February in relation to this guarantee of "labour to every citizen"; it was the employment of the workers on tedious, monotonous, unproductive earthworks at a wage of 23 sous per day. The National Workshops system, which was awarded an initial budget of five million francs (only consistent with the enrolment of some ten to twelve

Figure 75: The great barricade in the rue Fabour Saint-Antoine in Paris (June 1848).

Source: Illustrated London News, July 1, 1848. http://thefunambulistdotnet.files.wordpress.com/2012/01/the-insurgent-barricade-marctraugott007.jpg

thousand persons!), set out to offer constant work. Soon, despite the wages being only at or about basic subsistence level, it attracted the services of much of the casual labour of a Paris where economic dislocation was being experienced as diverse forms of private spending fell away in these uncertain times. To pay for these the new National Workshops and the other social programs, the provisional government placed new taxes. Among them was a tax on land of an additional 45 centimes to the franc already due. These taxes alienated the "landed classes"—now especially the small farmers and the land-owning peasantry of the rural areas of France—from the provisional government. Again it resulted in revolts that cost thousands of victims. Their protests resulted ultimately in the closure of the National Workshops on June 21, 1848.

The ensuing political struggle would result in the Second French Republic, where "Citizen King" Charles-Louis-Napoleon Bonaparte was elected on December 10, 1848 as president. Louis Napoleon Bonaparte III had won the election with a wide margin due to wide support by the peasantry. Campaigning from 8 August to 12 November 1850, he went about France stating the case for a revision of the constitution in speeches which he varied according to each place to rally popular support. On the night of 1/2 December 1851, the anniversary of the coronation of his illustrious uncle Napoléon I, he dissolved the chamber, re-established universal suffrage, had all the party leaders arrested, and summoned a new assembly to prolong his term of office for ten years. It was the *Coup of December 2 of 1851*, a coup with great similarity to the *Coup of 9 November 1799* that was staged by his uncle, Napoleon Bonaparte.

Next it would take four years for him to create the Second French Empire (1852-1871), a time of great industrialization and great economic expansion of railroads and banking—again a time with despotism, as all executive power was vested to the emperor. The people of the empire, lacking democratic rights, were to rely on the benevolence of the emperor rather than on the benevolence of their own elected politicians. The emperor was to nominate the members of the council of state, whose duty it was to prepare the laws, and of the senate, a body permanently established as a constituent part of the empire.

It looked as if France was back to the earlier 1800s when Napoleon Bonaparte ruled as enlightened despot. The emperor concentrated the powers of the state in his person. All executive power was entrusted to the emperor, who, as head of state, was solely responsible to the people. For the next decade, France had no democratic system. But that is another story….

Summary of the French Revolution and its Aftermath

The actual French Revolution is the first phase of a development that transformed French society in the first half of the nineteenth century (Figure 76). It started with financial-economic problems for the state in a framework of latent social unrest—enhanced by the climatic conditions of the time—due to the confrontations of the social classes. And there was the influence of the philosophers of the Enlightenment and their ideas about the way government should be organized and function.

Politically seen, the French Revolution was conservatism against nationalism and liberalism. Where the conservatists, often having something to lose, valued the power of the ancient regime and tried to limit the influence of the Enlightenment, the nationalists valued a government based on the consent of (the majority of) the governed. And the liberals valued individualism by promoting natural civil rights. These were the undercurrents of democratization and liberalism that fuelled the French Revolution. They resulted in periods of revolutionary politics, republican politics, (ultra-)royalist politics and bourgeois politics in the French theatre

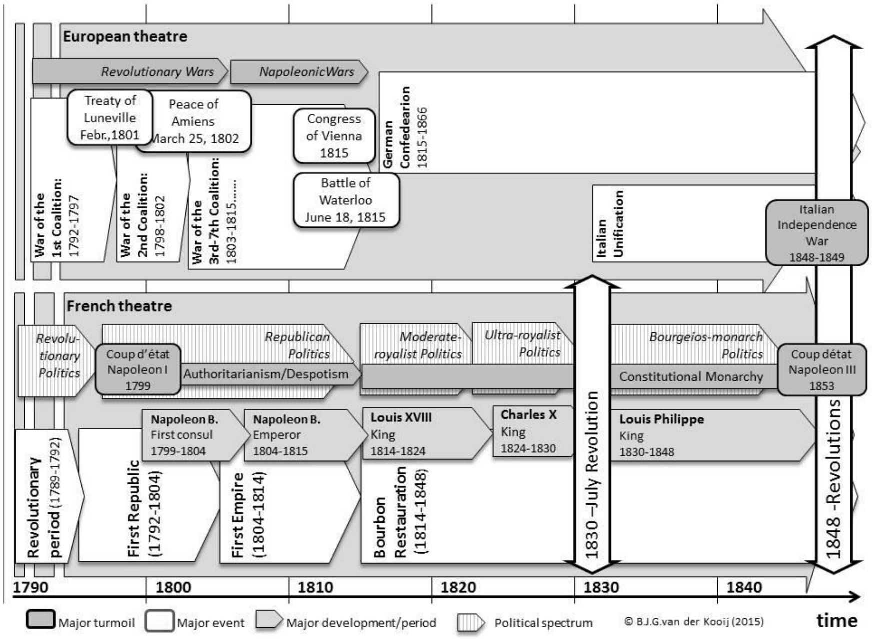


Figure 76: Overview of events during the first half of the nineteenth century (1790-1850).

Source: Figure created by author

(bottom Figure 76). Over time, each of them would become dominant for some time, to lose ground to another political dominance.

But there were other "currents" that created this period of massive social unrest, both in France and in parts of Europe. Economically seen, the French state's finances were facing problems due to overspending—the cost of warfare and defending the colonies and massive court expenditures—in an institutional system dominated by the venal office and an outdated guild system. The burden of taxation was put on the shoulders of the powerless class of the peasantry—and later some of the bourgeoisie—that formed the class of the Third Estate. A taxation that rigorously enforced the *Fermiers generaux* and caused revolts. Through all the revolts, the subject of taxation played an imported role. From the nobles in the 1780s, who opposed the taxation of land to the peasants (with the nick name Jacques le Bonhomme) who revolted against the 45-Centimes Tax in 1848.

Considering the first half of the nineteenth century, one can observe the major influence of the French Revolution in the affairs of the European theatre (top Figure 76). After the moderate beginnings of the aristocratic revolution, the bourgeois revolution and the peasant revolution, it turned after the dramatic events—the Reign of Terror—into of the first republic with the Directory and Consulate. In this phase, France established—in the revolutionary wars—its influence at its direct borders with client states of sister republics: the Batavian Republic, the Rhinelands, the Helvetian Republic, and the Italian states.

The following phase of imperialism, with the light despotism from Napoleon, terrified the European rulers afraid that the revolution would also attack their positions. Napoleon—and his expansion strategy—would spread the revolution into the other European countries, where the absolute royalty and the feudal aristocracy still ruled. They allied their forces and they rallied against Napoleon in several different confederations, resulting in Napoleon's Waterloo in 1814. The French Revolution had over time changed from an internal affair within French society to an external affair involving many European countries. The result was that the coalitions acted and fought with France—and especially Napoleon—a range of wars at the end of the eighteenth century and the beginning of the nineteenth century: two decades of social turmoil. As a side effect, it also stimulated the creation of the German Confederation.

> *The wars which raged almost continuously from 1792 to 1815 and which are generally, but not quite properly, called in English the Napoleonic wars, are the longest period of warfare which Europe has known since the early eighteenth century, and as they took place at a crucial stage of economic development, when the Industrial Revolution had just taken off in England and when its preliminary stirrings were showing in various places of the Continent, their impact upon the growth of industry in Continental Europe was quite serious.* (Crouzet, 1964, p. 567)

The dominance of the British Navy enabled a policy of naval blockades that seriously influenced merchant trade—not only from the Americas but from all the colonies—that crippled the economy of European countries.

> *… as a consequence, the great seaports of the Continent, which had been the hubs of its economic life in the eighteenth century, were completely crippled from 1807 onwards. Harbors were deserted, grass was growing in the streets, and in large towns like Amsterdam, Bordeaux, and Marseilles, population did actually decrease. …, the collapse of industrial production in the ports and in their hinterland … resulted from the loss of overseas markets and to a lesser degree from the difficulty in obtaining raw materials.* (Crouzet, 1964, p. 571)

After Napoleon was defeated and the Bourbon Restoration had put the monarchy back in the driver's seat, France seemed to be back at the time before the revolution. However, the basic societal structure had been changed. The nobility had lost its powerbase they earlier had established with the feudal system.

> *The cumulative effect of the abolition of the seigneurial system, tax privileges and venal office, the large inroads of expropriation, increased vulnerability of the noble whether as creditor or debtor, and a new inheritance law struck hard at the economic underpinnings of the nobility. Important as these blows were, however, the fundamental change in attitude that lies behind them was to act as an even more powerful corrosive in the course of the nineteenth century … The "bonds of subordination" both within the noble family and throughout the entire society had been "loosened". By 1825 the erosion of the hierarchical society upon which hereditary aristocracy rested was far advanced. … But an emerging society of self-confident, tenacious, middling and small landlords was not the aristocratic landed society of the Old Regime. Whoever won the Revolution, the noble landlord lost.* (Forster, 1967, pp. 85-86)

The almighty power of the church was gone, their role in education was minimized and other religions had found a place in French society. But the monarchy was back, and with it much of the nobility had returned.

It would take two other revolutions—the Revolution of 1830 and the Revolution of 1848—to create the second French Empire that would enable France to enter into the second half of the nineteenth century. A time in which—again—much would change as the result of the Second Industrial Revolution. But now it was not the mechanical technologies from the First Industrial Revolution, but the electrical technologies that would create the Second Industrial Revolution. For parts of Europe, the 1830 Revolution would be the start of the unification of the different states (eg Italian Unification and German Unification[108]).

Amazingly enough, all the revolts, turmoil and societal disruption had not paralyzed—as one would easily have expected—the progress of scientific thinking. Though science was suspect for a long time; "The murmurs of 1789 were a chorus by 1793: Intellect is the enemy of liberty; erudition is unsuited to a Republic; Robespierre rejects Condorcet's proposal to base education on science, as tending toward an intellectual aristocracy, and prefers a 'Spartan education in civic virtue' " (Gillispie, 1959, p. 680). Sure, the revolutionary circumstances for many individual

[108] See: B.J.G. van der Kooij: *The Invention of the Electric Light*. (2015) pp. 4-10

scientists (eg Ampere[109], Lavoisier) had their impact on their personal life. But Napoleon's legacy in the field of educational and scientific institutions (ie the Ecole Polytechnique and the Institute de France) still resulted in scientific achievements: "France was endowed at one stroke with her scientific institutions, and the first generation who taught and studied in them assured the restoration of her scientific leadership and its enlargement through the early nineteenth century" (Gillispie, 1959, p. 682). Antoine Lavoisier's work resulted in the roots of the Chemical Revolution and Andre-Marie Ampere laid the theoretical foundation for the understanding of electricity.

We have dwelt for a considerable time with the social and political changes that occurred in the first half of the nineteenth century in Europe. We put special emphasis on France and the French Revolution and its aftermath not because we are studying history but to paint a picture of the complex context for all those technical developments that would appear in that period of time. A context that—as we will see further on—dominates the stage for the discoveries, inventions and innovations to come. Among them of the General Purpose Technology of "Electricity" that would result in the Communication Era.

As France was lagging in entering the Industrial Revolution and proved not to be a player in the first developments that resulted in the electrical telegraph, one can wonder if the deeply rooted origins of French society played a role. The revolution may have transformed the time of privileges and inequality, into the intensely fought non-privileged and egalitarian society of "*liberté, égalité, fraternité*", but today, Paris still determines the heart and mind of a centrally controlled France. Even today it is still centralized government that privileges state-owned companies, where dominant unions rule state-owned and private companies and frustrate the small artisans of our time. But that is another story….

The Context for Technological Innovation

We started by realizing that *Technical Change* causes *Social Change*. But we added to this the assumption that social change also sets the stage for—maybe even causes or initiates—technical change. This would be a moment to evaluate that context—with its autonomous social change—in relation to the technical innovations we are going to observe further on.

[109] See: B.J.G. van der Kooij: *The Invention of the Electromotive Engine*. (2015) pp. 40-44

Revolutions

In the preceding observations, we described the context for innovation in the early nineteenth century as they were set by revolutions in the late eighteenth century; in casu the French Revolution. These socio-political revolutions created the context for the Industrial Revolution(s) to come. Realizing that the French Revolution was preceded by the American Revolution[110], one can easily see that both social-political revolutions have much in common. They both resulted in "changing the scene" as we will analyse separately. But both revolutions also differed considerably. To mention one dominant difference: Europe was still tied up in old societal structure of privileges and inequality, while America had become the "Land of Freedom" in the first half of the nineteenth century. And freedom was related to the implementation of the basic rights of Englishmen.

> *One of the many differences between the American and French Revolutions is that, unlike the French, Americans did not fight for an abstraction. Americans initially took up arms against the British to defend and preserve the traditional rights of Englishmen. The slogan "no taxation without representation" aptly summed up one of their chief complaints. The right to not be taxed without the consent of your elected representatives was one of the most prized rights of Englishmen. When this became impossible to achieve within the British Empire, Americans declared their independence and then won it on the battlefield. That is, Americans fought for tangible goals; they fought to preserve their traditional rights rather than to overturn an established social order.* (Busick, n.d.)

In France it was about overturning the established order; it was about "*liberté, égalité, fraternité*", a slogan[111] that includes freedom (*liberté*) but also two other important elements: equality (*égalité*) and brotherhood (*fraternité*). Both elements indicating it was about more than only freedom of the individual; it also related to the role of the community and the social structure . For the French Revolution to realize individual freedom, where all men were equal and responsible, the existing societal structure had to change. It included a societal change with a massive magnitude as it "would eradicate all hereditary nobility, venality of office, purchase of noble titles for money, hereditary privilege, monopolies, arbitrary arrests, seigneurial jurisdiction and illicit decrees. … The revolutionaries would establish liberty

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[110] To be described in the companion case study: B.J.G. van der Kooij, *The Invention of the Communication Engine 'Telephone'* (2015)

[111] This slogan was used in different forms and with different additions during the revolution. *Fraternité* wasn't always included, and other terms, such as *amitié* (friendship), *charité* (charity) or *union*, were also used. It was not until the 1848 Revolution that it became the official motto of the republic.

of commerce, liberty of conscience, liberty to write, liberty of expression" (Israel, 2014, p. 25). The French Revolution was fundamentally more complex, as there was no new, unexplored territory that had enabled a new society to be created. It was a change in an existing society in which the dominant monarchical and clerical powers were going to lose their former positions of societal power—although that was a process that would not be without considerable resistance.

So the French Revolution and the American Revolution were different in character. It was a long time ago that those differences between the revolutions were eloquently described by Marie-Jaen Caritat, Marquis de Condorcet[112], member of the Academie des Sciences and a Paris representative of the Assemblee in 1791, while he was awaiting his execution by guillotine in March 1794:

> *It was more complete, more entire than that of America, and of consequence was attended with greater convulsions in the interior of the nation, because the Americans, satisfied with the code of civil and criminal legislation which they had derived from England, having no corrupt system of finance to reform, no feodal tyrannies, no hereditary distinctions, no privileges of rich and powerful corporations, no system of religious intolerance to destroy, had only to direct their attention to the establishment of new powers to be substituted in the place of those hitherto exercised over them by the British government. In these innovations there was nothing that extended to the mass of the people, nothing that altered the subsisting relations formed between individuals: whereas the French revolution, for reasons exactly the reverse, had to embrace the whole economy of society, to change every social relation, to penetrate to the smallest link of the political chain, even to those individuals, who, living in peace upon their property, or by their industry, were equally unconnected with public commotions, whether by their opinions and their occupations, or by the interests of fortune, of ambition, or of glory. (Quote by J.M. Caritat, Marquise de Condorcet, 1794)* (Condorcet Caritat, 1795, p. 212)

Or to quote the words of the present-day historian Gordon Wood when he describes the difference between the two revolutions:

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[112] Nicolas de Condorcet (1743-1794), mathematician, philosopher and political scientist, was secretary of the Académie des Sciences, holding the post until the abolition of the academy in 1793 and in 1782, secretary of the Académie Française. In 1791, he was elected as a Paris representative in the Assembly, and then became the secretary of the Assembly. As the political majority changed several times, he became isolated and was branded as a traitor in 1793. His posthumously published *Sketch for a Historical Picture of the Progress of the Human Spirit* (1795) was perhaps the most influential formulation of the idea of progress ever written.

> *The American revolutionairies … did not kill one another; they did not devour themselves. There was no reign of terror in the American Revolution and no distant dictator—no Cromwell, no Bonaparte. The American Revolution does not have the same kinds of causes—the social wrongs, the class conflict, the impoverishment, the gross inequitable distribution of wealth—that presumably lie behind other revolutions. There were no peasant uprisings, no jacqueries, no burning of chateaux, no storming of prisons.* (G. S. Wood, 2011, p. 3)

The American Revolution was about changing government; the French revolution was about changing government and changing society. Sure, replacing the monarchy with a republic was quite a societal change in societal institutions, but there was more, as in changing the societal structure the social relations between people also changed.

What both revolutions have in common was regarding the position of the individual person in the societies of that time. Not anymore was it "inequality and privileges" in which a few people dominated a society, but the acknowledgement of the natural rights of men as expressed in the *The Declaration of the Rights of Man.* In a society that suppresses and enslaves people, either by religious powers or by physical powers, individual human behaviour is only focussed on survival. There is no slack for other aspirations and creativity is limited to the bare existence.

It was not the prosperous conditions for the majority of the European population, who initiated the revolutions. That the French Revolution developed as it did, was caused by social position of the masses; the peasants and the bourgeoisie. Social migration always has a cause, just like physical migration. Not welfare and good living conditions had motivated most of the immigrants to America to leave their country. Rather, it was precisely the poverty, oppression, wars and revolts and other oppressive conditions, which forced people to give up everything and to undertake the voyage and travel to the country of opportunities. Migration has in most cases a negative motivator. That was early times (eg Visigoths), in the Middle Ages (eg Huguenots) and that happens today (massive immigration to Europe in our times). Moreover, when those social changes have occurred, the time becomes ripe to initiate and apply the technical changes offered by the progress of times. Technical Change follows Social Change.

Spirit of Times

What can be observed in the preceding is that the societal structures underwent massive change in the revolutionary times. Whether it was the creation of a new nation by removing the shackles of governmental unfreedom, or whether it was the overhaul of the total societal structure, it all affected individual human behaviour.

In a time that the subsistence on life was dominated by the struggle for survival, the behaviour of people was geared to survival. The life of those early American colonists, trekking into the new, unexplored and often hostile country, was harsh. Life was cruel for the French peasant who lost his tenancy and became a vagabond, wandering from place to place[113]. Always, individual behaviour was geared to survival; food and safety. When food was scarce and people went hungry, they had to act. When people were threatened in their physical safety, they had to act. Sometimes the action was in the form of migration: finding better circumstances to live. The consequence was often warfare, as those who were invaded by the new immigrants often were inclined to defend their territory against the "vandals". That was the case for the physical migrations, but it was also true for the societal migration, where social classes of people demanded a place in society that was more than a physical presence. And the social classes that were already in place were resisting the invasion of the revolutionists that threatened the core of their existence.

The totality of individual behaviour among a collective created a societal behaviour described as the *zeitgeist* (spirit of the time). Take as an example the collective behaviour in America when everybody wanted to "go west": the period of westward expansion of the American colonies. It created the zeitgeist of the Wild West: a period "that transformed Europeans into a new people, the Americans, whose values focused on equality, democracy, and optimism, as well as individualism, self-reliance, and even violence." (Turner & Abbe, 1966).

Madness of Times

This is just one example of the many examples that can be found—like the time of the actual French Revolution itself. These were the spirits of time that ruled over a longer period. But there are also short-lived periods in time with specific collective behaviour, such as the period that was initiated by negative collective behaviour like the Great Fear (*la Grande Peur*) that flooded France in 1789 in a period in time when dramatic climatic conditions had created food shortages and grain speculation (Figure 50). Everywhere in France, peasantry undertook collective actions against what they considered to be the cause: the ruling class of the *seigneurs* and manorialism. Or take as another example the period in the French Revolution with the Reign of Terror (1793-1794). The time that started of

[113] Nothing has been changed when one observes the flow of refugees flooding Europe in 2015. Many originating from the Middle East with its political conflicts, and Africa with its economic and racial conflicts.

with the introduction in 1793 of the *Law of Suspects*: a law that made nearly everybody a suspect of anti-revolutionary behaviour. From former noblemen stocking the harvest to protests about the rising prices of bread, it created an economic terror, soon to be followed by the political terror initiated by the Comity of Public Safety under Robespierre, which organized the collective revolutionary paranoia. This was the—relatively short—period of time where terror ruled collective behaviour. Together they contributed to the revolutionary zeitgeist of revolts that resulted in the abolishment of feudalism in France.

These periods with a negative zeitgeist[114] were violent times that were crowded with wars. Many wars had to do with the interests of the monarchies themselves: such as the Spanish War of Succession (1701-1714) and the Austrian War of Succession (1740-1748). Others were related to economic dominance, such as the Seven Years War (1754-1763). And there were the revolutionary periods influencing the societal structure: the American Revolution (1765-1783) and the French Revolution (1789-1799). Each in its own way resulted in human casualties: soldiers on the battlefield, revolutionists during the revolution, and many innocent civilians as collateral damage. Violence was the main characteristic of the madness of times.

And in that period, with its "madness of times", with all its atrocities, something creative happened. The foundations for a massive technical change—later to be called the Second Industrial Revolution—were created. It was the result of the efforts of ingenious, curious and creative people: scientific, engineering and entrepreneurial people who, although living in the midst of the revolts and revolutions, became the founders of the *Era of Communication*. Like the founding fathers of the American and French Revolutions, we now will meet the founding fathers of the communication engine called telegraph.

The Beginning of the Era of Communication

For the Era of Communication to come, the 1830s were an interesting decade. After the Dane Hans Christian Oersted in 1821 got the experimental scientists excited about his experiments with electromagnetism, electricity became a hot topic in the scientific community of those days[115]. It fit the context of that time, as quite a lot was happening when many countries were hesitatingly entering the Age of the First

[114] Examples of periods with a positive, even exuberant spirit of times are La Belle Epoque (France, ca. 1870-1914) and the Gilded Age (America, ca. 1870-1900).
[115] See: B.J.G. van der Kooij: *The Invention of the Electromotive Engine.* (2015)

Industrial Revolution. Soon the knowledge about that magic phenomenon of electricity was vastly improved by the scientific and engineering contributions of many curious and inventive people: the thinkers and tinkerers of those days.

Take for example Europe, where in England, Michael Faraday created in 1831 his "coil" [116]. Or in Italy where scientific experimenting by professor Guiseppe Bottico in 1834 resulted in the first primitive electric motors. In England, William Sturgeon experimented in 1833 with a rotating electric device and an electromagnet. In Russia in 1839, the German-speaking Prussian Moritz Hermann von Jacobi proved that the electric motor he had developed in 1834 could power a boat with 14 people on the river Newa in St. Petersburg. By the end of the decade, the young British musical instrument maker Charles Wheatstone, already fascinated by the phenomenon of electricity and hearing of Jacobi's experiments, created three different electric motors.

In America, quite a lot was also happening in the field of electricity. In New York, Joseph Henry, the smart son of poor Scottish immigrants, made his first experiment with electromagnets, after having seen Sturgeon's magnets demonstrated. In 1831, he created an oscillating electric motor, followed in 1832 by a large electromagnet (ie the Yale Electromagnet) that could lift several hundred kilograms. Two years later, in 1834, the blacksmith Thomas Davenport, after seeing Henry's electromagnet, created his first electromotor and got it patented in 1837. In 1838, Charles G. Page started his lifelong fascination with electric motors as he developed his Axial Machine.

In short, these examples make it clear that in many scientific and engineering circles in the 1830s, curious and inquiring people were fascinated by the new phenomena of electricity and the fact that it could create power. They were intrigued with electricity that—due to electromagnetic force—could create linear movement (as with the electromagnet) and rotative movement (as with the electromotor). And they showed the fruits of their efforts to the world, publishing about their work and demonstrated their inventions at every opportunity (from public lectures to large exhibitions), thus inspiring others, as the scientists were not the only ones who got excited by this new phenomenon of electricity. Quite a few non-technical, entrepreneurial spirits would begin to see business opportunities in the application of electricity.

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[116] Also known as Faraday's Ring, a coil that proved the existence of mutual induction in the early electromagnetic transformer.

Later—in the 1860s—the application of the electric light would result in broad entrepreneurial activity, but decades before that, many creative spirits—without too much understanding of electricity—would become fascinated by the new application of electricity into the field of communication. Many of those individuals are lost in the fog of history, but some would become famous:

In the autumn of 1832 the packet ship Sully arrived in New York after departing Le Havre, France on October 1. On board was a forty-one-year-old painter who returned from his stay in Europe, where he had spent his time among the artists and art galleries of England, France and Italy. It had been a most stimulating voyage during the more than six weeks it took the packet boat to make the crossing—weeks where he had been discussing scientific progress with the other passengers on board. Among them was Dr. Charles T. Jackson, of Boston, who had attended some lectures on electricity in Paris and carried an electro-magnet in his trunk. The discussions went on about the speed of electricity traveling the electric wire. Already for some time fascinated by the phenomenon of electricity, the discussions stimulated the young man's ideas to use electricity for transmitting intelligence: with electricity he could transmit intelligence and record it at a distance. "During the voyage of six weeks the artist jotted his crude ideas in his sketch−book, which afterwards became a testimony to their date, that he cherished hopes of his invention may be gathered from his words on landing, *'Well, Captain Pell, should you ever hear of the telegraph one of these days as the wonder of the world, remember the discovery was made on the good ship Sully.'"* (S. I. Prime, 1875, pp. 251-257). After arriving in New York, this man called Samuel Finley Breese Morse, completely excited, told his brother Sidney about his ideas:

> *He was full of the subject of the telegraph during the walk from the ship, and for some days afterwards could scarcely speak about anything else. He expressed himself anxious to make apparatus and try experiments for which he had no materials or facilities on shipboard. In the course of a few days after his arrival he made a kind of cogged or saw-toothed type, the object of which I understood was to regulate the interruptions of the electric current, so as to enable him to make dots, and regulate the length of marks or spaces on the paper upon which the information transmitted by his telegraph was to be recorded.* (E. L. Morse, 1914a, p. 17)

On 22 April 1836, a thirty-year-old student in medicine returned to England from his stay in Paris and Heidelberg. After a stint of five years of military service in the Indian Army, he was contemplating a career in anatomical modelling: a promising opportunity as there was a high demand for wax models of anatomical sections for medical teaching. He already had one customer, his father being a distinguished surgeon who later became appointed professor of anatomy at the University of Durham. So the young man travelled Europe, attending university lectures on anatomy. At Heidelberg, a friend took him to a lecture in which Professor Georg Wilhelm Muncke demonstrated a copy of Schilling's single-needle telegraph: a telegraphic apparatus that could "write at a distance". This was an apparatus that was based on the experimental work of the German professors Wilhelm Eduard Weber and Carl Friedrich Gauss. The young student, William Fothergill Cooke, became so entranced with what he saw during the demonstration, that he gave up the study of anatomical model making and medicine and decided to put the novel invention into practical operation. Cooke sought to take it beyond merely the world of academia; he was seized with the idea of making a commercially practical telegraph system based on the needle galvanometer. And he acted....

> *Within three weeks after the day on which I saw the experiment, I had made, partly that Heidelberg and partly that Frankfort, my first electric telegraph, of the galvanometer form …* (von Hamel, 1859, p. 2).

A few decades later, in 1896, a twenty-two-year-old Italian, Guiglimo Marconi, would travel from Italy to England under the guidance of his cousin, Henry Jameson Davis. In his luggage were some black boxes and assorted paraphernalia of a new device he had developed: a telegraph that did not need any wires. He had developed his ideas, created and tested prototypes in several experiments and was now ready to take his invention to the next phase. The Italian government—both the bureaucracy of the Ministry of Post & Telegraphs and the Italian Navy—were not that interested in the fruits of his early experiments with (naval) mobile telegraphy. So he decided to leave for England, the home country of his mother, Annie Jameson, and try his luck there.

> *What better place to market it than in England, then the pre-eminent naval power? Second, and, probably, just as important, the Jameson family to which Annie belonged was financially well off and politically and socially well connected enough in the English commercial if not the technical entrepreneurial class to provide the support that would be required to carry out the Marconi "grand design". Finally, their good knowledge of the language and customs of the country (assuredly better even than those of Guglielmo's native Italy) was another deciding factor. …*
>
> *Notwithstanding such strong potential family support, it is important to stop a moment here to consider the tremendous odds Marconi was up against when he arrived with his black boxes and assorted paraphernalia in London on that*

February day in 1896. As Aitken again so aptly put it: "in 1896 Marconi was in effect a nobody, a man with practically no formal education, an inventor whose equipment differed in no basic way from the already known and demonstrated 'state-of-the-art', an alien with no family connections that could not safely be ignored if one had a mind to ignore them". (Paresce, 2015)

Both events in the early nineteenth century and the one event at the end of that same century were about young and grown up men fascinated by the opportunity electricity offered for communication over distance. Their work would herald the first communication engines that created the Era of Communication known as the telegraph (as in "distant writer"). One development took place in America; another took place in England, the third in Italy. Morse and Cooke laid the foundations for the cabled telegraphy. The two men eventually met each other at the end of the decade when they were commercializing their telegraph systems. The third man would create the foundations for wireless telegraphy[117].

Some Basics

Before we turn to their specific endeavours and contributions, for a better understanding of what is to come, we have to pay attention to some fundamental aspects of communication.

Communication is one of the basic forms of interaction between living beings. Animals communicate to find partners: from the rutting red deer to the nightly owl. People communicate through the non-verbal communication of attitudes and emotions to verbal communication in their mother tongue to exchange information. Communication was limited to distances the voice could bridge to transport the information by sound waves. When longer distances had to be bridged, additional tools and methods were needed, such as drumbeats, beacon fires, smoke signals and flag signaling. Many used light waves to transmit information. To cover larger distances, the homing pigeon and the professional runner transported messages. For ages, not much changed until mankind mastered the horse and the script. Then the courier system developed to physically transport information. It developed into the postal system, where physical documents (ie the postal mail: P-mail) were transported by post coach. In other words, communication is an essential and basic need for human beings—a need that was waiting, without realizing it, for a new technology to offer improved ways of communication.

[117] This development is to be described in: B.J.G. van der Kooij: *The invention of the communication engine 'Telephone'*. (2015)

Tele-communication got a boost when mechanical technologies were introduced. Semaphore used visual signs to bridge, in a relay system, large distances. From 5-10 km/hour for the runner or horse, the transmission speed rose to 500km/hour. In those times, information travelled with the speed of light, but only when there was enough visibility: not at night and not in bad weather conditions and only if the tower watchmen did their work properly. Then the introduction of the new phenomenon of electricity opened a range of new possibilities. Now electricity was used as the carrier of information, bridging the large distances with wires that transported the coded information, at least when they were in working order, as the climatic circumstances sometimes spoiled their functioning. Distant writing was born, and it was called telegraphy. Not hindered by visual constraints, it developed into world-spanning electrical telegraphy systems.

Enough basics for the moment. Back to the first half of the nineteenth century that, as shown before, had its specific dynamics. Dynamics caused by the spirit of times and the madness of times as illustrated by all those (social) revolutions that changed the social and political order. Amidst all this turmoil, the revolts and social disruptions, in a kind of parallel world, we find the development of scientific insights that would later change the world again: the technical revolutions.

Discovering Electromagnetism

As scientific thinking in the eighteen century developed, it focused on understanding the basic elements in nature. Among those was the understanding of the "Nature of heat" and the related "Power of fire" that resulted in the invention of the steam engine[118], not much later to be followed by the understanding of the "Nature of lightning" and the related "Electro-motive power"[119]. As the developments of electricity (ie the generation, transport and use of electricity) gave way to the ample availability of electric power, it resulted in a range of other scientific curiosities that were going to be linked to electricity.

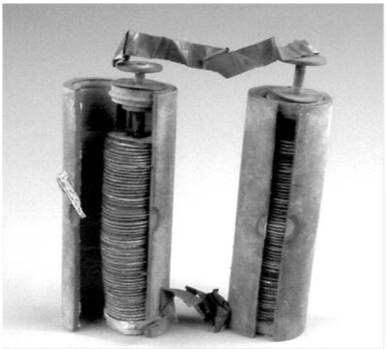

Figure 77: Allessandro Volta's chemical battery.

Source: http://alessandrovolta.it/wp-content/uploads/2011/07/144C.png

It was that the end of the eighteenth century and beginning of the nineteenth century that the foundations for the understanding of the nature of electricity were being created. Actually, it had started earlier with the discovery of *frictional electricity*. This was a form of electricity created by rubbing different materials together, resulting in electrical charges, as was shown by experiments executed by Benjamin Franklin (1706-1790) and others. The kite-carrying Franklin became famous for bringing lightning down to earth: his Philadelphia experiments. In these experiments, in 1750, he proved the existence of electricity by flying a kite in a thunderstorm. The kite twine conducted the "electric fire" along the wire to a key at the bottom. Others, like D'Alibard in France in 1752 and Georg Wilhelm Richmann in 1753 in St. Petersburg repeated his experiments. Their observations that lightning caused shocks was taken on by others who were able to create electricity differently with simple frictional machines (eg Hauksbee, Faraday, Nolet and others). The electricity generating apparatus was born.

In the second half of the eighteenth century, other scientist looked for different forms of electricity, like Luigi Galvani (1737-1798) who, dissecting frogs, discovered animal electricity, a new phenomenon: a frog's leg in a nerve-muscle preparation contracted every time the muscle and the nerve were connected by a metal arc, which usually consisted of two different

118 See: B.J.G. van der Kooij: *The Invention of the Steam Engine.* (2015)

119 See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015)

metals. The publication of his work got the attention of many scientists in those days. Among them we find Alessandra Volta (1745-1827), a professor of experimental physics that the University of Pavia. He experimented with a pile of plates of silver and zinc soaked in salt water, and his work resulted in another form of electricity: voltaic electricity. The "wet" battery was born (Figure 77).

Over time, these early scientist grasped more or less the nature of electricity. Based on the work of these early experimenters, others continued their explorations, and they added fundamental insight to the application of electricity. It was the Dane, Hans Christian Oerstad (1777-1851), who in 1820 observed during a lecture that a compass needle would move when an electric current passed through a nearby electric cable (Figure 78). It was to be the discovery of electromagnetism. Its publication created uproar in the savant community of those days.

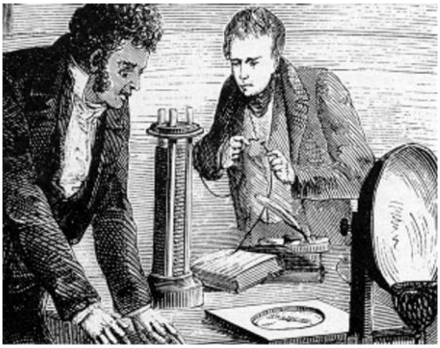

Figure 78: Hans Christian Oersted's needle experiment.

The voltaic battery is visible between the scientist.

Source: http://alessandrovolta.it/scoperte-e-strumenti/la-pila/

Hearing of these experiments, the Frenchman Andre-Marie Ampere (1775-1836) became excited by the discovery. After repeating Oersteds experiment, he started experimenting himself. Not much later, he was able to explain the mechanism behind Oersteds discovery, where an electric current influenced the movement of a magnetic needle. But it did not explain the reverse action: magnetism influencing electric current. That was done by Michael Faraday (1791-1867), who also became intrigued with Oersteds discovery. He studied it and experimented in 1831 with a soft iron ring with two sets of coils (as seen more or less in today's transformers). Connecting a battery to the first coil resulted in current in the second coil. He had found the induction effect and thus expanded the relation between magnetism and electricity: electromagnetic induction. It was then that William Sturgeon (1783-1850), who in 1825 conceptualized that electricity and the properties of metals could create a magnetic force: the electromagnet was born (S. P. Thompson, 1890, p. 199). Not much later, its enormous power was demonstrated by the powerful magnets created by Joseph Henry, as we will see further on.

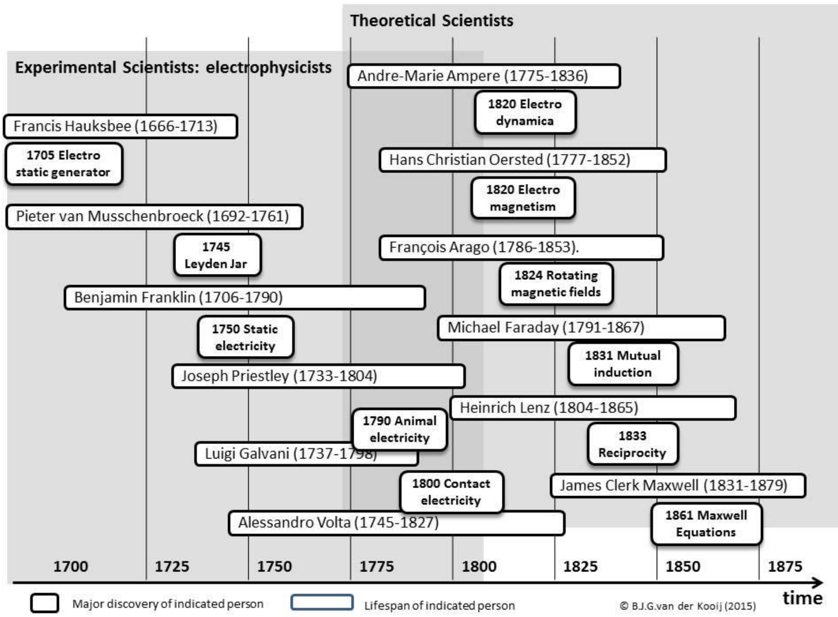

Figure 79: Science discovers electricity.

Source: Figure created by author

In the firmament of knowledge, on the path covered with scientific contributions to the phenomenon of electricity, the efforts of these scientists created milestones (Figure 79). This was, quite some time later, recognized when the highly awarded Elihu Thomson (1853-1937), then acting president of the Massachusetts Institute of Technology, held a presentation for the American Institute Of Electrical Engineers on October 8, 1920, in honour of Oersteds discovery a century before. He concluded, after describing in short the developments leading to the telegraph that changed the world of communication:

> *It is not necessary here to allude to the great developments in the field of electricity and electromagnetism as exemplified in generation and transmission of electrical energy. They have covered the past half century, but the foundation principles belong to those early years of upward of a century ago. Do we cause movement of iron masses by a current coil? It is the experiment of Oersted. Do we cause movement of coils, one with relation to another, as in our motors? It is the experiment of Ampère. Do we generate currents in a conducting mass in a magnetic field? It is the experiment of the Arago disk. When we measure current*

or energy by galvanometer, voltmeter, electrodynamometer, or wattmeter we have the work of Oersted, Ampère, Arago and Davy illustrated. But these early discoveries had a deeper significance still. They showed that electric currents and magnetism are inseparable – inseparable in practice, inseparable in theory. …

The discovery, then, of the relation between electricity and magnetism was in reality the discovery of a fundamental fact or principle lying that the foundation of the universe itself; the soul of energy, as also of matter, of electric waves from zero periodicity up to the most penetrating rays of the radium emanations. It is eminently fitting, then, that we celebrate the hundred anniversary of discoveries, the fruits of which have been of stupendous influence and value, and that the same time carry us to the very foundations of existence; but we meet also to do honor to the great men who first brought those discoveries to light. (Thomson, 1920, p. 1027)

Scientists ended up with knowledge about the fundamentals of electricity and magnetism, and they managed to use this knowledge and apply electricity in real life. Electricity was used to create linear movement (ie the electromagnet) and rotative movement (ie the electromotive motor). In both cases, it was electricity that was used for the transportation of energy. This would lead to an impressive world of inventions of its own. But there proved to be another use for electricity. Electricity would also become the medium for the transportation of information by means of telecommunication. And in those early days, two artefacts proved to be fundamental to its development: the galvanometer and the electromechanical relay.

The Magnetic Needle

A direct result from Oersted's discovery of the moving compass was an instrument called the galvanometer. This instrument was used to detect the presence of a—often weak—current and present its finding by a moving needle. The basic mechanism of the galvanometer is the same as an electro-motor: a coil in which runs an electric current moves under the influence of magnetism when constructed in an appropriate way.

Figure 80: Schweigger's galvanometer (1820).

Source: Inventions "made in Halle". http://www. international.uni-halle.de /im/1334235642_133_0.jpg

One of the people experimenting with this idea was the German Johann Salomo Cristoph Schweigger (1779-1857), a professor in physics and chemistry at universities in Munich and Halle. He was interested in the topic of weak currents. And on November 4, 1820, he presented his first experimental results (Figure 80):

> *In my lecture of September 16, I showed that Oersted's results depend, not on the voltaic cell, but only on the connecting circuit. The principle I have used for amplification of the effects, for the construction of an electromagnetic battery as it were, was the winding of wire around the compass, and I now present to the Society a bow-pattern of multiple-wound, wax-insulated wire. … Oersted succeeded in electromagnetic research by using a spark-producing cell, which could make a wire glow. My amplifying electromagnetic device needs only a weak circuit of copper, zinc, and ammonium chloride solution.* (Chipman, 1964, p. 130) (Chipman, 1964)

Two month after Oersteds publication, in 1820, he developed an instrument that would become known as Schweigger's galvanometer. His galvano-magnetic multiplier (*verdopplung apparat*) was made out of a coil with several turns that could move in a magnetic field (Figure 80). Independently of Schweigger, the German Johann Christian Poggendorf (1796-1877) built a crude galvanometer, also called a multiplier, similarly to that of Schweigger in 1821. In the same timeframe as these German scientists, in England, curious scientists were experimenting. Among those was the British electro-physicist James Cumming (1777-1861), who presented papers on his invention in April and May 1821, and published his findings in 1822. In Italy the physicist Leopoldo Nobili (1784-1835), experimenting with electromagnetism and expanding on Oersted's idea, created the astatic galvanometer in 1825-1826 (Figure 81).

Figure 81: Nobili's astatic galvanometer (1826).

Source: Museo Galileo, http://catalogue.museogalileo.it/gallery/NobilisLargeAstaticGalvanometer.html

> *A major problem of Schweigger's galvanometer was soon discovered. His galvanometer was effected by the magnetic field of the earth often enough to caused faulty measurements. Leopoldo Nobili of Italy fixed the problem sufficiently to make the galvanometer an*

indispensible measuring tool of electrical current. To prevent the needle always being aligned with the magnetic meridian when there is no current, Nobili, in 1826, devised a static system. This comprised two cylindrical, parallel magnetic bars whose magnetic poles were symmetrically aligned. The system was built in such a way that one of the bars was inside the multiplier and the other outside.[120]

The multiplier principle would follow a development trajectory of its own. Schweigger's galvanometer would later inspire the Englishman William Thomson, the later famous Lord Kelvin. He developed the mirror galvanometer—patented later in 1858—that was able to detect very rapid current changes (Figure 82) that, as we will see later on, saved the first Atlantic submarine telegraph cables. Again, quite a while later—in 1882—the Frenchman Jacques-Arsène d'Arsonval and Marcel Deprez were inspired by the multipier idea and developed a form with a stationary permanent magnet and a moving coil of wire. It was suspended by fine wires, which provided both an electrical connection to the coil and the restoring torque to return to the zero position. Finally, it was the Englishman and electrician Edward Weston [121], holder of dozens of patents, who improved the galvanometer further by using spiral springs (like in a balance wheel of a wristwatch) that he patented in 1888. This instrument became a basic instrument used for experimenting with electrical currents (ie our present day voltmeter). Thus the galvanometer became the apparatus for detection of weak electrical current in an electric circuit.

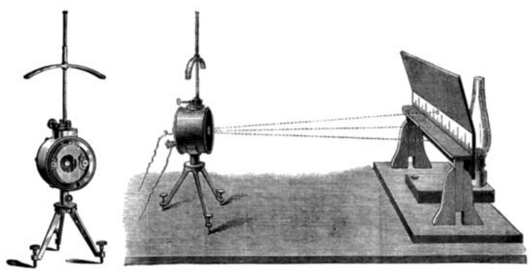

Figure 82: Drawing of Thomson's reflecting galvanometer.

Source: Wikimedia Commons

As we will see further on, the magnetic needle was also used by the early inventors of telegraphy. One of them was, quite some years later, Charles Wheatstone, who improved upon the galvanometer and was granted British Patent № 10,655 in 1845. The galvanometer would also—already in 1826—

[120] Source: Biography of Johann Salomo Christoph Schweigger. https://nitum.wordpress.com/tag/schweigger-developed-the-galvanometer-as-a-tool-for-measuring-the-strength-and-direction-of-electric-current/ (Accessed June 2015)

[121] See: B.J.G. van der Kooij: *The Invention of the Electric Light.* (2015)

stimulate Gauss and Weber in developing their telegraph-experiments. Thus the magnetic needle became a major component in the development of early telegraphy in Europe.

The Electromechanical Relay

On the other side of the Atlantic Ocean, in 1797, on a farm nearby Albany, New York, a young man was born who would later in his life become the Patriarch of American science; his name was Joseph Henry. His grandparents were poor Scottish immigrants that came to America in the time of the Revolutionary War. His father died while he was still young, and Joseph was raised by his grandmother.

After school, he worked at a general store, and at the age of thirteen became an apprentice watchmaker and silversmith. He became interested in science at the age of sixteen after reading a book of lectures on scientific topics titled *Popular Lectures on Experimental Philosophy, Astronomy, and Chemistry*. He was fascinated by the challenges in the domain of nature, and soon he was tutoring the children of the wealthy van Rensselaer family. This patron, the rich businessman and banker Philip Schuyler van Rensselaer, being the mayor of Albany and living at the Van Rensselaer Manor, had founded the Albany Academy in 1813. In 1819, Joseph Henry, given free tuition, entered the Albany Academy where he, after some explorations into medicine, prepared to have a career in civil or mechanical engineering. Henry excelled in his studies, even helped his teachers and became appointed professor of mathematics and natural philosophy at the Albany Academy in 1826. Soon he focused his activities on the field of electricity and started experimenting with electro-magnetic phenomena (Figure 83).

Figure 83: The first experimental electromagnet made in Albany by Joseph Henry (1829).

Source: Smithsonian, National Museum of American History, ID number EM 311176

> *At Albany he devised the means of making really powerful electromagnets and invented the first electromagnetic machine, that is, a device by means of which electricity was made to produce mechanical movement. … at this time, too, he made an independent discovery of induced currents in electricity which, however, Faraday in England had also made and announced first. Also, while that the*

Academy he devised an electromagnetic telegraph in which signals were transmitted by exciting an electromagnet located at a considerable distance from the battery. This device allowed bells to be struck. (Carmichael, 1967, p. 6)

Becoming more and more engaged in scientific work in the field of electro-magnetism, in Albany he started publishing about his experiments with magnets and electricity:

His first published paper on the subject was read in 1827 before the Albany Institute, and is entitled, "On some modifications of the electro-magnetic apparatus." It consisted simply of a brief discussion of several forms of apparatus designed to exhibit the mutual action of the galvanic current and the magnet, but does not appear to comprise any discussions of new ideas. … In 1831 he published in Silliman's Journal a paper on the development of great magnetic power in soft iron with a small galvanic element. This paper is in some sort a continuation of his first paper, the fundamental object of both being to show how the greatest development of magnetism could be obtained with the smallest battery. The ideas were suggested by the study of Schweigger's Galvanometer. (Newcomb, 1880, p. 6)

Henry experimented with magneto-electricity in the same period of time as Michael Faraday did his experiments in England. He discovered self-induction in 1830, where electricity is created when a magnet moves in a coil, and he worked on the galvanometer. In 1831, he published about linear electric motion in “On a Reciprocating Motion Produced by Magnetic Attraction and Repulsion” (Joseph Henry, 1831). The ideas he published here would become the foundation of the electro-mechanical relay as he experimented with his bell concept (Figure 95).

Henry reported his findings in Benjamin Silliman's American Journal of Science (hereafter Silliman's Journal) in January 1831. … For Henry did set out to demonstrate the practicability of an electromagnetic telegraph immediately after his paper appeared. His prototype consisted of a small battery and an "intensity" magnet connected through a mile of copper bell-wire strung throughout a lecture hall. In between the poles of this horseshoe electromagnet he placed a permanent magnet. When the electromagnet was energized, the permanent magnet was repelled from one pole and attracted to the other; upon reversing battery polarity, the permanent magnet returned to its original position. By using a pole-changer to cycle the electromagnet's polarity, Henry caused the permanent magnet to tap a small office bell. He consistently demonstrated this arrangement to his classes at Albany during 1831 and 1832. (Hochfelder, 1998b, p. 4)

In 1832 he went to the New Jersey College, later called Princeton College, to become a professor in natural philosophy. There he continued his work on electro-magnetism and developed more electro-magnets (Figure 84). He built himself a name as an expert electrician; not only because of his technical expertise but also due to his personality.

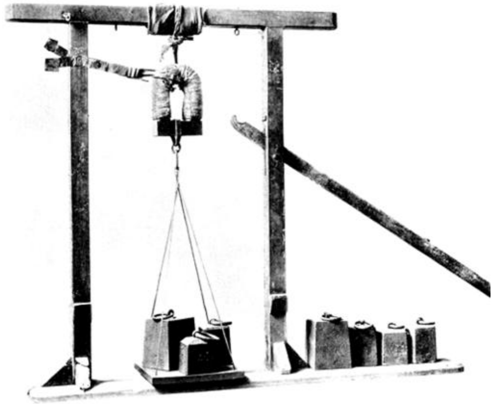

Figure 84: The Yale electromagnet made by Joseph Henry (1831).

Source: Henry, Joseph, 1797-1878. the Papers of Joseph Henry. Eds. Naan Reingold and Marc Roenberg. Washington : Smithsonian Institution Press, 1972-2008 Print.

> *His position that Princeton was in every respect most agreeable. His enthusiasm as a teacher could not fail to bring around him an appreciative body of pupils. He was not moved by any merely worldly ambition to seek a larger and more prominent field of activity, and was held in the highest esteem by the authorities of the college. He thus enjoyed what is almost the happiest lot of man, that of living in a community suited to his tastes and pursuits, and of being held in consideration by all with whom he came into contact.* (Newcomb, 1880, p. 15)

Henry met with other scholars active in the field of electricity and established in that period a name among his peers, and got well connected. He went, funded by Princeton, on a trip to Europe to meet Faraday and Wheatstone, demonstrating his ideas about self-induction.

> *In the spring of 1837 a small group of men in an English laboratory attempted an impromptu experiment: they had rigged up an electric circuit to carry a very feeble current, and they were trying to draw sparks by closing and opening the circuit. Charles Wheatstone touched together the two pieces of wire that completed the circuit. He drew no spark. Michael Faraday said that Wheatstone was going about it in the wrong way. Faraday made a few adjustments and tried his hand. Still no spark.*
>
> *A visiting American waited patiently while the two famous "electricians" argued back and forth over the probable cause of failure. As the American listened, he absently coiled a length of wire about his finger in a tight corkscrew. After a few minutes, he remarked that, whenever the two gentlemen were ready, he would gladly show them how to draw a spark. Faraday gave him one of his usual*

brusque answers, but the American went ahead. He added his little coil to one of the leads, and this time, when he opened the circuit, he drew sparks that were clearly visible. Faraday clapped his hands with delight and said, "Hurrah for the Yankee experiment! What in the world did you do?"

If Joseph Henry had had Faraday's temper, he might have blurted out, "If you would only read what I publish, and understand what you read, you'd know what you just saw!" Instead the Princeton professor patiently explained the phenomenon of self-induction to the man whom the world had already credited with the discovery of induction. (Wilson, 1957, p. 140)[122]

His advice was often sought by young inventors, for example by Samuel Morse, who was not too educated in matters of electricity or the blacksmith Thomas Davenport, who built his electric motor after seeing Henry's linear motor[123].

Being recognized as an expert in the field of natural sciences, in 1846 he became the first secretary of the newly erected Smithsonian Institution. Over time, as a famous scientist and director of the Smithsonian Institution, Henry received visits from other scientists and inventors who sought his advice. Henry was patient, kindly, self-controlled and gently humorous.

One of his interesting traits of character, and one which powerfully tended to make the Smithsonian Institution popular and useful, was a certain intellectual philanthropy which showed itself in ceaseless efforts to make others enjoy the same wide views of nature which he himself did. He was accessible to a fault, and ever ready to persuade any honest propounder of a new theory that he was wrong. (Newcomb, 1880, p. 30)

Some years before his death in 1878, a young inventor called Alexander Graham Bell contacted him. In 1875, Bell took his newly developed telephone-apparatus to the Institute to demonstrate it to Henry.

For an entire afternoon the two men worked together over the apparatus that Bell had brought from Boston, just as Henry had worked over the telegraph before Bell was born. Henry was now a veteran of seventy-eight, with only three years remaining to his credit in the bank of Time, while Bell was twenty-eight. ... "You are in possession of the germ of a great invention," said Henry, "and I would advise you to work that it until you have made it complete." "But," replied Bell, "I have not got the electrical knowledge that is necessary." "Get it," responded the aged scientist. (Casson, 1910, p. 30)

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[122] This would later be, as we will see further on, the link between the different telegraph discoveries: Henry met Faraday and Wheatstone, Wheatstone met Morse (see: Morse does Europe) and Morse met Henry, all in the 1837-1838 period.

[123] B.J.G. van der Kooij: *The Invention of the electro-motive Engine.* (2015), pp. 72, 76-78.

Bell was obviously quite stimulated by Henry, as he wrote to his parents some days later: "I cannot tell you how much these two words have encouraged me" (Bruce, 1990, p. 140). A year later, on June 25, 1876, Henry would be one of the judges for the electrical exhibits of the Centennial Exhibition in Philadelphia. There Bell's invention became the hot item of the Exhibition after the Emperor of Brazil, Dom Pedro de Alcantara, admired his invention. On 13 January 1877, Bell demonstrated his instruments again to Henry at the Smithsonian Institution. Henry was excited and invited Bell to demonstrate them again that night at a meeting of the Washington Philosophical Society. Not much later, Henry died in 1878.

The development of the electromechanical relay was quite fundamental, but it was technically not that complicated. After Oersted's discovery about the relation between electricity and magnetism, Faraday's concept of electromagnetic induction and Sturgeon's development of the electromagnet[124] and Joseph Henry's improvements by wrapping more wire around the iron core[125], it was clear that the electromagnet could be used in many applications (Hochfelder, 1998b).

The concept of the electromagnet was simple: by applying an electrical current through an electromagnet (Top, Figure 85), one could create a mechanical movement and, with the electromagnetically force, attract another iron body (Bottom, Figure 85). This was exactly what Henry did in 1835 when he created the electrical relay: the

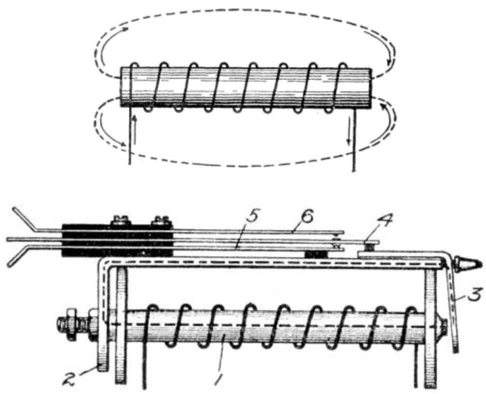

Figure 85: From bar electromagnet (top) to electro-mechanical relay (bottom).

The electromagnet (top, 1) used in a relay (bottom) to move an iron piece (3) that closes a switch (4-6).

Source: Cyclopedia of Telephony and Telegraphy. Vol. 1, http://www.gutenberg.org/files/15617/15617-h/15617-h.htm#CH_10

[124] See: B.J.G. van der Kooij: *The invention of the Electro-motive Engine.* (2015) pp. 63-65

[125] In fact Henry did two things: he created multiple short coils placed in parallel and multiple batteries in parallel, thus creating a larger body of electromagnetism due to the larger current: his quantity magnet. And he placed coils in series as well as batteries in series to create a higher voltage to compensate for the voltage drop over larger distances: his intensity magnet.

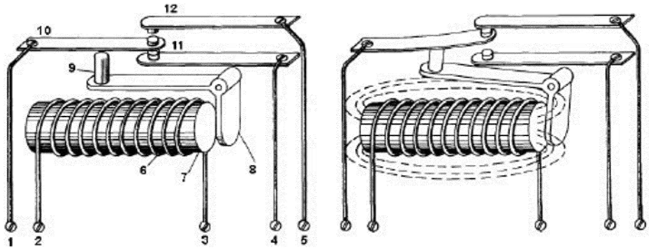

Figure 86: Principle of electromechanical relay: de-energized OFF (left) and energized ON (right).

When a current flows between (2) and (3), the electromagnet is magnetized, attracting metal lever (8). The lever moves point (9), which activates switch (10) from (11) to (12). Thus a connection is created between (1) and (5).

Source: http://history-computer.com/ ModernComputer/Basis/relay.html

combination of an electromagnet, spring and movable iron arm. (Joseph Henry, 1839).

Applying it to a switch and long wire, he proved it could be used to transfer a signal over a long distance. The nature of is signal being binary the relay had an "off" state (no current running) and it had an "on" state (current running) (Figure 86).

> *The electromagnet was not a difficult or demanding invention. … But the practical importance of any particular invention is not necessarily directly proportional to its intellectual content. In fact, the electromagnet is one of the handful of key inventions on which all electrical engineering and communications technology depend.* (Cardwell, 1976, p. 675)

The electromechanical relay became a key-component for the further development of communication and computing engines. It was the first digital technology, as it could distinguish between two states (ON-OFF).

And, as the basic system is quite simple (switch-long cable-magnet), this soon was used in a range of applications, systems such as the fire and police alarm systems, where it was used for distant sounding (Figure 87) and systems for distant writing: the printing magnetic telegraph. Or, in the words of

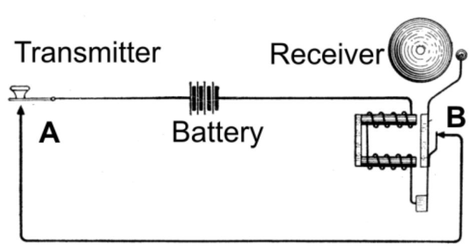

Figure 87: Principle of distant sounding.

Source: Adapted from Cyclopedia of Telephony & Telegraphy Vol. 1 http://www.gutenberg.org/ files/15617/15617-h/15617-h.htm an early pioneer in the electrical business, Elihu Thomson: "In the subsequent numerous developments of systems of signalling from the simple call bell to the fire alarm and printing telegraph, the electromagnet holds undisputed sway" (Thomson, 1920, p. 1027).

Others, maybe inspired by Henry's bell, developed similar systems, such as Sibrand Stratingh (1785-1841), professor in chemistry of Groningen, Holland, who in 1837 devised a telegraph in which the signals were made by electro-magnets actuating the hammers of two gongs or bells of different tones.

From the preceding, one can observe that over time electricity enabled new ways of communication. Starting with a simple bell, it grew then into simple systems like the fire alarm telegraph, and developed later in telegraphy systems, systems that also used sound as part of the communication. In this case, it was the clicking noises made by the receiver, then also called the *sounder* (Figure 88). Obviously, already in an early stage, telegraphy and sound became related. It would ultimately result in the *speaking telegraph*, also called the telephone.

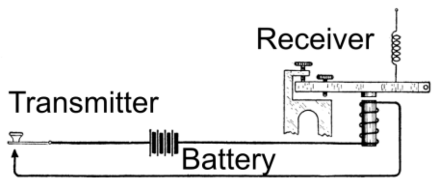

Figure 88: The principle of using an electromagnet in a circuit for distant writing and distant sounding (receiver).

Closing the switch of the transmitter (left) activates the electromagnet in the receiver (right) that creates movement.

Source: Adapted from Cyclopedia of Telephony and Telegraphy. Vol. 1, http://www.gutenberg.org/files/15617/15617-h/15617-h.htm#Page_39

Discovering Distant Writing

The basic idea of distant writing is about communication over a distance. Popularly described, it is about writing at point A and seeing the written text at point B located at some distance, where point A and point B are some way connected to each other. It was electricity that would open new ways to realize that connection and to cover the distances. However, before a technically usable and reliable system could be developed, several development trajectories were explored—trajectories that are often more characterized by engineering efforts than by the discovery of fundamental scientific principles.

Trajectory 1: Electro-static Telegraphy

As soon as electricity was discovered, in this case frictional electricity in the eighteen century, the first ideas were presented to use it for tele-communication; it resulted in the electro-static telegraph. In February 1753, in *Scots Magazine,* an article appeared from an author only known by his initials: C.M. He suggested using Leyden jars[126] to charge wires, one for each letter of the alphabet, with static electricity. The first working model based on this design was made by a Frenchman, Georges-Louis Le Sage (1724-1803), in 1774. LeSage's electrostatic telegraph used twenty-six insulated wires—one for each letter in the alphabet—and spanned across two adjacent rooms of his elegant mansion (Figure 89). His design was never converted into a usable system.

In 1802, another trajectory seemed to be followed by Jean Alexandre, a reputed natural son of Jean Jacques Rousseau. He was a politician and deputy to the Assembly and commissary-general of war during the French Revolution. Quitting all his political engagement, he had developed a secret telegraph system—the *telegraphe intime*—that he presented to dignitaries in Poitiers and Tours. But Alexandre refused to divulge the principle of his invention to anyone other than the First Consul Napoleon. Napoleon declined the meeting, and the new system was left to the academician citizen Delambre[127] for examination. As Alexandre would only demonstrate the machine to Napoleon, Delambre reported as follows:

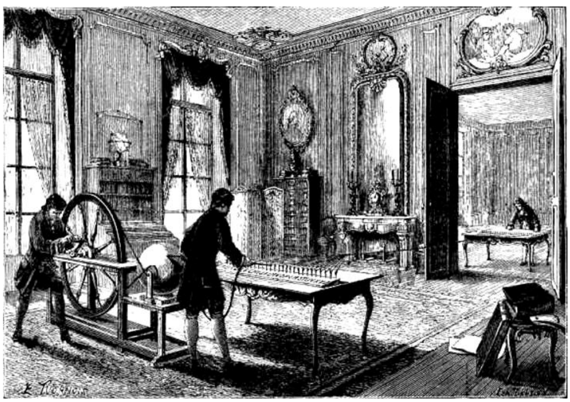

Figure 89: Le Sage's telegraph (1774).

Frictional electricity is created (left) by turning a wheel, charging an isolated globe acting as 'Leyden jar'.

Source: Scientific American Supplement, No. 384, May 12, 1883. http://www.gutenberg.org/files/8862/8862-h/8862-h.htm

[126] A Leyden jar is a device that can store electricity. In today's terminology we would call it a condensator.

[127] Jean Baptiste Joseph, chevalier Delambre (1749 – 1822) was a French mathematician and astronomer who was elected as a member of the French Academy of Sciences in 1792. In 1801, First Consul Napoleon Bonaparte took the presidency of the French Academy of Sciences and appointed Delambre its permanent secretary for the mathematical sciences.

> *All that we know is that this telegraph is composed of two similar boxes, each having a dial, round whose face are marked all the letters of the alphabet. By means of a winch, or handle, the pointer of one dial is moved to any desired letter or letters, and, that the same instant, the pointer of the other dial repeats the same movements, and in exactly the same order. When these two boxes are placed in two separate apartments, two persons can write and reply without seeing each other, and without being seen, and in such a way that no one can doubt the correspondence, which, moreover, can be carried on that any time, as neither night nor fogs can intercept the transmission. By means of this telegraph the governor of a besieged place could carry on a secret and continuous correspondence with a person four or five leagues distant, or even at any distance, and communication can be established between the two boxes as readily as one can hang a bell.* (Fahie, 1884, p. 116)

Still, Bonaparte, obviously having other pressing matters on his agenda, kept refusing to meet, and Alexandre persisted in his silence. So, in the end, nothing happened with his invention and he died at Angers in 1832 in great poverty, without having revealed his secret.

Other experimental scientists experimented with designs for similar electric telegraphs. Like the Catalan scientist Don Francisco Salva Campillo (1751-1828) of Barcelona, who in 1796 used sparks from a Leyden jar on a 26-mile line (Yuste, 2010, p. 2). Elsewhere, static energy would still be used for powering these systems. With examples of the static telegraph proposed by Harrison Gray Dyar (1828) between New York and Philadelphia and the static telegraph of Francis Ronalds in 1816/1823 in London, Britain.

> *This telegraph* [of Ronalds] *consisted of a single wire encased in glass tubing, which was then placed in a wooden trough in a trench filled with ear. The wire was kept charged using a friction machine. At each end, clockwork dials were used to indicate the letter or figure being transmitted. It was slow, but it worked. Ronalds never patented his invention but offered it to the Admiralty for government use. The Admiralty were not interested. They saw telegraphy as 'wholly unnecessary' and couldn't see how it could be more useful than semaphore. One person did benefit from is work - Charles Wheatstone. He saw the telegraph as a boy, and later patented the first working electric telegraph with William Cooke.*[128]

Francis Ronald would, in 1823, write down his experiments in "Descriptions of an Electric Telegraph and other electric apparatus" (Ronalds, 1823), the first work on electric telegraphs. His work inspired

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128 Source : http://www.eiet.org/resources/library/archives/biographies/ronalds.cfm (Assessed January 2015)

others, among those Charles Wheatstone, who we will meet further on. All these experiments faced the same problem: the source of electrical energy in the Leyden jar had to be charged by frictional machines creating static electricity.

Clearly, the electricity from the Leyden jar was a limiting factor for the development of distant writing in the form of electrostatic telegraphy. But that would change when Alessando's voltaic chemical battery became available in 1800. However, it took a while before that source of electricity was to be implemented, as there was much more to be invented before the electro-magnetic telegraphy would be born in the 1830s. It is obvious that the idea of an electric telegraph was "in the air" throughout the late eighteenth and early nineteenth centuries, and there were many experiments, though no practical telegraph using static electricity was devised. In fact, static telegraphy would prove to be a dead-end technology.

Trajectory 2: Electro-chemical Telegraphy

Some of the early experimenters looked upon electricity from a chemical point of view. As electricity was the result of an electrochemical process, could the *electrolyse* mechanism not be used for communication over distance? It resulted in the electro-chemical telegraph. Curious and inquiring minds in different places had already discovered the basic phenomena. In hindsight, the thinking was rather simple. When the mixing of two solutions results in electricity (the chemical battery from Volta), why should then not the addition of electricity result in the decomposition of liquids into its components (eg gasses)?

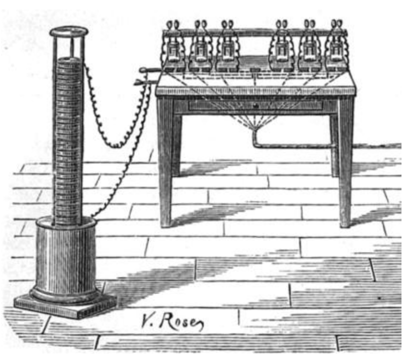


Figure 90: Salva Campilla's electo-chemical telegraph (1804).

At left the voltaic battery used as source of electricity.

Source: Yuste, A.P.: Francisco Salva's Electrical Telegraph. http://oa.upm.es/8539/2/INVE_MEM_2010_83801.pdf

A British chemist, William Nicholson (1753–1815), learned about the voltaic pile and constructed a similar cell together with Antony Carlile (1768–1840). In 1800 they discovered the electrolytic decomposition of water into its two constituent gases, hydrogen and oxygen. A few attempts were made to use is electrolytic phenomenon as a means of signal transmission. In 1798, the Spanish Franscisco Salva ́y Campillo (1751–1828) used the development of hydrogen bubbles on the negative electrode as a signal indicator. (Huurdeman, 2003, p. 30)

These properties were soon used to realize telegraphy, for example—again—by the Catalan scientist Don Francisco Salva Campillo (1751-1828) of Barcelona, who in 1804 wrote a new report to the Barcelona Academy of Sciences: "Second report about galvanism as applied to telegraphy" (Yuste, 2010, p. 2). He devised in 1804 an electro-chemical telegraph (Figure 90).

It did not take too long before in Germany the physician, anatomist, anthropologist and paleontologist Samuel Thomas von Sömmering (1755-1830) was experimenting with an electro-chemical telegraph system.

> *A German anatomist, Samuel Thomas von Sömmering (1755–1830), conceived the same idea and demonstrated it to the Munich Academy of Science in 1809. Sömmering's electrochemical telegraph was also demonstrated to Napoleon, who rejected the solution as "une idée germanique." In 1811, von Sömmering, with the assistance of Baron Schilling von Cannstadt, repeated experiments with his electrochemical telegraph using wires, insulated with sealing wax, that were passed through the river Isar.* (Huurdeman, 2003, p. 30)

Samuel Thomas von Sömmering was also interested in electrical phenomena, particularly those phenomena that were related to the biological and medical sciences. Sömmering started his experiments with electrical machines during his stay in London, and he had numerous discussions about electricity with the German scientist Georg Christoph Lichtenberg (1742-1799) and the Prussian geographer Alexanders von Humboldt (1769-1859). Particularly, Sömmering was working with galvanic cells, and this work brought him to the development of the electrochemical telegraph. This interest increased as the German government who, seeing the performance of Chappe's optical system of communication, wanted an improved (optical) telegraphy-system stimulated him.

> *The Bavarian Academy of Sciences was in one of his* [Minister Montglas] *departments of administration, and Dr. Soemmerring, as one of its most celebrated members, was from time to time invited to come to dine with him at Bogenhausen, near Munich, where he lived. This was the case on the 5th of July, 1809, when the Minister expressed to him the wish to get from the Academy of Sciences proposals for telegraphs, having, as I allow myself to suppose, in view no other but optical (mechanical) telegraphs with improvements. Soemmerring, referring to this dinner, noted in his diary only: "The Minister wishes to get from the Academy proposals for telegraphs.* (Hamel & Cooke, 1859, p. 7)

On the August 29, 1809 he exhibited the electro-chemical telegraph in action before a meeting of the Academy of Sciences at Munich. He used a device with 26 wires (one wire for each letter of the German alphabet) terminated in a container of acid (Figure 91). At the sending station, a key, which brought a battery into the circuit, was connected as required to each of the line wires. The passage of a current caused the acid to decompose chemically, and the message was read by observing in which of the terminals the bubbles of gas appeared. This is how he was able to send messages, one letter that a time. [129]

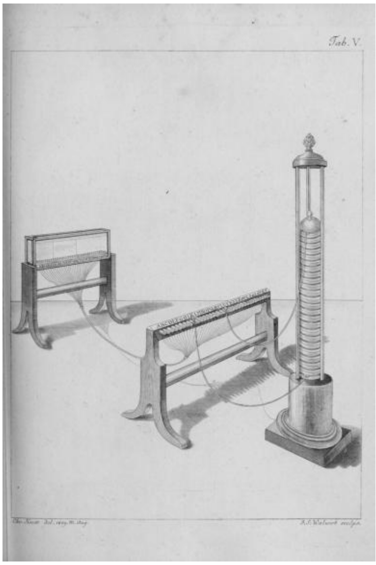


Figure 91: The electro-chemical Sömmering telegraph (1810).

The battery (right) is connected with the keyboard (middle). The wires connect to the indicators (left).

Source: Wikimedia Commons, Denkschriften der Königlichen Akademie der Wissenschaften zu München (1809-1810)

His electro-chemical principle of telecommunication came to the attention of Baron Pawel Lwowitch Schilling von Cannstedt (1786-1837). This son of a Russian Army lieutenant became a diplomat working for the Russian embassy in Munich. During this period, Schilling witnessed for the first time the phenomenon of electricity.

> *On the 7th of September, 1810, Soemmerring called on Baron Schilling to invite him to his lodgings, in order that he might have the pleasure of showing him the action of the telegraph through wire carried round the whole house in which he then lived. It was Leyden's house, nearly opposite the Max Gate. The wires were first covered with a solution of india-rubber, and then varnished. … The war then impending between France and Russia made Baron Schilling desirous of finding a means by which such a conducting cord should serve for telegraphic correspondence between fortified place and the field, and likewise for exploding powder-mines across rivers.* (Hamel & Cooke, 1859, pp. 15, 21)

Schilling experimented with the ignition at a distance of gunpowder (in German: *Das Fernzünden*). In the autumn of 1812, he actually exploded powder-mines across the river Neva, near St Petersburg. This was at the time Napoleon was on his Russian campaign. Von Cannstedt took part in the war against Napoleon, and, after the Russian Army marched through Paris in 1814, he experimented with detonations across the river Seine.

[129] Source: Biography of Samuel Thomas von Sömmering. https://nitum.wordpress.com/tag/developed-an-electrochemical-telegraph-where-e-signal-was-transduced-electrochemically-as-bubbles-originating-from-electrochemical-water-decomposition/

Through Sömmering, von Schilling became acquainted with another important player in the emerging field of telegraphy: Johann Schweigger.

> *Baron Schilling, having made at Soemmerring's the acquaintance of Schweigger, of course could not foresee that one day an invention of this gentleman, the multiplier, would enable him to make at St. Petersburg the first electro-magnetic telegraph.* (Hamel & Cooke, 1859, p. 27)

More further on about Schilling's experimenting and the contributions that followed from his work.

Both electro-static telegraphy and the electro-chemical telegraphy development trajectories proved to be dead-end technologies. However, with the advancement of electro-magnetism, soon some new trajectories opened up. Several contributions of a more scientific nature did create the basic understanding, and the fundamental artefacts, for is advancement.

> *Four scientific principles must be understood in order to create a useful electromagnetic telegraph. First, above all, is the production of galvanic currents by chemical action. This was demonstrated by Alessandro Volta in 1800, and the current was soon afterwards discovered to decompose water by electrolysis, and to heat fine wires. Chemical action in batteries was the only practical source of electricity for telegraphs until almost the end of the century, except for the occasional use of the magneto for intermittent currents. The second principle is the production of a magnetic field by a current, together with the means by which it can be intensified and caused to have a practical effect. G. D. Romagnesi of Trent seems to have been the first to observe, in 1802, that a current affected a magnetic needle, and a certan J. Majon observed that an unmagnetized needle near a current became magnetized. Such reports were little noticed until Oersted published his more detailed observations in 1820. Ampère then quickly worked out the magnetic action of a current, and Schweigger of Halle, in the same year, showed how to intensify its effect by winding the conductors in coils with the needle within, often called multipliers. The third principle is the temporary magnetization of soft iron. In 1825, Sturgeon wound the wire around an iron core and showed that this greatly increased the forces that could be exerted, showing the way to making strong electromagnets that would exert considerable forces on an iron armature. Finally, the requirements for designing an outdoor circuit of great length were established by Ohm (1827), Steinheil (1833)and Wheatstone (1836). This rested mainly on an appreciation of Ohm's Law, V = IR, and the meanings of electrical pressure and electrical current. Few of the earlier proposals for an electromagnetic telegraph got far enough to encounter the problems of a long outdoor circuit, which would generally have proved insurmountable. Indeed, the problem was not practically solved until after 1840, with the bare wire line supported by insulators on poles.* (Calvert, 2000).

Trajectory 3: Needle Telegraphy

It was Ampere, who, just after Oersted's discovery, in 1820 proposed to use in Sömmering's system—instead of the earlier mentioned electro-chemical devices—the galvanometer as receivers.

> *Ampère, who, as is well known, bestowed most particular attention on the subject brought, in 1820, before the scientific world through Oersted, mentioned that it might perhaps be possible to make use of the deviation of the needle for telegraphic purposes, but neither he nor anyone else then constructed such an instrument.* (Hamel & Cooke, 1859, p. 40)

Luckily, later his idea was followed up upon by Schilling and developed into the needle telegraph. It took Schilling a couple of years, but in 1828 he had an apparatus to show.

> *It was reserved for Baron Schilling, at St. Petersburg, to make the first electro-magnetic telegraph. Having become, as we know, through Soemmerring, at Munich, passionately fond of the art of telegraphing by means of galvanism, he now used for it the deflection of the needle, which he placed within the multiplier of Schweigger horizontally on a light vertical axle hanging on a silken thread, and bearing a circular disc of paper, coloured differently on each side. To make the needle move steadily and prevent oscillations, Schilling had fixed to the lower extremity of its axle a strip of thin platina plate and immersed it in a cup of mercury. By degrees he simplified the apparatus. For a time he used five needles, and, at last, he was able to signalise even with one single needle and multiplier, producing by a combination of movements in the two directions all the signs for letters and numbers.* (Hamel & Cooke, 1859, pp. 40-41)

Schilling was not only experimenting, he was also travelling extensively, thus spreading the knowhow of early telegraphy. In the early 1830s, Schilling was quite active with his telegraph—next to such activities as travelling to China on a diplomatic mission. Back home in Russia, he demonstrated the instrument to the tsar in St. Petersburg and, in 1832 he travelled Europe, presenting his apparatus in Bonn.

> *In the month of September he attended the meeting of the German Naturalists at Bonn, on the Rhine, where, on the 23rd, he exhibited his telegraph before the Section of Natural Philosophy and Chemistry, over which Georg Wilhelm Muncke, Professor of natural philosophy at the University of Heidelberg, presided. Muncke was much pleased with Schilling's instrument, and he determined at once to get one for exhibition at his lectures.* (Hamel & Cooke, 1859, pp. 43-44)

Therefore, Schilling had—in addition to his earlier electro-chemical system—developed another telegraph system where he applied the galvanometers. It used quite a lot of wires to realize the transmission (Figure 92). Schilling also demonstrated the telegraph at the congress of physicists in Bonn, at the Physical Society in Frankfurt, where two Germans—Carl Friedrich Gauss and Wilhelm Eduard Weber—saw Schilling's 1832 demonstration. They were very interested in Schilling's apparatus and it sparked their curiosity.

It is good to realize that Schilling's work evolved in several different trajectories: one was the trajectory followed by the Russians, another the trajectory followed by the Germans, Gauss and Weber, and the third—some years later through the Muncke-connection—followed by the Englishmen William Cooke. We will pay attention to each of them, starting with the Russian and German trajectory.

Russian Trajectory: Originally, the Russian tsar was not too interested in Schilling's apparatus, but others were signifying that this discovery could be important:

> *In a letter dated September 15, 1836, the British government offered to buy Schillings new design. This time, however, Nicholas I of Russia also showed interest. In the same year, successful experiments were made and a commission was appointed to advise Nicholas I on the installation of Schilling's telegraph between Kronstadt and his imperial palace, Petershof. However, on July 25, 1837 Schilling died and the project was canceled.* (Huurdeman, 2003, p. 54).

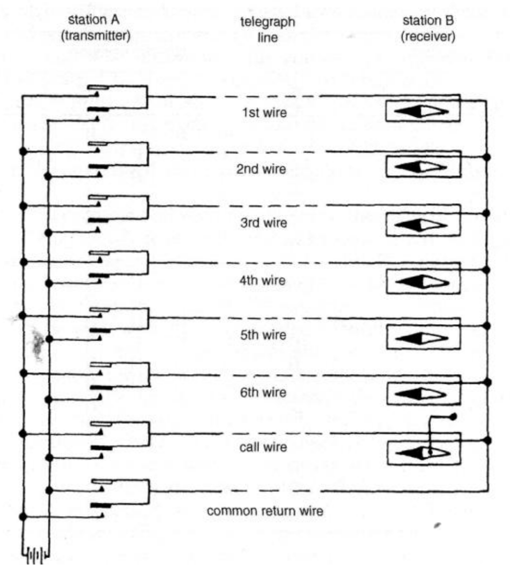


Figure 92: Circuit diagram for Schillings six needle galvanometer telegraph (1832).

Source: Beauchamp, K. 2001. p.29

In Russia, scientists such as Boris Semyonovih Jacobi (1801-1874) continued Schilling's work. He constructed, in the period from 1842-1843, various telegraph lines to connect the Winter Palace with other military and administrative centres.

German trajectory: In Germany, the mathematician Carl Friedrich Gauss (1777-1855) and his younger assistant, the German physicist Wilhelm Weber

(1804-1891), working at the Gottingen University in 1833, developed a system to communicate between their laboratories (located three kilometer from each other). As they were involved in the practical validation of Ampere's theoretical work, Weber's scientific work resulted in improving the galvanometer into the more sensitive mirror galvanometer. It was quite understandable that they used this galvanometer for their side project of communication, as they had seen from the demonstration of Schilling's apparatus that this form of telegraphy would certainly be feasible.

Their telegraph consisted of a wire running atop the buildings, connected to a galvanometer that would react to the electric pulses it received and a commutator to change the direction of the current. The code was based on moving the receiving needle from the centre to left or right position. In this receiver, they needed a small telescope to see the deflections (Figure 93). This way Gauss and Weber could communicate at the speed of six words per minute. Their concept proved to be working, but it was not transformed into a practical product.

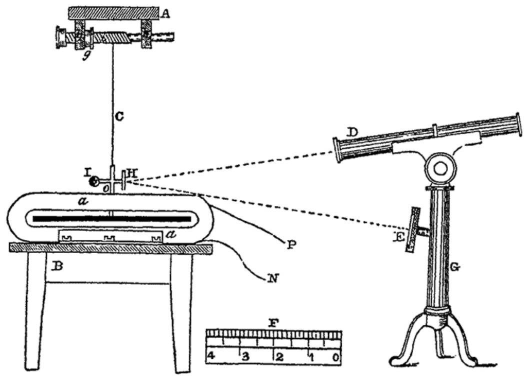


Figure 93: The Gauss and Weber telegraph (1833).

Source: Shaffner, T.P.: The Telegraph Manual. http://quod.lib.umich.edu/m/moa/agy3828.0001.001/142?page=root;size=100;view=image

One reason could be that Weber was expelled from the University when he became entangled in the politics of that time. However, they had involved their earlier student and later Professor, Carl August von Steinheil (1801-1870) of the Munich University. He contributed to Gauss and Weber's design and simplified it. But he also added an additional feature: a writing device that recorded with ink pens on a ribbon of traveling paper.

At the time of consulting with Gauss and Weber, in 1835, Steinheil was making a scientific journey through Vienna, Berlin and Göttingen. Professor Steinheil devised a receiver consisting of two bar magnets in a large, 600-turn coil. The magnets were pivoted so that one or the other moved when the current was in one direction or the other. Fine ink siphons were connected to the magnets, so that

> *dots could be printed on a moving strip of paper, and a suitable alphabetic code was devised, ... A bell alarm was included in the system, which could work that 6 words per minute (33 characters a minute).* (Calvert, 2000)

In 1835, the first railway was created between Nurnberg and Furth. Steinheil suggested to add a telegraph line next to it. Then Steinheil, working on train rails as conductors, discovered by accident in 1837 that the earth could be used as return for the electric circuit. It reduced not only the cost of cabling; it also created a better circuit which could cover longer distances. It was also Steinheil who added the concept of the graphic register to the electric telegraph and published about it (in *Memoires of the French Academy des Sciences*, September 10, 1838). He reported on an experimental telegraph line between Munich and Bogenhausen erected in 1837. Later, Steinheil contributed to the development of a telegraph network for the Austrian Empire in the 1840s, and he started the Swiss-telegraphy network[130].

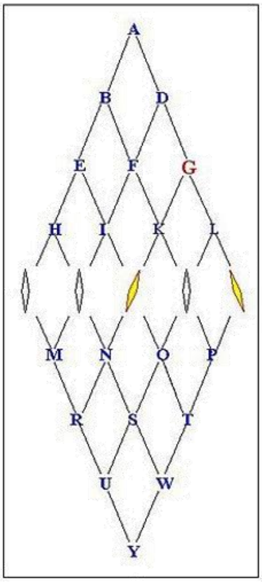


Figure 94: Principle of needles identifying letter of the alphabet.

The figure shows how two needles of a five-needle system identify the letter "F".

Source: Wikimedia Commons

The Gauss/Weber/Steinheil concept proved to be working; however, it was not transformed into a practical product. Gauss, Weber and Steinheil were philosophers, not businessman. Their contributions as scientific explorers to the electric telegraph had to be complemented by the creative efforts of the entrepreneurial engineering scientist. Luckily, the Gauss/Weber/ Steinheil concept was also used for educational purposes by others like Professor Muncke of Heidelberg. And there it was observed by a young Englishman named William Cooke in March 1836. This encounter would lead to the British trajectory of the needle telegraph.

> *Fortunately, William Fothergill Cooke (1806–1879) had attended Muncke's lectures in Heidelberg, and he went back to England with another copy of Schilling's needle telegraph. Together with Charles Wheatstone (1802–1875), he made an improved version for which a patent was applied for on June 12, 1837,*

[130] Steinheil would also work on the electric clock. In 1839 he describes the principle of a master clock driving slave clocks. A feature that would become important in telegraphy.

> *two weeks before the inventor of the original idea, Schilling von Cannstadt, died in St. Petersburg. In the same year, Samuel Finley Breese Morse (1791–1872) demonstrated a telegraph at the University of New York in which the electromagnetic force was not used to deflect a needle but to produce a coded written message. Thus the era of electrical telegraphy started in 1837 almost simultaneously in Great Britain and the United States. (*Huurdeman, 2003, p. 55)

The preceding brushstrokes of the development of early needle telegraphy show the importance of the work and activities of one dynamic, and obviously rich, man. That was Baron Pawel Lwowitch Schilling von Cannstedt, who died too early to see what he had instigated.

Trajectory 4: Electro-magnet Telegraphy

Already in 1825, William Sturgeon demonstrated the workings of the electromagnet, an electric coil around a piece of soft metal that would become magnetic. This horseshoe piece of iron could attract other metal pieces when a battery supplied a current to the coil of electric wire around it. Sturgeon's electromagnet, which could be regulated by closing and opening the circuit, converted electrical energy into useful and controllable mechanical force that could create movement[131].

> *William Sturgeon, the inventor of the electro-magnet, was born at Whittington, In Lancashire, in 1183. Apprenticed as a boy to the trade of a shoemaker, at the age of nineteen he joined the Westmoreland Militia, and two years later enlisted into the Royal Artillery, thus gaining the chance of learning something of science, and having leisure in which to pursue his absorbing passion for chemical and physical experiments. He was forty-two years of age when he made his great, though at the time unrecognized, invention. … In 1835 he presented a paper to the Royal Society containing descriptions, inter alia, of a magneto-electric machine with longitudinally wound armature, and with a commutator consisting of half disks of metal. For some reason this paper was not admitted to the Philosophical Transactions. Afterwards printed it in full, without alteration, in his volume of Scientific Researches, published by subscription in 1850. From 1836 to 1843 he conducted the Annals of Electricity. He had now removed to Manchester, where he lectured on electricity at the Royal Victoria Gallery. He died at Prestwich, near Manchester, in 1850.* (S. P. Thompson, 1890, p. 199)

Next came the improvements of that force and American physicist Joseph Henry, who also experimented with Schweigger's galvanometer.

131 See : B.J.G. van der Kooij: *The invention of the Electro-motive Engine.* (2015) pp. 63-65

> *Henry's interest in devising electromagnetic instruments was partly pedagogic: he wanted to impress his students that Albany Academy with dramatic class demonstrations. Thus he sought to amplify electromagnetic effects. Somewhere in reading contemporary journals, Henry noticed what he called "Prof. Schweiger's galvanometer". As he understood it, that device was distinguished by: "several strands of wire, each covered with silk, instead of one". Henry regarded this innovation -- to put wires in parallel -- as what made his electromagnet more prodigious in action than its predecessors. Henry's premier electromagnet was the first construction combining all these features that once: separate insulated wires wound into multilayer coils successively positioned around an iron horseshoe. The wire ends of each coil could be attached in succession (series). Alternatively, their similar ends could be "soldered" together and contacted directly to the battery's ends, to make multiple coils (parallel). Configurations combining both types of attachment were also possible. When similar ends of all nine coils (fully in parallel) were connected to the zinc or copper of a small single voltaic pair, the magnetized horseshoe lifted up to 750 pounds.* (Cavicchi, 2002, pp. 1, 2)

Henry managed to create in 1829 a large *quantity magnet* (also called the Yale magnet) that could lift a weight of several hundred of kilograms (Figure 84). But electro-magnet design was not only about force and large currents, it was also about feeble currents as the result of losses in the length of the electrical cables. In 1831, Henry designed a multi-coil intensity magnet and demonstrated, during 1831-1832, a primitive form of the telegraph. He created an experiment in which he could ring a bell in another campus building. It became known as his bell experiment (Figure 95) (A. Mossoff, 2014, p. 28).

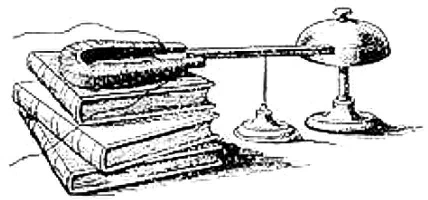


Figure 95: The bell experiment by Joseph Henry (1831).

Source: Henry, Joseph, 1797-1878. the Papers of Joseph Henry. Eds. Naan Reingold and Marc Roenberg. Washington : Smisonian Institution Press, 1972-2008 Print.

> *His prototype consisted of a small battery and an "intensity" magnet connected through a mile of copper bell-wire strung throughout a lecture hall. In between the poles of this horseshoe electromagnet he placed a permanent magnet. When the electromagnet was energized, the permanent magnet was repelled from one pole and attracted to the other; upon reversing battery polarity, the permanent magnet returned to its original position. By using a pole-changer to cycle the electromagnet's polarity, Henry caused the permanent magnet to tap a small office bell. Next it was about creating greater distances between the switch and the 'bell'. That was realized with the electromechanical relay. So by 1835, Henry had demonstrated, that least in a laboratory and lecture-hall setting, that an*

electromagnetic telegraph was possible. His "intensity" magnet would become the basis of Morse's repeater, which allowed signals to travel great distances; his "quantity" magnet formed the heart of Morse's recording instrument; and his "intensity" to "quantity" relay became with some modification Morse's arrangement for connecting his local receiving circuit to a long-distance telegraph line. But Henry never sought to commercialize his system, or even to demonstrate it on a larger scale. He saw his telegraph as a particularly effective lecture-hall demonstration of the principles of electromagnetism.[132]

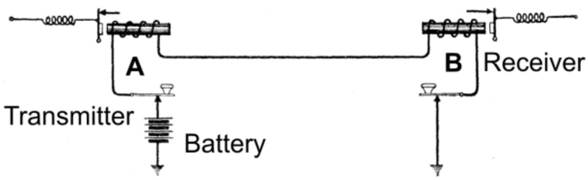


Figure 96: Principle of distant writing between Point A and Point B.

Source: Adapted from Cyclopedia of Telephony & Telegraphy Vol. 1 http://www.gutenberg.org/ files/15617/15617-h/15617-h.htm

Given the combination of battery, switch, cable and bell, the fundamental components for tele-communication were available. And the first systems were soon realized: the simple door bell (Figure 87) and the more extensive municipal fire alarm telegraphs. In Boston, USA, in 1852, the physician William Channing, assisted by Moses G. Farmer, who was a knowledgeable electrician, developed a municipal electric fire alarm system[133]. The fire alarm was soon extended to a police alarm, creating a dedicated telegraph network in the cities.

The bell experiments showed that distant sounding between two points—point A with the transmitter and point B with a receiver—with an electromagnet was possible. It created the basis for relay-based telegraphy (Figure 96).

Overview of Scientific Contributions to Telegraphy

These rough brushstrokes of the trajectories of telegraphy show a picture of all the basic efforts to understand the transmission of signals over distance by the means of wires to transport an electric signal. It started with electro-static telegraphy using frictional electricity (because it was the only type of electricity available at that time) and used a lot of wires. Those initial electro-statical efforts were followed by efforts of the upcoming chemists to

[132] Source: http://siarchives.si.edu/oldsite/siarchives-old/history/jhp/joseph20.htm
[133] See: B.J.G. van der Kooij: *The Invention of the Electromotive Engine.* (2015)

create an electro-chemical communication device when the electro-chemical source of electrical energy (the voltaic cell) came available. It would result in two important trajectories: the single/double/multi wire systems using either a needle or a relay some decades later, when the voltaic battery was used as a source for the electric energy.

Although many experimenting scientists contributed to these developments, not too much of their efforts survived in the written annals of history. Some did, however (Figure 97).

Concluding, one could say that in the second half of the 1830s as the scientific and engineering foundations for the electric telegraphy had been created with the discoveries around the galvanometer and the electro-magnet. The time was ripe for the further application of electricity, especially now that the electro-chemical battery—a source of electrical energy that had considerably matured in the decades after its discovery by Alessandro Volta—was readily available. As communication is such an essential part of human interaction, this field of application soon became the focus of the experimental scientists. It would lead to different development trajectories of the early development of electric telegraphy. Both electro-static telegraphy and electro-chemical telegraphy did not

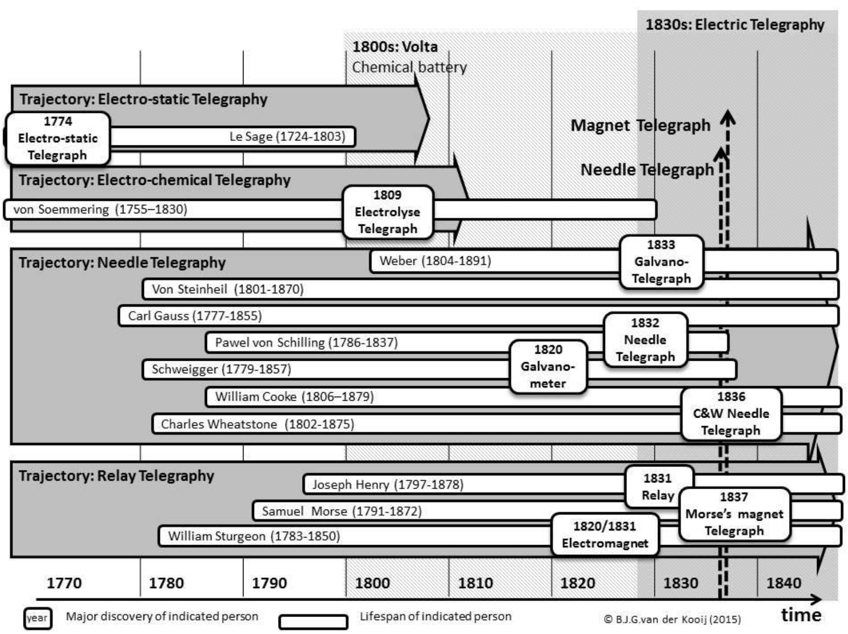


Figure 97: Trajectories for electric (cabled) telegraphy.

Source: Figure created by author

survive over time, but two others—quite different in nature—did, and they originated the Age of Communication.

Originating from Oersted's discovery of the moving compass needle—ie the discovery of electro-magnetism—different trajectories developed (Figure 97). On one hand, we see the use of the galvanometer to realize the needle telegraph, with its variations of needle-positions to identify letters of the alphabet, a concept that would be implemented in several European countries. On the other hand, we see a development of a totally different system: the telegraph based on the electro-mechanical relay: a concept that would be implemented in America. The latter development trajectory would in time gain momentum.

The Communication Engine Telegraph

The development of electric telegraphy, like the earlier steam engine with its railway system, was a gradual development due to the experiments and devices of a long train of thinkers and tinkerers. All in all, a number of experimental scientists and engineers were involved in the early years of telegraphy (Table 1). The 1830s were in many respects the period of incubation of the new technologies, as many basic phenomena were discovered then. However, it took a while before their efforts created the electric telegraph networks that erupted all over the world, many along railway lines, in the middle of the nineteen century.

Table 1: Some early inventors of electric telegraphs through the year 1840

Year	Inventor	Type
1753	C.M.	Electrostatic telegraph
1777	Alessandro Volta	Electrostatic telegraph
1800	Don F.Salva	Electrochemical telegraph
1802	J. Alexandre	Secret telegraph
1809	S.T. Sommerring	Electrochemical telegraph
1816	F. Ronalds	Electrostatic telegraph
1820	A.M Ampere	Magnetised needle
1824	W. Sturgeon	Magnetised needle
1827	Harisson Gray Dyer	Electrostatic telegraph
1831	J.Henry	Electromagnetic telegraph
1832	P.L Schilling	Magnetised needle
1832	S.F.B Morse	Electromagnetic telegraph
1833	Gauss, Weber	Magnetised needle
1836	K. Steinheil	Magnetised needle
1837	S. Stratingh	Electromagnetic telegraph
1837	Cook & Wheatstone	Magnetised needle
1840	Cook & Wheatstone	Electromagnetic telegraph

Magnetized needle = galvanometer
Source: (Beauchamp, 2001) Adapted from Table 2.1, p.26

> *The first electric telegraph established in Europe for the actual transmission of dispatches between distant points, was between London and Birmingham, in 1838. The first line in France was constructed, in 1844, between Paris and Rouen, along the line of the railway. The lines between Paris and Orleans, and Paris and Lille, were constructed in the years 1847 and 1848. The first fine constructed in the United States was put in operation in the month of June, 1844, between Washington and Baltimore. The next year it was continued to New York and Boston, and in 1846 to Buffalo and Harrisburg.* (Prescott, 1866, p. 9)

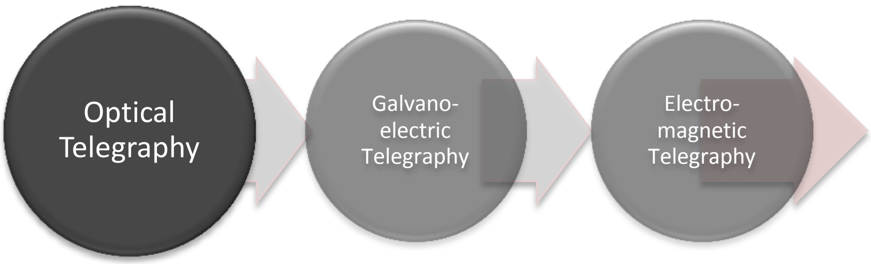
In fact there were several parallel developments that resulted in the communication engine telegraph, one being the development of the specific artefacts: the telegraph apparatus. Next, there was the development of the code for the transmission of the information. The third development was the development of the infrastructure: the network of telegraph lines. Sometimes these developments were all combined in one, such as Chappe's optical telegraph, which combined artefacts (ie towers), infrastructure (ie transmission network) and code (ie Chappes's code). Sometimes the developments were separated (like Morse's code, which was used by many other developers of artefacts).

Another way to look at the communication engine telegraph—in today's terms—would be the distinction between the hardware, the software and the orgware. The hardware is the artefacts (ie transmitters and receivers) and network elements (ie telegraph lines). The software is the code (ie Morse code, Baudot code), and the orgware is the organizational structure and operational knowhow incorporated in companies. The combination of the hardware, software and orgware create what we call today tele-communication technologies.

Tele-communication is about the transmission of information over long distances. Often important governmental, public and private information related to warfare. Like the fabled run of the dispatch runner Pheidippides with news about the victory at the Battle of Marathon, Greece, in 490 BC to the more recent German system for coded information: the famous Enigma machine for communication between U-boats (submarines) and German headquarters in World War II. That kind of communication related to governmental/military activities was soon complemented by communication by private parties like enterprises, such as the distribution of news as it was published in newspapers. Quite often, the name of the newspaper would include the word "telegraph" (eg the *Daily Telegraph* or the *Boston Telegraph*). Or it was about the transmission of information on the share prices on the stock markets as it was distributed from the stock exchange to stock brokers.

As telecommunication is indissoluble related to the transmission of information, the communication engine, as the information-processing engine, constitutes an essential part of the communication system. It is time to look at how it all came about.

The Invention of Optical Telegraphy



The concept of tele-communication as we know it today was not new when electrical telegraphy developed. Before 1800, it was the optical telegraphs that made it possible to communicate over long distances with high speed. As it certainly had its limitations, it proved to be important to the information exchange in administrative and military applications.

Early Telecommunication Efforts

As the traditional ways of communicating over long distances (eg Indian smoke signals, Greek torches, homing pigeons carrying a message, messengers on a horse or postal services by stage coach) had their drawbacks, already in the eighteen century, engineering efforts had resulted in the development of long-distance communication systems. Like the *acoustic telegraph* developed by the French monk Dom Gauthey, using long tubes struck with a hammer to transmit messages by sound over some distance (Figure 98).

In the French army, Captain de Courrejoles developed an optical signalling system. It was used in February 1783 on the west coast of Greece, where a British squadron had blocked French vessels.

> *In February 1783, De Courrejolles was engaged in battle with the English fleet, that 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 Hood. De Courrejolles had a simple optical telegraph erected that 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. Inspired by this success, De Courrejolles submitted a proposal to the French Minister of War to have the army adopt optical telegraphs for signalling purposes. Though De Courrejolles was unsuccessful that at time, he may well have paved the way for Chappe.* (Holzmann & Pehrson, 1995, pp. 4-5)

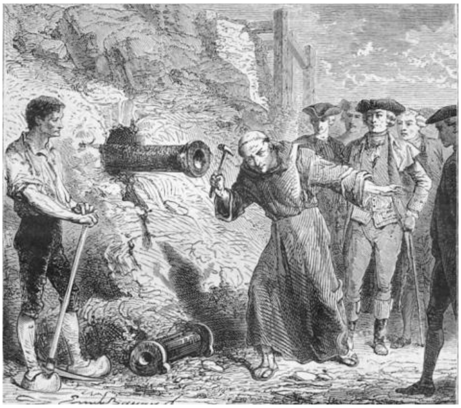


Figure 98: Dom Gauthey testing his acoustic telegraph (1782).

Source: Belloc, Alexis La Télégraphie Historique. (1888) p.30. http://www.collectionneurptt.fr/livre-pdf/455.pdf

Or take the "whole communication system" developed by the German Johann Andreas Benignus Bergsträsser (1732-1812), with visual and auditory signals. After trying fire, smoke, explosions, torches and mirrors, he described in his book *Ueber Signal-, Order- und Zielschreiberei in die Ferne, oder über Synthematographe und Telegraphe in der Vergleichung aufgestellt zur Ehre der Britten und Teutschen gegen die Franzosen und ihre anmasliche Erfindung* (About Signal, Ordering and Target Scribbling into the Distance, or About Synthematograph and Telegraph in Comparison to the Glory of the British and Germans Against the French and their Invention) a system that he called the *synematographe*: An experiment for his synematographe was implemented in 1786. Nevertheless, that was all that resulted from his ideas.

The trigger for the optical systems was the newly developed optical telescope. Although the concept was already long time known, it were the spectacle making centers in the Netherlands and Germany that had added considerably to its development in the early 1600s. It was the Englishmen Robert Hooke (1635-1703) who had already formulated in the seventeenth century some thoughts in a lecture for the Royal Society on May 21, 1684 titled *On Showing A Way How To Communicate One's Mind at Great Distances*. In this presentation he proposed to use relay stations showing characters that could be seen using such a telescope. He distinguished, next to the code for the content of a message, also the control code aiding in the transfer of the message, and he proposed the use of protocols for the transmission[134].

> *THAT which I now propound, is what I have some Years since discoursed of; but being then laid by, the great Siege of Vienna, the last Year, by the Turks, did again revive in my Memory; and that was a Method of discoursing at a Distance, not by Sound, but by Sight. I say, therefore, 'tis possible to convey Intelligence from any one high and eminent Place, to any other that lies in Sight of it, tho' 30 or 40 Miles distant in as short a Time almost as a Man can write what he would have sent, and as suddenly to receive an Answer, as he that receives it hath a Mind to return it, or can write it down in Paper. Nay, by the Help of three, four, or more of such eminent Places, visible to each other, lying next it in a streight line, 'tis possible to convey Intelligence, almost in a Moment, to twice, thrice, or more Times that Distance, with as great Certainty, as by Writing.* (Hooke, 1684)

His proposal for the optical communication network was never implemented, but the concept of optical telegraphic transmission was born.

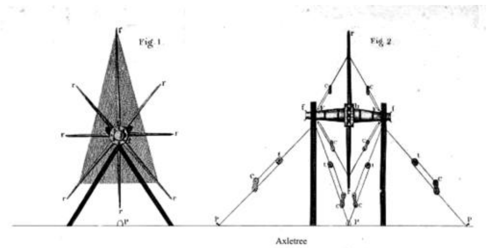


Figure 99: Construction of Edgeworth's Tellograph (1767).

Source: Wikimedia Commons

In England, experiments were also underway in the eighteenth century, such as the experiments executed by an Irish landowner named Sir Richard Lovell Edgeworth (1744–1817). Edgeworth first designed his optical telegraph as a means of conveying intelligence[135], called the *tellograph* in 1767. It consisted of a single large pointer that could be rotated in 45 degree increments (Figure 99). Each of the eight possible positions of the pointer indicated a signal element. And the meaning of that signal element could be found in a codebook.

---

[134] Examples of control codes: I am ready to communicate [synchronization]. I am ready to observe [idem]. I shall be ready presently [delay]. I see plainly what you show [acknowledgement]. Show the last again [an error code]. Not too fast [rate control]. Show faster [idem].

[135] As later in 1797 described by him in "An Essay On the Art Of Conveying Secret And Swift Intelligence". the *Transactions of the Royal Irish Academy,* Vol. 6 (1797), pp. 95-139

I refer for the precedency, which I claim in this invention. In that year I invented the idea of my present Tellograph, proposing to make use of wind-mill fails instead of the hands or pointers, which I now employ. …

What I have hierto described relates to a large and permanent establishment, for the management of which one man is required that each pointer, one that the telescope and another that the vocabulary; but for ordinary purposes a single pointer with one man to work it, and another that the telescope with a smaller vocabulary, are sufficient. With this reduced apparatus we can with ease speak that the rate of one word per minute to a great distance, as the time loft by intermediate stations this but small. (Edgeworth, 1797, pp. 126, 132-133)

He envisioned the use of his invention in the future and realized that his invention was not the best way to communicate and just a beginning of a trajectory of developments to come:

THOUGH I have bellowed much 'attention and labour upon this subject, I do not pretend to fay that the means of Tellographic communication which I have invented are the best that can be devised. Imitations without end may be attempted; pointers of various shapes and materials may be employed; real improvements will alto probably be made, and perhaps new principles may be adopted. The varieties of art are infinite, and none but persons of narrow understanding, who feel a want of resources in their own invention, are jealous of competition and disposed to monopolise discoveries. the thing itself must sooner or later prevail, for utility convinces and governs mankind; and however inattention or timidity may for a time impede its progress, I will venture to predict that it will that some future period be generally practised, not only in these islands, but that it will in time become a means of communication between the most distant parts of the world, wherever arts and sciences have civilized mankind. (Edgeworth, 1797, pp. 138-139)

One can conclude that the need to communicate over longer distances fascinated many creative minds, who all in their own way contributed to the concept of telegraphy: distant writing. This all illustrates the concept of an optical coded transmission over distance, developed over time in different regions. In addition, it was stimulated primary by military and governmental considerations. That fast communication over distance was important—that is, faster than a courier on a horse— for the military is quite obvious. In addition, the governing institutions of those times had a need for bridging the distances, as we will see further on.

The Chappe Optical Telegraph

In France also, communication over distance developed gradually. But France at the end of the eighteenth century was in turmoil. The prelude to and the early turmoil of the French Revolution had left its traces in society, within the capital and the countryside, as well as at the borders where military operations took place (see chapter Context). Especially for those taken place away from Paris, the revolutionary government certainly had a need for fast communication. But "fast" was limited to the speed of a courier on a horse or 200 miles/day for a homing pigeon. Then a new player appears in the field of optical communications.

Claude Chappe (1763-1805) was a member of the French nobility, his grandfather having been a baron. Born in 1763 in the village of Brulon, department of Sarthe in the region of Pays-de-la-Loire in northwestern France, he had four brothers. His father, Ignace Chappe d'Auteroche (1724-1783), had worked as a parliamentary lawyer and *directeur des domaines* of the king. His uncle, the Jesuit Abbé Jean Chappe d'Auteroche, was a celebrated French astronomer. Being the second son and in line with the tradition that nobility occupied influential positions in the church, Claude was destined to join the clergy:

> *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 that La Flèche, about 30 km (18 miles) southeast of Brûlon. 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. …*
>
> *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.* (Holzmann & Pehrson, 1995, p. 49)

So Claude Chappe had the motivation, means and the opportunity to spend time on scientific experimentation. However, as a result of the early days of the French Revolution, a range of traditional privileges held by the nobility and the religious orders was abolished by a new Legislative Assembly in 1789. This affected both Claude and his brothers in their living circumstances.

> *As a small side effect, Claude Chappe lost his religious benefices on 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. Together they decided to set up a shop to work on telegraphs. (Holzmann & Pehrson, 1995, pp. 50-51)

The change from the protective religious environment of the cloister back to the worldly environment of the countryside must have been considerable. It did not stop them from picking up an old idea from childhood: communication with visual and sound signals.

From Prototype to Demonstration

After a lot of experimenting with different approaches (like the pendulum system of synchronized clocks), which were recorded in affidavits witnessed by officials in 1791, they ended up with a system that would later become known as the Chappe system. It consisted of codes and protocols[136], a construct (the semaphore tower) and an infrastructure (the network of towers). But before that could be realized, it took some entrepreneurial effort, political manoeuvring and financial investment, part of which were his first demonstrative experiments that were held in Paris (Figure 100).

Figure 100: Demonstration of the Chappe's semaphore (1793).

Source: Wikimedia Commons

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 Sare. 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

[136] 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 position of the regulator and indicators indicated a character (letter or cypher).

> *able to gain access to the Legislative Assembly to defend his proposals personally. … With help from his brother Ignace, Claude obtained permission to address the Assembly in Paris on 24 March 1792 to explain his plan.* (Holzmann & Pehrson, 1995, p. 55)

His address on March 24, 1792—in the midst of the French Revolution and during the revolutionary wars against the First Coalition—has to be seen in that context. It was a political card he played clearly. He was even prepared to apply a "no cure, no pay" method if his demonstration would fail. He spoke to the Assembly:

> *Mr. President, 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 an 40 miles in under 46 minutes. … Among the many useful applications for which this discovery can be used, there is one at, under the present circumstances, 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. … I will perform this experiment, and in addition, that any distance that is requested, and I ask only, in case of success, to be reimbursed for the expenses that are made.* (Holzmann & Pehrson, 1995, p. 56)

Those words of Citizen Chappe were in the spirit of the time; the "savants" (scientists) were contributing to the revolution. The proposal was sent to a committee. In the meantime, to prepare for the demonstration, it took some additional experimenting that got the interest of bystanders.

It did not take long, however, before their work was opposed by the angry mobs who thought that the telegraphs were used to send signals to the enemy, which at this time included royalists, Austrians, Prussians and Englishmen. At the time he was ready to demonstrate, the Legislative Assembly was disbanded to be replaced by the National Convention. As his brother was not re-elected, part of his political influence was lost. And all the political turmoil of 1792 was more pressing than a demonstration of a mere invention.

> *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.* (Holzmann & Pehrson, 1995, p. 58)

The French State Telegraph

Finally, on April 1, 1793, after some lobbying and a debate on the proposal, three delegates were appointed, and a sum of 6,000 francs was made available to construct the telegraphs that could "write in the air". The critical test was held that July 12, 1793, after the erection of the telegraphs was protected again from distrustful onlookers (Figure 100). When tested, its construction proved successful.

> *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. Claude Chappe was given the title of Ingénieur Télégraphe, with the military rank of an engineering lieutenant, a salary of 600 francs per month, and the permanent use of a government horse*[137]. (Holzmann & Pehrson, 1995, p. 61)

One of the places where a semaphore would be constructed was on the top of the Pavillon de Flore, part of the Palais du Louvre in Paris. The Pavillon de Flore was used by the revolutionary executive committees—among which the infamous Comity on Public Safety—during the heyday of the French Revolution (Figure 101). Around 1800, the network was taking shape; in 1804, the Paris-Lyon-Turin line was added (Figure 103).

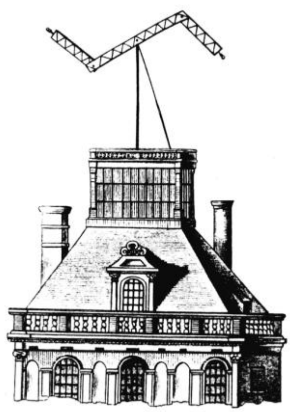


Figure 101: Chappe semaphore on top of the Pavillon de Flore, section of the Palais du Louvre, Paris (1794).

Source: Wikimedia Commons

A year later, on July 16, 1794 the line started to send messages. Soon it proved to be quite useful, as promised by Chappe originally.

> *On 15 August 1794 the first official message passed along this line from Lille to*

[137] The equivalent of today's company car.

Paris, reporting the recapture of the city of Le Quesnoy 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. (Holzmann & Pehrson, 1995, p. 64)

Soon more lines were added, such as the line from Paris to Strasbourg (1798) and from Paris to Brest (1799). Again it was the stimulus from the military that was more and more engaged in the Napoleonic Wars against the coalitions of European countries (Figure 102). As the Pavillon de Flore was used by the revolutionary executive committees—among them the infamous Comity on Public Safety—during the Revolution, a semaphore was placed on top of the building (Figure 101). Around 1800, the network was taking shape; in 1804, the Paris-Lyon-Turin line was added (Figure 103).

Figure 102: Military use of the Chappe semaphore (1794).

Source: Wikimedia Commons, Popular Science Monly Volume 44

His optical telegraph might have been a success, but for Claude Chappe, life was more complicated. He had to fight other claimants of the system (such as his former associate, the clock maker Bréquet and Captain de Courjolles), claiming priority or trying to get a part of this communication market. It made him depressed, and on Wednesday January 23, 1805, he committed suicide by jumping into a well outside the Telegraph Administration at l'Hôtel Villeroy in Paris. His brothers took over his work.

The network was also extended outside France. The northern branch of the network (Paris-Antwerp-Amsterdam) was put in use in 1809-1810 (Figure 104). The southern branch went to Italy: first to Milan (1804) then to Venice (1810).

Napoleon soon put his weight behind further implementation of the network, as he saw the advantages of speedy communications. The responsibility of the network was placed under the Ministry of War, later under the Ministry of the Interior (ie the police). In 1812, brother Abraham Chappe was commissioned again by Napoleon, this time to develop a mobile version of Chappe's telegraph that could be deployed during the

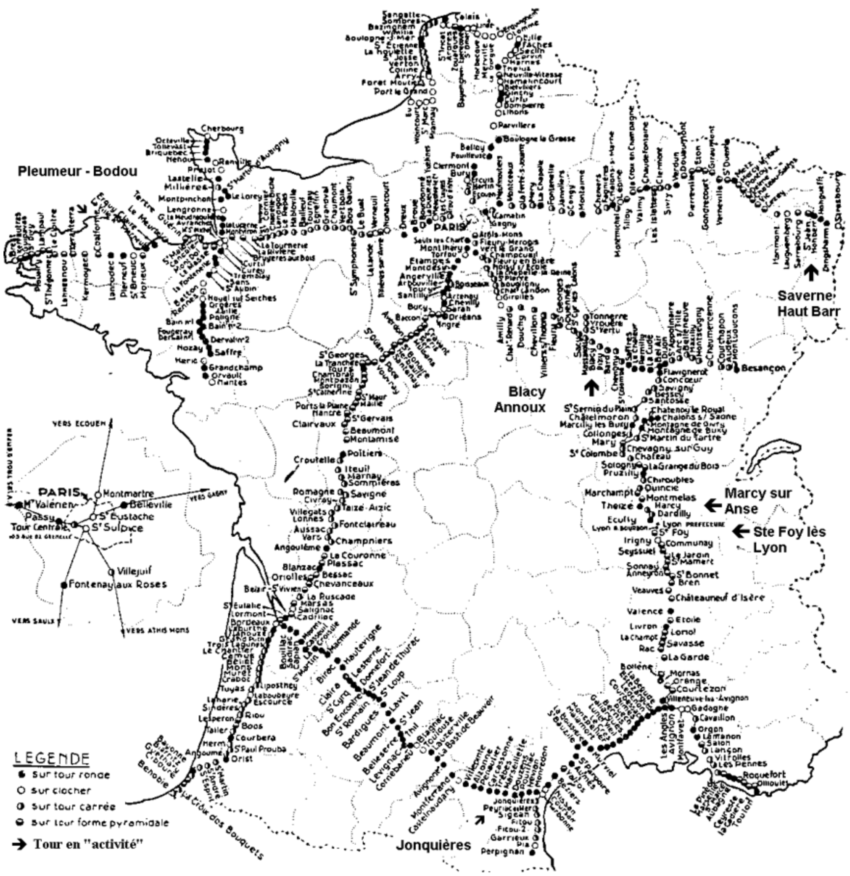


Figure 103: The network of Chappe semaphores.

Source: www.telegraph-chappe.com

invasion of Russia in that year. His design was still in use in 1853 when the Crimean War took place. During the following decades, the four brothers would continue to be involved in the lines.

> *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 that each station, the network employed well over 1,000 people, including nearly forty telegraph inspectors and twenty directors.* (Holzmann & Pehrson, 1995, p. 78)

The arising competition of private telegraphy lines was soon halted, as the government issued a bill on March 14, 1837 that forbade unauthorized transmission of signals from one place to the other. But by then the

Figure 104: Northern Branche of the Chappe semaphore network (1793).

Source: Wikimedia Commons

competition for the optical telegraph came from a totally different technology: the electrical telegraph. Although the electric telegraph was not taken too seriously at first, in the *Courier Francais,* which appeared July 5, 1841, it was argued that:

> *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. … 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 that all times, it cannot seriously be considered suitable for the needs of the Government, and the day is not far distant when is truth will be clearly demonstrated.* (Holzmann & Pehrson, 1995, p. 92)

Luckily, it did not work out as predicted, and after some tests, on July 3, 1846, the French government decided to begin replacing the optical telegraph system with an electric one. France was lagging England, where the first installation of an electrical telegraph was already done as early as 1837. However, the optical telegraph system was not soon abolished. As late as 1852, the French network of optical telegraphs still connected 29 of France's largest cities to Paris.

Remarkably, due to the restrictions of private use, the communication needs of private enterprises were for a long time still served by the old-fashioned homing pigeons.

> *As long as governments monopolized the semaphore, the business community used another communication technology, the homing pigeon. Pigeons were the mainstay of the news agencies until the electric telegraph made them obsolete. In the 1830s, Correspondence Gamier and Agence Havas used them to carry messages between Paris, Brussels, and French provincial cities. With couriers and pigeons Charles-*

> *Louis Havas got news from the Brussels morning papers to Paris by noon and to London by 3 p.m. The Times had a pigeon post between Paris and Boulogne in 1837. By 1846 there 25,000 homing pigeons in Antwerp alone.* (Headrick, 1991)

Claude Chappe's telegraph was in use for 61 years. It was the first and largest network using an optical telegraph in continuous operation: over more an sixty years. By 1855, they were replaced with the Morse electrical telegraphs. It was the beginning of the era of the Victorian Internet, where not only the government but also the public could use the fruits of telegraphy.

Telegraphy: A Military Affair

During its technological lifetime, many improvements were made in optical telegraph systems—systems that came into use in other countries as well, such as the system with two movable arms designed by the English admiral Home Riggs Popham (1762-1820). His design was improved upon in 1822 by Colonel Charles W. Pasley (1780-1861). Or take the three-arm system of the Frenchman C. Depillon that was installed in 1807 in a line from Vlissingen (Netherlands) to Bayonne (France). The English Lieutenant Watson designed in 1827 another system with a single support column with three indicators that could be set in 10 positions (Figure 105). His design was used in Germany to construct the first line between Berlin and Koblenz in 1833 (Figure 107), in America (1838) and Australia (1827).

In the Scandinavian countries, the optical telegraph was implemented based on Chappe's concept. It resulted in the shutter telegraph, designed by Abraham Niclas Clewberg-Edelcrantz (1754-1821)—a diplomat/courtier who was raised to peerage at the age of 35 and became a member of the Swedish Royal Academy of Sciences in 1797.

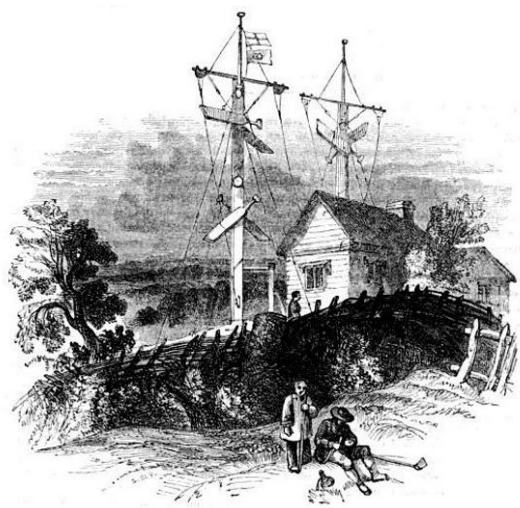


Figure 105: Watson's telegraph at Forest Hill (1842).

Source: http://distantwriting.co.uk/ noncompetitors.html

> *In September 1794 the first news came from France about the telegraph developed by Claude Chappe. Intrigued by this idea, Edelcrantz immediately started to work on his own version of an optical telegraph. Within a few months, he was ready for a demonstration. It was held on King Gustaf IV Adolph's fourteenth birthday, 1 November 1794.* (Holzmann & Pehrson, 1995, p. 3)

This arm-like concept—similar to Chappe's concept—was soon abandoned for the 10-shutter system, and the first Swedish telegraph-lines were constructed and manned by military personnel.

Clewberg-Edelcranz was more than an intelligent, charming man interested in the scientific issues at that period in time and writing "A Treatise on Telegraphs" in 1796. As a diplomat, he was travelling Europe in 1801-1804 extensively on a diplomatic and scientific mission. That is, he tried to obtain information of the process to distil alcohol as it was used in Scotland and the technology to manufacture iron in England, and he went to Berlin, London and Paris—all this in a period of time when the French were realizing their revolutionary expansion (see Chapter Context: The First Republic). Could one call this "industrial espionage avant la lettre"? Or it was just the exchange of scientific knowledge?

> *Edelcrantz managed his task skillfully. He made contacts everywhere, using charm, wit, and intelligence. He reported his findings in letters sent back to Sweden, often using secret messages added to a regular, innocent text by using a special invisible ink which could be read only by heating the paper on which it was written. He brought back close to one thousand books from his journey. Edelcrantz's ingenuity opened doors virtually everywhere he went. While he was visiting Berlin, for instance, Edelcrantz invented an improved boiler and was promptly admitted as a member of the Royal Academy of Sciences in Prussia. …*
>
> *In London, in 1803, Edelcrantz invented a new safety valve for steam engines, for which he was awarded a silver medal and yet another coveted membership in an esteemed organization, this time the Society for the Encouragement of Arts, Manufactures, and Commerce. He met James Watt, who invited him to visit his steam engine factory in Birmingham. While in Birmingham, Edelcrantz promptly decided to buy four steam engines to bring back to Sweden. He persuaded Samuel Owen, Watt's collaborator in Birmingham, to come to Sweden to install the steam engines for him. Owen would later decide to stay in Sweden and start a new company. He became an important figure in Swedish industrialization. …* (Holzmann & Pehrson, 1995, pp. 10-11, 14)

Edelcranz brought home a rich harvest of improvements in arts, sciences, agriculture and manufacturing.

His Danish counterpart, the naval captain Lorenz Fisker (1753–1819), realized another variation in the optical telegraphy. He used eighteen rotating flaps. Captain Ole Olsen in turn improved upon his system in 1808. Edelcrantz also continued to improve upon his system. From all the military involvement, it was clear that that telegraphy was a military business and a governmental affair whose development was strongly influenced by the context of that time.

> *In the period 1807-1809, with the renewed threat of war with France and Russia, Edelcrantz made new efforts to extend the telegraph network in Sweden. … In November 1809 the Swedish network consisted of approximately 50 stations spread out over a distance of some 200 km (124 miles), and provided employment for 172 people.17 It included lines from Stockholm to the city of Gävle in the north, Landsort in the south and Eckerö on Åland in the east. The telegraphs were used to signal the arrival of ships, but they also served an important early warning task for enemy attacks.* (Holzmann & Pehrson, 1995, p. 17)

Also in England, Lord George Murray (1761-1803) used Edelcrantz's concept for his shutter telegraph that was first used in 1796 (Figure 106).

> *George Murray's design remained in active use until circa 1816. Perhaps as a result of frustration with the limitations of Murray's system, over 100 new designs for telegraphs were submitted to the British Admiralty and the British Parliament between 1796 and 1816.* (Holzmann, 1996a, p. 3)

Not long after Claude Chappe successfully demonstrated the feasibility of optical telegraphy in France in 1794, the governments of most countries in Europe received and solicited proposals for similar constructions. Eventually, this lead to the creation of at least one or more experimental lines in countries such as Sweden, England, Denmark, Norway, Finland, the Netherlands, Spain and Germany (Holzmann, 1996b).

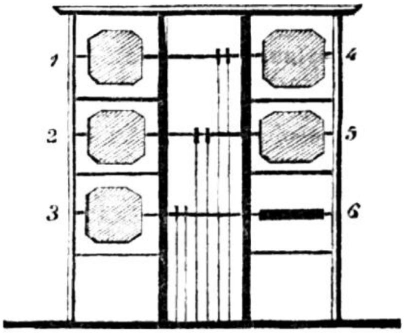


Figure 106: Lord Murray's shutter telegraph (1796).
Source: Wikimedia Commons

One has to realize that the success of optical telegraphy was during the period of the revolutionairy wars, with the wars of the First and Second Coalition. This was the time that the Duke of Brunswick declared he had the intent to restore the French monarchy (Declaration of Pilnitz, 1791) and that the Netherlands were concurred in a surprise attack during the Bavarian Campaign (1795), as were the Prussian Rhinelands (Treaty of

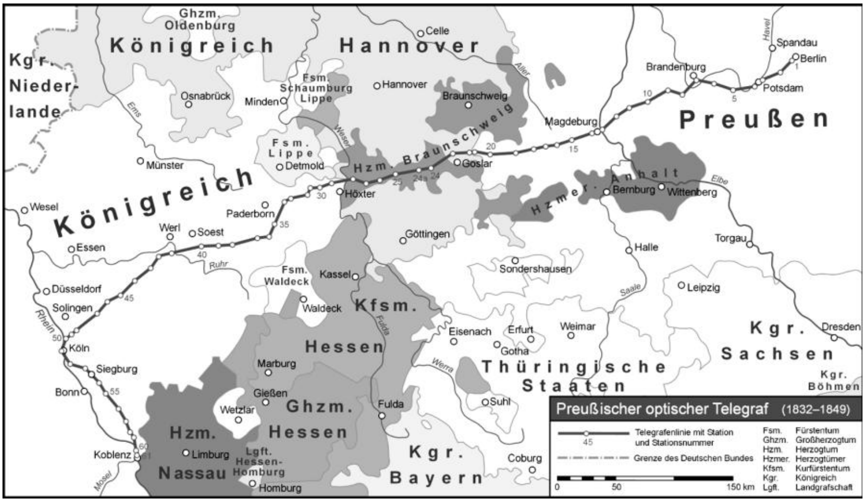


Figure 107: The optical telegraph line between Koblenz and Berlin (1832-1852).

Source: http://www.optische-telegraphie.de/linie.html, Wikimedia Commons

Basel, 1795). France was rapidly expanding, creating vassal states (the sister republics of the Bavarian Republic, the Helvetic Republic, and the Ligurian and Cisalpine Republics).

After 1800, monarchies all over Europe and their military closely observed Napoleon's military activities. News about the progress and fate of battles was important. Military could really use a faster way of communicating than the traditional military couriers on horseback. From the Scandinavian semaphore network initiated by Edelcrantz to the British Admiralty creating a warning system in case Napoleon should invade England, militaries everywhere improved their communication networks. Some of the optical lines were short lived, depending on the actual military threat during the Napoleonic Wars. Others were longer lived, as their contribution proved to be important in governmental communications over time. In Germany, the longest optical telegraph line between Koblenz and Berlin functioned from 1832 to 1852 (Figure 107).

For Official Business Only

One could wonder why the optical telegraph did not lead to a frantic business development. As communication is such a fundamental need, one could imagine that the markets for the optical telegraph services would be booming. That was not the case, and to find out why, one has to see this example of technological progress in the context of its time. It is not too remarkable that the main interest in optical telegraphy was from the military, and public use at that time was not even considered at all (Burns, 2004, pp. 49-52).

The French optical telegraphy system was initially developed as an instrument of war and diplomacy. The Chappe system was implemented during the French Revolution and its aftermath. With the arrival of peace, it became an instrument of governmental administration. The use of the communication system originally was for official business only—that is to say, for governmental use. In France, the stimulus for the implementation of the Chappe system (in terms of financing, supporting legislation, protection of workplaces) came from the government. Only distributing the results of the national lottery were allowed. In England, the exclusive use was also for the government when the British admiralty implemented the first system (ie Lord Murray's shutter telegraph). Governments excluded mostly private parties from using their lines. Only a few European countries allowed private lines to be created (eg Britain later in time). That was different in America, where several optical telegraph systems operated successfully on a commercial basis (Field, 1994, pp. 345-346).

Although others before him contributed to the concept, the impact of Chappe's system was so large, his network and system so widely used, copied and improved upon, that Claude Chappe can be considered as the inventor of the optical telegraph system, as was already concluded at his suicide in 1805 in the French publication *Moniteur*:

> *Mr. Claude Chappe, the inventor and administrator of the telegraph, died Wednesday last, that 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 art into an application so simple, so methodical, so certain, and so universally adopted, that he can be regarded its true inventor.* (Holzmann & Pehrson, 1995, p. 70)

The optical telegraph was, next to the initial investment of setting up the network[138], also quite expensive to run. Each station needed a shift of

[138] Up to our present time, one can find the remnants of optical telegraphy in the street or location names, such as the Potsdam Telegraphenberg in Germany, Telegraph Hill in San

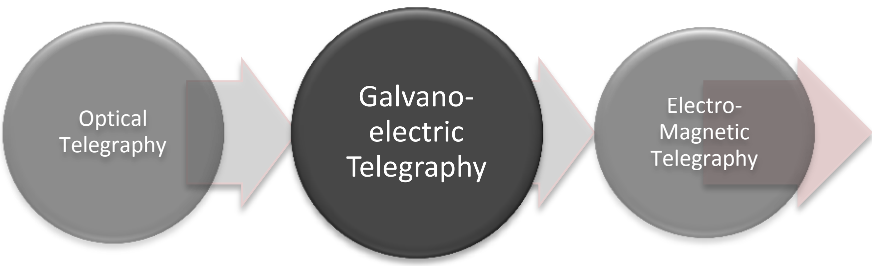
operators, and the weather conditions needed to be favourable. At night, communication was impossible. Due to governmental dominance, only official messages were transmitted. But the Chappe system proved that telecommunication was possible. It was the start of a development that would ultimately lead to the Victorian Internet of telegraph-based communication[139].

But before that could be realized, another basic principle of the system of optical communication had to be discovered. The application of electricity would enable the breakthrough for communication over distance: tele-communication with electric telegraphy.

Francisco and Boston, and many Telegraph Hills in England. The same goes for the name Beacon Hill.

[139] The telegraph variant of the railway semaphore was used much longer, up to present times.

The Invention of the Needle and Pointer Telegraph



Telecommunication over longer distances had proved to be feasible, but the technology of that time—dominantly mechanical with optical aspects—was limiting its performance. In the meantime, electricity had been discovered, and many scientists and gentlemen engineers were exploring its phenomena. The more engineering-oriented types tried to apply electricity in a range of different applications, from the use of electricity in power applications (eg the electric DC motor[140]) to the use of electricity for writing at a distance. It started with a simple apparatus: the galvanometer, as invented by the German Johann Schweigger. As we saw before, the roots of galvanometer-based telegraphs were in Germany, but much of the early development into a workable for public use telegraph system took place in Britain.

As described before, the origin in the galvanometer can be found in in the effort to measure weak electrical currents. Following Hans Christian Oersted's discovery of the relation between electricity from Volta's battery

[140] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015)

and magnetism as published in 1820. It was the German Johann Schweigger (1779-1857), professor of physics and chemistry at the Academy of Sciences in Munich, who developed the electromagnetic multiplicator, used for the demonstration of weak currents: the Schweigger multiplier (Figure 108). A discovery that would become the basis for the telegraph that was later to be developed by Cooke and Wheatstone.

Early Contributions to Telegraphy in Britain

In the late 1830s in Britain, there had been gentlemen engineers active in experimenting with electricity for distant writing. One of them was the physician Edward Davy (1806-1885). In 1836, Davy published "Outline of a New Plan of Telegraphic Communication", and he carried out telegraphic experiments in Regent's Park in 1837. He created a needle-based telegraph system that received the transmission on a recorder (Davy's recorder) and obtained a patent on July 4, 1838.

In 1837, he demonstrated a working model of his twelve-needle telegraph in Exeter Hall. Davy managed to interest two railway companies in his telegraph but left England before developing a practical system or completing negotiations. Eventually his patent was bought by the Electric Telegraph Company in 1847 for 600 pounds. (Symons, 1996).

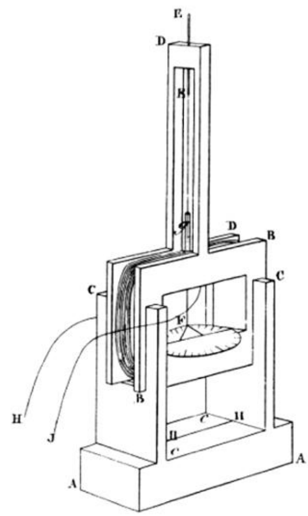


Figure 108: Schweigger multiplier used by Oersted in 1823.

A in magnetic needle is held in a light, paper sling that F, suspended by a fine, vertical fiber.

Source: Chipman, 1964

Before that happened, he had great plans for the exploitation of his invention. However, his entrepreneurial activities in organizing the Voltaic Telegraph Company were cut short by his decision to leave for Australia.

> *Edward Davy proposed the first company of proprietors for the working of an electric telegraph. On September 8, 1838 he launched the prospectus of the Voltaic Telegraph Company, of 5 Exeter Hall, Strand, London, with a joint-stock capital of £500,000 in 10,000 shares each of £50, requiring a deposit of £5. … A Board of Directors was assembled: Sir Francis Knowles*

FRS, John Wright, James Emerson Tennent MP, William Bagge MP and a Mr Harrison. … [141]

As one can observe from the "MP" indication in the citation, some members of Parliament (MP) were more than just professionally and politically interested in the new development of telegraphy.

The price of Davy's new telegraph patent was to be £10,000[142] *and "one or two thousand shares". The draft prospectus was circulated to railway companies throughout England, seeking wayleaves or rights of way as well as capital during 1838. Mr Brunel, junior, and the directors of the Great Western Railway called on Davy to view his telegraph. Other companies contacted during 1838 included, in order of approach, the London & Birmingham, London & Southampton, Birmingham & Gloucester, Midland Counties, Bristol & Exeter, Grand Junction, Birmingham & Derby, and London & Brighton. All of this advanced corporate activity was undertaken in the year that W F Cooke and Charles Wheatstone obtained their first patent. It took them, or rather W F Cooke, another ten years of negotiations and heartache before they got to the same state.*

… Early in 1838 Edward Davy launched his chemical recording telegraph in direct competition with Cooke & Wheatstone's patented needle instrument. The new telegraph utilised three wires with individual circuits that combined to work by means of six keys both a two-needle telegraph with a third needle as a "shift" function, and a printer that recorded a six-element cypher on a continuous roll of chemically-treated calico cloth by means of six clockwork-driven metallic cylinders. … It was completed on January 4, 1839. Davy, anticipating that the railway companies would beat a path to his door to pay for rights, began to organise the Voltaic Telegraph Company. But by the summer of 1839 Edward Davy had abandoned all his plans and sold his operative chemist business at 390 Strand to Dr William George Welch and had sailed to a new life in Australia. [143]

Quite surprising was the reason why he wanted to emigrate. It seemed quite a drastic way to escape his wife.

In London, Davy married Mary Minshull; they had one son, George Boutflower Davy, who was born before 1837. Their marriage had irretrievably broken down, and Mary Davy tried unsuccessfully to divorce her husband by 1838. Her extravagance and Davy's lack of business sense led to mounting debts, which he

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141 Source: Roberts, S. Distant Writing; Non-Competitors. http://distantwriting.co.uk/noncompetitors.html (Accessed April 2015)
142 This would be equivalent to some £ 33 million in 2013, calculated on the basis of economic power. Source: http://www.measuringworth.com/ukcompare/relativevalue.php
143 Source: Roberts, S. Distant Writing; Non-Competitors. http://distantwriting.co.uk/noncompetitors.html (Accessed April 2015)

settled with help from his father. To free himself from his wife Davy decided to emigrate. He left his son in the care of his family, and set sail for Australia intending to take up a smallholding in April 1839.[144]

From Needle Telegraph to Pointer Telegraph

Davy was just one of the electrical scientists in the second quarter of the nineteenth century that was experimenting with the galvanometer as a tool for writing at a distance. It would lead to one of the two major innovation streams that would prove to be a watershed in telecommunications: the telegraph using the galvanic needle. And two British gentlemen, a scientist and an entrepreneur, would be highly responsible for that development: Charles Wheatstone and William Fothergill Cooke.

Charles Wheatstone (1802-1875)

The Englishman, *Charles Wheatstone* (1802-1875), born in a family of musical instrument makers, music publishers and music teachers, was at the age of fourteen for a while apprenticed to his uncle, a maker and seller of musical instruments. After the death of his uncle in 1823, he—together with his brother—took over the business. As he was more interested in science than in business, he experimented with sound, and studied the transmission of sound through rods, and stretched wires. He tried to make sound visible with sand, as explored by German physicist Chladni, later using water as Oersted had already done in 1813. He created musical instruments like the flute harmonique, a keyed flute, in 1818. Soon he was experimenting with strings and glass rods connected with the soundboards of instruments (like a piano) to transmit the sound to a lyre in another room. The results of his experiments were shown in public concerts in London

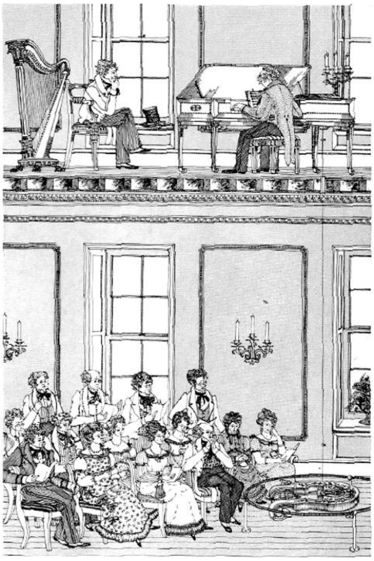

Figure 109: Principle of the enchanted lyre created by Wheatstone (1821).

The wire went through the ceiling, where it connected to the frame of a keyboard instrument in an unseen room. Musicians would play upstairs, and the sound would be conducted down the wire to the lyre downstairs.

Source: Bowers, 1975

144 Source: Biography Edward Davy, http://www.aim25.ac.uk/cgi-bin/vcdf/detail?coll_id=11427&inst_id=110&nv1=search&nv2= (Accessed April 2015)

from 1821 (Figure 109). One of these instruments was the "enchanted lyre", which was used for concerts in various places for a couple of years.

> *In May* [of 1823] *the Danish scientist Hans Christian Oersted (1777-1851) visited London and saw the Enchanted Lyre. Wheatstone was not then acquainted with the scientific community and Oersted provided his introduction. Wheatstone and Oersted found that they had in fact performed several similar experiments and Oersted encouraged Wheatstone to write his first scientific paper which was read that the Academy of Sciences in Paris in June 1823, and published the same year in England.* (Bowers, 1975, p. 502)

Wheatstone, who had become a close friend of Michael Faraday who also loved music, continued his experiments with sound. He was experimenting with tuning forks, repeating experiments published by others studying acoustics, and became known for his studies on sound. He published several papers and participated in the friday evening discourses at the Royal Institute, like the lecture on resonance on February 15, 1828, that was presented by Faraday because Wheatstone could hardly give a lecture himself.

> *Wheatstone was incapable of giving a good public lecture himself, and the association with Faraday was to prove invaluable to him. Faraday loved music and was intrigued by Wheatstone's current field of study which was the nature of musical sound and the modes of vibration of various sounding bodies. Faraday put his lecturing talents that Wheatstone's disposal and gave several discourses with material supplied by Wheatstone, the first being in 1828.* (Bowers, 1975, p. 502)

In the meantime, Wheatstone had to take care of the business: Charles & William Wheatstone. His most significant practical work in sound was the development of the concertina, an instrument that was manufactured by his firm. But he also conducted more fundamental research, such as trying to measure the velocity of an electronic spark (Figure 110) (Wheatstone, 1834).

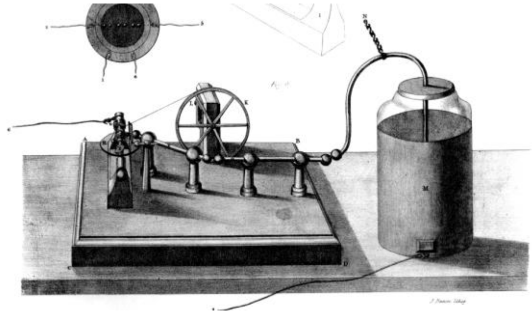

Figure 110: Wheatstone's apparatus for measuring the velocity of electricity (1834).

Source: (Wheatstone, 1834) p.592

> *Although several people before Wheatstone had attempted the measurement they were all defeated by the problem of measuring a very small interval of time. Wheatstone solved that problem with the aid of a revolving mirror. His method was to discharge a Leyden jar through a circuit which included three spark gaps which were mounted close together in a straight line and connected in series through long lengths of wire.* (Bowers, 1975, p. 504)

In 1834, Wheatstone, who had through the years won a name as a scientist for himself, was appointed to the chair of experimental philosophy (ie physics) at King's College London, a chair he would retain for the rest of his life. There he experimented with electricity in the mid-1830s (Wheatstone, 1837). In 1837, he published a paper in the *Philosphical Magazine* with the title "On the Thermo-electric Spark", and he worked on an alternative for the wet battery: his telegraph magneto (Figure 112).

The Telegraph Magneto

Wheatstone by now had considerable knowledge of the new phenomenon of electricity. Already, in the early 1840s, he had experimented with magneto-electric devices that should supersede the galvanic battery. This source of chemical electricity was in practical use a cumbersome and limited source of electricity. Many scientists had already tried to improve upon it, like John Frederick Daniell (1790-1845), professor of chemistry at King's College, who created the much better performing Daniell cell. This battery used two solutions as an electrolyte and gave a more constant current than its predecessors. Wheatstone also worked on the galvanic battery using a single electrolyte. But the chemical device was not practical, and something else had to be found that could be used as a source of electric energy.

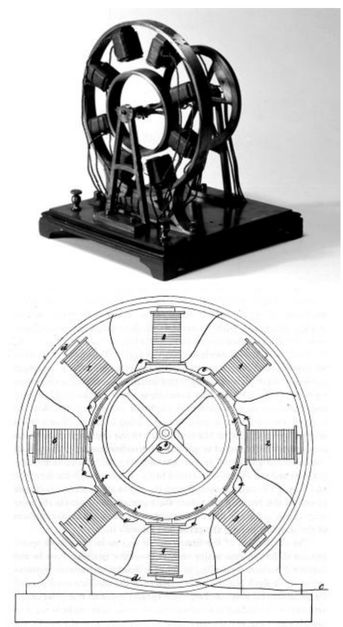

Figure 111: Wheatstone's experimental electro-magnetic eccentric engine (1841).

Model (top) and drawing (bottom) from British Patent № 9,002 of 1841.

Source: Science museum (top), (Bowers, 2001) p.77 (bottom)

One must realize that it was in the early 1830s that Faraday had made his discovery of magneto-electric induction, the quest for the replacement of the galvanic battery by a magneto-electric engine (today called electric dynamo or electric generator). It resulted in linear machines that, functionally seen, were a copy of the steam engine[145] but instead of a steam cylinder, it used an electric coil in which an iron magnet moved. It resulted in the reciprocating generators[146], as they were called.

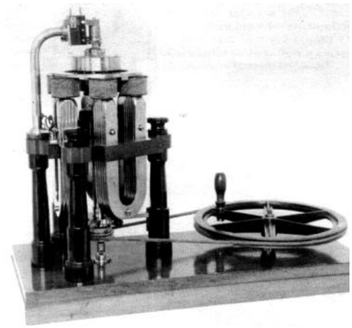

Figure 112: Wheatstone's experimental magneto-electric battery (1841).

Source: www.electric-history.com

It is quite understandable that these machines had a voltage output that reflected that movement. And that was not a smooth, constant movement. But when such a machine should replace the galvanic cell, a constant current was needed. So Wheatstone developed

Table 2: Some British patents granted to Charles Wheatstone (1829-1875)

Patent №	Granted	Description
5,803	June 19, 1829	Wind musical instruments
7,154	July 27, 1836	Wind musical instruments
7,390 [1]	June 12, 1837	Electrical Telegraphs (needle telegraph)
8,345	January 21, 1840	Electrical Telegraphs (pointer telegraph)
9,022	July 7, 1841	Producing, regulating and applying electrical currents
10,041	February 8, 1844	Concertina and other musical instruments
10,655 [1]	May 6, 1845	Electric Telegraphs and other apparatus
1,239	June 2, 1858	Electric telegraphs, and apparatus connected therewith
1,241	June 2, 1858	Electro-magnetic telegraphs and apparatus
2,462	October 10, 1860	Electro-magnetic telegraphs
220	January 28, 1867	Electric telegraphs
2,897 [2]	November 3, 1870	Electric telegraphs
2,172 [2]	August 18, 1871	Electric telegraphs; magneto-electric machines (provisional only)
39 [2]	January 4, 1872	Musical instruments
473 [2]	February 15, 1872	Electric telegraphs; magneto-electric machines
2,771	August 5, 1875	Electric telegraphs (Patent granted to R. Sabine as executor of C. Wheatstone)

1) Patents together with William Cooke. 2) Joint patents of Wheatstone and J.M.A.Stroh

Source: Bowers, 1975. P.233-234

[145] See: B.J.G. van der Kooij: *The Invention of the Steam Engine.* (2015)

[146] The reciprocating electro-motor is the complementary engine. Here electromagnets placed in a coil create linear movement when a current is applied. B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015) pp. 72-75

a magneto-electric battery, as he called it, applying the rotary principle and rotating a number of coils above permanent magnets (Figure 112). This engine was the object of his British patent № 9,022 on July 1841. It was a rotary engine in which a number of magnets (five or more) and a soft iron coil were applied to create a more constant current.

Wheatstone also made a series of electro-magnetic engines. Using the example of the steam engine, he tried to apply linear movement. But it was not effective, as also other inventors had experienced, and the efforts in this research trajectory soon evaporated. It proved to be a dead-end trajectory (Bowers, 2001, pp. 63-86). But the rotary version was to be used later as the telegraph-magneto. His electro-magneto device, operated by a crank that would be used to power the ABC-telegraph, would result from these experiments.

Wheatstone, originally active in musical instruments and now occupied by electricity and telegraphy, took out a range of patents on instruments and telegraphs (Table 2). The important patents related to telegraphy would become the ones he obtained with William Cooke.

William Fothergill Cooke (1806-1879)

William Fothergill Cooke (1806-1879), the son of a surgeon, was educated that the University of Edinburgh before he joined the East India Company Army at the age of nineteen in 1825. After resigning commission in 1833 due to bad health, he studied anatomy and physiology in Paris in 1833-1834, acquiring great skill at modelling dissections in coloured wax. In the summer of 1835, while touring in Switzerland with his parents, he visited Heidelberg and was induced by Professor Tiedeman, director of the Anatomical Institute, to return there and continue his wax modelling. So he did; he started working on anatomical models, and in March 1836, he visited Heidelberg. There he attended a lecture given by Professor Georg Wilhelm Müncke. He saw a demonstration with a telegraphic apparatus on the principle introduced by Pavel Schilling in 1835. Cooke was quite impressed and later wrote about it.

> *About the 6 of March, 1836, a circumstance occurred which gave an entirely new bent to my thoughts. Having witnessed an electro-telegraphic experiment, exhibited about that day by Professor Muncke, of Heidelberg, who had I believe taken his ideas from Gauss, I was so much struck with the wonderful power of electricity, and so strongly impressed with its applicability to the practical transmission of telegraphic intelligence, that from that very day I entirely abandoned my former pursuits, and devoted myself henceforth with equal ardour, as all who know me can testify, to the practical realization of the Electric*

> *Telegraph; an object which has occupied my undivided energies ever since.* (W. F. Cooke, 1857, pp. 24-25)

The device he saw demonstrated was using a galvanometer and performed a binary action (left or right position) depending of the polarity of the current. It brought him, in March 1836 still in Heidelberg and later in Frankfurt, onto the idea of making an apparatus himself. It was an apparatus—called his *Heidelberg Telegraph*—that used six wires to form three circuits influencing the three needles. And he already could imagine a use for it: the rapidly developing railway system, where communications over distance were needed, especially on one-line tracks, where trains from both sides were traveling; one needed information about the location of the trains in order to avoid collisions.

> *Within three weeks after the day on which I saw the experiment, I had made, partly at Heidelberg and partly at Frankfort, my first electric telegraph, of the galvanometer form, which is now at Berne. It has been written for and shall be laid before the arbitrators. I used six wires forming three metallic circuits and influencing three needles. I worked out every possible permutation and practical combination of the signals given by the three needles, and I thus obtained an alphabet of twenty-six signals. …*
>
> *My earliest apparatus thus comprised, in a complete though improvable form, two essential parts of my system of a practical electric telegraph, viz., the detector and the reciprocal communicator: a third of equal importance is the ALARUM, without which the electric telegraph would require to be constantly watched, like ordinary telegraphs.* (Hamel & Cooke, 1859, pp. x, xi)

But he also foresaw a broader application, as in 1836 he wrote a pamphlet for his project called "Plans for establishing a rapid telegraphic communication for political, commercial and private purposes, in connection with the extended lines of railroads now in progress between the principal cities of the United Kingdom, through the means of Electro-Magnetism" (W. F. Cooke & Clark, 1895). Later, in 1842, he published his ideas on how railway communication could improve safety in a publication called "Telegraphic Railways". This document was about monitoring the locations of trains.

So the vision was there, but more was needed to get practical results. Cooke sought out somebody who could help him convert his ideas into a working prototype. He needed a skilled instrument maker.

> *It is interesting to note that what totally crystallized Cooke's interest in the telegraph actually came to him just after the 1836 Moncke demonstration of the Schilling telegraph principles witnessed at Heidelberg. It was while enroute to Frankfort by carriage that Cooke became further inspired; as he intently read*

Mrs. Somerville's "Connection of the Physical Sciences." As his own letters and writings from this period sent to his mother Mrs. Cooke confirm, once back in London, Cooke immediately sought out proficient machinist and clockmaker practitioners there. … Kerby[147] became one of two main craftsmen Cooke would choose to make his first experimental telegraphs. Moore of Clerkenwell would be the main clock maker who would provide the telegraph clock drive mechanisms for Cooke and his first telegraph instruments. [148]

After returning in London and finding the *mechaniciens*—also called machinists—who created the prototypes of his first clock-based design, he showed the device he had created to the directors of the Liverpool and Manchester Railway[149]. He called it the mechanical telegraph. But they found it to be too slow and too complex, so he designed a simpler device—the three needle telegraph (Figure 113)—and had it installed in

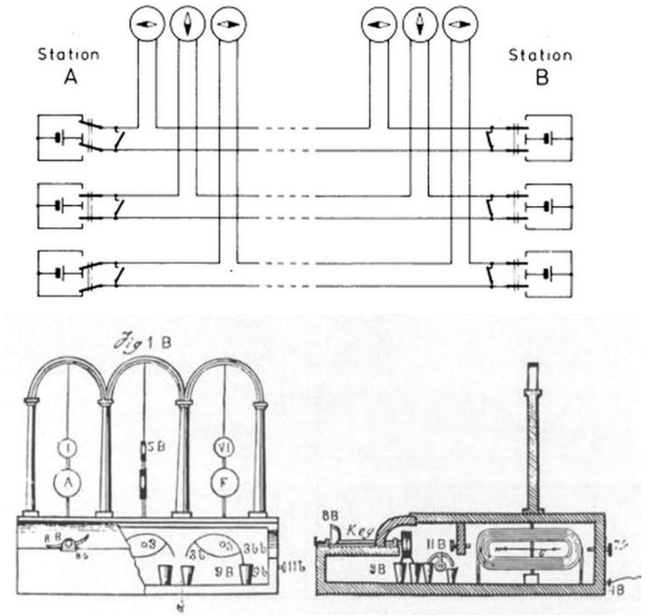

Figure 113: Cooke's reciprocal telegraph system with three needles (1836).

Source: Aschoff, V Geschichteder Nachrictentechnik: Band 2. p.146-147

[147] Frederick Augustus Kerby (1815-1894) came from a family of instrument makers. His father Francis was a curator of instruments at London University; his uncle Henry was listed as a mathematical instrument maker on the 1841 census and his younger brother Scott Kerby was listed as a philosophical instrument maker in the 1861 census. These instrument makers would provide the technology (skills and know-how) for the creation of the early telegraph instruments. But Frederick Kerby would play an even more interesting role after he emigrated to America. He took with him Cooke's workbooks, found a hundred years later, that illustrated Cooke's role in the development of the early telegraphs.

[148] Source: William Fothergill Cooke. Biography. http://ethw.org/William_Fothergill_Cooke (Accessed April 2015)

[149] The Liverpool and Manchester Railway was the first railway to use steam power exclusively. Horse-pulled traffic was abandoned completely. Signaling train traffic, originally done by policemen waving their arms, was soon done by flags and lamps.

April 1837. But still it lacked in performance, and Cooke went for advice to Michael Faraday and professor Ritchie, both well-known *electriciens*. They referred him to Charles Wheatstone (Liffen, 2010, p. 270). The ensuing meeting between the two men would be the beginning of pointer telegraphy in Britain. In the course of his life, Cooke would obtain patents, some in his own name, some together with Charles Wheatstone (Table 3).

Table 3: British patents granted to William F. Cooke (1837-1875)

Patent №	Granted	Description
7,390 [1]	June 12, 1837	Electrical telegraphs (needle telegraph)
7,614	April 18, 1838	Electric conductors in lead or iron pipes
8,345	January 21, 1840	Electrical telegraphs (pointer telegraph)
9,465	Sept. 8, 1842	Insulated overhead wires, etc.
10,655 [1]	May 6, 1845	Electric telegraphs and other apparatus

1) Patents together with Charles Wheatstone

Source: Bowers, 1975. P.233-234

Wheatstone and Cooke Meet

On February 27, 1837, Wheatstone met with Cooke, who had by that time already experimented with parts of a telegraphic system of his own. He had tried to measure the velocity of electricity and experimented with the galvanometer concept of Schweigger's multiplier. Later he would improve and patent the galvanometer with an iron core (GB-Patent № 10,655 of 1845). So here was an ideal complementing source for knowhow for Cooke.

Although sharing the same interest, they had two different orientations in life.

> *Both were interested in developing an electric telegraph, but their approaches were quite different: Wheatstone was pursuing a piece of scientific research, Cooke was embarking on a business venture. Cooke told Wheatstone that his intention was to take out a patent. Wheatstone told Cooke that his own intention was the advancement of scientific theory.* (Bowers, 2001, p. 119)

Cook, obviously an entrepreneurial type, had already had the experience with prospective clients for his own experimental telegraphs—experiments that were not too successful. Wheatstone had the knowledge on electricity and telegraphy—a knowledge that was enhanced when he had, on April 11, 1837, met with some American visitors, among them the eminent Professor Joseph Henry. Henry told Wheatstone about his experiments using an electromechanical relay for sending messages over distances and the use of magnetic coils for stepping up the voltage to solve a basic problem of DC-voltage, as it always decreased over distance.

> *It had been quite propitious timing that Henry had met with Wheatstone just after the partnership formation between Cooke and Wheatstone in 1837. Henry's knowledge that allowed for the electric current in a telegraph circuit to be 'stepped-up' was the key factor that brought to the Cooke and Wheatstone system the primary edge towards its perfection.*[150]

In May 1837, Cooke and Wheatstone agreed to join forces[151]: Wheatstone contributing the scientific knowledge and Cooke handling the business affairs. They were to be equal partners, and Cooke would receive 10% of the profits as a manager's fee. The deed of partnership was dated 19 November 1837 (Liffen, 2010, pp. 270-271).

Cooke and Wheatstone's Telegraphs

So Cooke and Wheatstone decided to work together in developing a telegraph system based on galvanometer needles. That year, 1837, proved to be quite a busy year. As the experimental Cooke and Wheatstone telegraphs became perfected, Cooke was busy with schemes for its introduction. Finally, the UK patent was filed in May 1837 and granted as English patent № 7,390 on June 12, 1837 for "Improvements in giving signals and sounding alarums in distant places by means of electric currents transmitted through metallic circuits"[152]. It was a patent for the five-needle telegraph.

Experimenting, Prototyping and Patenting

Remarkably—even strangely—enough, in the 1838-1840 experiments, one of the first prototypes of another type was developed. It had a great similarity to the electric clock, in which Wheatstone—and others like Alexander Bain—were interested in at that time[153]. It had a face, not with the time-indicators, but with the letters of the alphabet and the decimal numbers. The electrical impulses from the transmitter would activate the electromagnets (ie a coil with an iron core) that initiated—powered by a

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[150] Source: http://www.ieeeghn.org/wiki/index.php/William_Foergill_Cooke#American_Professor_Joseph_Henry_tells_Wheatstone_of_his_Relay

[151] The combination of two people with different knowhow and experience is seen throughout the creation of inventions: from the instrument maker James Watt and the entrepreneur Matthew Boulton (steam engine) through the electrical engineer Steve Wozniak and the entrepreneur Steve Jobs (Apple).

[152] We are hampered in giving more details on the actual patent descriptions as before 1852 no patent specifications were printed. They were mentioned in some journals, but an interested person could only know the content of a specification by paying a fee to be allowed to see the enrolled copy (Bowers, 2001, p. 126).

[153] Different opinions are vented by historians as to what was the early beginning of the prototyping phase; was it a needle system (the Heidelberg telegraph) of was it a mechanical clock-based system?

weight—the movement of a pointer (Figure 114) (Blumtritt, 2005, p. 37).

This action originated the name "pointer telegraph" or "dial telegraph" that would be used for a subsequent development. Noteworthy is the fact that this development used electromagnets (Zetzsche, 2013, p. 15).

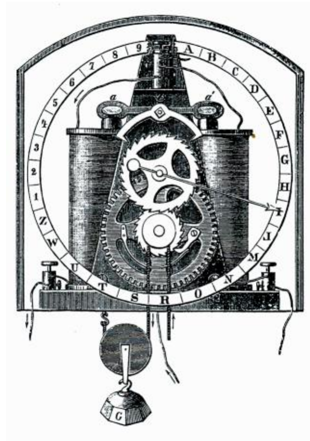

Figure 114: Cook and Wheatstone prototype Telegraph (1839?).

Source: Zetsche, K.E.: Kurze Abriss der Geschichte der Telegraphie. (1874) p. 15. Blumtritt, O: Nachrichtentechnik, (2005) Deutches Museum, Munchen.

As this is such an important development, completely different from the needle instruments, we should try to explore the basic mechanism for a moment. It is easy to see that the dial telegraph has its origin in the pendulum-based clock (Figure 115, left). In the clock, the movement of the dial was used to indicate time, and the rocker would be powered by a weight. In the dial telegraph, the movement of the dial was used to indicate the letters imprinted on the face. The energy for the movement of the dial was taken from a weight; the movement itself would be controlled by the electromagnet. In fact, several design versions were tried to realize this idea (Figure 115, right).

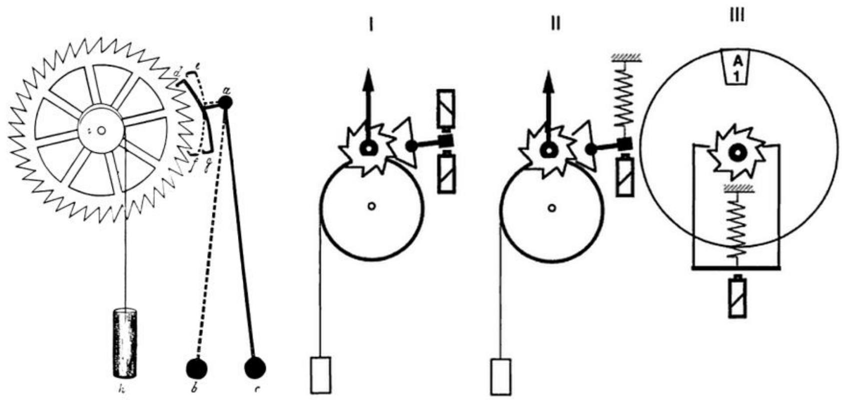

Figure 115: Principle of movement of Cooke & Wheatstone's pointer telegraph.

In a clock (left) the rotary movement caused by the weight (h) is controlled by the movement of the rocking lever (d-e, f-g). This rocking is controlled by the movement of the pendulum (a-b, a-c). In a dial telegraph (right) the rocking can be controlled by: 1) two magnets (figure I), 2) by a magnet and a spring (figure II) or 3) by a magnet alone (figure III).

Source: Huurdeman (2003) p. 70, Figure 6.11

Back to the needle concept that was explored extensively, such as the prototype of a three-needle telegraph (Figure 113) they demonstrated on July 4, 1837, within a newly-built carriage shed at Camden Town in North-London on the London & Birmingham Railway (L&BR).

> *On Tuesday 4 July Cooke, by working flat out, had installed a 13-mile circuit inside the carriage shed. That morning about twenty of the L&BR's directors, together with Stephenson, witnessed a demonstration given by Cooke alone, as Wheatstone for some reason could not be present. The instruments used were the two 'mechanical telegraphs' Cooke had made for the Liverpool & Manchester Railway, and his 'Heidelberg' (Schilling) pattern instruments with the horizontal coils and suspended needles. The demonstration went well and another was arranged for Monday 10 July for Stephenson, Creed and John Prevost, a director of the L&BR.* (Liffen, 2010, p. 271)

The next trial was with the prototypes of the four-needle telegraph Wheatstone had constructed (Figure 116).

> *On Tuesday 25 July another demonstration took place. This time Cooke was at Camden Town and Wheatstone at Euston. Recalling the occasion for Latimer Clark in 1875, Cooke said that 'At the second experiment Wheatstone had arranged a hastily-made telegraph with 4 needles suspended vertically'. This represented one of the most fundamental innovations Wheatstone made towards the successful introduction of the electric telegraph. By tipping up the Schilling design through 90 degrees and placing a board behind it, it became possible to make the telegraph self-indicating if letters were written on the board. Wheatstone weighted the needles so that they would remain vertical when no current was flowing, and he added stops on either side of them to limit their movement and make their action more positive. He arranged twelve letters in a diamond formation so that the movement of any two needles simultaneously pointed to the appropriate letter.* (Liffen, 2010, p. 273)

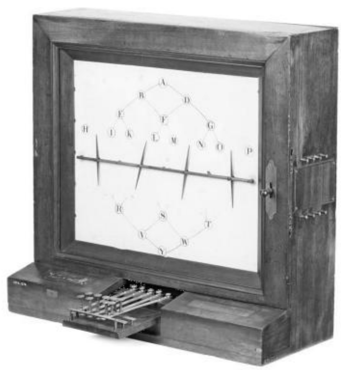

Figure 116: Model of Cooke's four-needle telegraph (1837).

A prototype, fit with Wheatstone's ten-button permutating keyboard of the four-needle electric telegraph instruments patented by W. F. Cooke in 1838 and installed on the Great Western Railway between Paddington and West Drayton in 1839.

Source: Sciency Museum, Liffen (2010), http://distantwriting.co.uk/cookewheatstone.html

After they laid the copper wires along the tracks under the ground between the stations, embedded in tear-soaked wooden battens, the next demonstration took place. Now they used Wheatstone's new prototype: the five-needle telegraph (Figure 117).

Figure 117: The final prototype of the Cook and Wheatstone five-needle Telegraph (1837).

Source: Wikimedia Commons

> *At 8 o'clock in the evening of Wednesday 6 September Stephenson and Creed joined Cooke in his 'den underground' at the winding engine house, Camden Town, while Wheatstone was at Euston accompanied by Cooke's brother Tom. Messages passed to and fro on the new twenty-letter five needle instruments for more than an hour without a hitch. Stephenson was deeply impressed and said he would recommend to the L&BR's directors the general adoption of the electric telegraph on the railway. A demonstration to the Chairman and some of the directors of the L&BR took place a fortnight later, on the morning of Friday 22 September.* (Liffen, 2010, p. 274)

Six weeks thereafter, the directors of the Stephenson-owned railway company told Cooke that they no longer had interest in the telegraph.

They submitted this five-needle telegraph for the patent application in the second week of December 1837. It was to be the first English patent for an electric telegraph (Figure 118). This patent was complemented by a Scottish patent that was sealed on December 12, 1837, and an Irish patent that was sealed in April 23, 1838 (Bowers, 2001, pp. 119-129)[154]. "A week later Cooke sent off the specifications, drawings and models in application for a United States patent, though for some reason this was not granted until 1840" (Liffen, 2010, p. 275).

The preceding shows all the efforts that went in this early phase to realize—with a leading potential customer—the first prototypes of a multi-needle telegraph. These experiments were needed to decide upon the final application of the patent. To acquire this patent, and its Scottish and Irish

[154] Before 1852 England, Scotland and Ireland had separate, though similar, patent systems.

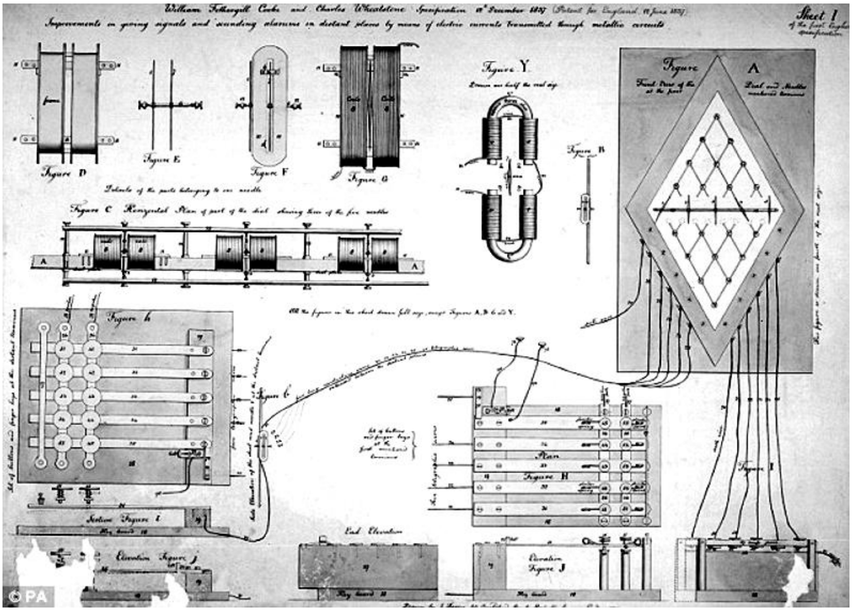

Figure 118: Patent 7,390 description for the Cook and Wheatstone five-needle telegraph (June 12, 1837).

Source: www.dailymail.co.uk/sciencemuseum, (Liffen, 2010) p.281

equivalents, they spent £800[155], over forty times the average male's annual earnings at that time. Cooke was to spend a similar sum on experimental instruments and materials by 1838.

Although Edward Davy opposed their patent, as he had filed a caveat for his own telegraph (Davy's recorder, 1838), and William Alexander from Edinburgh, both failed. Cooke and Wheatstone later opposed in their turn several other patent applications—such as Edward Davy's application in 1838—but they failed also. And, in June 1838, they opposed against Samuel Morse, who tried to establish an English patent for his own invention. There they were more successful on the grounds that it had already been published and due to that fact could not be patented as stipulated in the England Patent Law (Bowers, 2001, p. 112). A third opposition was against a patent application by Henry Pinkus in 1840 that failed also.

[155] Equivalent to £ 1,087,000 in 2013 based on income value respective to economic status. Source: www.measuringworth.com

All these early oppositions illustrate the importance that was attached to Wheatstone and Cooke's master patent of 1837. It would influence the development of British telegraphy for at least another fourteen years, the period the patent granted protection.

Exploitation of the Invention: The Railways

They started exploiting their five-needle telegraph system and tried to sell it to railway companies. One of them was the Great Western Railway. Cooke, at the end of his financial resources, entered into a contract with Isambard Kingdom Brunel (1806-1859), a mechanical and civil engineer that had—among other projects—built the Great Western Railway.

> *This business engagement between Cooke and Brunel successively allowed the use of the Great Western Railway lines for further needed experimental trials with telegraph equipments that Cooke was developing now mainly with Frederick Kerby, his "mechanician." A five needle model of telegraph first constructed during the initial telegraph trials between the London and Birmingham Railway was given up as too expensive. Thus, in 1838, an improvement reduced the number of needles to two, and a patent for this was taken out by Cooke and Wheatstone. Nearly fourteen months following the May 1838 agreement signed between Cooke and Brunel, and after extensive tests and installations, the telegraph system for the Great Western Railway commenced operations on 9 July 1839. At a cost of £2,817, the line traversed a thirteen mile stretch connecting the Paddington with the West Drayton station. This was part of the London-Paddington to Bristol line of the Great Western Railway and was intended for use solely for internal functions of the "GW" railway and was still, essentially, "experimental."* [156]

The Cooke and Wheatstone needle telegraph was put into real operation in 1839 along the railway between Paddington and West Drayton, operated by the Great Western Railway. As the five-needle telegraph was not practical, it was replaced by a single needle and two-needle telegraph.

Early in 1840, the House of Commons Select Committee on Railway Communication turned their attention to the electric telegraph. On Tuesday 6 February, the committee interviewed Wheatstone and Saunders on the subject (Liffen, 2010, p. 277).

> *Before a parliamentary committee on railways in 1840, Wheatstone stated that he had, with Cooke, obtained a new patent for a telegraphic arrangement; the new apparatus required only a single pair of wires. Yet, the telegraph was still too*

[156] Source: William Fothergill Cooke. Biography. http://ethw.org/William_Fothergill_Cooke (Accessed April 2015)

costly for general purposes. In 1840, for the London and Blackwall Railway telegraph installation, however, Cooke and Wheatstone succeeded in producing the "single needle" apparatus, which they patented. Thus, from that time the electric telegraph became a practical instrument, soon adopted on all of the railway lines throughout the country. Another main aspect of the primary design was also brought forth during the London and Blackwall Railway installation. This installation combined this simplified "single needle" dial into what became widely known as the "five dial" telegraph system; combing five "single needle" dials from one single needle dial into "five dials." [157]

The Pointer Telegraph

The five-needle telegraph had some major drawbacks; it needed six expansive long-distance wires, it was slow—the transmission of letter by letter required close attention of the operator—and it had a limited letter set—the letters C, J, Q, U, X and Z couldn't be sent. Another drawback was that this telegraph system needed a skilful operator. Soon they developed a new system: the three-wire, two-needle system (1841), a system that was soon to be followed by the two-wire, one-needle system. But still, the need obviously was for a more simple system, easier to operate and with smaller investments.

That system would be the pointer telegraph (also known as an alphabetic telegraph or dial telegraph), which was introduced, after considerable experiments, by both Cooke and Wheatstone each designing their own versions in 1840. It was named the ABC telegraph, and it worked as follows:

Figure 119: A model of the indicator of Wheatstone's ABC pointer telegraph (1840).

Source: www.sciencemuseum.org.uk/

The ABC telegraph system consisted of three main components - the generator, the communicator, and the indicator. The communicator and the indicator were mounted on top of a wooden box. The generator was inside the box and was operated by a handle projecting through one end of the box. The generator consisted of an armature carrying a coil of fine wire and rotating between the poles of

[157] Source: William Fothergill Cooke. Biography. http://ethw.org/William_Fothergill_Cooke (Accessed April 2015)

a set of permanent magnets. Rotating the armature by means of the external handle generated a series of positive and negative current pulses which were fed into the telegraph line to the receiving station.

The communicator controlled how the current pulses were transmitted. It had a circular dial with the letters of the alphabet marked around its periphery and a needle pivoted at the centre of the dial. Opposite each letter on the communicator dial was a key. To transmit a letter, the appropriate key on the communicator was depressed and the handle of the generator was turned. When the number of pulses corresponding to the selected letter had been transmitted, the communicator disconnected the generator from the telegraph line. The communicator needle rotated while the generator was transmitting and stopped at the transmitted letter when the generator was disconnected.

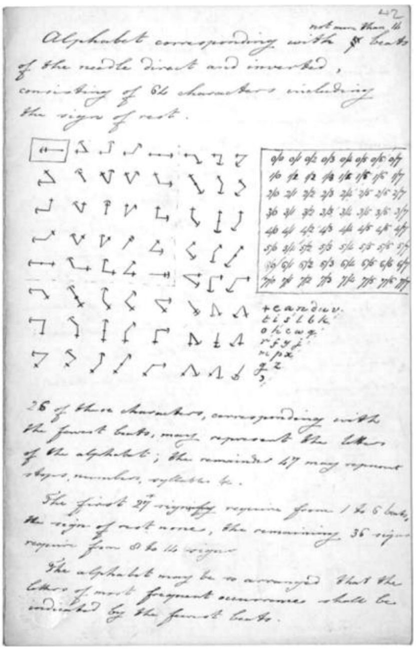

Figure 120: Wheatstone's dial based code for his repeating recorder (1842).

Notes describing the use of needles (arranged like clock hands) to correspond to the alphabet on a dial for a 'repeating recorder',

Source: www.sciencemuseum.org.uk/

At the receiving end, the indicator decoded the pulses from the communicator. The indicator had a circular dial with the letters of the alphabet marked around its periphery and a needle pivoted at the center of the dial. As the pulses were received the needle moved around the dial and stopped at the appropriate letter.

Provision was made to ensure that the communicator and indicator were properly synchronized, and it was possible to transmit numbers and punctuation marks as well as letters. Apparently speeds of about 15 words per minute were possible. [158]

The development of the pointer telegraph was related to the clock technology in which Wheatstone was interested, as we will see later on when we discuss the contributions of Alexander Bain. The idea behind it was simple: the dials of a clock can be used to transmit information about

[158] Source: http://museumvictoria.com.au/collections/themes/1798/the-wheatstone-abc-telegraph. (Accessed January 2015)

time, and those dials can also be used in telegraphy by transmitting text. Wheatstone developed different ideas about this principle, as is obvious from his notes (Figure 120) .

The ABC telegraph, pointing to the transmitted letter on the dials, was quite easy to use and became popular. Some 10,000 units were manufactured (Figure 121).

Both Cooke and Wheatstone took out patents for their own improvements of the telegraph: Wheatstone in 1837 and 1840 (see Table 2) and Cooke in 1838 (GB patent № 7,614) for improvements like the "alarum" that could give a bell signal, drawing attention to an incoming message (Table 3). The pointer telegraph was granted patent № 8,345 on January 12, 1840. The patent that was granted for further improvements later in 1845, British Patent № 10,655, was the result of both of their contributions (Table 4).

Figure 121: A later model of Wheatstone's ABC Pointer Telegraph (1858).

Source: http://www.telegraphsofeurope.net/page30.html

This had been a time of experimenting and demonstration. Telegraphy had been developed from the first conceptual idea, through the (scientific) testing of that concept into a working apparatus and prototypes; now came the time for a) further developing the technology and b) trying to get the market to respond to the concept of the period of exploration. The main question was obviously what the specific application for telegraphy would be.

Table 4: British patents granted to Cooke (1837-1845)

Patent №	Granted	Description
7,390 [1]	June 12, 1837	Electrical telegraphs (needle telegraph)
7,614	?, 1838	Alarum
8,345	January 21, 1840	Electrical telegraphs (pointer telegraph)
10,655 [1]	May 6, 1845	Electric telegraphs and other apparatus

1) Patents together with Charles Wheatstone

Source: Bowers, 1975. P.233-234

First Application of the Telegraph

Cooke had some ideas, as he was aware of the signalling problems of railway companies: the first application should be railway traffic control to prevent accidents from happening. On single lines with trains travelling in both directions, this was an issue of importance:

> *As Captain Mark Huish, General Manager of the London & North-Western Railway, was to write (rather elaborately, and with his customary awareness of economy) in March 1854: "If only one collision of a passenger train, with its sickening accompaniments of suffering, to say nothing of its heavy expense, were prevented by free use of the telegraph, the immunity would be cheaply attained, and the cost of the improvement be amply compensated.* [159]

This regarded, for example, the traffic control between the Euston Square and Camden Town stations of the London & Birmingham Railway Co. in London (Figure 122). Here Cooke held several trials to show how their telegraph could be useful for their control needs.

Figure 122: The London & Birmingham Railway's Euston Square Station (1838).

Source: http://distantwriting.co.uk/cookewheatstone.htm

Although the London and Birmingham Railway declined the use of Cooke's telegraph, these were the first prototype demonstrations that were, after a hiatus, to be followed by others. In 1839 the Great Western Railway Co. allowed Cooke to create the first permanent telegraph line between their Paddington and West Drayton stations over a distance of thirteen miles. This line was later extended in different stages. The second permanent line was constructed alongside of the short three-mile track of the London & Blackwall Railway.

> *The successful traffic control of the London & Blackwall Railway immediately inspired several other short cable-worked lines, railway lines in long tunnels and*

[159] Source: Roberts, S.: Railway Signal Telegraphy 1838 – 1868. http://distantwriting.co.uk/railwaysignaltelegaphy.html (Accessed April 2015)

> *single track lines to adopt Cooke & Wheatstone's electric telegraph for train management over limited distances, but not yet for public messages.* [160]

The first application of the telegraph as a traffic control system had been created. Next came another challenge: the application for messaging. As the technical development of the telegraph apparatus had progressed, this would be for another type of telegraph: the dial telegraph—also known as the ABC Telegraph—as designed in different versions by both Cooke and Wheatstone. It got public attention on several occasions.

One such occasion came on May 16, 1843, when the circuit between London and Slough on the Great Western Railway was opened for messages by Cooke & Wheatstone's agent, Thomas Home. This was Britain's first public telegraph service, albeit an exercise in generating publicity. It had some distinguished customers.

> *Slough was convenient for the Royal residence that Windsor and the Queen's household and her government were soon patronising the electric telegraph in mutual, widely-reported, exchanges. … the Emperor Nicholas of Russia, when on a visit to Queen Victoria that Windsor, took the opportunity whilst passing*

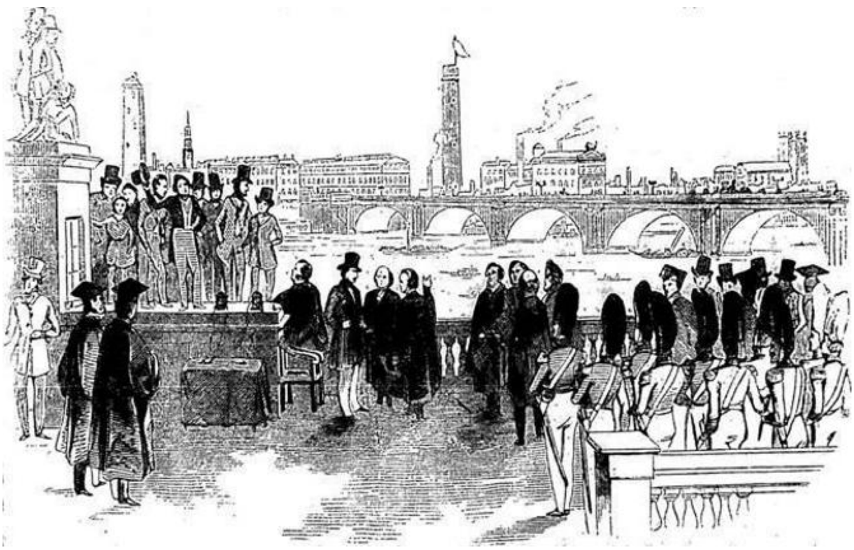

Figure 123: Wheatstone demonstrating his dial telegraph to Prince Albert (1843).
Source: http://distantwriting.co.uk/cookewheatstone.htm; Illustrated London News, July 1843

160 Source: Roberts, S.: Railway Signal Telegraphy 1838 – 1868. http://distantwriting.co.uk/railwaysignaltelegaphy.html (Accessed April 2015)

through Paddington station on the Great Western Railway on June 3, 1844 to inspect the workings of the telegraph office. [161]

Another occasion was the event in which the telegraph was demonstrated to the royal consort Prince Albert (Figure 123):

At the end of June 1843 Wheatstone demonstrated this circuit and his latest dial telegraph that sent roman alphabet rather an code or cipher, to Prince Albert, the Queen's consort, on the occasion of the opening of a Royal Museum of Scientific Instruments at King's College, on the terrace of Somerset House. [162]

The breakthrough for the new magic communication by wire, although in a military application, came in 1844 when the Board of the Admiralty replaced a redundant naval semaphore with the use of the Cooke & Wheatstone's new telegraphic system between Whitehall in London and the naval headquarters at Portsmouth alongside of the London & South-Western Railway. They were to pay £1,200 per annum for the use of the circuit. On parallel lines, he was allowed to transmit railway messages and public messages. Public use would have to wait for some years to become effective. But soon there was another event that put the telegraph into the spotlights of public attention.

The Electric Constable

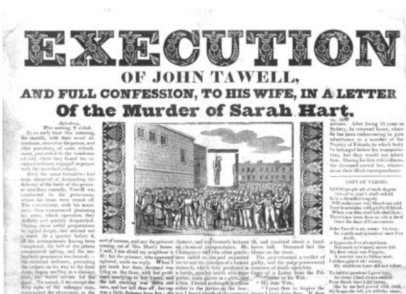
EXECUTION
OF JOHN TAWELL,
AND FULL CONFESSION, TO HIS WIFE, IN A LETTER
Of the Murder of Sarah Hart.

Figure 124: Publicity about the hanging of John Tawell (1845).

Source: www.capitalpunishmentuk.org/Tawell%208.jpg

A dramatic demonstration of the use of telegraphy was given in January 3, 1845, when a man called James Tawell—who dressed like a Quaker—was suspected to have murdered a woman called Sarah Hart. After the murder, he was seen taking the train at Slough. His description was forwarded by telegraph to the station of Paddington. It said:

A murder has just been committed at Salt Hill and the suspected murderer was seen to take a first class ticket to London by the train that left Slough at

[161] Source: Roberts, S.: Railway Signal Telegraphy 1838 – 1868. http://distantwriting.co.uk/railwaysignaltelegaphy.html (Accessed April 2015)
[162] Source: Roberts, S.: Railway Signal Telegraphy 1838 – 1868. http://distantwriting.co.uk/railwaysignaltelegaphy.html (Accessed April 2015)

> *7.42pm. He is in the garb of a Kwaker* [sic] *with a brown great coat on which reaches his feet. He is in the last compartment of the second first-class carriage.*[163]

At Paddington Station the railway policeman Sgt. William Williams identified and followed him to his lodging house. He was arrested the following day. In the following trial in March, 1845, he was found guilty and hanged outside the court in the presence of some 10,000 people. The whole affair drew a lot of public attention (Figure 124), and so did the new phenomenon of telegraphy. [164]

> *The telegraph received a massive amount of positive publicity. the Times declared: "Had it not been for the efficient aid of the electric telegraph, both that Slough and Paddington, the greatest difficulty, as well as delay, would have occurred in the apprehension* [of Tawell]*."* [165]

Controversy and Arbitration

In the 1840-1841 period, a difference arose between Cooke and Wheatstone as to the share of each in the honour of inventing the telegraph. Cooke was an inventor/entrepreneur who wished to protect by patent and then to commercially exploit his inventions. Wheatstone, on the other hand, was an academic with no interest in commercial ventures. He intended to publish his results and allow others to freely make use of them. Cooke contended that he alone had succeeded in reducing the electric telegraph to practical usefulness—he claimed to be the shaper and introducer—at the time he sought Wheatstone's assistance. On the other hand, Wheatstone maintained that Cooke's instrument had never been and could never be practically applied.

The bitter controversy was brought into arbitration on November 16, 1840, before some distinguished men: Sir Marc Isambard Brunel (the engineer of the Great Western Railway) and Professor Daniel (a respected electric scientist). Ultimately, in the spring of 1841, the Cooke and Wheatstone arbitration process came to a close. A statement dated 27 April 1841, prepared by Marc Isambard Brunel and J. F. Daniell, Esq. known as "The Award" was issued.

> *The conclusion of the arbitration panel found however that Cooke had contributed to the business and management skills necessary to bring the telegraph into the mainstream; which was true. Cooke had handled all of the details that made*

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[163] Source: The Murder of Sarah Hart. http://www.btp.police.uk/about_us/our_history/crime_history/ murder_of_sarah_hart_1845.aspx. (Accessed April 2015)
[164] Source: http://www.johntawell.com/the-case/ (Accessed April 2015)
[165] Source: The Murder of Sarah Hart. http://www.btp.police.uk/about_us/our_history/crime_history/ murder_of_sarah_hart_1845.aspx. (Accessed April 2015)

> *certain that the systems were produced by his craftsmen Kerby and Moore. Cooke had negotiated all of details and business arrangements for the installations with the railroad companies and their agents. Cooke hired all of the Cooke and Wheatstone's system's telegraph installation workers. Cooke also oversaw all of the telegraph installations. It was claimed by the arbitration panel that Wheatstone had contributed his scientific skill to construct a stable and dependable device on which the business could be built. This also was true. The panel tried to be fair to both parties, giving the upper hand in the arbitration to neither.* [166]

Some years later, however, Thomas Fothergill Cooke wrote a defence of his brother's contribution called "The Authorship of the practical electrical telegraph of Great Britain", stating that the arbitration had been not an "amiable and unmeaning compromise": "It was fought out sentence by sentence- fought out keenly and defiantly to the last; - and that under circumstances most favourable to the elucidation of truth" (T. F. Cooke, 1841, p. ix). And in 1854, William Cooke published a pamphlet entitled: "The Electric Telegraph: was it invented by professor Wheatstone?" (W. F. Cooke, 1857). He kept on denying Wheatstone's claim as being the inventor of the electric telegraph. As Cooke had worked on inventing both the needle and alphabetic telegraph, he claimed priority—a claim that was substantiated about 150 years later as his workbook—Cooke's "Naamlyst" Journal[167]—was found (in America in the late 1990s[168]).

> *Historians have credited more of the telegraph's actual invention to Charles Wheatstone over that of William Fothergill Cooke. The discovery of Cooke's manuscript journal however contains substantial documentation, extensive notes and drawings in his own hand regarding the invention of the first perfected digital electric binary action commercial telegraph.* [169]

This surprising journal had travelled a long way, as his instrument maker, the *mechanicien* Frederick A. Kerby, had taken it with him when he

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[166] Source: http://www.ieeeghn.org/wiki/index.php/ William_Fothergill_Cooke# American_Professor_Joseph_Henry_tells_Wheatstone_of_his_Relay. (Accessed April 2015). See also: William Fothergill Cooke. Biography. http://ethw.org/William_Fothergill_Cooke (Accessed April 2015).

[167] Lipack, Richard Warren: Sir William Fothergill Cooke's Newly Discovered Original Notebook/ Journal For The World's First Commercial Telegraph. Source: http://w1tp.com/Cooke/

[168] In the late 1990s, over one hundred fifty years later, the Cooke journal was discovered in the United States by American author, historian and archivist Richard Warren Lipack while attending an antiques trade show in Atlanta, Georgia. It has been named the Codex Lipack.

[169] Source: William Fothergill Cooke. Biography. http://ethw.org/William_Fothergill_Cooke (Accessed April 2015).

emigrated to America in 1842. He had been the key witness on Cooke's behalf during the arbitration.

Obviously this was—in part—a semantical discussion on what an invention was. But it mainly was about priority—a priority question that was not about the monetary reward related to the invention (that aspect was solved quickly). It was about the honour of being the inventor: was it the scientist/engineer or the inventor/entrepreneur?

> *The discovery of Cooke's detailed 1836-1842 manuscript journal however now provides proof that runs contrary to the inaccurate notion that Cooke's only function was that of being the one behind the 'business side' of the Cooke and Wheatstone telegraph. Granted, Cooke did indeed run all of the 'business side' of the partnership, but the Cooke journal now clearly reveals that his stake in actually inventing and producing working telegraph systems was more prominent than what over a century long breadth of telegraph scholars and historians have led history to believe.* [170]

Apart from the discussion of who invented the ABC-telegraph, there is the question if somebody else could have been the inventor of the dial-telegraph. This topic will be addressed when we look at the life of the clockmaker Alexander Bain.

The Electric Telegraph Company

Back in the mid-1840s, the expansion of the British telegraph system paralleled the development of the railways. Like the railway system, the telegraph in the United Kingdom had begun to expand exponentially. That development was different from the development in some other countries.

> *The relationship between the two industries was a natural one; the telegraph was useful for signaling and other safety measures, while railways offered telegraph companies opportunities for extension along their way leaves. …*
>
> *First, there was never as close a connection made in Britain between the telegraph and military and security purposes as was the case in some continental countries …, and the role of the state in promoting the telegraph for its own purposes as opposed to the public's which was seen in, for example, France, Sweden, and the Austro-Hungarian Empire did not emerge during the first three decades of the industry in Britain. Secondly, Britain differed in the competitive strategy of its firms from the pattern of development in the United States. … .*

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[170] Source: William Fothergill Cooke. Biography. http://ethw.org/William_Fothergill_Cooke (Accessed April 2015).

> *In Britain the management of the Electric, the industry leader, followed a different approach of seeking profits through accommodation with rival firms as they entered the field. … In effect, a cartel with the aim of fixed prices emerged …* (Perry, 1997, p. 416)

Early Years of the Electric Telegraph Company

That brings us to the dominant company of those early days of the British telegraph. Cooke had, in August 1846, together with the businessman and politician Lewis Ricardo (1812-1862) of the Ricardo family of City merchants and railway engineer George Parker Bidder, created a company they called the Electric Telegraph Company[171].

> *During 1845 the number of new contracts being taken out for telegraph installations moved the scale of the business beyond the ability of Cooke and Wheatstone to deal with as a partnership. The threat of competition, too, required that their interests be protected by the formation of a company. Following negotiations with George Parker Bidder and John Lewis Ricardo, a prominent businessman, the Electric Telegraph Company (ETC) was incorporated by Act of Parliament in 1846.* (Liffen, 2010, p. 289)

The necessary agreement by Parliament in the form of the Electric Telegraph Company Bill had passed with little scrutiny in February, March and May of the same year. The only opposition, that of the inventor Alexander Bains, had been dealt with swiftly. On June 19, 1846, Parliament signed the resulting Electric Telegraph Company Act.

> *The Electric Telegraph Company's Act of Parliament had several clauses that set a precedent for working electric communication; its circuits had to be open for the sending and receiving messages by all persons alike, without favour or precedence, subject to a prior right of use for the service of the Government, and subject to such charges and regulations as the Company might make.* (S. Roberts, -) [172]

Eight stockholders who furnished a total of £112,000 for 4,480 shares supplied the total joint stock capital of £600,000[173]. As they were liable as individual partners, the initial shareholders had something to loose. George Bidder, Ricardo's uncle, had paid up £38,500 (presently equivalent to £3,253,000). Cooke paid up £29,000 (equivalent to £2,450,000), John Lewis

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[171] The present giant company British Telecom is a direct descendant of this company.
[172] Source: Roberts, S.: Distant Writing, The Electrical Telegraph Company. http://distantwriting.co.uk/ electrictelegraphcompany.html. (Accessed April 2015)
[173] Equivalent to ca £8,793,000 in 2013, calculated on the basis of the real price of a commodity. Source: www. measuringworth.com.

Ricardo [174] £18,200 (equivalent to £1,538,000) and Samson Ricardo £15,00 (equivalent to £1,301,000). These were large amounts to invest in a new venture with uncertain prospects that would not be able to pay dividend before 1849. (Kieve, 1973, pp. 48-50)

Before it could begin full operation, the primary formation of the Electric Telegraph Company was contingent on securing all of Charles Wheatstone's telegraph patent interests. This was done by paying the mutually agreed amount of £160,000 (equivalent to £13,840,000) for Cooke and Wheatstone's earlier patents. Cooke received £91,158 in total for his patents rights and business (equivalent to £7,884,000) partly dependent on profits for the proposed company and partly in shares (Kieve, 1973, p. 43).

> *Cooke had agreed, prior to the establishment of the Company, to finance the expansion of the telegraph by assigning the majority of his patent rights to J L Ricardo and G P Bidder. This assignment valued Ricardo's share at £60,000 and Bidder's at £55,000, in addition to Cooke's minority that £45,000[175]. The three partners transferred all their rights in the patents to the Company by an indenture or contract dated August 5, 1846. … Cooke received £50,000 and Wheatstone £30,000[176] in cash. …Wheatstone was paid £20,000 in commutation of his royalty rights and £10,000 for his share in the Scottish, Irish and Belgian patents.* (Kieve, 1973, p. 43)

The establishment of the Electric Telegraph Company in 1846 was the final parting of ways for Cooke and Wheatstone, who had started working together in 1837. It had been a decade of cooperative efforts that created the foundations of British telegraphy (Bowers, 2001, p. 141).

Soon the company expanded its activities, as indicated in the act. It created "the railway of thought".

> *From its commencement it intended to be a national enterprise, connecting the major cities and towns of the country by electric telegraph. After absorbing the original line to Southampton, the first long circuit it constructed was north alongside of the London & North-Western Railway, which came to an agreement with the Company in the autumn of 1846, from London to the major manufacturing town of Birmingham, which it completed in mid-1847. This line*

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[174] John Lewis Ricardo was a businessman, member of Parliament and banker who had inherited, through his wife, a large estate in Scotland.

[175] Equivalent to ca £3,533,000 in 2013, calculated on the basis of the real price of a commodity. Source: http://www.measuringworth.com/ukcompare/relativevalue.php

[176] Equivalent to ca £2,355,000 in 2013, calculated on the basis of the real price of a commodity. Source: http://www.measuringworth.com/ukcompare/relativevalue.php

was continued north to reach the industrial city of Manchester on November 14, 1847. (Kieve, 1973, p. 43)

By 1847, the total length of the telegraph lines along the railways was a thousand miles. However, the late 1840s were not the most favourable circumstances for the telegraphic business to develop. As the expansion of the telegraph lines slowly proceeded, it was faced with the *Railway Mania* [177] (1840-1845). This was a burst of speculative investment in Britain that resulted in a massive exploitation of new telegraph lines, all of them created by Acts of Parliament (Figure 125). The investments needed took hundreds of millions of pounds out of the economy. It made it hard to finance all the new telegraph lines, especially when the *Railway Bubble* busted in 1846. The collapse of the railway bubble was just one of the many circumstances in

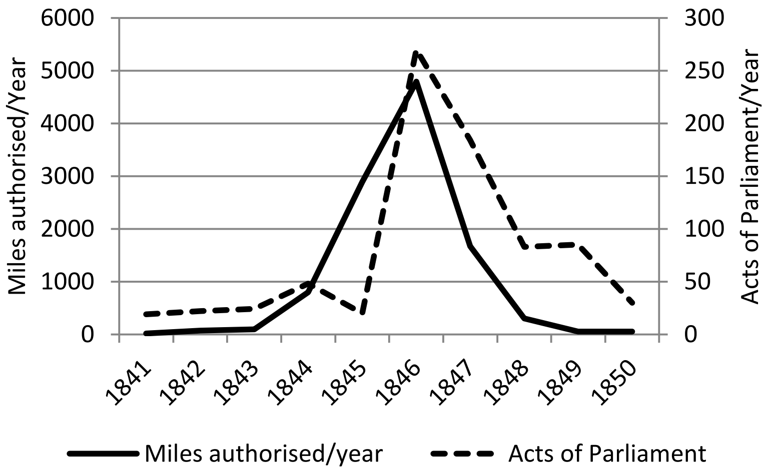

Figure 125: Railway mania visualized in terms of miles authorized by acts of Parliament.

Source: http://distantwriting.co.uk/cookewheatstone.htm

[177] *Railway mania* was the period where many entrepreneurial activities related to railroad infrastructure were undertaken. It peaked in 1846 when 272 acts of Parliament, as proposed in their individual bills, were passed in order to create the new companies. As the railroad companies were promoted as a foolproof venture, investment opportunity attracted speculators, rich aristocrats, banks and business. Among those were members of Parliament (MP) who had a private interest in passing the bill. A third of the railways were never realized, though, many due to mismanagement and bad business practice, inadequate initial financing, poor planning, and little attention paid to the question of whether the technology could do what entrepreneurs claimed. But it also became apparent that some of the proposed companies had a fraudulent background. The mania ended when railroad stocks proceeded to sink by 50% from 1846 to 1850 (Odlyzko, 2012).

that period of time hindering the development of electric telegraphy.

> *Like the house of cards falling, is was to be followed by a money panic in the City of London as common commercial credit dried-up; then by a food panic as the corn import trade was affected by the failure of credit and by the Europe-wide destruction of the potato crop through disease. All this was compounded by revolutionary unrest in France, Belgium and the German states in 1848, damaging continental trade. To cap it all the United States mounted an unprovoked invasion of Mexico disrupting Atlantic commerce with both countries. The five years between 1845 and 1850 were to be some of the most difficult for trade and business in the century, and it was to be so for the new Electric Telegraph Company.* (Kieve, 1973, p. 43)

The Electric Telegraph Company's first five years were ones of negotiation and construction: making deals for access rights or wayleaves, building overhead lines, training and employing clerks, opening stations, and promoting the new medium to the public. A great deal of money was expended in a short time, but revenues grew slowly. Only in 1849, when the skeleton of the national network was completed, could the telegraph be said to be secure as a business. But due to the Cooke and Wheatstone's patent position, it had a monopoly on the telegraph business for their type of telegraph equipment. So entrepreneurial people that wanted to start a telegraph line had to take a license from the Electric Telegraph Company.

In 1851, the patent protection for the GB-patent № 7,390 formally ended. The strategy followed by the Electric Telegraph Co after that expiration of the master patent, and when other entrants to the telegraph market started to appear, was seeking profits through accommodation with rival firms: the Electric Telegraph Company merged with the International Telegraph Company in 1855. This latter company had created telegraph lines with the Netherlands and Belgium (1853) through submarine cables from Orfordness to Scheveningen (known as the Hague cables) and from Dover to Calais. It resulted in the creation of the Electric & International Company—a company that continued to grow by developing telegraph lines and offering telegraph services (Figure 126).

> *Between 1855 and 1865 the Electric's market share dropped steadily from 70% to 47%. (thereafter it rose to 57% by 1868.) In effect, a cartel with the aim of fixed prices emerged, cemented by an 1865 agreement to withdraw what had been a uniform tariff of 1s. for 20 words between certain major cities and to substitute a more expensive fee schedule.* (Perry, 1997, p. 418)

This 1865 pricing decision also influenced the emerging discussions about nationalization that could be heard more and more voices that would like to expand the role of the Post Office in telegraphy in regard of the

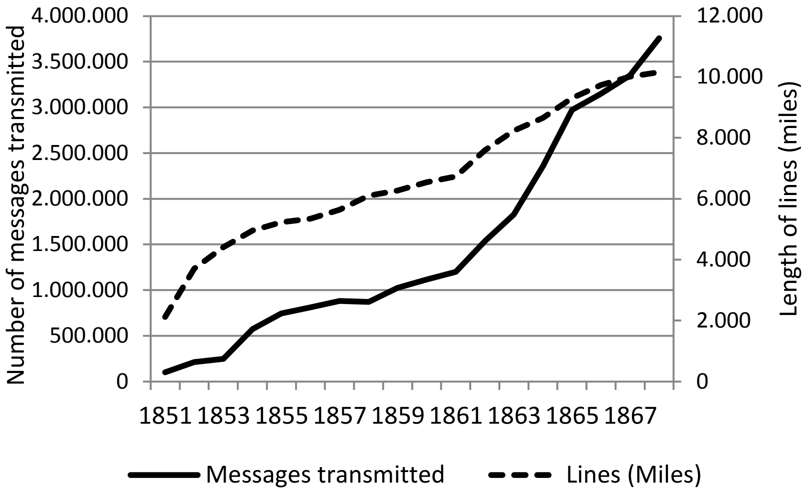

Figure 126: Development of the system of the Electric & International Telegraph Company (1851-1868).

Source: Kieve. J.: the Electric Telegraph, p.68

public interest. In July 1866, the Post Office director Frank Ives Scudamore, in "A Report to the Postmaster General Upon Certain Proposals", criticized the current state of service provided by the private British as charging excessive tariffs and providing inadequate service. He proposed nationalization as being the interest of the community as a whole. As we will see further on, the principle of nationalization received parliamentary approval in July 1868, and the following year a Money Bill[178] was passed to implement the purchase (Perry, 1997, p. 420).

By that time, the Electric and International Telegraph Company had become a large organization.

> *In 1868, its final year of independent working, the Electric & International Telegraph Company had a paid-up capital of £1,177,425, only a trivial £7,550 of which was on loan, with 10,007 miles of line (50,065 miles of wire) through-out England, Wales, Scotland and Ireland, as well the offshore islands. It was healthy and wealthy enough to pay down £60,000 in debentures, borrowed to finance its cables, in the previous twelve months. The Company's*

[178] A *money bill* or *supply bill* is a bill that solely concerns taxation or government spending (also known as appropriation of money).

> *1,465 clerks and 759 messengers sent 3,137,478 inland messages and 539,188 foreign messages. It possessed 7,245 telegraph instruments, of which 662 were inkers or printers.* [179]

In a period of about twenty years (1846-1867) (Figure 127), the Electric & International Telegraph Company had grown from a company with revenues of about £30,000 to a company with revenues of about £350,000[180].

After the controversy, over the years, Cook and Wheatstone became less and less involved in the electric telegraph, but their contribution to society was acknowledged, and in 1867, Cook was knighted, followed by Wheatstone two years later.

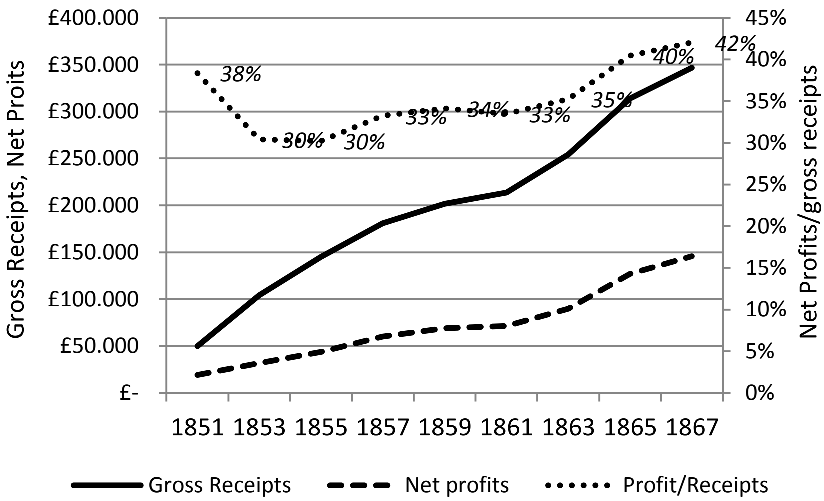

Figure 127: Development of the revenues and profits of the Electric & International Telegraph Company (1851-1867).

Source: Kieve.J: The Electric Telegraph, p.91

[179] Source: Roberts, S. Distant Writing; The Electric Telegraph Company. http://distantwriting.co.uk/ electrictelegraphcompany.html (Accessed April 2015)

[180] Equivalent to £2,595,000 resp. £27,680,000 in 2014, calculated on the basis of the historic standard of living. Source: http://www.measuringworth.com/ukcompare/ relativevalue.php

The Universal Telegraph Company

Some years later after the network of the Electric Telegraph Company had matured considerably (Figure 128), as the result of his continuous development efforts into public telegraphy, Charles Wheatstone had created his *Universal Telegraph.* This was an electric telegraph made for ordinary people to use in their offices, workplaces and homes: the first instrument to interconnect private subscribers through hubs or exchanges. It was patented in 1858 and consisted of two compact dials: the communicator and the indicator. It did not require galvanic batteries and, as it indicated individual letters and numbers by means of a rotating needle, could be worked by anyone who could read. This system was oriented at private telegraph lines to be used by newspapers, banks, police and other public organizations such as manufacturing firms and ship-building yards.

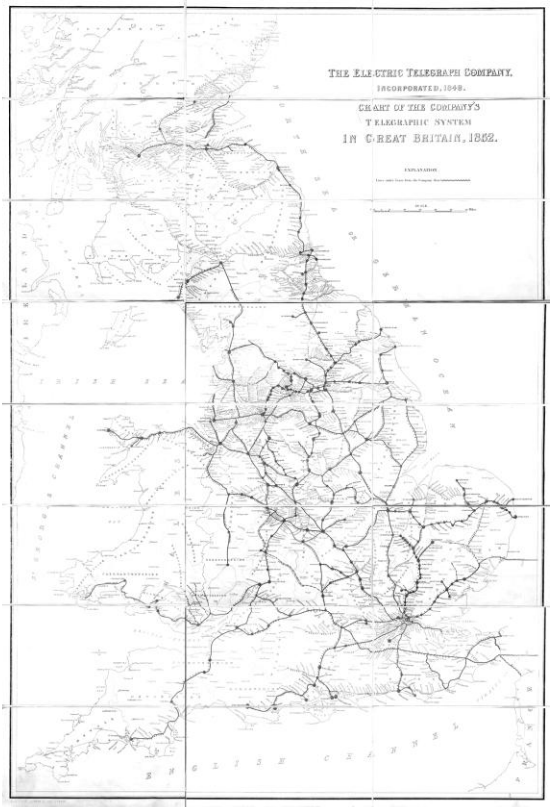

Figure 128: Chart of the telegraphic system of the Electric Telegraph Company (1852).

Source: http://distantwriting.co.uk/Documents/ETC%20GreatBritain%201852.jpg

The Universal Private Telegraph Company—with its first directors being Wheatstone and the entrepreneur William Fairbairn—was projected on September 20, 1860 to acquire Charles Wheatstone's patent of 1858 for his perfected magneto-electric dial apparatus. The company announced that "The main object of is Company is to enable the Government Offices, Police Stations, Fire Stations, Banks, Docks, Manufactories, Merchants' Offices, and other important Public and Private Establishments to have a private system of communication with their own Establishments and Manufactories that distances, either from their offices or residences...". The company obtained a Special Act of Parliament for its statutory incorporation on June 7, 1861, with a capital of £100,000 in 4,000 shares of £25, half of which were called-up[181]. One of the largest stockholder was Wheatstone. The company operated from 1861 to 1868, when the British government acquired it during the nationalization of the telegraph companies.[182]

Patent Infringements

It is clear that experimenting and the consequent discoveries and inventions had a value to the person who executed the experiment: it was his work, he put the effort in, he paid for the—often considerable—costs involved, etc. So, the inventor obviously wanted to protect his work—the protection of intellectual property as we call it today. Sometimes the motives to seek protection by patenting an invention were financial; sometimes it was about the (scientific) honour of being the first to invent.

Patent Law of 1852

In Britain in the first half of the nineteenth century, the system of protecting intellectual property was in its infancy. It originated from the letters of patent royalty could issue for a specific privilege, like a manufacturing monopoly (The Statute of Monopolies, 1624)

> *In 1624 as part of the skirmishing between Parliament and the Crown leading up to the English Civil War, the English Parliament passed the Statute of Monopolies. This had the effect of limiting the power of the Crown to grant monopolies to making such grants only to inventions for limited periods (14 years — the duration of two training periods for craft apprentices) and most importantly only for "manners of new manufacture" that were introduced into the realm by the recipient of the monopoly. Such grants were, however, conditioned on their not being "mischievous to the state" (for example, by raising prices of commodities) or "generally inconvenient."* [183]

Originally it was an exclusive right to manufacture, intended to stimulate the economy and the royal purse. It evolved in about two hundred years

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[181] The value of the issued shares that have remained fully or partially unpaid, and whose holders have now been called upon to pay the balance.
[182] Source: Roberts, S. Distant Writing; The Universal Telegraph. The lost Future of Telegraphy. http://distantwriting.co.uk/privatetelegraphy.html (accessed April 2015)
[183] Source: *A brief history of the patent law of the United States*. http://ladas.com/a-brief-history-of-the-patent-law-of-the-united-states-2/ (Accessed Juin 2015)

into the *patent*, representing a legal right obtained by an inventor providing for exclusive control over the production and sale of his mechanical or scientific invention. It was a contract between the individual and society.

> *Every useful discovery is, in to Kant's words "the presentation of a service rendered to Society." It is, therefore, just that he who has rendered this service should be compensated by Society that received it. This is an equitable result, a veritable contract or exchange that operates between the authors of a new discovery and Society. The former supply the noble products of their intelligence and Society grants to them in return the advantages of an exclusive exploitation of their discovery for a limited period.* [184]

This evolution was the result of the views of Enlightenment philosophers about natural rights (see Chapter Context)—views that saw the results of intellectual work also as property (ie Locke's doctrine that each individual possessed in the state of nature the executive power to enforce his natural rights to life, liberty and property). One of the key issues was novelty.

> *By the end of the eighteenth century and the beginning of the nineteenth century, numerous judges,… either subconsciously or deliberately used the terminology and arguments of Locke's natural rights philosophy to develop their two requirements for patents: specification and novelty.* (Adam Mossoff, 2000, p. 1313)

As a result of the first Industrial Revolution—with its abundance of novel products and systems—patenting became important.

> *Inventors paid heavily, and separately in England, Scotland, and Ireland, for the temporary (14 years in the first instance), and uncertain privileges since intellectual property "rights" depended on court decisions. British patents offered some protection to inventors, but did not provide complete barriers to access and use by others. … Yet the system before the reforms of 1852 remained cumbersome and administratively expensive.* (Greasley & Oxley, 2007, p. 341)

It was not until the 1852 Patent Law Amendment Act that the situation changed. Not only were the initial costs of obtaining a patent dramatically reduced to £4 [185] for the application and specification, also the yearly renewal fees were lowered. It resulted in a dramatic expansion of patent activity: from about 400 patents sealed in the 1840s it jumped to approximately 2,000 in the 1850s (Boehm & Silberston, 1967, pp. 23, 33; MacLeod, Tann, Andrew, & Stein, 2003).

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[184] Source: *A brief history of the patent law of the United States*. http://ladas.com/a-brief-history-of-the-patent-law-of-the-united-states-2/ (Accessed Juin 2015)

[185] Equivalent to £ 388 in 2013 based historic standard of living costs. Source: http://www.measuringworth.com/

The patent not only became important in Britain; other countries in the early nineteenth century adopted the concept of intellectual property. In America, the first patent act was passed in 1790 and a separate patent office was created in 1802. In France, Section 1 of the French law of 1791—issued during the French Revolution (see Context)—already stated, "All new discoveries are the property of the author; to assure the inventor the property and temporary enjoyment of his discovery, there shall be delivered to him a patent for five, ten or fifteen years"[186]. In the Netherlands, patent rights were established in 1817, to be abolished in 1869, just in time to support the local growing industrialization, among which was the electric light industry[187].

Patent Infringement on the C&W Master Patent of 1837

Apart from the objections of other inventors like Alexander Bain, the № 7,390 master patent of Cooke and Wheatstone had not be challenged by too many parties in its early days. Sure, publically Wheatstone had done all that was possible to claim priority of the electric printing telegraph over Alexander Bain's invention of the printing telegraph, but he did not succeed in establishing his claims in court.

That changed after the creation of the Electric Telegraph Company (ETC), when it became clear that telegraphy was serious business. Then they had to head of infringements on their patent and go to court on several occasions. One of them was the case of infringement when John Nott and John Gamble applied for a patent on a dial telegraph.

> *John Nott of the city of Cork in Ireland obtained a patent for a dial telegraph on January 20, 1846. This apparatus used two keys to work an electrically-controlled ratchet that propelled a pointer around a large dial to indicate letters and numbers. By the end of the year Nott had taken into partnership D P Gamble and J R Gamble. … [John] Gamble was a pragmatist and quickly realised the future of the telegraph lay in cooperating with the trunk lines of railway extending out from London.*[188]

The ensuing activities Gamble developed—as a rich merchant he had considerable influence in the city and in government through his firm's provision contracts with the shipping companies and with the admiralty—

[186] Source: "A Brief History Of The Patent Law Of The United States." http://ladas.com/a-brief-history-of-the-patent-law-of-the-united-states-2/ (Accessed April 2015)
[187] See: B.J.G. van der Kooij: *The invention of the Electric Light.* (2015) pp. 139-140.
[188] Source: Roberts, S : Distant Writing, Chapter 8 : Non-competitors http://distantwriting.co.uk/noncompetitors.html. (Accessed April 2015)

became a threat to the newly formed Electric Telegraph Company.

> *The ETC had not been incorporated for many months before its patent monopoly was tested. During the summer of 1846 an ABC pointer telegraph patented by John Nott and John Gamble was installed on the London and North Western Railway between Northampton and Blisworth. The ETC considered that it violated its patents and applied for an injunction to restrain Nott and Gamble. The motion was heard in the Vice-Chancellor's Court in December 1846 and January 1847. Both sides entered affidavits from many prominent scientists and engineers, together with examples of apparatus built in accordance with the various patents.* (Liffen, 2010, p. 289)

The case *ETC v. Nott and others* dragged on through several hearings, but in the end, ETC lost the case.

> *The Electric Telegraph Company pursued Nott and Gamble ruthlessly through the Court claiming patent infringement. The first suit was heard on November 13, 1846 when they sought an injunction against the use of Nott's apparatus. It was refused. Between February 10 and 19, 1847 a much more substantial case was presented against Nott and Gamble. In this the affidavits, from Prof George Henry Bachhoffner, Prof William Thomas Brande, John Raymond Brittan, clockmaker, Isambard Kingdom Brunel, civil engineer, William Carpmael, engineer, Prof John Thomas Cooper, John Farey, engineer, James Sealy Fourdrinier, engineer, Charles Frodsham, chronometer-maker, Prof William Allen Miller, William Newton, engineer, Peter Mark Roget of the Royal Society, George Stephenson, civil engineer, Robert Stephenson, civil engineer and Prof Charles Wheatstone, totalled 133 pages. Once again the Court of Chancery refused an injunction without legal proof of patent piracy by Nott and Gamble. …*
>
> *The telegraph company almost immediately commenced three more actions against Nott and Gamble. These lasted from March 30, 1847 until 1848, when they were abandoned. On December 14, 1846 Pitt Gamble was bluntly informed that the London & North-Western Railway and the Electric Telegraph Company were in negotiation and that other parties were no longer involved in the telegraph issue.* [189]

So, the case was settled, and as part of the settlement, Gamble became secretary to J. Lewis Ricardo, ETC's president.

[189] Source: Roberts, S : Distant Writing, Chapter 8 : Non-competitors http://distantwriting.co.uk/noncompetitors.html. (Accessed April 1815)

Soon there came the next case of infringement, when Alfred Brett and George Little applied for a patent. The instrument was devised by George Little and financed by Henry and Alfred Brett, London brandy distillers. It challenged Cooke and Wheatstone telegraph with a two needle indicator and a horizontal (left and right) handle to communicate (Figure 129).

> *Within a short time the 1837 patent was to be challenged again and this time it was necessary to demonstrate the operation of the equipment. In 1847 Alfred Brett and George Little patented what they regarded as a novel design of telegraph indicator. The ETC felt it infringed their patents and in 1849 brought an action in the Court of Common Pleas against Brett and Little. … The hearings took place at the Guildhall on 21, 22, 23 and 25 February before Lord Chief Justice Wilde and a special jury.* (Liffen, 2010, pp. 289, 291) [190]

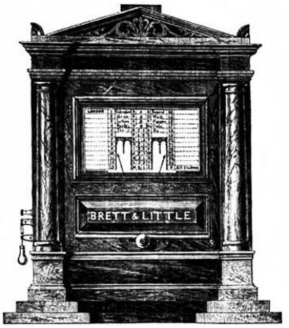

Figure 129: Sketch of Brett & Little two needle Telegraph (1847).

Source: http://distantwriting.co.uk/instruments.html

The Electric Telegraph Company bought the patent in 1851 and suppressed its use.

This description of the patent infringements and their resulting legal skirmishes brings us to a remarkable development in British telegraphy—a development in which, next to the obvious technical dimension, the human dimension plays a big role. It is about individual characters, about class distinction in British society, and about ethics.

Bain's Telegraphs: From Chemical Telegraph to Dial Telegraph

Cooke and Wheatstone were not the only ones who were busy in the new technology of needle telegraphy. Like Cooke and Wheatstone had developed different systems, like the dial telegraph, there were other gentlemen engineers who were dedicating their time to work on telegraphy. Important to realizing all these contributions was the existence of the fine-mechanical technology of instrument making available at that time—the knowhow and the skills for making mechanical instruments developed over time. Many of them were involved in clock making and concentrated their activities in London.

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[190] About the clear outcome of the case *ETC v. Brett and Little* no information could be found. See for more information: English Reports in Law and Equity: Containing Reports of Cases in ..., Volume 4, pp. 347-352.

Clockmaking Technology

Because of the Hugenot persecution in France in the seventeenth century, many skilled protestant artisans had gone to England. In London, they lived and worked together in areas like Soho and Clerkenwell. Many streets were almost wholly occupied by workmen engaged in the various subdivisions of the trade, such as escapement maker, engine turner, fusee cutter, springer, secret springer, finisher and joint finisher. Their specialized craft was lightly regulated by the Worshipful Company of Clockmakers (a guild established by Royal Charter in 1631), whose horological jurisdiction extended to a ten-mile radius around the City of London. Clerkenwell became the headquarters of the trade and continued as such while verge watches were in use, attracting some of the most renowned clock and watch makers of the eighteenth and nineteenth centuries to live and work in the area.

One of the well-known clock making firms, Barwise & Frodham, was run by John Barwise Sr. It was known for making pocket chronometers and pendulum clocks. In 1842, John Barwise became operations director of the British Clock and Watchmaking Company, a venture aimed at mass producing watches—quite a risk in a highly individualized industry that relied upon small groups of highly skilled and specialized craftsmen working by hand-creating precise and expensive timepieces. The idea that machines could put them out of work terrified them, and they viewed such mass-manufacture desires with great hostility. Under the banner of the clockmaker guild, the Worshipful Company of Clockmakers, they petitioned Parliament and succeeded in getting the private Bill annulled. This created a problem in financing the company, and three years later the venture collapsed. An early industrialization attempt had failed.

His son, John Barwise Jr., worked as an instrument maker for Alexander Bain. Together, Bain and Barwise, working on an electric clock, where a battery and a solenoid moved the pendulum, were granted a patent in 1841. But before that happened, there was something else on the agenda….

Bain's Printing Telegraph (1841)

Scott Alexander Bain (1810-1877), born in a humble family, was working a croft, being a herdsman in the summer and attending school in the winter. He had followed an apprenticeship at John Sellar, a clockmaker, where he became an instrument maker. After a stay in Edinburgh, he went in 1837 to Clerkenwell in London, then—as described—the centre of clock and watchmaking in London. There he was confronted by the new phenomenon of electricity.

The spectacle of electricity was all the rage in London's exhibition culture at the time. Bain attended public lectures on electricity at the Polytechnic Institution and the Adelaide Gallery, two very popular scientific attractions, where he witnessed great electrical machines demonstrated. [191]

In 1838, Bain began to contemplate how a clock could be operated from an electrical battery. His ideas progressed during the next two years into two concepts, and in 1840, he showed a model of an electric clock[192] to one of his friends, an editor of the Mechanics Magazine. He was advised to contact professor Wheatstone, who he had met on several times. This is the story (Burns, 1993 Appendix 1; Finlaison, 1843) in the original text of their advocate, Finlaison[193]:

1840, 18 August: Mr. Bain waited upon the Professor, by appointment, taking with him the two through models showing the principles of both inventions, when the Professor bought the one of the Printing Telegraph, under certain conditions.

1840, 10 October: Mr. Bain (with Mr. Barwise), applied for a patent for his Electro-Magnetic Clocks. N.B.-Mr. Wheatstone by means of a caveat for Telegraphs was enabled, in 1838, to oppose Mr. Davey's patent; but not having lodged any caveat in respect of clocks, this patent of Mr. Bain's passed without opposition. (Finlaison, 1843, p. 109)

Figure 130: Bain's electrical clock (1840).

Source: Wikimedia Commons, Deutsches Uhrenmuseum

Wheatstone—like so many other *electriciens*—needed skilled *mechaniciens* to realize his ideas. Bain, being an instrument maker, hoped he could be one of them. So Bain could have showed his work on electric clocks in August 1840 as a proof of his capabilities. The fact is that Wheatstone employed Bain from August-December 1840 "under a written arrangement not to communicate what he was about to any other person without his (Mr. W.'s)

[191] Source : http://www.sciencemuseum.org.uk/online_science/explore_our_collections/people/bain_alexander#sthash.z2jG3Fdd.dpuf

[192] With an electric clock, the electro-magnetic pendulum is used to power the clock, instead of springs or weights .

[193] See also for the description of the analysis made by Finlaison: Perry Fairfax Nursey: *Iron: An Illustrated weekly Journal for Iron and Steel.* Vol 39. pp. 64.

permission". In today's terms, this would be a confidentially clause in a contract. Also a fact is that Wheatstone bought one of Bain's models of a printing telegraph for £5, with the promise of £50 more if it was commercialized. It stays a question if this was part of an employer-employee relationship (as Wheatstone saw it) or that a case of an inventor seeking a patron. (Finlaison, 1843, pp. 67-69)

Not much later though, Wheatstone published in a Royal Society paper "On the Electro-Magnetic clock", a device that was seen as a predecessor of the ABC-Telegraph. As he did not consider the contribution of a mere technician worth mentioning, he suggested it to be his invention. Needless to say, Bain was furious when he found out.

> *1840, 26 November: Mr. Wheatstone exhibited an electromagnetic clock that the Royal Society, which he announced as his own invention.* (Finlaison, 1843, p. 109)

Luckily, Bain had obtained the GB-patent № 8,783 in January 11, 1841, together with another clockmaker John Barwise for an electric clock (Figure 131).

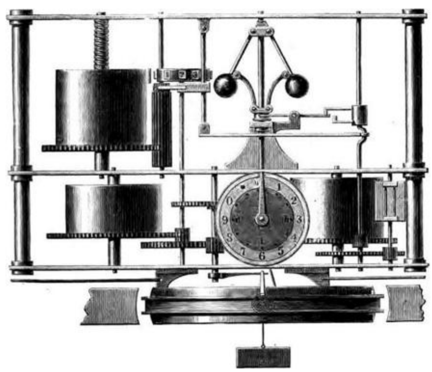

Figure 131: Bain's type-printing telegraph (1841).

An electrically-controlled mechanical telegraph. It used the rotating indicator to print numbers spirally on the upper drum. One recognizes the clockwork approach in the design.

Source: http://distantwriting.co.uk/bain.html

The partnership produced sixty of Barwise and Bain's electric clocks, some of them to be exposed at an exhibition at the Royal Polytechnic Institution during July, August and September 1841. However, in January 1841 Barwise accidently learned that Wheatstone was to exhibit his invention at the Adelaide Gallery and served him with a notice of injunction, resulting in the withdrawal of the invention.

> *1841, 28 March: Mr. Bain's Electro-Magnetic Clock was exhibited and lectured on that the Polytechnic Institution.* (Finlaison, 1843, p. 109)

In December 1841, he also had designed a type-printing telegraph for railway signalling and was granted patent № 9,204, together with Lieut. Thomas Wright, R.N., and had it displayed at the exhibition (Figure 131). The mode of operation was interesting, as described by Cooke when he was furiously opposing Bain's work, later in 1843:

> *It is, that instead of causing a coil of wires to move a magnetic needle, they cause the needle to move the coil of wires, a colourable evasion of our patent. … They bring the anvil to the hammer, instead of following the more usual and convenient method, bringing the hammer to the anvil. … Thus viewing the printing telegraph commercially, and as a question of legal right, it is clear that … it is either our property, or public property.* (Knight & Lacey, 1868, p. 108)

During that period, Bain claimed to be the inventor of the electric clock. Wheatstone got wind of this, and a bitter dispute—that was to last their lifetimes—ensued. (Burns, 1993, Appendix 1). In the year 1842, in a public debate, many letters of both Bain and Wheatstone were published in the Literary Gazette (Finlaison, 1843, pp. 115-124).

It was a controversy in which Wheatstone seemed to have used some disputable practices (Finlaison, 1843, p. 14):

> *1841, 22 May: Some person, on behalf of Messrs. Cooke and Wheatstone, proposed to bribe the proprietors of the Inventors' Advocate, if Mr. Bain's letters, concerning his invention of the Electro-Magnetic Clocks, were excluded from that journal.*
>
> *1841, 9 September: Mr. Bain (with Lieutenant Wright, R.N.), applied for a patent for an Electric Printing Telegraph, and some other electric machines.* (Finlaison, 1843, p. 109)

And with this last application, they came again in conflict with Wheatstone, who had applied for a patent (in the form of a caveat-equivalent).

> *1841, 9 June: Mr. Wheatstone having applied for a patent, "For Improvements in producing, regulating, and applying Electric Currents", he was directed by Sir John Campbell to deposit an account of what he intended to protect under is comprehensive title.*
>
> *1841, 6 October: Mr. Wheatstone opposed the patent being granted, when he stated to Sir Frederick Pollock that one object contemplated in his patent, then in progress, "was a plan to enable a man in London to print a letter in Edinburgh", and upon is statement the Attorney General refused to grant the patent solicited by Lieut. Wright and Mr. Bain, as far as related to printing.*
>
> *1841, 9 October: Mr. Bain ascertained the fact of the Professor having deposited the paper of the 9 June with the former Attorney General. Sir Frederick Pollock was therefore requested to open that paper, and if he found the Professor's verbal statement made to him, not to agree with his written statement made two months previously to Sir John Campbell, it was submitted that he should revise his judgment.* (Finlaison, 1843, p. 109)

The attorney general examined the deposit accordingly, and the result was that he immediately passed Mr. Bain's patent. No mention had been made, by Wheatstone, of a printing telegraph at all (Finlaison, 1843, p. 71).

The humble instrument maker, Bain, had beaten the distinguished scientist, Wheatstone. It would start a long-time controversy between the two men. It was just one of the many disputes Bain would have in his life.

> *By all accounts he was a difficult man to negotiate with and according to some a ferocious drunk. He was, unfortunately, intemperate to excess; contriving disputes with Wheatstone over electric clocks, with Bakewell over copying telegraphs and with Shepherd, another patentee of clocks, as well as with the Morse Syndicate in America … In truth Bain's principle character weakness was an inability to collaborate with his peers; a plain mechanic, he never had a scientific or technical mentor, nor an education that would have allowed him to appreciate the work of others. Moreover, he was unable to maintain any of the professional partnerships that he attempted with which to channel his ideas into consistent reality. He seems to have gone out of his way to give offence to potential allies.*[194]

Over a range of years, Bain developed what was going to be called the chemical telegraph. It started in December 1841 when he created a different type of galvanometer. Instead of making signals by a pivoted magnetic needle under the influence of an electromagnet, he made them by suspending a movable coil between the poles of a fixed magnet, thus avoiding the traditional galvanometer principle Cooke and Wheatstone used.

> *The most important idea in the patent is, perhaps, his plan for inverting the needle telegraph of Ampere, Wheatstone and others, and instead of making the signals by the movements of a pivoted magnetic needle under the influence of an electrified coil, obtaining them by suspending a movable coil traversed by the current, between the poles of a fixed magnet…* (Munro, 1891, Appendix IV)

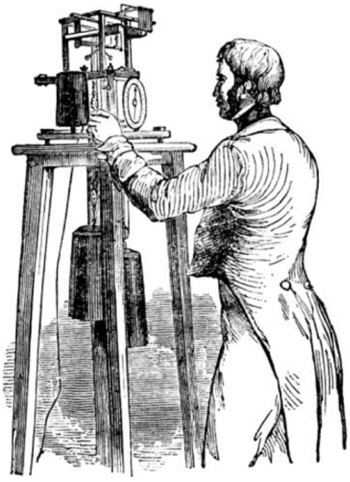

Figure 132: Bain's Electric Printing Telegraph (1844).

The double electro-magnet at the head, the dial with a constantly rotating hand below, the rising printing cylinder and the tubular mercury key to the left. The two weights power the rotation of the dial and the printer.

Source: http://distantwriting.co.uk/bain.html

194 Source: Roberts, S : Distant Writing, Bain. http://distantwriting.co.uk/bain.html

Continuing its development, in 1843 he obtained GB-patent № 9,745 for his more elaborate recording telegraph, where a metallic stylus brought down by the electric current wrote the dots and dashes on a chemically prepared paper. Other telegraph recorders using chemically prepared paper for the permanent recording of signals followed this work. In 1843, he developed the I&V Telegraph (patented as GB-patent № 10,838, 1845) that came in direct competition with Cooke and Wheatstone's telegraph. In 1846, he also patented an improved electro-chemical telegraph in England (GB-patent № 11,480, 1,846) and obtained US-patent № 6,837 on October 30, 1849.

Later he would design the copying telegraph, the first of a type of communication machines that would be called *facsimile machines*. Over time, Bain would be granted a range of US-patents (Table 5) and British patents (Table 6) related to telegraphy. Bain's telegraphs—he was of Scottish origin—were used on a telegraph line alongside of the Edinburgh & Glasgow Railway in December 1845.

Table 5: Telegraph-related US patents granted to Alexander Bain (1848-1863)

Patent №	Granted	Description
US 5.957	December 5, 1848	Improvement in copying surfaces by electricity (copying telegraph)
US 6.328	April 17, 1849	Improvement in electric telegraph (chemical telegraph)
US 6.837	October 30, 1849	Improvement in electro-chemical telegraph (with Robert Smith)
US 7.406	May 28, 1850	Improvement in electro-chemical telegraph (disk receiver), (with G. Westbrook and Henry Rogers)
US 32.854	July 23, 1861	Improvement in telegraphs (electro-acoustic telegraph or earpiece)
US 37.997	March 24, 1863	Improvement in electric telegraphs (galvanic dial telegraph) (with W.H. Allen)
US 38.530	May 13, 1863	Improvement in keys for electric telegraphs (silent key) (with W.H. Allen)
US 38.929	May 12, 1863	Improved call for telegraphs (alarm) (with W.H. Allen)

Source: USPTO, http://distantwriting.co.uk/bain.html

When in 1846 the Electric Telegraph Co was to be created, Bain wrote a petition to the House of Commons of the English Parliament, who was to issue the act. He claimed that Cooke and Wheatstone's patents were valueless, as they were in violation of his patents and "consequently not deserving of Parliamentary encouragement … , that the said Bill should thought not, pending such litigation, to pass… ". In other words, he

Table 6: Some British patents granted to Alexander Bain (1841-1852)

Patent №	Granted	Description
8,783	January 11, 1841	Application of moving power to clocks and timepieces (with John Barwise)
9,204	Dec. 21, 1841	Application of Electric Currents to Railway Signaling Telegraphs (with Lieut. Thomas Wright, R.N.)
9,745	May 27, 1843	Production and regulation of electric currents, electric timepieces and electric printing and signal telegraphs (chemical telegraph)
10,838	Sept 25, 1845	Electric clocks and telegraphs, insulated wires
11,480	?, 1846	Telegraph
14,416	May 29, 1852	Electric telegraphs and electric clocks and timekeepers, apparatus connected therewith

Source: Dredge, Abstract of patents. distantwriting.co.uk/bain.html

opposed the creation of the Electric Telegraph Co. because he had a patent issue. His petition was debated upon in the Committee, each party supplying witnesses, their solicitors discussing the legal aspects as "learned friends". In the hearing, it was said that "Mr. Bain deems it to be injury to the community at large to pass an Act which will virtually exclude your petitioner from fair and honest competition in the art of constructing Electric Telegraphs."

> *The bill was carried through the House of Commons, but Bain's statement made such an impression in the House of Lords that the Lords' Committee was of the opinion that the company ought to make an arrangement with Bain and that the Bill might be thrown out if it declined to do so. Thus Bain was bought off, subsequently being elected a director, although he soon resigned. He held 150 ordinary shares on 1 July, 1847, but was not a shareholder by December 1848.* (Kieve, 1973, p. 44)

So, Mr. Bain got £3,750 worth of shares in 1846 and soon disposed of them for cash. The Electric Telegraph Company also paid Bain £7,500 for his initial clock and telegraph patents in Britain and allowed him £2,500 contingent on his services to the firm in 1846. When he patented the fast telegraph in 1848, the Electric Telegraph Company purchased the rights for Britain for £13,250, half in cash, half in shares. Soon, he became even more of a wealthy man as he was paid (somewhere in 1850-1851) £20,486[195] for his patents. (Kieve, 1973, p. 83)

[195] Equivalent to ca £ 1.608.000 in 2013, calculated on the basis of the real price of a commodity.

Although Bain's telegraphs were originally mainly used in England (like along the Edinburgh & Glasgow Railway), his telegraphs were quite popular on the continent and the U.S. The Austrian government adopted Bain's principle for the telegraph network, and soon Russia and Prussia followed. In 1848, Bain went to America to file a patent application. For this chemical telegraph, he was granted US-patent № 6,837 (Figure 133). His arrival was enthusiastically reported by the *Scientific American* magazine, anticipating a competitor to the overwhelming Morse syndicate.

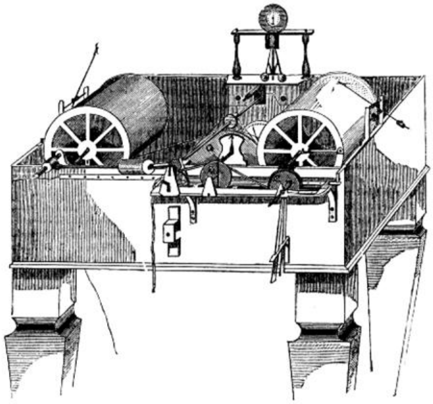

Figure 133: Bain's Chemical Telegraph (1848).

The first version demonstrated in the United States. Clockwork-driven receiving and recording drums covered in sensitive paper in the box and a rotary transmitter using tape tat the front.

Source: http://distantwriting.co.uk/bain.html

Indeed, soon his patent application was fiercely opposed by the Morse syndicate and rejected by the Patent Office who refused to issue the patent on the grounds of interference with a caveat applied for by Morse. After Bain's appeal, however, the court judged differently. The Patent Office was ordered to grant the patent for the chemical telegraph, and shortly after this, he sold his first patent licensing right to Messrs. Rogers and Barwain Lea of Baltimore, who established a line of the Chemical Telegraph between Philadelphia and Baltimore (Anonymous, 1853).

His chemical telegraph was also used by the American Henry O'Reilly, who opposed Samuel Morse's monopoly. To implement the rival system, Bain and O'Reilly formed the New York and New England Telegraph Company, which was to operate a line between Boston and New York. Soon there were more lines opened using Bain's telegraph.

> *When Alexander Bain returned to London in 1850, he was, apparently, comfortably off, living with his wife, Matilda, in a large house in Hammersmith, a small, smart suburb of London, on the river Thames, with five servants and a teacher for their six children. One of his neighbours there was Charles Wheatstone. His chemical telegraph patent in America was validated, despite the attacks of the Morse Syndicate; over two thousand miles of circuits had been built using his rights. At this time Bain still possessed valid, and possibly valuable, patents in British North America, France, Belgium and Austria for the chemical*

telegraph; in England for a musical instrument and for the electric ship's log; and in France for the electric clock. Bain also claimed to possess 100 shares in the Mississippi & Illinois Telegraph Company, 1,354 shares in the People's Telegraph Line (Louisville to New Orleans), 100 shares in the Ohio, Indiana & Illinois Telegraph Company, 225 shares in the Vermont & Boston Telegraph Company and 71 shares in the New York State Telegraph Company; all of some value in America. [196]

When O'Reilly became entangled with Morse, Bain was also drawn into the lawsuit initiated by the Morse syndicate. However, a compromise between the two parties was arranged as "there were strong arguments for peace". An agreement to unite the two companies into a new organization, the New York and New England Union Telegraph Company, was drafted and implemented. After 1852, no Bain lines were in operation. It seems that Bain personally lost a great deal of money in litigation against Morse. (Burns, 1993, p. 7)

The lawsuit cost Bain dearly financially, but in June 1852 following his return to England, the Bain-run New York State Telegraph Company was sold for over $65,000, and by the end of the year, his telegraph lines were no longer operating in America. [197]

In the meantime, he exhibited his clocks and telegraphs at the Great Exhibition of 1851 in London, securing a place in the Crystal Palace. He was living in Hammersmith, close to the Wheatstone residence: quite a luxurious lifestyle. But that was not to last for a long time. After some other short-lived business attempts that failed, like the Electric Time Company, in December 3, 1852 Alexander Bain

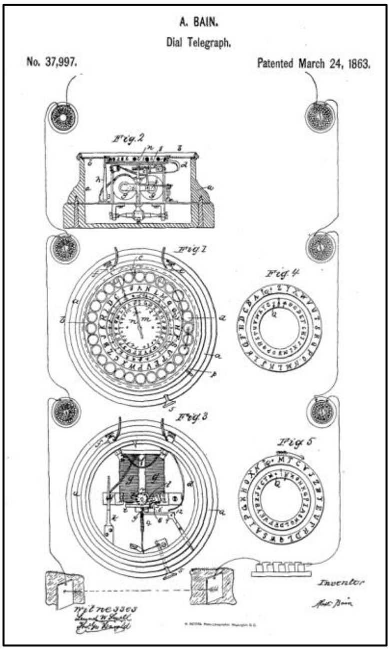

Figure 134: Patent № 37,997 for Bain's Dial Telegraph (1863).
Source: USPTO

[196] Source: Roberts, S : Distant Writing, http://distantwriting.co.uk/bain.html (Accessed April 2015)
[197] Source: http://www.whittlespublishing.com/userfiles/shop/200/e%20Cainess%20Influence.pdf (p.4) (Accessed April 2015). $65,000 is equivalent to ca $28 million, calculated on the basis of income value.

was declared bankrupt, owing £12,422 to unsecured creditors with just £932 [198] in assets.

> *He appeared before the court on December 16, 1852 and several times during the spring of 1853. There were three classes of bankruptcy certificate, the first was granted almost immediately if it came about through unavoidable losses or misfortunes; the third if there were willful or criminal intent, and was a "stigma for life"; Bain fell into the second class, between the two, although described as "utterly reckless as to the consequences" of his borrowing in mitigation he had given up all he had, his shares and his patents, to his creditors, and there was no fraud or preference in his accounting. He was given a year in April 1853 to co-operate and settle with his deeply suspicious creditors with an allowance of £3 a week from the estate. Bain was finally discharged from bankruptcy on May 11, 1854.* [199]

Bain's later years were still occupied with his inventive activities. He developed an alphabetic telegraph, the Bain Dial Telegraph, in 1863 (Figure 134). Samples were made—US-patent № 37,997 was granted in March 24, 1863—and it would, almost certainly, have been successful in Britain where private wire telegraphy was becoming popular, but its technology was too sophisticated for America. Being born as a poor man, he died in 1877 as a poor man.

Figure 135: Bain's Dial Telegraph (1863).

Source: http://www.uvm.edu/~dahammon/museum/dialtelagraphLR.jpg

> *Alexander Bain died in 1877 whilst living in a "home for incurables", depending on a pension organised through the charity of former employees of the telegraph companies, having sadly lost all of the opportunities that his electric clock, his chemical telegraph and his I & V telegraph had offered.* [200]

Alexander Bain's life started and ended in poverty. Not much later, in the 1890s, the following was written about his contribution to telegraphy.

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198 Equivalent to ca £1,178,000 respectively £ 88.360 in 2013, calculated on the basis of the real price of a commodity. Source: www.measuringworth.com

199 Source: Roberts, S : Distant Writing, http://distantwriting.co.uk/bain.html (Accessed April 2015).

200 Source: Roberts, S : Distant Writing, http://distantwriting.co.uk/bain.html (Accessed April 2015).

Considering the early date of his achievements, and his lack of education or pecuniary resource, we cannot but wonder at the strength, fecundity, and prescience of his creative faculty. It has been said that he came before his time; but had he been more fortunate in other respects, there is little doubt that he would have worked out and introduced all or nearly all his inventions, and probably some others. His misfortunes and sorrows are so typical of the 'disappointed inventor' that we would fain learn more about his life; but beyond a few facts in a little pamphlet (published by himself, we believe), there is little to be gathered; a veil of silence has fallen alike upon his triumphs, his errors and his miseries. (Munro, 1891, Appendix IV)

Later Development in Needle and Pointer Telegraphy

Like Bain, numerous other inventors improved upon the telegraph. They came from England, Scotland and Ireland and patented their work. But they came also from France and Germany to patent the instruments they had developed. Many of them continued to improve upon the concepts realized by Cooke and Wheatstone.

Needle telegraph: The concept of the needle-telegraph was further exploited by several British inventors. Among those were Edward Highton's single-needle telegraph (1852), George Edward Dering's needle telegraph (1852) and W.T. Henley's single and double needle magneto-electric telegraph (1851/52).

Dial telegraph: The concept of the dial telegraph was further exploited by several inventors. They created telegraphs such as Siemens & Halske's dial telegraph (1847), W.H. Hatcher's single and double index machine (1848), Gustave Froment's alphabetic telegraph (1850), Jacob Brett's rotary telegraph sender (1851) and W.T. Henley's magneto-electric dial telegraph (1861).

Some of these developments—the ones that had some impact one way or the other—will be described further on. They originated from the basic ideas developed in the early days of telegraphy—a time that saw the concepts of the needle telegraph complemented by the relay-based dial and pointer telegraph. It resulted in a flood of patents, as the inventors were eager to protect their work now that financial interests were becoming important. But it was not only the individual inventors that were interested in telegraphy. All over Europe, governments that started to realize that electric telegraphy was a replacement for the existing optical telegraph systems were erecting telegraph lines. Some administrations were not too eager, though....

France Copies Chappe

France, as described earlier, being continuously at war in the first part of the nineteenth century, had adopted the optical telegraph system of Claude Chappe and implemented it by the Administration du Telegraphe. Although the administration opposed the new form of electrical telegraphy, the fact that in Britain, Germany and the United States electric telegraphy was rapidly adopted, made it so that—by the early 1840s—the French government could not avoid considering converting to electrical telegraphy. But they found a French solution. Although they evaluated both the English concept of Cooke and Wheatstone as well as the American concept of Morse, the choice—surprisingly—was for a French-designed system: the Foy-Brequet electric telegraph system[201]:

> *The electric telegraph was introduced to France by Cooke and Wheatstone alongside of the Paris & Versailles railway in 1842; circuits by the Paris & Rouen railway in May 1845 and the Paris & Lille railway in July 1846 followed. The lines were soon absorbed into the administration of the télégraphe aérien, the Bonaparte-era optical system that only worked Government messages; it eventually opened its circuits to the public on March 1, 1851. After the brief experiment with Cook & Wheatstone's two-needle apparatus the state circuits used the Foy-Breguet instrument that copied the indications of the aerial telegraph, but by 1852 the American telegraph, the key-and-register, was being used in all public French circuits.* [202]

It was Louis François Clément Breguet (1804-1883), French physicist and famous watchmaker, who built the early telegraph apparatus used in France. Its code reflected the Chappe code and used two needles to create a display similar to the Chappe (optical) telegraph (Figure 136). Soon, Maison Brequet (also quite famous for the watches and clocks it manufactured for the French nobility) constructed telegraph equipment used all over Europe. The first use was restricted to the government and military. It took until 1850 before private persons were permitted to dispatch messages, but not after their identity was rigorously investigated.

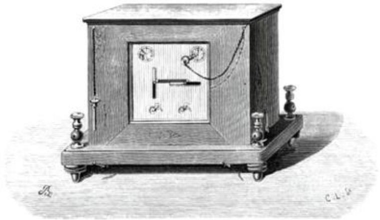


Figure 136: Foy-Brequet Telegraph (1842).

Source: Lequeux, J., Sheehan, W. : Le Verrier-Magnificent and Destestable Astronomer. (2013) p. 255

[201] Alphonse Foy was the bureaucratic director of the optical network.

[202] Source: Roberts, S. Distant Writing; The rest of the World 1838-1868. http://distantwriting.co.uk/Comparisons.html (Accessed June 2015)

That was the French solution: state control and rigid bureaucracy. But it resisted the dawn of the new times, and the Foy-Brequet telegraph was replaced in 1854 by Morse telegraph systems. In 1861, Hughes telegraph systems were adopted (Sauer, 1869, p. 797).

All over Europe, telegraphy became under the attention—and influence—of the different states. As an example, we will cover the development of the German electric telegraph system further on when we exploit the activities of Werner Siemens and his company, Siemens & Halske—developments resulting in spreading electric telegraphy into Russia, Scandinavia and Austria.

Patent Activity

Back to the developments in Britain where, parallel to the improvements made by Cooke (needle-telegraphy) and Wheatstone (alphabetic telegraphy),

Table 7: Significant British telegraph-related instrument patents other than Cooke & Wheatstone patents (1838-1863)

Patent №	Granted	Inventor	Description
7,719	1838	Edward Davy	Telegraphic Communication
9,204	1841	Alexander Bain	Printing Telegraph
9,745	1843	Alexander Bain	Chemical Telegraph
10,939	1845	Jacob Brett	Printing Telegraph
11,480	1846	Alexander Bain	Chemical Telegraph
11,974	1847	William Reid	Electric Telegraphs
12,039	1848	Edward Highton	Electric Telegraph
12,054	1848	Jacob Brett	Printing Telegraph
12,236	1848	William Thomas Henley	Magneto Telegraph
12,352	1848	Frederick C. Bakewell	Copying Telegraph
14,331	1850	Charles Tilston Bright	Magneto Telegraph
13,352	1850	Thomas Allen	Electric Telegraph
12,929	1850	Edward Highton	Electric Telegraph
13,062	1850	Ernst Werner Siemens	Galvanic Dial Telegraph
13,938	1852	Edward Highton	Electric Telegraph
185	1853	William Thomas Henley	Magneto Telegraph
1,110	1854	Meinrad Wendel Theiler	Type Printing Telegraph
2,103	1855	Charles Tilston Bright	Bell Telegraph
2,453	1857	Meinrad Wendel Theiler	Direct Printing American Telegraph
938	1858	David Edward Hughes	Printing Telegraph
228	1859	William Andrew	Electric Telegraph
512	1859	Charles William Siemens	Magneto Dial Telegraph
861	1860	Gaetano Bonelli	Typo-Telegraph
734/2,464	1861	William Thomas Henley	Magneto Dial Telegraph
2,147	1861	Meinrad Wendel Theiler	Improved Type Printing Telegraph
241	1863	David Edward Hughes	Printing Telegraph

Source: http://distantwriting.co.uk/appendices.html a range of other inventors became active. As can been seen from the year of conception[203], many of the British telegraphy improvements were realized in the late 1840s/early 1850s (Table 7). Some were for non-infringing inventions, but others were. One of the reasons for this increased patent activity could be found in the ended patent-protection for Cooke & Wheatstone's master patent of 1837, as shown in Figure 137.

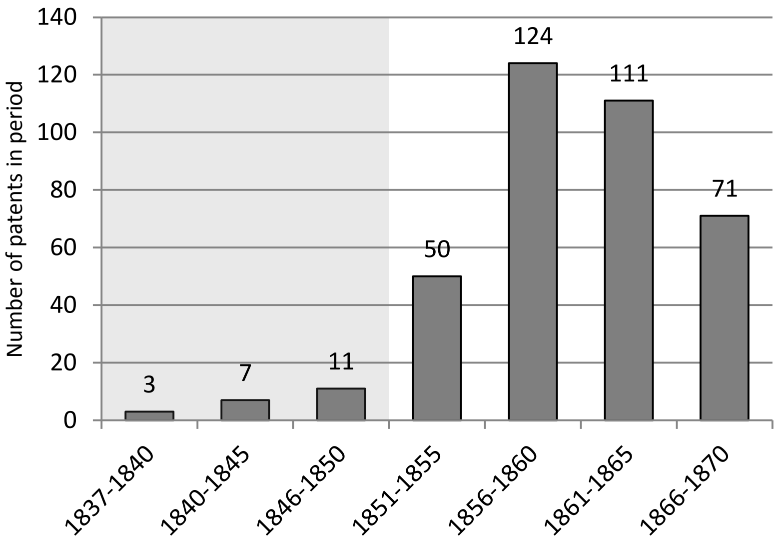


Figure 137: Indication of British patents in the period from 1837-1870 related to the totality of galvanic telegraphy: instruments, cables, methods, etc.

Shaded area indicates patent protection for the Cook and Wheatstone 1837 patent.

Source: Dredge (1882)

Experimenting in telegraphy was focusing on the telegraph instruments (the apparatus) themselves and the system components needed for the network (eg poles, isolators, cables). Among the many inventions in apparatus that had been patented (Table 7) were those that did not infringe on the C&W patent of 1837: the patents of Jacob Brett (1848), Edward Highton (1848), William T. Henley (1848) and Frederick C. Bakewell (1848). Next there were the apparatus developed around the time of expiration of the C&W master patent: the patents of Charles Tilston Bright

[203] It is difficult to establish the moment a new invention is conceived. Is it the moment the idea of concept was conceived, the moment the first working apparatus was realized, the moment of application for a patent or the granting date of the patent?

(1850) and Thomas Allen (1850). Or the apparatus were developed in a country where they were not covered by any patent protection, such as in Germany with the inventions of *Werner Siemens* (1850).

A remarkable fact was that many of the scientist-engineers active in experimenting with telegraphs were also experimenting with electric motors (eg Varley, Wilde and Siemens)[204]. From a technical point of view, this connection is quite logical, as both phenomena are related to electromagnetism.

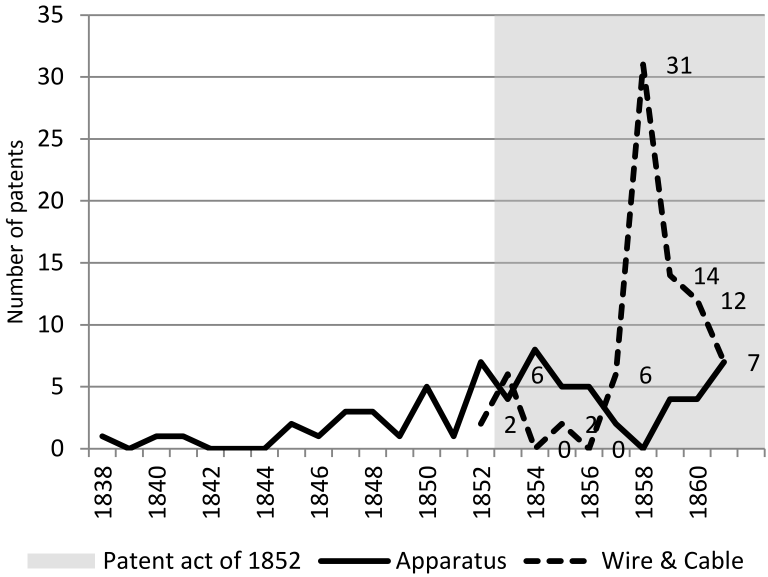


Figure 138: Indication of British patent activity into telegraph instruments (apparatus) and system-components (wire & cable).

Shaded area indicated influence of new Patent Law of 1852.

Source: Dredge (1882)

Regarding the focus of the patent activity, one can observe that originally the inventors were working on the instruments (the apparatus in Figure 138). But as soon as the C&W master patent expired, the focus shifted to the system components (wire and cable), especially the submarine cable, as we will analyse more in depth further on when we are looking at the entrepreneurial activity around the Atlantic cables. Obviously, the new

[204] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015). pp. 131-134

approach of the Patent Act of 1852 would also have had influence on easier access to the patenting system because the financial threshold for patent application had been lowered considerably.

One of effects of the submarine cables was that it became more and more obvious that the electro-physical properties of long electric cables were influencing the transmission. So scientists and engineers were more and more focusing on the electrical behaviour of the transmission lines.

Duplex Telegraphy and Artificial Lines

Especially as the length of the cables increased, and even more in harsh underground and submarine conditions, other factors started to contribute to the problems the early pioneer telegraphists were facing. There was the isolation of the cable and the di-electrical behaviour[205] of the cable. The first one would find its solution in new material— gutta-percha—, which we will explore later on. The second one was more of a scientific nature. The electrical scholars of that time—Michael Faraday, James Maxwell, William Thomson, Samuel and Cromwell Fleetwood Varley, Georg Ohm and Gustav Kirchhoff—had already contributed to the fundamental understanding of electrical circuits. It had become clear that next to resistance, capacitance and induction played a role in telegraph cables. But there was more needed to get the theory applied in reality.

A related element was the cost of the lines—often being the major components in financing a telegraph line—that required a more economic use by sending as many messages, as fast as possible, in both directions. This was cumulating in *duplex telegraphy* (both directions[206]) and *multiplexing telegraphy* (more messages at the same time).

Duplex telegraphy used several methods, like the differential duplex (Figure 139) and the bridge duplex (Figure 141). Although different in their technical aspects, both used balancing with an artificial line of capacitors, inductors and resistors: the balancing network (see both figures).

[205] That is the behavior of electric voltage and current on a transmission line in relation to distance and time. The relation between voltage (V) and current (I) results in the resistance: R=V/I (Ohm's law); in the case of capacitance (C) the impedance (Z) is $Z_C=1/j\dot{\omega}C$; and in the case of induction (L), the impedance is $Z_L=j\dot{\omega}L$. The phase factor $\dot{\omega}$ indicates that the current lags the voltage (induction) or precedes the voltage (capacity).

[206] Duplex telegraphy allows for the simultaneous transmitting and receiving of telegraph signals at each end of a telegraph line (invariably comprising one conductor with earth return). Its commercial advantage over simplex telegraphy, in which two-way transmission is possible, but not simultaneously, is that the theoretical capacity of the system is increased by 100%.

In Germany, the differential duplex concept was used by C. Frishen on the Hanover-Gottingen line (1854) and in Austria by William Gintl on the Vienna-Prague line (1854). In England, it was experiments by S. Newall on the Manchester-Altrincham line (1854), and W.H. Preece on the Southampton and Cowes line (1856).

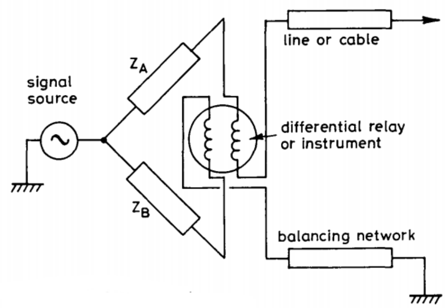


Figure 139: Principle for the differential duplex circuit.

Source: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4647765&tag=1

> *The idea of the bridge duplex connection is usually attributed to M. Maron who described it in 1863 and proposed to work it on the line between Berlin, Hanover and Cologne. It has also been suggested that Werner Siemens proposed the method as early as 1856.* (Strange, 1985, p. 545)

Soon, quite a few patents were issued on this concept of balancing. The Englishman Cromwell F. Varley (1828-1883) obtained British patent № 206 in 1860 and № 3,453 in 1862. And the American Joseph Barker Stearns (1831-1895) obtained British patent № 3,344 on November 11 in 1872 and the US patent № 132,931 on November 12, 1873, for a differential bridge circuit using a special magnet with two windings: the differential relay (Figure 140) (Beauchamp, 2001, p. 82).

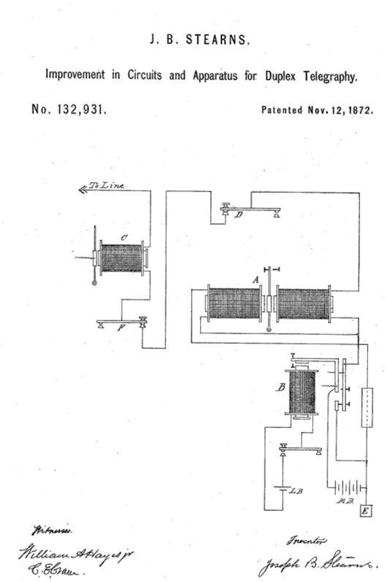


Figure 140: J.B. Stearns US-re-issue patent 132,931 on telegraph circuitry (1872).

Source: USPTO

> *Stearns had by now obtained a British patent (3344 dated November 11th 1872) in which he claimed the use of condensers together with a resistive artificial line for balancing, but the use of*

> *condensers with telegraph signalling had also been the subject of various patents granted to C.F. Varley who, together with William Thomson and Fleeming Jenkin, had, in 1865, formed a syndicate to jointly work their respective telegraph patents. … Between 1854 and 1870 he [C.F.Varley] was granted seven English patents, which included the use of 'induction plates' or condensers specifically in telegraph applications. In particular, Patents 1509 of 1859 and 3453 of 1862 proposed a combination of resistance and capacitance to form an artificial line which would accurately model a sub-marine cable.* (Strange, 1985, p. 547)

By that time, the 1870s, the Post Office Telegraph had been formed. They applied the balancing concepts at several telegraph landlines, and they were concerned about the patent position of both C.F. Varley and J.B. Stearns and started investigating their patent positions. In the end they paid a sum of $20,000 as royalty to J.B. Stearns

In the meantime, submarine cables had similar problems as the long landlines. Here balancing was also needed. In 1874, the American Alexander Muirhead (1848-1920) was granted British patent № 3,663 (dated Oct 23, 1874), which included "an accumulator or condenser, especially suited to duplex working, (and) is made by taking two strips of thin metal or tinfoil and laying one over the other, with insulating material between." He applied the bridge duplex (Figure 141). This patent was followed by others, such as British patent № 684 (February 2, 1875), British patent № 3,374 (September 27, 1875), British patent № 2,564 (June 21, 1876) and later patents in 1876, 1877 and 1888, all proposing balancing arrangements (Strange, 1985, p. 550).

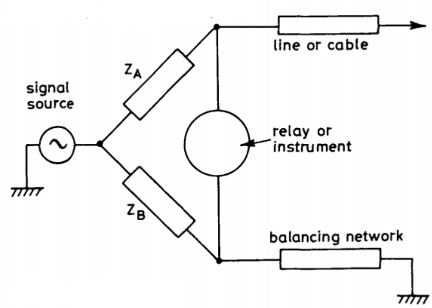


Figure 141: Principle for the Bridge duplex circuit.

Source: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4647765&tag=1

How relevant this balancing was became especially clear with the Atlantic telegraph cables due to costly failures we will discuss later on.

> *On January 2nd 1884, Alexander Muirhead and the Commercial Cable Co., who operated cables between England and France, England and Canada and Canada and New York, signed an agreement under which the cable company*

> *was licensed to use this (amongst other) patents on payment of a royalty for and during their remaining life, ie until 1897 under US Patent Law. This arrangement continued until June 1891 when the cable company refused to make further payment on the grounds that the US Patent had expired, US Patent Law holding that, where a patent for a similar invention had been granted in another country at an earlier date, the US Patent automatically expired along with the prior foreign patent. In this case the cable company claimed that the 1880 US Patent was for an invention identical to the 1876 British Patent which expired after 14 years.* (Strange, 1985, p. 550)

It was in 1894 that Muirhead & Co. started a court case against the commercial cable. It was complicated by the fact that both US patent law and British patent law were involved, but the case finally settled in favour of Muirhead & Co. This decision, however, was reversed on appeal. Here again, the question of priority is a diffuse one. Many engineers contributed, but some contributions were more effective than others. The total development is often a winding road with many different marking posts, in which knowledge is accumulated. Whatever the case, to the development of the early "balancing" telegraph lines, on both land and submarine, much can be contributed to both Cromwell Fleetwood Varley and Joseph B. Stearns, while J. Muirhead largely contributed to its refinement (Table 8).

> *S.A. Varley [brother of Cromwell], however, had already reasoned and demonstrated that a long line or cable could be modelled to any degree of accuracy by the use of resistors and capacitors, all that was necessary to replace the resistive balancing network for short lines, but it was an appreciation by the Post Office of C.F. Varley's earlier work that directed the attention of Stearns and, later, J. Muirhead to this possibility.* (Strange, 1985, p. 551)

Table 8: Significant British Duplex Telegraph patents

Patent №	Granted	Inventor	Description
BR 2,555	1854	C.F.Varley	Balancing: Use of capacitors and resistors
BR 1,509	1859	C.F.Varley	Balancing: Use of capacitors and resistors
BR 206	1860	C.F.Varley	Balancing: Use of electrolytic capacitors and resistors
BR 3,453	1862	C.F.Varley	Balancing: Inserting condensors at end of cable
BR 3,344	1872	J.B.Stearns	Duplex telegraphy and circuits therefore (Re-issue 1873)
BR 2,870	1873	J.B.Stearns	Duplex telegraphy: Artificial line
BR 3,879	1873	J.B.Stearns	Duplex telegraphy: Artificial line
BR 3,663	1874	A.Muirhead	Various balancing arrangements
BR 3,374	1875	A.Muirhead	Various balancing arrangements
BR 2,564	1,876	A.Muirhead	Various balancing arrangements

Source: (Strange, 1985)

For the duplex technology, soon special equipment was developed: the duplex telegraph stations. American inventors like Moses G. Framer and Thomas Edison soon developed their apparatus and obtained patents. Different techniques were tried, among which were the vibrating or undulatory currents that would become important in telephony. But that is another story….[207]

Some Later British Inventors of Telegraphs

It is not possible to describe the efforts of all these inventors, but we could try to illustrate the spirit of the time by describing the people and their inventions that were quite different. Many of them, starting as telegraph engineers working for others, exploited their inventions by creating companies. Many of them became innovator-entrepreneurs.

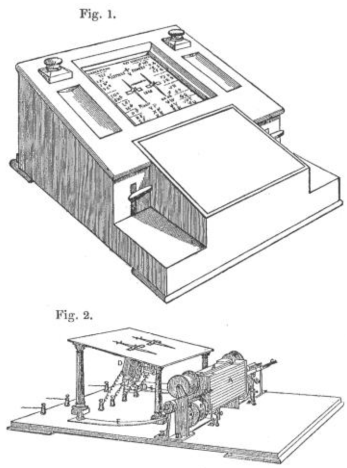


Figure 142: W.T.Henley Double Needle Telegraph (1852).

Source: http://www.ndl.go.jp/exposition/e/s2/7.html

William Thomas Henley (1814-1882): This telegraphic engineer was born in humble circumstances and became an instrument maker who worked for professor Daniell and professor Wheatstone. He developed the magneto-electric double needle telegraph (1852) that was used by his British and Irish Magnetic Telegraph Company and its successors between 1851 and 1868 for domestic circuits (Figure 142). It had no battery as a power supply, but the instrument was powered by pedal keys to rotate a magneto-electric dynamo. William Thomas Henly's apparatus also used its own code: Henly's code. In 1852, his concept was improved upon by the twenty-year-old Charles Tilston Bright. The two entrepreneurial and inventive men would later be instrumental in the realization of the Atlantic telegraph cable. Henley founded W.T Henley's Telegraph Works Co Ltd. Next to his instrument making, he went into the manufacturing of electric cables—a booming market in the 1850s. Henley set up as a submarine cable maker in 1857, and by 1859, he had his own factory

[207] See: B.J.G. van der Kooij: *The Invention of the Communication Engine Telephone*. (2015)

beside the Thames at North Woolwich.[208]

Charles Tilston Bright (1832-1888): Bright started his working career as a clerk for the Electric Telegraph Company at the age of fifteen. In the early 1850s he became an engineer for the Magnetic Telegraph Company, where he supervised the laying of submarine cables. Later he helped organize—with the American Cyrus Filed and the Englishmen John Watkins Brett, brother of the inventor Jacob Brett—the Atlantic Telegraph Company. This company would realize the first Atlantic cable from Trinity Bay in Newfoundland to Valentina, Ireland on August 5, 1858. The acoustic telegraph, known as Bright's Bells—a double needle instrument—was one of the inventions and improvements he introduced into the working of the telegraph (1856). He became later a Member of the British Parliament and president of the Society of Telegraphy Engineers and Electricians.

Edward Highton Jr. (1817-1859) and his brother *Henry Hilton* (1816-1874): Edward Highton was an Telegraphic engineer to the London & North Western Railway Company. His brother, schoolmaster and reverend Henry Hilton developed the gold leaf telegraph (1846). Later, the patent rights were sold to Cooke and Wheatstone to be used in England. In Europe, their telegraph only was used on a telegraph line in Baden, Germany. Their work resulted in several patents: Henry in 1844 and 1846 and Edward in 1850 and 1852 (see Table 7). Technically their work in telegraphy was not that dramatic, but their entrepreneurial contribution was high as they became the first competitor of the Electric Company. On July 25, 1850, they incorporated the British Electric Telegraph Company by Act of Parliament with Edward Highton Jr. as managing director.

> *The British company was to remain inert for two years, without a mile of line, until Cooke & Wheatstone's master patent expired and until it was able raise working capital. The latter was made difficult by the shareholders' lack of limited-liability, compounding the risk being incurred in opposing by the well-established Electric Telegraph Company.*[209]

Their company—in 1853—merged with the European and American Electric Printing Telegraph Company (1851-54) to form the British Telegraph Company.

[208] Source: Goodwin, G.: Henly, William Thomas http://en.wikisource.org/wiki/Henley,_William_Thomas_%28DNB00%29

[209] Roberts, S : Distant Writing, Competitor and Allies. http://distantwriting.co.uk/competitorsallies.html. (Accessed June 2015)

There were others, sometimes from a different background, that contributed considerably to the progress of the telegraph. Again, only a few can be recounted here. They have in common one of the great leaps in the development of worldwide telegraphy: the Atlantic submarine cables.

Edward Wildman Whitehouse (1816-1890) was a surgeon by profession who experimented with electricity and became a member of the Royal Institution in 1857. In 1856, he was appointed electrician to the Atlantic Telegraph Company and was, as one of the four projectors, responsible for the testing of the 1857/58 cables and for the design and operation of the equipment that would transmit the telegraph signals between Ireland (European landing) and Newfoundland (American landing). But those early cable projects soon ran into problems. The failure of the first attempt of the Atlantic cable was contributed to his approach to get the cable working with a too-high voltage. It destroyed the cable. Whitehouse became the scapegoat of the disaster (Green, 2014).

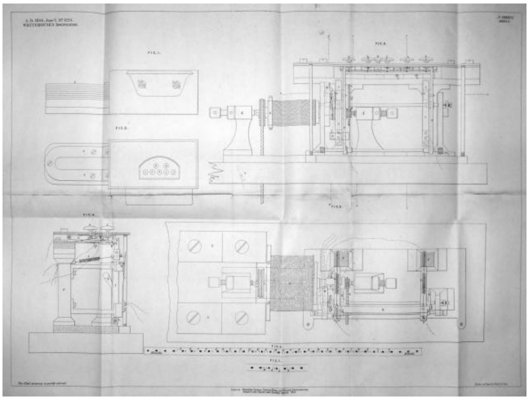


Figure 143: Whithouse patent № 1,225 of June 2, 1852 for a chemical telegraph.

Source: http://atlantic-cable.com/Books/Whitehouse/Patents/W1225-S1.jpg

Whitehouse was clearly a man of great scientific curiosity, making contributions to medicine, telegraphy, astronomy and meteorology. He was issued 35 patents between 1848 and the early 1880s for inventions ranging from telegraphy to roller skates. In the field of telegraphy, he took out several British patents, such as patent № 2,885 sealed on December 12, 1853; patent № 1,225, sealed on June 2, 1854 (Figure 143); patent № 2,617, sealed on November 20, 1855; patent № 1,726, sealed on July 21, 1856 and Patent № 1,862, sealed on August 1, 1860.[210]

[210] Roberts : S. History of the Atlantic Cable & Undersea Communications. Edward Prnage Wildman Whitehouse. Source: http://atlantic-cable.com/Books/Whitehouse/eoww.htm. (Accessed June 2015)

William Thomson (1824-1907) was both a scientist and engineer. In the world of science, he became professor at the University of Glasgow in 1846. At the age of twenty-two, he found himself wearing the gown of a learned professor in one of the oldest universities in the country and lecturing to the class of which he was a freshman but a few years before. In the field of telegraphy, he became known for his involvement of the transatlantic submarine cables[211] between Britain and America. For his work on the transatlantic telegraph project, he was knighted by Queen Victoria, becoming Sir William Thomson, 1st Baron of Kelvin. The laying of that Atlantic cable was not realized without problems, though, and it needed several attempts over nearly a decade before it would operate properly.

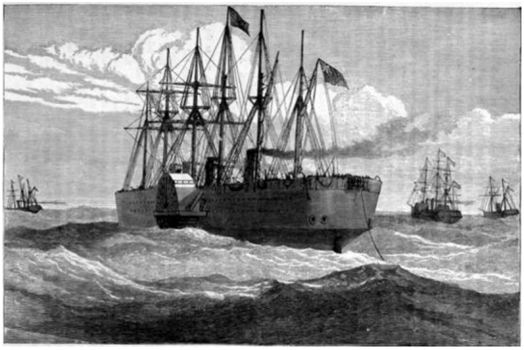


Figure 144: The Great Eastern cable ship.

Source: Whymper, F.: the Sea: Its Stirring Story of Adventure. www.gutenberg.org

The attempts in 1857 and 1858 involved the two largest warships in the world, the USS Niagara and HMS Agamemnon. The 1857 expedition ended in failure when the cable snapped as it was being released from onboard the ship. A second attempt in 1858 also failed. In a third attempt during July and August

[211] The making of insulated cables was one of the contributing technologies for underwater telegraph cables. An isolating material, gutta-percha, was used. This is the adhesive juice of the isonandra gutta tree that was introduced to Europe in 1842 by Dr. Montgomerie, a Scotch surveyor in the service of the East India Company. Twenty years before, he had seen whips made of it in Singapore, and believed that it would be useful in the fabrication of surgical apparatus. Faraday and Wheatstone soon discovered its merits as an insulator, and in 1845 the latter suggested that it should be employed to cover the wire which it was proposed to lay from Dover to Calais. It was tried on a wire laid across the Rhine between Deutz and Cologne. In 1849, Mr. C. V. Walker, electrician to the South Eastern Railway Company, submerged a wire coated with it, or, as it is technically called, a gutta-percha core, along the coast off Dover. The following year, Mr. John Watkins Brett laid the first line across the channel. It was simply a copper wire coated with gutta-percha, without any other protection. The transatlantic cable consisted of a strand of seven copper wires, one weighing 107 pounds a nautical mile long, covered with three coats of gutta-percha, weighing 261 pounds per nautical mile and wound with tarred hemp, over which a sheath of eighteen strands, each of seven iron wires, was laid in a close spiral. It weighed nearly a ton to the mile, was flexible as a rope, and able to withstand a pull of several tons (Munro, 1891).

1858, the Niagara and the Agamemnon successfully laid the first operable transatlantic cable …

The project's team of scientists, electricians and engineers onboard ship was enormous for the time, with 33 men just handling the cable. Unfortunately, the 1858 cable failed after only three weeks. The failure was ultimately attributed to high signaling voltages which "burned out" the line. A four attempt was made in 1865. At that time, the largest ship afloat was the bankrupt steamship the Great Eastern. That year, the Great Eastern was refitted to carry over 500 crew and provisions, more an 8,000 tons of coal, and over 2,700 miles of cable weighing more an 5,000 tons. The new cable was nearly four times as bulky and almost twice as heavy as the 1858 cable based on design changes recommended by Professor Thomson and the Chief Engineer Charles Bright. The 1865 cable again broke in mid-ocean, leaving the expedition with another failure. A fifth attempt in 1866 finally brought success. the expedition that year not only succeeded in laying a fresh cable, but also recovered the broken 1865 section from the ocean floor and attached it to a new portion laid in 1866, completing a second line. By September 1, both the new 1866 and the repaired 1865 cables were completed; becoming the first successfully operating Atlantic cable connections between Ireland and Newfoundland, a distance of nearly 2,100 miles.[212]

German Activity in Pointer Telegraphy: Werner Siemens[213]

In Germany, it was Werner Siemens (1816-1892)—the son of a modest farmer who had fourteen children—that played an important role in the early days of telegraphy[214]. He was living in the time that the Prussian landowning class of the Junkers ruled over the peasantry, and he grew up on the estate (Obergut) of Herr von Lenthe in the aftermath of the Napoleonic Wars. In 1814, the Kingdom of Hanover was created by the Congress of Vienna, and the British George III had become King of Hanover. Due to the English link, this area was also called the Royal Hanoverian Province of Great Britain. In his biographic memoir, it states:

Werner's family would be categorized among the upper levels of the educated middle class. But the family's financial circumstances were in stark contrast to its

[212] David & Julia Bart: *Sir William Thomson, on the 150 Anniversary of the Atlantic Cable*. Source: http://atlantic-cable.com/CablePioneers/Kelvin/ (assessed January 2015).

[213] We described the role of Werner Siemens related to the electric motor already compactly in another case study titled *The Invention of the Electro-motive Engine*. But as his own recollections so beautifully describe his work in relation of the spirit if the time of his days in Germany, we explore here his work related to telegraphy more in depth, citing from his "Recollections" extensively.

[214] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015) pp. 112-113

> *social status and were exacerbated still further by the persistent agrarian crisis of the 1820s, making it difficult for the children to get a formal education consistent with middle-class aspirations.* (Siemens, 2008, p. 9).

In his own words, he recollected later:

> *For twelve years my parents enjoyed a happy life in Lenthe. Unfortunately, however, the political condition of Germany and especially of Hanover, then again under English rule, was very depressing to a man like my father. The English princes, who then kept court at the Hanoverian capital, troubled themselves but little about the welfare of the country, which they regarded chiefly as a hunting ground. The game laws were in consequence very strict, so that it was a common remark that in Hanover to kill a stag was more criminal than to kill a man!* (Siemens, 2008, p. 35)

The family moved in 1823 to the Menzendorf estate near Schönberg in Mecklenburg, as his father became entangled in exactly such game-conflicts. There Werner went to the Bürgerschule till 1829, followed by the grammar school in Lübeck. In 1835, at the age of eighteen, he had entered the military Corps of Engineers of the Prussian Army in Berlin, and he obtained his technical education at the Artillery and Engineering School. He came in touch with the subjects of those days: early chemistry and pioneering electricity and it lead to his early experimentation with electric plating in the artillery workshop of the school.

> *The three years which, from the autumn of 1835 to the summer of 1838, I spent at the Berlin Artillery and Engineering School I reckon to be the happiest of my life. The social life with young people of the same age and with the same aims, the common study under the guidance of able teachers, of whom I will mention only the mathematician Ohm, the physicist Magnus, and the chemist Erdmann, and whose instruction opened to me a world new and full of interest, made this time one of extraordinary enjoyment. … I believe it was one of the happiest moments of my life when a German silver teaspoon, which I had dipped into a beaker filled with a solution of hyposulfite of gold and connected with the zinc pole of a Daniell cell, while the copper pole was connected with a louis d'or as anode, changed in a few minutes into a golden spoon of the finest and purest luster.* (Siemens, 2008, pp. 52-53, 63)

He sold the right of using his electroplating method in 1842 to a Magdeburg jeweller for forty Louis d'Or and lodged a petition for a patent. He obtained the protection for a period of five years. As his parents had died when he was about twenty, he became the sole provider for nine younger siblings in 1839. The revenues from his first inventions might have lightened that burden, but:

> *I was therefore obliged to look out for some way of earning money in order to fulfill my obligations as senior of the family, and that appeared to me to be easier in Berlin than elsewhere. (Siemens, 2008, p. 65)*
>
> *In Berlin, my efforts to earn money by my inventions were soon attended with success, although I was very much hampered as a military officer by being considerably restricted in the choice of devices for initiating business undertakings. I succeeded in concluding an agreement with the German silver manufacturer J. Henniger, by which in return for a share in the profits I agreed to set up an establishment for him for gilding and plating in accordance with my patent. Thus arose the first establishment of its kind in Germany. In England, a Mr. Elkington had already started a similar establishment, employing another process, now in general use – viz. depositing from gold and silver cyanides – which was soon widely extended. …*
>
> *William succeeded in selling our English patent to Elkington for £ 1,500. This in our then circumstances was a colossal sum, which put an end for some time to our financial difficulties. … On his return from England, William reentered his Magdeburg factory, but soon found he had lost his relish for such small undertakings, after becoming acquainted with the large scale of English industrial operations and acquiring a taste for English life. He accordingly proposed to settle in England, and as I approved of the project, we took out a patent there for the jointly elaborated differential governor [regulator for a steam engine], in order to facilitate its introduction into England.* (Siemens, 2008, pp. 67-68, 69)

This first entrepreneurial act, born out of necessity to earn a living for him and his siblings, would be the start of more experimenting with electro-plating. His brother now located in England, he went to visit him, and was impressed and stimulated by what he observed. Later, he made a visit to Paris—at that time bustling with the first Great Industrial Exhibition of 1844—which he reached by travelling on the top of the mail coach. It gave him a flavour for the world outside the Germany of those days. Back in Berlin, he became involved in scientific circles of the physicists of those days (ie Magnus, Dove, Reiss, Helmholtz, Wiedemann):

> *Association and cooperation with these young men, distinguished by talent and earnest endeavor, strengthened my preference for scientific study and labors, and kindled in me the determination to be in future the votary of pure science alone. But circumstances were stronger than my will, and the native impulse never to let acquired knowledge lie idle, but as far as possible to make some use of it, led me ever and again back to technology. And so it has been all my life. My affection has always been given to pure science as such, but my labors and achievements have been for the most part in the domain of applied science.* (Siemens, 2008, p. 73)

Experimenting with electricity and trying to determinate the velocity of projectiles—he was still in the military—he came in touch with a model of Wheatstone's dial telegraph. It would be the start of his venture in telegraphy. In 1847, using extremely simple materials—a cigar box, tin-plated sheet iron, a few scraps of plain iron and a bit of insulated copper wire—he built a dial telegraph that operated reliably and was, thus, far superior to previous equipment. "My telegraph uses only one wire, can be played with keys like a piano, and combines the greatest reliability and such speed that one can telegraph nearly as fast as the keys can be pressed. Yet it is ridiculously simple and quite independent from the strength of the current," he reported to his brother Wilhelm (Siemens, 2008, p. 10).

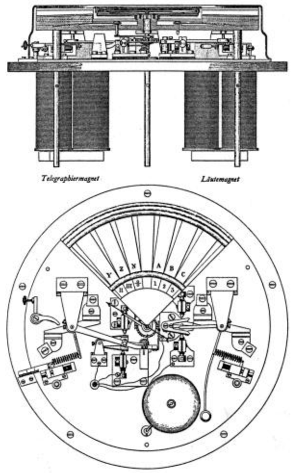


Figure 145: Siemens patent for the pointer telegraph (1847).

Source: Courtesy of Siemens Corporate Archives, Munich.

As this design model needed prototypes, he entrusted the construction of his new device to a precision-instrument maker named Johann Georg Halske (1814-1890), whom he knew from the Physics Society, an association of ambitious young practitioners and researchers who met at the house of physics professor Gustav Magnus on the Kupfergraben in Berlin (Siemens, 2008, p. 79). Halske was a gifted *mechanicien* who was constructing precision instrument in 1844, working in his workshop Berlin. The Prussian metropolis, with its many workshops, had by that time become a centre for the precision mechanics' craft, with many of its craftsmen of Hugenot origin[215].

Halske and his partner Friedrich Boetticher specialized in designing and building laboratory and demonstration equipment for physics and

[215] Huguenots as immigrants to Brandenburg and Berlin began to arrive at the end of the seventeenth century. They came as Protestant religious fugitives (*réfugiés*) from Catholic France. Altogether, about 20,000 Huguenot *réfugiés* arrived. It is estimated that a fifth of all Berliners at the start of the eighteenth century were of Huguenot origin. As good skilled persons with urgently needed expertise, the Huguenots were the highly-qualified migrants of the time. Source: http://www.berlin.de/775/en/city-of-diversity/diversity-in-berlin/2655-3757-the-huguenots.en.html. Accessed June 2015)

chemistry, as well as optical and geodetic instruments. They worked mainly for the university, and this invitation to construct a telegraph apparatus ensured an additional lucrative source of support for their joint craft operation (Blocher, 2014, p. 24). So Halske created the Siemens & Halske pointer telegraph (Figure 146).

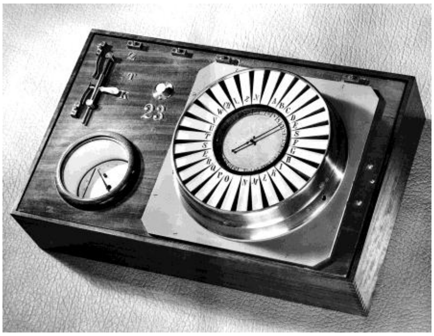


Figure 146: Siemens pointer/dial telegraph (1847).

Source: Courtesy of Siemens Corporate Archives, Munich.

Siemens, in the meantime, through his activities in the Physics Society and the Polytechnic Society, became more and more convinced that his future would be in telegraphy.

> *… the growing responsibility for my younger brothers and sisters, matured my resolution to relinquish military service and by means of telegraphy, whose great importance I clearly perceived, create for myself a new vocation, which should also afford me the means of fulfilling the duties I had undertaken toward my younger brothers. I was therefore intent on the preparation of my new telegraph, which was to form the bridge to the new career, when an event occurred which threatened to throw all my plans to the winds.* (Siemens, 2008, p. 79)

That event was the result of the spontaneous signing of a petition to *Protest gegen Reaktion und Muckertum* (protest against reaction and religious cant) after a public lecture. Siemens and his fellow military comrades from the artillery workshop were reprimanded. To avoid being sent back from the artillery school to their regiments, Siemens wanted to prove his indispensableness and quickly managed to create a new form of guncotton.

> *By good luck, the idea of guncotton occurred to me. This had been discovered a little while before by Professor Schönbein in Basle, but had not yet been brought into use. It appeared to me beyond question that it could be so improved as to be made available for military purposes.…About eleven o'clock I had packed a goodly quantity of faultless guncotton, and sent it with a formal explanatory letter to the war minister. The result was glorious. The minister of war instituted a shooting trial in his large gardens, and, as it went off brilliantly, immediately induced the heads of the ministry to make a regular trial with pistols. On the very same day, I received an official order direct from the minister to repair to the powder manufactory at Spandau, which had already been instructed to place everything required at my disposal, to institute experiments on a larger scale. It is seldom, I fancy, that a memorandum to the war office has been so quickly acted*

> *upon! Of my returning to the brigade there was no more talk.* (Siemens, 2008, pp. 83, 85)

Siemens, when his guncotton proved not to be too serviceable, devoted himself again to telegraphy. Soon he was to assist a staff commission, which was deliberating on the introduction of electrical instead of optical telegraphs. As open airlines were considered—by the military—to be vulnerable to vandalism by the public, he explored subterranean conductors. But that was easier said than done. Luckily, through his brother William in England, he came in contact with gutta-percha.

> *At my suggestion the commission gave orders for more considerable experiments with such wires insulated by gutta-percha, which were begun in the summer of 1846 and continued in 1847. In samples placed on the track of the Anhalt Railway in 1846, the gutta-percha was rolled around the wire. It turned out, however, that the seam thereof became loosened in the course of time. I accordingly constructed a screw press, by which the heated gutta-percha was cohesively pressed around the copper wire under the application of a high pressure. The conducting wires, coated by the help of a sampler press constructed by Halske, proved to be well insulated and permanently retained their insulation.* (Siemens, 2008, p. 89)

The new way of isolation was used in the Berlin-Potsdam line, and the first long subterranean wire from Berlin to Grossbeeren was laid (1847). These experiments strengthened his conviction that electric telegraphy was the future of long-distance communications. He wrote to his brother:

> *… I have now practically decided to make a career of telegraphy, whether in or out of the army. Telegraphy will become an important branch of scientific technology in its own right and I feel the call to further its organization since I am convinced that it is still in its early childhood …* (Siemens, 2008, p. 90)

Figure 147: View at the Siemens & Halske workshop at Schöneberger Strasse in Berlin (1847).

Source: www.Siemens.com

So he created on October 1, 1847, together with Georg Halske and his cousin Georg Siemens, the Telegraphen-Bauanstalt von Siemens & Halske (Siemens & Halske Telegraph Construction Company) under a partnership agreement. The two active owners would each receive two-fifths of the company's income, while the cousin, as a silent partner, would receive one-fifth. They opened, two weeks later on October 12, a workshop on Schöneberger Strasse (Figure 147) (Blocher, 2014, p. 26).

> *Since Halske like myself lacked available resources, we had recourse to my cousin, Georg Siemens, a barrister residing in Berlin, who lent us 6,000 thalers*[216] *for the erection of a small workshop on condition of a share in the profit for six years. The workshop was opened on October 12, 1847, in the rear part of a house in the Schöneberger Strasse – where Halske and I also took rooms…* (Siemens, 2008, p. 90)

As Lieutenant Siemens was well connected with the higher echelons of the military and the ruling aristocracy, he could advocate telegraphy among the governmental decision makers of those days. It would prove to create interesting contacts for his later entrepreneurial activities—activities that were influenced by the major European turmoil of that time: the 1848 Revolutions that occurred all over Europe[217].

> *The report of the astonishingly favorable results of these experiments [the Berlin-Potsdma and Berlin-Grosbeeren lines] went the round of the higher circles in Berlin, and brought me a command from the Princess of Prussia to give a lecture in Potsdam on electric telegraphy to her son, later Crown Prince Frederick William and Emperor Frederick. …*
>
> *I had found little time to give heed to the wild commotion which, since the February revolution in Paris, was spreading all over Germany. With elemental force the mighty stream of political excitement rushed onward, tearing down all the feeble dikes which the existing powers aimlessly and without plan opposed to it. Discontent with the prevailing state of things, the hopeless feeling that they could not be changed without violent subversion, penetrated the entire German people and extended to the upper strata of the civil and even the military administration of Prussia.* (Siemens, 2008, pp. 92, 93)

The revolutionary movement spread rapidly, resulting in popular demonstrations, also in Berlin at the Alexander-Platz on the night of March 18-19, 1848 (Figure 148).

> *I saw from my windows how a division of this citizen guard came in great excitement from the Castle Square and threw their scarves and staves on the square in front of the Anhalt Gate with the cry "Treachery! The military have fired upon us!" In a few hours the streets were covered with barricades, the sentries were attacked and in part overpowered, and the struggle with the garrison, which*

[216] About a thousand English pounds in those days. The equivalent would be about DM 20,000 (pre-2000).

[217] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015) pp. 7-11

for the most part confined itself to defense, and without exception remained true to their flag, quickly extended over a large part of the town. …

It was a critical moment, for to a certainty the struggle would have been renewed in the Castle Yard, where a battalion had been stationed, a struggle the outcome of which, as the rest of the military had left the town by royal order, would have been exceedingly doubtful had not a savior appeared in the person of young Prince Lichnowsky. From a table placed in the middle of the Castle Square he addressed the crowd in a loud audible voice. He said His Majesty the King had in his great goodness and grace put an end to the struggle, in that he had withdrawn all the military and had entrusted himself entirely to the protection of the citizens. All demands would be granted, and they should now go quietly home. The speech manifestly made an impression. To the question from the people whether everything was really granted he answered – "Yes, everything, gentlemen!" "Smoking too?" sounded another voice. "Yes, smoking too" was the answer. "In the Tiergarten also?" – was further enquired. "Yes, you may smoke in the Tiergarten also, gentlemen." That was decisive. "Well, then, we can go home" was the general exclamation, and in a short time the cheered-up multitude left the square. The presence of mind with which the young prince – probably on his own responsibility – conceded the liberty of smoking in the public streets and the Tiergarten possibly averted more serious mischief. (Siemens, 2008, pp. 94-95)

Figure 148: Berlin, Alexander-Platz, the night of March 18-19, 1848.

Source: www.welt.de

About these events, he wrote to his brother in March 1848:

> *I hasten, dear brother, to send you my first greeting from a free country! What a change in 2 days! The two shots fired by mistake on the Castle Square have brought Germany a whole generation forward at one bound. Outside my window the Civic Guard of my district is just falling in. The rest of the military is withdrawing from the town with funeral music, as the people demand. It was a frightening but beautiful night. The bright full moon was encircled by a brilliant halo, all windows were shining brightly wherever the fight was not raging. In the streets no sad or anxious face, only a terrible earnestness in the features of all the people, including the women, combined with belligerence and the humor so characteristic of the Berliners even in the most serious situations. On that fearful night I solemnly made my apologies to the Berliners for the bad opinion which I previously had of them! I listened with tears in my eyes to the sound, powerful logic of people from the lowest classes and I have become convinced that no nation can be more ripe for freedom. You should have seen how courageously they all rushed on when the word went around: "Here they come – Forward brothers!" If only we had weapons, was the general cry, it would soon be over, but even without them we will win. And just think, during the whole revolution not a single street lamp was broken, not a single piece of private property touched! All the houses stood open and the crowd surged through them up and down stairs but not a thing was stolen. Can one now not be proud to be called a German?* (Siemens, 2008, p. 96)

Those events had a particular consequence for Siemens. In the summer of 1848, the young Telegraph Construction Company received its first prestigious major order: a government contract to build a telegraph line more than 500 kilometres long between Berlin and Frankfurt am Main, where the German National Assembly was convening in the aftermath of the revolutionary March uprisings of 1848. This, the longest telegraph line on the European continent at the time, was put up within an extremely short time, so that on March 28, 1849, the election of King Friedrich Wilhelm IV of Prussia as German Emperor was wired to Berlin within the very hour it was announced. It was a technical sensation that attracted attention not just within Germany but—most significantly—from abroad (Siemens, 2008, p. 12).

Soon, more telegraphy lines were started: a line from Berlin to Cologne and the Prussian frontier at Verviers, and after that others to Hamburg and Breslau. Then the frontiers were crossed, with the telegraph line from Cologne to Brussels.

> *During the construction of the line I got to know the entrepreneur of the pigeon post between Cologne and Brussels, a Mr.Reuter, whose useful and profitable business appeared to be hopelessly destroyed by the laying of the electric telegraph.*

> *When Mrs. Reuter, who accompanied her husband on his journeys, was lamenting over this destruction of their business, I gave the couple the advice to go to London, and there set up a dispatch-forwarding bureau, such as had just been established in Berlin by a Mr. Wolff , with the cooperation of my cousin the aforementioned law counselor Siemens. The Reuters followed my advice with remarkable success. Reuter's telegraph agency in London and its founder, the rich Baron Reuter, have today a worldwide reputation.* (Siemens, 2008, pp. 127-128) [218]

As the military authorities force him to make a decision—either become involved in government telegraphy or resign from the military—he chose the latter. That ended his military career.

> *The final decision concerning the turn I should give to my future life had now to be made. The military authorities had only with reluctance granted the extension of my order for service with the Ministry of Commerce, and had emphatically declared that an extension of the same would not be granted. I had the choice either of stepping back into active military service, or of going over to government telegraphy, in which my position as managing engineer was assured, or lastly of renouncing every position of public service, and devoting myself entirely to private scientific and technical activity. I decided in favor of the last.* (Siemens, 2008, p. 128)

His relations with the military and the state commission on telegraphy deteriorated after problems with the isolation of underground cables occurred. Werner Siemens, the military man, decided to go and work in the new promising field of telegraphy. He was no longer to be the "market maker", bringing in the projects; he would expand his company:

> *…, the factory for telegraphic apparatus, which I had founded along with my friend Halske, and into which I had reserved the right of entry, had already under his excellent management obtained considerable recognition by reason of its remarkable achievements. The great importance of electric telegraphy for practical life was perceived, and the managers of railways in particular began to increase the efficiency of the lines and the security of their working by laying down telegraph wires for intelligence and signals. In connection with this an abundance of interesting scientific and technical problems cropped up, which I felt a vocation to solve. My choice therefore could not be a matter of doubt. In June 1849, I requested my discharge from the military service, and soon afterward also resigned*

[218] In 1851 Paul Julius Freiherr von Reuter (Baron de Reuter, 1816-1899), after an interlude in Paris where he started as a translater for Havas, he opened in London, the center of world information, a telegraph service between London, Paris and Berlin. He made a fortune with sales of political and economic news by Reuter's telegrams. (Huurdeman, 2003, p. 88)

> *my office as technical manager of the Prussian state telegraphs.* (Siemens, 2008, p. 130)

Also, in 1850, he was faced with competition, as Samuel Morse's system was introduced in Germany.

> *The simplicity of Morse's apparatus, the relative facility of acquiring the alphabet, and the pride which fills everyone who has learned to use it and which causes him to become an apostle of the system, have in a short time ousted all dial and older letter-printing apparatus. Halske and I at once perceived this superiority of the Morse telegraph, resting on manual dexterity, and made it our task therefore to improve and perfect the system as far as possible mechanically.* (Siemens, 2008, p. 137)

Siemens wrote about his experiences with telegraphy, published the "Memoire sur la telegraphie electrique", and read it before the Paris Academy of Sciences in April 15, 1850. He was proud and stated: "This public testing of my literary firstborn in the telegraphic domain by famous members of the first scientific tribunal in the world produced a deep and very stimulating impression upon me" (Siemens, 2008, p. 139).

Figure 149: A Troika of the Russian express mail service.

Source: www. welt.de

The focus was now on international development. Through the efforts of his brother William in Engl*and, he presented his* telegraph apparatus at the Great Exhibition of 1851 in London. But the business went also in another direction: Russia. In 1852, he travelled by postal coach, troika (four-wheeled peasant's cart with three horses (Figure 149)) and kibitkas (horse powered sledges) to Riga and St. Petersburg. There he received a cordial welcome from the most celebrated representatives of Russo-German science, like the academicians Kupffer, Lenz, Jacobi and von Baer. Getting there had been quite an adventure.

> *As I traveled for the first time into Russia proper, knowing no Russian, I had to look about in Riga for a traveling companion. In a newspaper advertisement such a person turned up, who possessed a kibitka and spoke German and Russian*

> *perfectly. As appeared when we were already on the road, this was an elderly merchant's wife from Riga, who sought in this way to subsidize her annual business trip to St. Petersburg. She had packed the sledge so full of straw and bedding that one could only lie down in it, and then had the mat covering close over one's face. It had become bitterly cold, and the nearer we got to our goal the stronger became the dry, keen northeast wind, which with 18 degrees below zero Réaumur mocked at the warmest wrapping. Then I learned in Russian fashion to drink hot tea in great quantities, as soon as a station was reached, for only in that way could any warmth be obtained.* (Siemens, 2008, p. 165)

He managed to do good business, as he obtained the commission to lay an underground line from St. Petersburg to Oranienbaum, with a cable junction to Kronstadt. Then his brother Carl Siemens became involved in the business (Figure 150).

> *In the autumn of 1853, Carl completed the Kronstadt cable line to Count Kleinmichel's perfect satisfaction. This was the first submarine telegraph line in the world which has remained permanently serviceable. … In the spring of 1854, the Crimean War broke out. We received in consequence the commission to construct as quickly as possible an overhead telegraph line along the high road from Warsaw to St. Petersburg, or rather to Gatshina, which was already connected with St. Petersburg by an underground wire. …Thus the line, about 1,100 versts [two-third of a mile] long, was completed in a few months, to the great astonishment of the Russians, who were unaccustomed to quick and well-organized work. … The speedy construction of a line from Moscow to Kiev was entrusted to us. Between the former town and St. Petersburg an underground line was already in operation, as mentioned before. Then in quick succession lines were ordered from Kiev to*

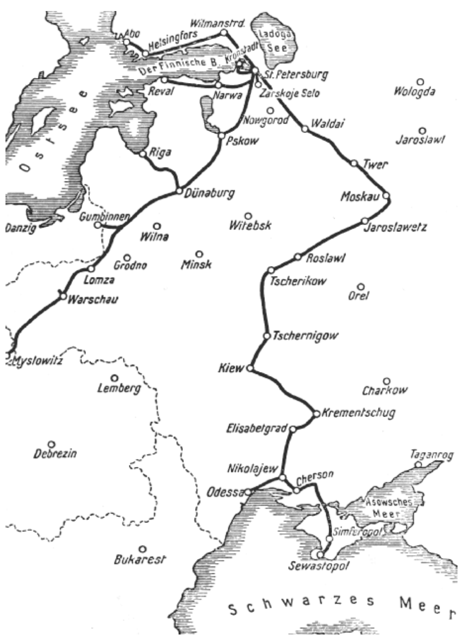


Figure 150: The Russian state telegraph network built by Siemens & Halske, 1852–1855.

Source: (Siemens, 2008) p.182

> *Odessa, from St. Petersburg to Reval, from Kowno to the Prussian frontier, from St. Petersburg to Helsingfors; after overcoming infinite difficulties these were all completed in the years 1854 and 1855, and were of great utility to the Russian Empire in the Crimean War raging at the time.* (Siemens, 2008, pp. 181-183)

And so it was in the Crimean region that the British laid their submarine telegraph cables that made communication with London possible.

As a result of all this increasing business, the company, Siemens & Halske—originally a workshop where telegraph apparatus were individually made by instrument makers like Halske—experienced a meteoric growth and was becoming a factory.

> *By the end of 1848, the company had ten employees. Most were metal workers and mechanics who had to be given additional training to build telegraphs. By the next year, the company's abundant order backlog had made it necessary to double the staff. But this proved to be a significant problem. First of all, the supply of adequately qualified workers was limited. Second, Halske was scrupulously concerned to hire "only the best workers". And they had to work hard. As a rule, they spent about 60 hours a week at the lathe or other machine tools, sweating in the crowded, low ceilinged, poorly ventilated factory rooms—which, still worse, were overheated by furnaces and steam pipes.* (Blocher, 2014, p. 31)

This fast growth also created another problem. Halske's perfectionism in technical affairs came into conflict with Siemens' sense for business. And business they needed, as Siemens leave of the military had also resulted in decreasing projects in Germany.

> *The cancellation of the Prussian government contracts in 1851 posed a serious challenge for Siemens & Halske. The only real option was to bring in orders from other countries. The London Great Exhibition of that year offered an ideal opportunity for the Telegraphen-Bauanstalt to make its debut on the international scene. Werner von Siemens and his three brothers William, Friedrich, and Carl made the journey to England to pursue contacts with potential clients, but as hard as they worked, they met with no success. …*
>
> *Meanwhile, the business connections that Werner had been nurturing in Russia as early as 1849 now began to pay off. In 1853 the company signed an agreement with the Russian government that would help Siemens & Halske grow to unprecedented dimensions. By 1855, the Russian contracts would cause business volume to quintuple, and operations in Russia would remain a cornerstone of the company's business for years.* (Blocher, 2014, pp. 34-35)

Here one observes the classical problem of the two pioneers in the early stage of development of a company: they outgrow each other when the company grew in size (sales, people, and activities). It is a pattern that can be observed repeatedly: the technical—often of a more perfectionist nature—partner versus the commercial—often of a more opportunist nature—partner. The cooperation seemed to have a limited survival rate[219].

> *Halske's natural talent, his sensibility as an artist in the field of mechanics, stood in the way of the victory march of the factory system as a new form of commercial mass production, which was spreading increasingly to the former 10-employee workshop. But he was unable to escape the change—by the end of the 1850s, the Telegraphen-Bauanstalt came more and more to look like a factory. The Berlin firm now had about 150 workers; individual work rooms had specialized in specific parts of the increasingly mechanized production line.* (Blocher, 2014, p. 36)

After some business attempts created by Werner and William—they explored the production of water meters and submarine cables (both booming markets at that time) and failed—the differences became more and more obvious. Therefore, Halske resigned in 1867 from the company.

> *The departure of his business partner, already announced at the beginning of the 1860s, weighed heavily on Werner von Siemens. After all, he was only too aware of what he had in Halske. But Werner could not be other than who he was, any more than his partner could. From his viewpoint, Halske was going straight into retirement—something the entrepreneur found inconceivable. "I cannot and will not retire yet, I hate a lazy pensioner's life, I want to work and be useful as long as I can." Siemens' goal still remained, as it always would, to carry his company onward to more and greater successes. … Johann Georg Halske and Werner von Siemens parted in complete amity. Their friendship had been too long and close for anything else.* (Blocher, 2014, p. 45)

Siemens & Halske became a major manufacturer of telegraph equipment and produced many telegraph systems, among them telegraph stations based on Morse's concept (Figure 151).

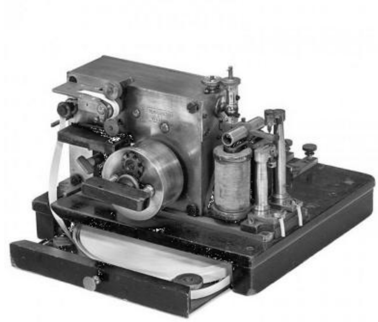
For Siemens, next to the expansion of telegraphy—like creating a factory in London in 1863—a new business was looming at the horizon: the development of the electromotive engine self-exciting dynamo that was to replace the cumbersome electric battery—a development that was stimulated by the power needs of the telegraph systems. But that is another

[219] In England, the cooperation between the scientist Charles Wheatstone and the businessman William Cooke had not lasted long and ended in a dispute about priority. In America, the more conceptually oriented Samuel Morse and the practically oriented Alfred Vail ended their cooperation in 1848.

story....[220]

> *But since the maintenance of very large batteries, such as the working of long lines with uniform current or intermittent battery current requires, was troublesome and costly, Halske and I tried mechanically to transform battery currents of low tension into uniform currents of higher tension. … The name given by me to the apparatus, "dynamo-electric machine," has also become general, although frequently corrupted in practice into "the dynamo."* (Siemens, 2008, pp. 260, 355)

This short description illustrates the interconnection of people active in the pioneering telegraph industry. They illustrate that from all these inventions resulted a considerable business activity. Some of the world's largest corporations (such as the German Siemens AG) found their origins in these early entrepreneurial activities. Or, in other words, from the "cluster of innovations" resulted the "cluster of businesses".



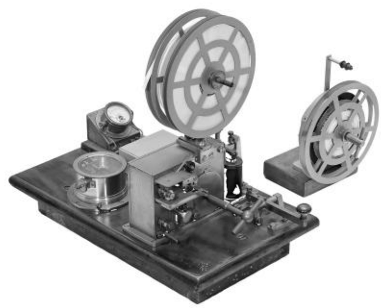


Figure 151: Morse Telegraph stations built by Siemens & Halske.

Source: www.liveauctioneers.com (top); www.the-saleroom.com (bottom)

The Invention of Needle and Pointer Telegraphy

The invention of needle telegraphy—as it was realized on the European continent—was a momentous event in the development of telecommunication. The preceding systems—such as the different optical systems—had already proved that telecommunication was advantageous to society, or at least in most cases to the government of societies. Then the electric predecessors—the electro-static and electro-chemical telegraphs—indicated that the versatility of electricity made it a possible medium to use for communication over longer distances. But the invention of the electro-magnetic galvanometer was needed to stimulate further development of

[220] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015) p. 87

needle telegraphy—a development that in its turn would lead to the development of pointer telegraphy.

Looking at the timeline of Cooke and Wheatstone's early endeavours (Figure 152), one observes that William Cooke's ideas about telegraphy were the fruit of his acquaintance with scientific contributions that took place on the European continent (eg Schilling, Gauss, Weber and Steinheil)—contributions that coincided when Cooke became acquainted with them through the lecture given by Professor Muncke in Heidelberg. Here the contributions of the scientists (using the galvanometer to indicate incoming communication) were converted into the idea of a needle-based telegraphic apparatus that could be used for specific purposes: the Heidelberg idea.

> *When Mr. Cooke saw the telegraphing, and was told the instrument could work through great distances, the idea struck him that such a thing might be useful in England, particularly in tunnels along the railroads.* (von Hamel, 1859, p. 50)

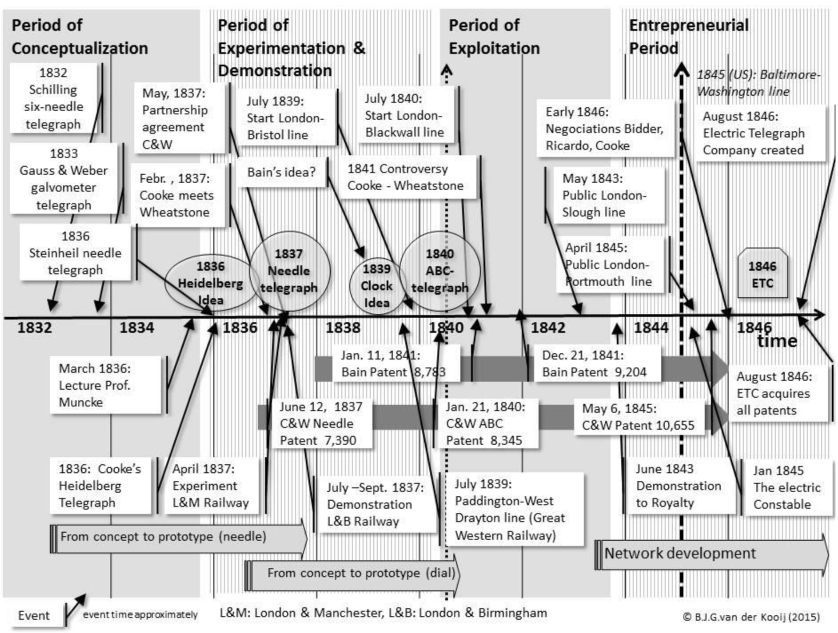


Figure 152: Timeline of Cooke's and Wheatstone's endeavors around telegraphy.

See text about Alexander Bain's telegraph for details about Bain's idea.

Source: Figure created by author

One could image that moment: a young man in his thirties, having built up quite some experience in life (eg his military service in India), maybe not too satisfied with his present occupation, who saw in his mind a concept of something fascinating. A moment of insight of something that he could undertake, a challenge to realize for his entrepreneurial mind. A moment in which his vison of something new to undertake, and—maybe—the discontent with his present station in life, came together. Now all that was needed was the guts to pick up the challenge that he saw in his mind.

In a relatively short time, Cooke picked up the galvanometer idea in 1836 (the Heidelberg idea in Figure 152). His own early construction (the Heidelberg telegraph) was converted by the *mechaniciens* into the needle telegraph[221]. From the early and patented five-needle telegraph to the one/two needle telegraphs, these apparatus were used for experimention and demonstration purposes to attract the potential customers of the railroad communication, as their application was seen to be in rail telegraphy. An important patent for a needle-based system—GB patent № 7,390, 1837—was obtained by Cooke and Wheatstone in 1837. In the short period of 1-2 years, the "galvanometer idea" was converted into something tangible (and patentable).

Then there was the second development. Here Wheatstone came on stage as he influenced the development of a different concept: the "clock idea" in Figure 152. It was an idea that might have been borrowed from somebody else, like Alexander Bain's idea to use an electric clock for the development of a printing telegraph (Figure 131). Whatever the case, Wheatstone's ideas were obviously influenced by the clock principle (Figure 114), with the result that GB patent № 8,345, 1840 was granted for the ABC telegraph (Figure 121). The galvanometer used in the needle telegraph was replaced by the electro-magnet used in the pointer telegraph. Bain's concept continued the use of the galvanometer-principle to avoid being in conflict with the patent for the ABC-telegraph, where Wheatstone applied the electro-magnet. It would lead to two different development trajectories.

In a following period, both Cooke and Wheatstone tried to exploit their inventions by building telegraph lines along railways. They managed to build a thousand miles of lines in England in the early 1840s. Bain was

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[221] Cooke's very first mechanical telegraph was made by John Brittan, a clockmaker with Moore Brothers in 1836; it was the size of a barrel organ and was never completed. Brittan went on to build clockwork telegraphs and alarm bells for Cooke in 1837 and 1838 and attended the first demonstration of the electric telegraph on the London & Birmingham Railway on behalf of his employers, the Moore brothers. Source: http://distantwriting.co.uk/ cookewheatstone.html. (Accessed June 2015)

more successful abroad, and he became involved in the Morse-O'Reilly conflict in the United States. It was not before the start of the Electric Telegraph Company that both development trajectories came together when the ETC bought both the patents of Cooke and Wheatstone as well as Bain's patents.

Who Invented the Needle and Pointer Telegraph?

We now turn our attention to the famous questions of "Who did it? Who invented the...?"—also known as the priority-question. One could wonder if in the case of the needle telegraph and the pointer telegraph the same question can be posed.

From a technical point of view, it is clear that the development of the early telegraph was the work of many minds: not only the contributions of the early experimental scientists (to be called *contributing inventions*) but also the contributions towards the implementation of the concept into working artefacts (to be called *contributing innovations*). Among those were the clockmaker, Alexander Bain, and the businessman, William Cooke: practical, engineering-oriented people who combined the perceived need in the market with the possibilities electric technology had to offer. It was the so-called needle telegraph that they conceptualized and developed into practical artefacts. Next, it was their ABC telegraph that started the development of pointer telegraphy. But before the pointer telegraph went into practice on a larger scale than just the demonstration of experimental installations to railway companies in the late 1830s, it would take some years and a lot of technical experimenting and improvements.

> *Although the Stephenson assisted London and Birmingham Railway telegraph trials are often referred to as the first commercial electric telegraph line in the world, it would actually be the installation of the Cooke and Wheatstone telegraph system opened for use on London and Blackwall Railway line in July 1840 that would come to garner that distinction.*[222]

From a legal point of view, it was their 1837 patent that described the workings of telegraphy using electromagnetic needles. The five-needle telegraph, as described in GB patent № 7,390, started a chain of developments, both technical and commercial, that would create the telegraphic infrastructure for writing over a distance. Setting aside the individual contributions to the invention described in the patent—both Cooke and Wheatstone claimed the honour of being the inventor—their

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[222] Source: William Fothergill Cooke. Biography. http://ethw.org/William_Fothergill_Cooke (Accessed April 2015)

cooperative contribution was formalized in the patent. It was a patent that was already challenged during its application, and it was the infringement cases later on that showed its importance. However, one could hardly speak of patent wars, as that seemed not to fit in the British culture of those days.

That being the case, the invention of the moving coil telegraph, a variation of the needle telegraph, was claimed by—and rewarded to—Alexander Bain in an early stage. Even more, Bain's patent for his printing telegraph made him the "inventor of telegraphy"—at least in the eyes of the analyst John Finlaison in his *Account of some Applications of the Electric Fluid to the Useful Arts by A. Bain, with a Vindication of his Claim to be the First Inventor of the Electro-Magnetic Printing Telegraph, and also of the Electro-Magnetic Clock* of 1843 (Finlaison, 1843):

> *Thus, no allusion is made in those letters to the fact, that Mr. Bain, jointly with Mr. Barwise, is the legal proprietor of the invention of the Electric clock, by letters patent of 8th January, 1841; and that, jointly with Lieutenant Thomas Wright, of the Royal Navy, he is also the legal proprietor of the Electric Printing Telegraph, on vastly improved principles, by a patent sealed on the 7th of December following; both which patents were vehemently, bust unsuccessfully opposed by Mr. Wheatstone in person. This, it is humbly conceived, is the suppression of a very material fact.* (Finlaison, 1843, p. 7)

> *It is certainly possible that one man may have the legal right to an invention, while the moral claim belongs to another; in this work we trust we have brought forward proofs enough to convince the most sceptical mind that the moral as well as the legal right to the inventions of the Electro-Magnetic Printing Telegraph and Electric Clock, both belong to Mr. Alexander Bain; and that the claims to these inventions set up by Professor Wheatstone, are, in the last degree, the reverse of doing "unto others a ye would wish that they should not do unto you".* (Finlaison, 1843, p. 108)

Legally and morally Bain might have had priority, but in terms of impact, his telegraphy system, although used in many telegraph lines, did not have the societal impact that the Cooke and Wheatstone contributions had[223].

In terms of impact of society, certainly the Cooke and Wheatstone telegraphs started a new and faster way to communicate in Britain.

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223 One could dispute if the needle telegraph was a basic innovation as we define it. Its impact was limited, although its patent had a major influence that seems to have been limited to railroad applications. Other scholars consider the five-needle telegraph as being the most important of the two developments. Not being in the position do conclude on this matter, we consider the combination of both inventions to be the basic innovation.

Although "fast", as we are still talking in terms of 10-15 words per minute, was relative. Their pioneering work resulted in the Electric Telegraph Company that dominated early British telegraphy and proved that it had a future. Telegraph lines had erupted not only in England and the British Empire, but all over Europe. In England, the use of the telegraph was seen as a public facility. The Electric Telegraph Acts (1846, 1863) made their expansion possible. But telegraphy, as to be used by the general population, still was seen as something that the government should control. The 1846 Act, for example, allowed the Postmaster General to take control of the telegraphs in the interests of national security, as it did during the Chartist Uprising of 1848[224].

From a business point of view, the implementation of the pointer telegraphy, which started with the creation of the Electrical Telegraph Co. in 1845, also had a considerable impact on society. Because Cooke's right to fix wires for commercial lines on the poles of the railway telegraphs was bought by the new company, commercial/public telegraphy—as complementary to governmental and military telegraphy—was created. It formed the beginning of the institution of telegraphy in Britain.

> *Before the telegraph, business relations were personal; that is, they were mediated through face-to-face relations, by personal correspondence, by contacts among people who, by and large, knew one another as actual persons. The overall coordination of these atomic relations and transactions was provided by the "invisible hand" of the market. With the telegraph and, of course, the railroads and improvements in other techniques of transport and communication, the volume and speed of transactions demanded a new form of organization of essentially impersonal relations—that is, relations not among known persons but among buyers and sellers whose only relation was mediated through an organization and a structure of management. …*
>
> *Through the telegraph and railroad the social relations among large numbers of anonymous buyers and sellers were coordinated. But these new and unprecedented relations of communication and contact had themselves to be explained, justified, and made effective. What we innocently describe as theory, law, common sense, religion were means by which these new relations were carried through to explicit*

[224] While in 1848 the European Revolutions swept all over Europe, the British government was facing the Chartist movement, demanding their democratic rights. Was Britain facing a similar revolution? In March 1848, the crowds protested in London and petitioned the House of Commons. The government had already initialized state surveillance by the secret police, which surveilled the leaders and communicated possible uprisings by telegraph. Thus the early telegraph became the eyes and ears of the government.

> *consciousness and "naturalized"—made to seem merely of the order of things.* (Carey, 1983, p. 4)

Certainly, the chain of developments that started from Cooke and Wheatstone's early efforts, had impact—impact that, for the people in the mid-1800s, meant progress.

> *The telegraph and its possibilities certainly fascinated the Victorians. From the early 1840s onwards there was a steady stream of celebratory literature as a succession of pundits sought to explain the telegraph to their publics. For many the telegraph seemed to epitomize the Victorians' optimistic faith in progress. It was a tangible demonstration of the truly revolutionary changes that a scientific understanding of nature could bring to society. Commentators waxed lyrical over the way in which the new invention made the mysterious fluid, electricity, subservient to mankind. It was as if a way had been found of harnessing the lightning. … Victorian commentators almost unanimously regarded the telegraph as a technology that had had a profound effect on their perceptions of time. It broke down conventional assumptions concerning the relationship between time, place and distance.* (Morus, 2000, pp. 456, 463)

A Cluster of Innovations for Needle and Pointer Telegraphy

From the preceding, one can observe that the discoveries that were made by the experimental scientists like Gauss, Weber, Steinheil and Schilling were contributing to the basic understanding of the usability of the galvanometer in a communication engine. These early experiments resulted in workable systems that proved feasibility, but they also made it clear that much had to be done before a proper working artefact could be introduced to the market of those days.

As the need, in this case a latent need, perceived by entrepreneurial people like William Cook in the application of railway communications—directly related to the issue of railway safety—was evident, it was the development of the technology and its related artefacts that took more time. From Schilling's first six-needle telegraph of 1832, it took five years to develop Cooke and Wheatstone's five-needle telegraph (1837). And it took a couple of years more to create the ABC telegraph (1840)—the type of telegraph—also called the dial or pointer telegraph—that became the working horse of telegraphy (Figure 153).

The invention of telegraphy, as developed by William Cooke and Charles Wheatstone, was de facto the start of an innovation trajectory for needle telegraphy. As this concept had several disadvantages (ie many wires, complex (de)coding and slow transmission speed) it proved a dead-end technology. The invention of the printing telegraph, as developed by

Alexander Bain, started a parallel trajectory of developments that competed with the pointer telegraph invented by Cooke and Wheatstone. Both trajectories were related to system components: telegraph equipment (ie apparatus) and components (ie cables) and the total system of the telegraph network (ie telegraph lines). The Bain trajectory, although originally used extensively, was not to be the path for further development.

The trajectory of the dial telegraph (also known as pointer telegraph), that started with the ABC telegraph created by Cooke and Wheatstone proved more successful. Their concept enabled easier message input, faster single-line transmission and output that is more appropriate. It was to become the dominant design that inspired many other developers of telegraphic equipment.

It would lead to a massive development of the telegraphic infrastructure in Britain and the rest of Europe, with the earlier described social impact, among which was a massive loss of business among people who operated homing pigeons. They, and their pigeons, were soon out of work. After the exclusive governmental rights of use were adapted, it became an

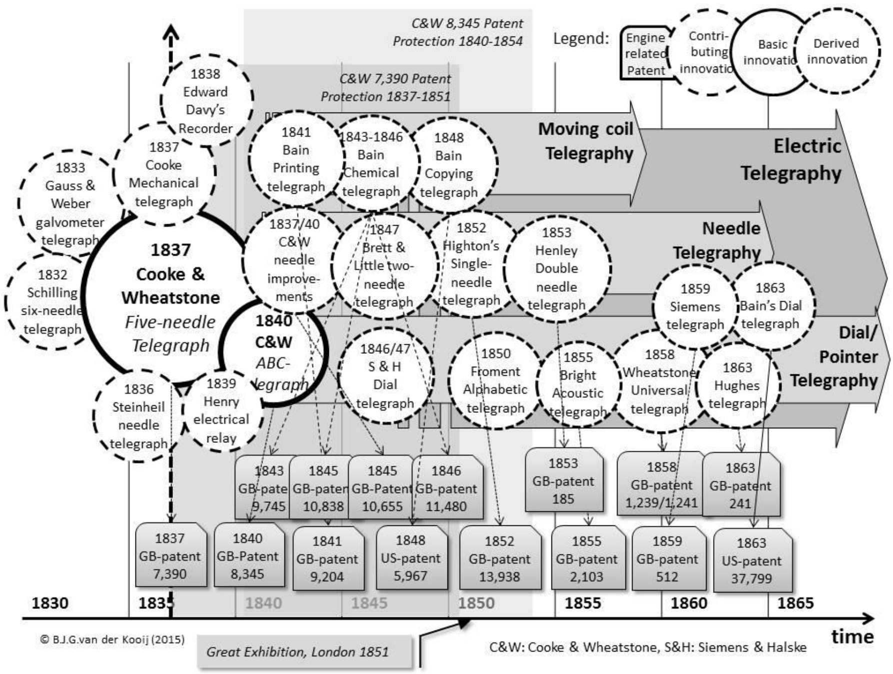

Figure 153: The cluster of innovations around Cooke & Wheatstone's 1837-needle telegraph and 1840-dial telegraph.

Source: Figure created by author

infrastructure created and used by the private telegraphic service providers. Companies that bought the telegraph equipment they needed from the new arising businesses of the telegraph instrument manufacturers. But it was not until after the patent protection for the C&W master patent had expired (1851) that other inventors and manufacturers entered the field with their own improvements of the telegraphic apparatus. It created an Industrial Bonanza.

Industrial Bonanza: Telegraph Manufacturers

As soon as it became obvious that telegraphy would fulfil a need and that profitable business could be generated—as shown by the pioneering Electric Telegraph Company—other companies were organized and started offering their services to the public. It would create the British telegraph boom.

It was also in 1851 that the Great Exhibition of London (in full "Great Exhibition of the Works of Industry of all Nations"), one of the first popular world fairs of culture and industry took place (Figure 154). Six million people—equivalent to a third of the entire population of Britain at the time—visited the Great Exhibition. At the exhibition, a telegraph system (made by the Reid brothers for the Electric Telegraph Company) was installed to support the running of the exhibition.

> *The system, which enabled the policemen at the exhibition to inform gate staff of any pickpocket, instructing them to lock the gates until the culprit was apprehended, was highly visible to the exhibition visitors —the promotional potential of which was fully understood by Reid.* (Steadman, 2010, p. 236)

Obviously, the Electric Telegraph Company had a large display on the exhibition.

> *In pride of place were Cooke & Wheatstone's patent apparatus; the famous five-needle telegraph used at Euston Square in 1837, the first two-needle instrument, two common two-needle telegraphs, a single-needle telegraph, a portable single-needle telegraph and a detector or portable galvanometer. There were side stands showing eight different patterns of electro-magnetic alarm (bells) in several sizes; eight dial telegraphs ranging through the Wheatstone 1840 galvanic prototype to his latest magneto version, including his electric register or counting machine and Nott & Gamble's apparatus.* [225]

[225] Source : Roberts, S : Distant Writing, http://distantwriting.co.uk/electrictelegraphcompany.html

But they were not the only ones. Other telegraph companies were also present. Among them were the telegraph manufacturers showing their instruments.

> *Ominously for the Company in the year that the patent expired there were fifteen other separate exhibits of telegraphic apparatus in the Great Exhibition; with W S Alexander, Thomas Allan, Frederick Bakewell, Alexander Bain, Jacob and John Watkins Brett, the British Electric Telegraph Company, George Edward Dering, Charles French, William Thomas Henley, Archibald McNair, Henry Mapple, William Reid, Charles Vincent Walker and Francis Whishaw in the British stands, and Siemens & Halske in the Prussian stands.* [226]

Among the exhibited telegraphs were the Reid two-needle and one-needle telegraphs, an adaptation of the C&W apparatus (Figure 155). Wheatstone's former instrument maker, the Reid brothers, made them. They were the Electric Telegraph Company's former contractor, whose services were terminated—by ETC—in 1848.

Figure 154: The Crystal Palace of the Great Exhibition of London (1851).
Source: https://kickasshistory.files.wordpress.com/2014/07/victorians109-tl.jpg

[226] Source : Roberts, S : Distant Writing, http://distantwriting.co.uk/ electrictelegraphcompany.html

The British Telegraph Boom

By the end of the 1840s, it was obvious that telegraphy would be an important new way of communicating over distance. The pioneering work of the Electric Telegraph Company had clearly proved that there was a need to be fulfilled. Soon other initiatives were undertaken to create telegraph companies—companies that would offer telegraphic services to the public, businesses and newspapers (Table 9).

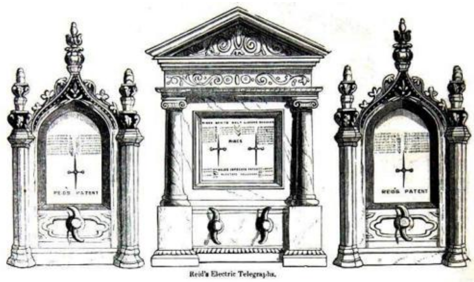

Figure 155: Reid's two-needle and one-needle Telegraphs at the Great Exhibition of London (1851).

Source: http://atlantic-cable.com/CableCos/ReidBros/Reids-Telegraphs-1851.jpg

One of those companies was the British Electric Telegraph Company, which was incorporated by special Act of Parliament on July 29, 1850. It was formed to work the patents of Henry and Edward Highton, essentially a single-needle, single-wire telegraphic instrument with galvanic batteries, its wires carried overhead on poles. It planned to supply its services, like the Electric Telegraph Company, by using overhead circuits alongside railways. However, as they initially failed to get cooperation from many railroad companies, it took some time before their first network along the Lancashire & Yorkshire Railway was created.

> *By February 1853 the Company covered fifty towns with 330 miles of line. In mid-1853 it had 600 miles of line, east and west, from Liverpool to Goole, through every important town in Lancashire and Yorkshire, northeast from Liverpool to Newcastle, and was proceeding northwards to Carlisle, Glasgow and Greenock. the British company's circuits encompassed the northern counties of England and reached Glasgow, the commercial and industrial metropolis of Scotland by late 1853, expending a little over £20,000 of its capital.* [227]

Another competitor, the English & Irish Magnetic Telegraph Company, was amortized by a special Act of Parliament on August 1, 1851, as the Magnetic Telegraph Company, with a capital of £500,000 to work the 1848 joint patents of W. T. Henley and D. G. Foster for needle telegraphs. The word *magnetic* originated from its use of magneto-electric

[227] Source: http://distantwriting.co.uk/competitorsallies.html

dynamos instead of batteries as a power supply, and its use of putta-percha as isolation for the cables. Henly was knowledgeable in telegraphy, as he had been the instrument maker to Charles Wheatstone and a contractor to the Electric Telegraph Company. The name of the company was extended with English & Irish in 1852 as they intended to connect Britain with Ireland by an underwater telegraph cable.

The Magnetic eventually became the dominant telegraph company in the relatively small market of Ireland connecting the country's major cities of Belfast, Dublin, Galway, Cork and Queenstown, mainly next to railways. Its circuit south from

Table 9: Some of the early Telegraph Companies in Britain

Name	Existence	Description/Activities
Electric Telegraph Company	1846-1855	Company set up by William Fothergill Cooke and Joseph Lewis Ricardo using Cooke and Charles Wheatstone's patents for the needle telegraph.
British Electric Telegraph Company	1850-1853	Company formed by act of Parliament in 1850, and used the patents of Henry and Edward Highton.
United Kingdom Electric Telegraph Company	1851-1870	Company established by act of Parliament in 1851, but did not start active operation until July 1860.
English and Irish Magnetic Telegraph Company	1852-1857	Company founded by royal charter in 1852 to work the patents of William Thomas Henley and David George Foster.
British Telegraph Company	1853-1857	The British Electric Telegraph Company merged with the European and American Electric Printing Telegraph Company (1851-54) to form the British Telegraph Company.
International Telegraph Company	1853-1855	The International Telegraph Company was formed by the Electric Telegraph Company in 1852. The ETC obtained a concession from the Dutch Government in 1852 to lay wires from Orfordness, on the east coast of England, to Scheveningen in Holland and then to the Hague.
Electric and International Telegraph Company	1855-1870	In July 1855 the Electric Telegraph Consolidation Act enabled the ETC and ITC to formally merge, becoming the Electric and International Telegraph Company (EITC). By 1868 it was the largest telegraph company in the country.
London District Telegraph Company	1859-1870	Company created to develop telegraphic communication within a radius of four miles from Charing Cross (London), with provision to extend to 20 miles.
Universal Private Telegraph Company	1861-1870	Company established by an act of Parliament in June 1861, but did not become fully operational until 1863.

Source: Private Telegraph Companies. http://www.btplc.com/egroup/btshistory/btgrouparchives/majorcollections/infosheetprivatetelegraphsissue1v3.pdf

Dublin to Cork alongside of the Great southern & Western Railway was completed on June 1, 1853. [228]

The European & American Electric Type-Printing Telegraph Company (1852) was another early, successful, if short-lived, competitor to the old company. In January 1852, it became the second company, after the Electric Telegraph Company, to commence constructing a circuit to connect London with the north of England, starting to lay wires next to the obsolete coach road by way of Birmingham to Liverpool and Manchester, completing its line in May 1854 just before the Magnetic company's.

[Established was] a new company in 1851 under English law, the European & American Electric Type-Printing Telegraph Company, with a capital of £200,000, in 40,000 shares of £5, of which £93,000 was soon paid-up, to connect London, Liverpool and Manchester by one mainline (Dover, London, Birmingham, Manchester and Liverpool). […] the company and its capital was auorised by Special Act of Parliament on August 7, 1851. (Ibidem)

The European & American Electric Type-Printing Telegraph Company became the first effective challenge to the Electric Telegraph Company.

These were some of the companies that were organized and started operating in the early 1850s. But also new companies were organized later on (Beauchamp, 2001, pp. 77-81):

The London & District Telegraph Company (1859), being located in London, was facing a long and tedious process to obtain permission from house owners for their roof-top wires. It realized 80 stations but was not commercially successful.

The United Kingdom Electric Telegraph Company (1860) was formed to develop telegraph communication over public highways and along the towpaths of canals.

The Universal Private Telegraph Company (1860) was organized to link specific business premises to one another by private lines and offered no services to the public, thus avoiding the need for public offices.

The Reuters Telegraph Company (1859-1860) was a public telegraph company, but used by the newsgathering Reuters company, established in 1851. The service had originated in Germany where Paul Julius Freiherr von Reuter had a news service using mail carrier homing pigeons.

[228] Source: http://distantwriting.co.uk/competitorsallies.html

The Exchange Telegraph Company (1862) was also a private news distribution service that effectively did not start its operations until 1872. It linked the stock exchanges in the larger English cities like London, Liverpool, Birmingham.

Telegraph Entrepreneurs: Tycoon John Watkins Brett

The technical inventor types of entrepreneurs who created a business to exploit their patents did not only dominate the early days of the development of telegraphy. There were also others, not technically educated, who saw business opportunities in the new fascinating phenomenon of writing on a distance.

It was John Watkins Brett (1805-1863), an art dealer of high reputation, who was dedicated to the idea of connecting Britain with Europe and other continents.

> *Then there came the bolt from the blue – truly a bolt of lightning. Sometime later John Watkins Brett said that it was over a cup of tea, early in 1845, that he and his brother first discussed the possibility of an electric telegraph connection across the English Channel, "and in the month of July, in the same year, they drew up a plan for not only uniting England and France, but Ireland, and the most distant colonies in India." … At about the time as he was tinkering with 'atmospheric' railways, early in the year 1845, Jacob Brett had been toying, according to his older brother, with the idea of an autographic telegraph by which handwriting could be transmitted over distance, to sign documents, for example.*[229]

It was in the period of the *Railway Mania*, in which John and his brother lost quite a bit of money, that Brett became acquainted with telegraphy. From James Christy Bell of New York, Royal House's representative who was to exploit House's telegraph system in Europe, he bought the European rights to the telegraph of Royal Earl House. He managed to obtain British patent № 10,939 on November 13, 1845 (from which half of the profits would go to House). The patent included the means of constructing an underwater cable that was to act as an oceanic line. Having the technical side secured, he then started to organize a company. With the revenues from selling his paintings and financial support from his brother Jacob Brett, he registered the General Ocean Telegraph Company on June 16, 1845. A year later, on November 14, 1846 the firm was re-registered as the General Oceanic & Subterranean Electric Printing Telegraph Company. But that was just the beginning.

[229] Source : Roberts, S.: The Moving Fire. http://atlantic-cable.com//CablePioneers/Brett/ (Accessed April 2015)

From the middle of 1845 there were to be a long series of company registrations by the Bretts, customarily in the name of Jacob Brett, before even a part of these telegraphic ambitions were to come to fruition. … with such capital as they could raise the Bretts had several models of the type printer manufactured in London and by March 19, 1847 had created yet another skeletal joint stock firm, the provisional Electric Printing Telegraph Company for Land and Ocean Communication, with a capital requirement of £250,000 in 12,500 shares. [230]

One has to realize that creating a telegraph connection between England and France, in the perspective of the Napoleontic Wars at the beginning of the century and the European Revolution of 1848 building up, was not an easy affair. It was politically complex as also the different governments had different opinions on the role of private enterprise. The British Parliament had no desire to intervene in private business and certainly would not to grant any form of monopoly, an anaema to the politics of the time.

On the Continent of Europe the matter was very different; 1848 was a year of revolution. Revolution, as usual, being speedily displaced by the regime of a despot; in France, the last of the Bourbon monarchs, Louis-Philippe, was dispossessed by Citizen Louis-Napoleon Bonaparte, who rapidly escalated his role from prime minister to Prince-President and then to Emperor of the French. As despots go Napoleon III was benign, and, learning from the problems of his grand-oncle, was keen to absorb the technology of the British. the Bourbon bureaucracy was quickly subsumed into a Bonapartiste technocracy strongly allied to Britain. [231]

Brett succeeded in obtaining a concession for an electric telegraph from England to France in 1849 for a period of ten years. His first efforts to lay a cable failed, however, due to the construction of the cable. That changed when, by his Submarine Telegraph Company between France and England (1849), in 1851 had laid reliable underwater cables to the continental kingdoms.

This company was followed by the Submarine Telegraph Company between Great Britain and the Continent of Europe (1851), yet another elaborate, all-encompassing title so common to the Brett enterprises. Also in 1851, a Bill was passed for the European & American Electric Type-Printing Telegraph Company (1851), which was another successful early, if short-lived, competitor to the old company. In January 1852, it became the second company, after the Electric Telegraph Company, to

[230] Source : Roberts, S.: The Moving Fire. http://atlantic-cable.com//CablePioneers/Brett/ (Accessed April 2015)
[231] Source : Roberts, S.: The Moving Fire. http://atlantic-cable.com//CablePioneers/Brett/ (Accessed April 2015)

commence constructing a circuit to connect London with the north of England, starting to lay wires next to the obsolete coach road by way of Birmingham to Liverpool and Manchester, completing its line in May 1854 just before the Magnetic company's.

> *There followed a series of amalgamations with the companies competing with the dominant Electric company. The European company was bought in 1854 by the British Telegraph Company, which had circuits in the north of England and Scotland, as well as its own cable to Ireland. This in turn merged with the Magnetic Telegraph Company to form, in 1857, the British & Irish Magnetic Telegraph Company. the Submarine Telegraph Company and the British and Irish Magnetic Telegraph Company came to a monopoly agreement on 12 April 1859 by which they would use only each other's circuits for foreign and domestic messages. In each of these connections John Watkins Brett passed seamlessly from board to board, acquiring larger and larger stakes in these domestic companies.* [232]

By April 22, 1857, John Watkins Brett was director of the second largest domestic telegraph company in Britain, with circuits throughout England, Wales, Scotland and Ireland, as well of the company managing all of its connections with the entire continent of Europe; even then it was a multi-million pound enterprise. His company Submarine Telegraph Company between France and England, was the only company that was not part of the state network in France.

These are just of the few of the more entrepreneurial initiatives that were undertaken to create telegraph companies. Of the 64 companies formed between 1846 and 1868, sixty-eight percent failed (Kieve, 1973, p. 96).

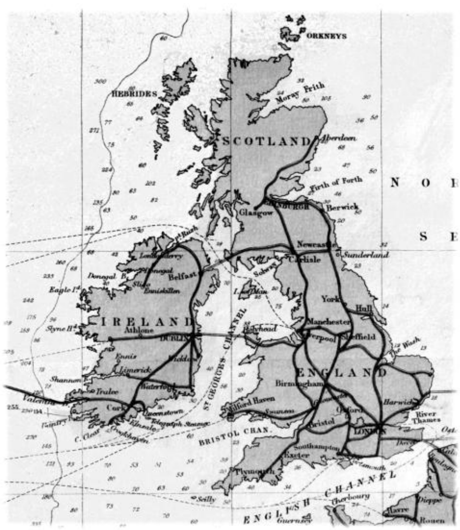

Figure 156: Great Britain Telegraph lines (1856).

Source: www.atlantic-cable.com

[232] Source : Roberts, S.: The Moving Fire. http://atlantic-cable.com//CablePioneers/Brett/ (Accessed April 2015)

In the midst of the boom period, England had seen a massive increase in telegraph lines (Figure 156). In some two decades, pointer telegraphy had conquered the British Islands. In 1850, Great Britain had 2,200 miles of telegraph; by 1867 it had 80,000 miles.

Cluster of Businesses

The pioneering Electric Telegraph Company dominated British telegraphy. It was in the early 1850s, after all those efforts described before, that the British telegraphy market started to be economically successful. Then quite a few companies were started, some using telegraphs systems competing with Cooke and Wheatstone's telegraphs, such as Highton's and Henley's telegraph (Figure 157).

And it was in the late 1850s that the industry changed as the result of a range of amalgamations. The Electric Telegraph Company had merged with the International Telegraph Company into the Electric & International Telegraph Company (1855). The British & Irish Magnetic Telegraph Company was the result of the merger of the British Electric Telegraph Company and the English & Irish Magnetic Telegraph Company in 1857. The Brett Companies had been consolidated into the Submarine Telegraph

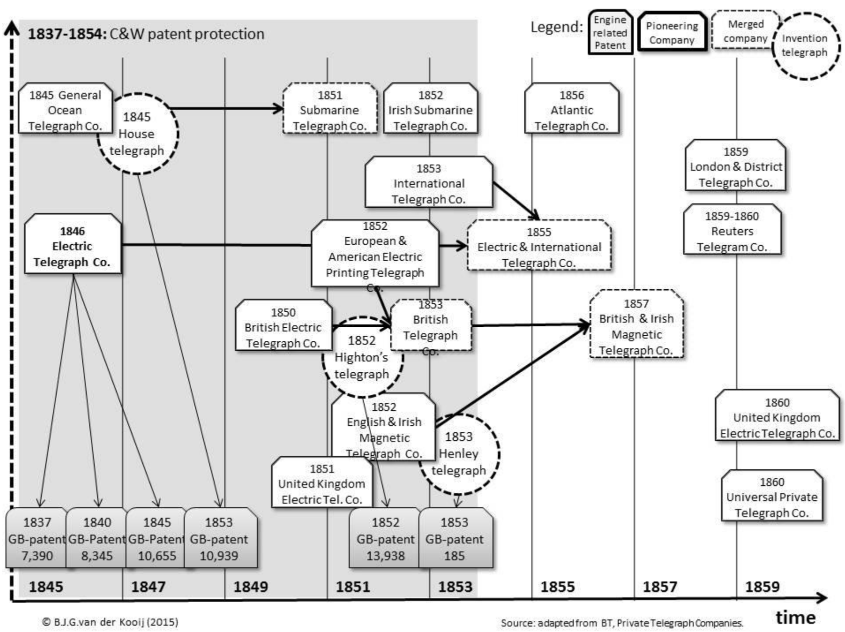

Figure 157: Cluster of business of telegraph companies (service providers) in Britain.

Source: Figure created by author

Company (1851). These mergers and acquisitions (Figure 157) took place in the 1850-1860 period. It would be the prelude to the biggest merger: the nationalization of the state that resulted in the Post Office Telegraphs.

Early Manufacturers of Telegraph Equipment

As it is impossible to pay attention to all those entrepreneurial activities that were undertaken by both the inventors of the telegraphic systems, the implementers of the telegraphic network services and the manufacturers of the telegraphic equipment, we will only try and illustrate some of the developments after Wheatstone and Cooke's invention.

Manufacturing Telegraphic Instruments

The first telegraph apparatus developed by people like Cooke and Wheatstone were made by instrument-makers, often also active as clockmakers.

> *Most of these early instruments were made by Moore Brothers, church and house clock makers, of 38 Clerkenwell Close, Clerkenwell, London. There were then three brothers Moore, Benjamin, Richard and Josiah, engaged in the clock business. The firm was also known as John Moore & Sons. Wheatstone's earliest electrical apparatus was made by Watkins & Hill, philosophical instrument makers, of 5 Charing Cross. Subsequently, from about 1838, Cooke & Wheatstone commissioned William Reid, of 25 University Street, St Pancras, to make their telegraph models and other electrical implements. Reid was to become one of the largest telegraph manufacturers and contractors for works in Britain, and was to be associated with Wheatstone until his death in the 1860s. … Cooke's very first mechanical telegraph was made by John Brittan, a clockmaker with Moore Brothers in 1836; it was the size of a "barrel organ" and never completed. Brittan went on to build clockwork telegraphs and alarm bells for Cooke in 1837 and 1838, and attended the first demonstration of the electric telegraph on the London & Birmingham Railway on behalf of his employers, Moore Brothers.* [233]

From these early instrument makers emerged the later manufacturers of telegraph equipment. There were relatively few specialist suppliers of telegraphic materials, apparatus, insulators, and so on. In London during the 1850s, there were only three suppliers of instruments: William T. Henley, William Reid and John Sandys. These were the entrepreneurs that had enlarged their instrument-making facilities into the manufacturing of telegraph equipment.

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[233] Source: Roberts, S. : Distant Writing; Cooke and Wheatstone. http://distantwriting.co.uk/cookewheatstone.html (Accessed April 2015)

Early Manufacturing of Telegraph Cables

It is obvious that transmitting of messages across a wire by the means of electricity has different aspects. Next to the technical issues there is the safety aspect. Depending on the current type and the potential level (eg direct current below 40V) electricity is not dangerous. That changes with higher potential levels, which can become lethal for humans. Then, obviously, good isolation is needed as a safety precaution. But there are other reasons that creating an isolated cable would be important. In the case where the telegraph wire is suspended on poles, the air is used as an isolator. And for the connection to the poles, ceramic and glass isolators were applied (Figure 158). But in cases where a cable had to enter buildings, or even more important, had to cross water, another medium of isolation is needed. Many materials were tried: cotton, tar, wood, rubber. But it was the use of gutta-percha that would create a breakthrough in cable-making. Resulting in the crossing of oceans by the oceanic cables.

It started with the use of copper wire[234]—instead of iron that was used till that time—for the telegraph lines. Next, to add strength and bypass technical problems of induction, it was twisted into a rope. The isolation was realized by covering the wire with cotton or silk spread spirally over the wire. Next, the cotton was steeped in India rubber to protect it from the damp. But it was a poor isolation. Contrary to natural rubber (also called caoutchouc[235]) that—prior to vulcanization—would get brittle and break down in sea water, the coagulated latex that was produced by trees from the *Palaquium gutta* genus from the Malaysian peninsula, was more useful. It was commonly called gutta-percha, being a thermo-elastic latex that was soon used for its electrical isolating properties.

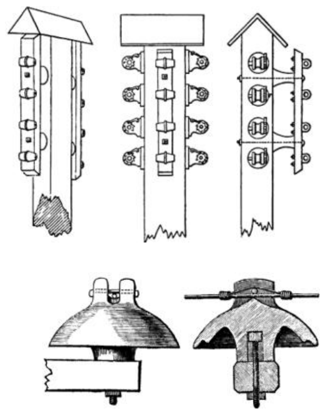

Figure 158: From isolator to cable pole.

Cooke's Original Telegraph Poles 1843 (top), Charles Bright's Patent Insulator 1858 (Bottom).

Source: www.distantwriting.com, www.imgkid.com

The problem was how to create a cable in which the electric wire was surrounded by the isolating material. First, it was done by rolling strips of

[234] As the story goes, the copper wire was invented by two Dutchman fighting about a penny and thus stretching the penny into a wire.

[235] Caoutchouc is the name for a latex from the pará tree, which grew in south America. In the 1870s, they were introduced in India, Malaysia and Indonesia on rubber plantations.

gutta percha around the wire. That did not work out, and putting two wires between two slates of gutta percha was tried. That did not work either. Finally the problem was solved by Charles Hancock, who, at his rubber works, adapted a machine originally designed for making gutta percha tubing. Being a cork maker, he had obtained a patent on May 15, 1844 for "certain improvements in cork and other stoppers, and a new composition or substance which may be used as a substitute for and in preference to cork" that would give him the exclusive right to manufacture gutta percha—an important patent that would be challenged by infringements (eg *Hancock v. Brunsen*). Others experimented with the material for isolation purposes, patented their processes (like Barlow and Foster and John Lewis Ricardo in 1848). In addition, in Germany it was Werner Siemens who, together with Johan Georg Halske, designed a machine for covering wire with gutta percha pressed round the wire through a cylinder and die without a seam.

In England, some entrepreneurial efforts would contribute largely to the underwater telegraph cables: cables laid in a hostile environment at enormous investment. Let us have a look that some of the companys manufacturing those cables. It started with companies making metal wire cables for ships, mines, etc.:

It was Robert Samuel Newall , owner of a wire rope manufacturing company, who obtained a patent in 1840 for wire rope making by winding a spiral of wire around a core of hemp rope. He soon came in conflict with the patents of Andrew Smith from 1835 and 1839. After the court had solved the debate, he then created the R.S.Newall and Co. to make wire ropes for mining, railway, ships rigging, etc. (Figure 159). That company obtained, after some legal squirmishes in which Robert Samuel Newall made extravagant claims as to the invention of iron wire rope and to submarine telegraphy in general, contracts for submarine cables, like the contract for an armored cable for the 1851 cross-Channel cable between

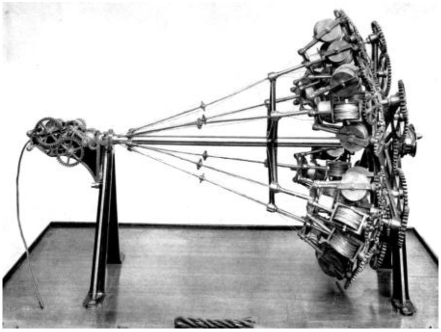

Figure 159: Model of R.S. Newall's original compound wire-rope making machine.

Source: http://atlantic-cable.com/CableCos/Telcon/index.htm

Dover and Calais for the Submarine Telegraph Co.[236]

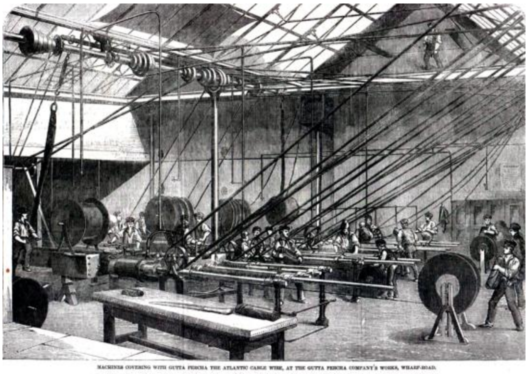

Figure 160: The Gutta Percha Company (1863).

Machines preparing the Atlantic Cable.

Source: www.imgkid.com

The Gutta Percha Company was established in 1845 by Henry Bewley and Samuel Gurney, making all kinds of decorative figures, commemorative plaques and other household items from gutta percha, but also industrial products like tubes. They were working together with Charles Hancock, member of an illustrious family active in rubber and resin, who had patented a stopper made out of resin in 1841. In 1845 they formed a kind of cartel in which the Gutta Percha Company would manufacture Hancock ideas.

> *Then, on July 29, 1848, Charles Hancock obtained a new patent for improvements in the manufacture of gutta percha. This was for "an apparatus for covering or coating wire or cord to an infinite length with any plastic substance"; a machine that was to unquestionably revolutionize telegraphy. For the first time an electrical conductor, in copper wire, could be economically insulated with resin to any degree, to any length; such insulated wire was to be used almost immediately for both underground and underwater electrical circuits. In terms of profit it was eventually to subsume all of the other, very considerable, manufacturing activities of the Gutta Percha Company.*[237]

This patent caused friction between the partners, as all underwater and underground cables manufactured between 1848 and 1863 were to be insulated with gutta percha applied to copper wire using Hancock's patented wire-covering machine. And there was a large license fee involved in that process. What were those underwater cable projects? Take for example the 1850 and 1851 cross-channel cables between

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[236] Source: http://atlantic-cable.com/CableCos/Telcon/index.htm (Accessed April 2015)
[237] Source: Glover, B. : History of the Atlantic Cable & Undersea Communications. The Ancestors of the Telegraph Construction & Maintenance Company. http://atlantic-cable.com/CableCos/Telcon/index.htm . (Accessed June 2015)

Europe and England. The first attempt at the Dover-Calais connection in 1850 failed due to a poorly designed cable, but the second attempt, in 1851, succeeded with a better cable. Soon, other underwater cables were laid linking Great Britain with Ireland, Belgium and the Netherlands. The next major attempt to span the sea was the project from the Atlantic Telegraph Company for telegraph cables crossing the Atlantic Ocean. The first attempt failed, and in the spring of 1858, a second attempt was made. After a short period of operation, that failed also. It would take until 1864 before, through the efforts of the Anglo-American Telegraph Company, and an improved cable design, a working telegraph connection was created.

In the creation of the underwater cables, much of the improvement was the work of George Elliot (1814-1893), a self-made businessman who started working in the coal mines, a colliery owner by 1840. In that capacity, he had dealt with a wire rope manufacturer, Kuper & Company. After this company bankrupted, he became its manager, and in 1854 he was the proprietor of the company after he paid off the creditors and the original members of the firm. Then the company Glass, Elliot & Co was created by George Elliot and his accountant Richard Glass. They combined the experience of wire-rope making with the gutta percha isolation techniques.

The Telegraph Construction and Maintenance Company was created in 1864 in taking over the telegraph manufacturing business of Glass, Elliot & Co and the Gutta Percha Co. They were the ones that contributed to the construction of the Atlantic cables. The core was made by the Gutta Percha Company, and the outer sheathing was made by Glass Elliot & Co and R.S. Newall & Co. the manufacturing of the cable started in February 1857; it would be a cable 2,500 nautical miles in length for a contract price of £225,000[238].

> *Its first major contract was to lay a cable across the Atlantic for the Atlantic Telegraph Company on the basis of no payment if the expedition failed, which is what happened in 1865. Another attempt in 1866, is time for the Anglo American Telegraph Company and again using the Great Eastern, succeeded, as well as the recovery and completion of the 1865 cable. the company took the bulk of its payment in the shares of Anglo American.*[239]

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[238] Equivalent to ca 19 million pounds in 2014, calculated on the basis of the real price of a commodity. Source: www. Measuringworth.com.

[239] Source: Glover, B. : History of the Atlantic Cable & Undersea Communications. British Submarine Cable Manufacturing Companies. http://atlantic-cable.com/CableCos/BritishMfrs/. (Accessed June 2015)

The Telegraph Construction and Maintenance Company would become the dominant manufacturer in the cable industry for the next hundred years. They would support the British hegemony in cable-laying across the oceans.

The British Telegraph Monopoly

At the end of the 1860s, a situation existed that would change the British Telegraph (service) industry. It was a situation that had several dimensions: there was the technical dimension of the telegraph systems, the commercial aspect of the services rendered by the different service provides. And there was the political dimension.

Over the last decades, telegraphy had become part of the communication infrastructure in Britain. By 1868, the British public telegraph network consisted of 150,000 km of telegraph wires, 3,381 telegraph stations and another 1,226 telegraph stations provided by the railway companies. At the maturity of the telegraph companies, during the early 1860s, there had been a technical consolidation into three wholly independent, incompatible national operating systems: Cooke & Wheatstone's single-needle telegraph with the Electric Telegraph Company, Bright's acoustic telegraph with the British & Irish Magnetic Telegraph Company, and Hughes' printer with the United Kingdom Electric Telegraph Company. These systems were not technically compatible and created some problems when telegrams had to be transmitted along lines using different systems (Kieve, 1973).

Services were provided by five major telegraph companies (Table 10) and a range of smaller companies. Their services were heavily criticized: too expensive, unreliable, too many errors and too many delays.

> *The general malaise in Britain was seen as resulting from inter-company rivalry and costly duplications of services. The Continental telegraph services had been state-owned since their inception in the 1840s, and their generally improved service was considered to stem from a central unified operation. In Britain, the case for similar reform was being pursued by advocates both within and without parliament … By the late 1860s all these companies had become involved in preliminary discussions with the Postmaster General, who had been campaigning for the telegraphs to become an arm of the postal services for some time. … these discussions eventually led to decisions in Parliament, incorporated in the Telegraph Acts of 1868-1869.* (Beauchamp, 2001, p. 73)

Table 10: The five major telegraph companies (1868)

Name	Registration date	Leng of line (km)	Payment made (1868-£)	Payment made (equivalent 2013-£)*
Electric & International Telegraph Co.	1846	16.000	£ 2.939.000	£ 230.700.000
British & Irish Magnetic Telegraph Co.	1849	7600	£ 1.244.000	£ 97.660.000
London & District Telegraph Co.	1859	555	£ 60.000	£ 4.710.000
United Kingdom Electric Telegraph Co.	1860	2700	£ 562.000	£ 44.120.000
Universal Private Telegraph Co.	1861	223	£ 184.000	£ 14.400.000
Reuter's Telegram Co.	1851	-	£ 726.000	£ 56.990.000

*) Calculated on basis of the real price of the commodity. Source: www.measuringworth.com

The columns on the right indicate the amount (actual and in today's value) that was paid at the moment of nationalization for the company to the shareholders.

Sources: Beauchamp, 2001. Table 3.2, p.74

It would be this political discussion, which would put a movement into action that would lead to a major change in the British telegraph system: the nationalization of the private telegraph industry and the creation of the British Post Telegraph, part of the British Post Office.

The Telegraph Acts of 1868-1869

English politics, as diverse, opportunistic and heterogeneous as in any democratic system, could not have failed to miss the rapid development of the telegraphy infrastructure. As it was not only a technical matter, the related problems of its implementation and—later—its use in society, would certainly have been a matter of public debate.

Take, for example, the matter of erecting the lines throughout the towns and countryside. It had created strong opposition. The telegraph companies had solved much of the way-leave problems by using railway tracks, towpaths of canals and highways to erect their lines. But in the cities, the wires cluttered the rooftops. They presented not only a visual problem; they also caused danger to the public when they broke. These problems had already resulted in some early regulation with the Telegraph Act of 1863 titled "An Act to regulate the Exercise of Powers under Special Acts for the Construction and Maintenance of Telegraphs". The act described the rights of telegraph companies to install lines and the regulations that applied in all normal circumstances: along public roads, across private land, alongside railway tracks and canals, and on the seashore, including the rights of occupiers and landowners.

On the other hand, the natural monopoly that had been established by the Electric Telegraph Company was obvious. Their focus was primarily on connecting larger cities, having limited (although sometimes quite pompous) telegraph offices and charging high prices for a not-too-reliable service. Their performance was the subject of many debates in political circles. Much of the technology was in its infancy, much had to be discovered, experience had to be build up and standards had to be created. But the complaints were still heard in the mid-1860s when many political parties serviced the public interest.

> *A report of a committee of the Edinburgh Chamber of Commerce, for example, criticized private management [of telegraph companies] for a rate structure so complex as to inhibit usage, frequent delays and inaccuracies in the delivery of messages, and the relatively small number of offices. (The private companies connected approximately 1,000 cities and towns as opposed to the much more extensive Post Office mail and financial service network.) The attitude of the press was equally critical. As the Economist put it, "There is, probably, no interest which is so cordially disliked by the press [as are the telegraph companies...". Not only did newspapers experience the same problems noted by the Edinburgh Chamber of Commerce, but the provincial press was particularly frustrated by the contractual arrangement with the companies which employed the companies to gather news. The arrangement had not worked well, and in November 1865 John Edward Taylor of the Guardian spearheaded the formation of a cooperative news agency, the Press Association. However, the telegraph companies refused to release the newspapers from the contracts, and a stalemate emerged.* (Perry, 1997, p. 418)

In addition, the experiences with recent developments in the railway infrastructure were still fresh in the minds of politicians. There was also the railway mania and its flood of bills to develop railway lines and the numerous acts for establishing the proposed companies had overwhelmed Parliament—projects that were eagerly reported upon by the newspapers. Next to the successes, they were also reporting on the failures and collapses of several railway projects. The mania was followed by the financial panic of 1847 with the collapse of the British financial markets and the crash of the stock markets after the Railway Bubble busted in the late 1840s. This had occupied many in government and politics and influenced the political setting after the new phenomenon of telegraphy proceeded to gain momentum. After its birth in 1837 and the end of the 1840s, it certainly was concluding its infancy period. Now telegraphy was facing its growth period after the expiration of Wheatstone and Cooke's master patent in 1851. It was when that telegraph boom started that telegraphy was certainly becoming a matter of public interest.

Nationalization: The Post Office Telegraph

So, telegraphy became a political matter. Should the government continue a laissez-fair attitude and leave the development to the market-parties as in the United States? Or should the government exercise a more regulatory role, as any form of communication was a fundamental concern of government? Should telegraphic communication not be treated the same as postal communication? Should the Post Office not be the organization to implement the telegraph infrastructure? So in the early 1860s, many contributed to the debate: either pro or contraire. Like the member of Parliament John Lewis Ricardo (1812-1862), nephew of the economist David Ricardo, being also a banker and chairman of a railway company, who wrote a memorandum to Gladstone, chancellor of the exchequer[240], in 1861 to promote nationalization.

> *Ricardo compared the position in Great Britain with that on the continent where the telegraph was 'at once seen and understood as so powerful an engine of diplomacy, so important an aid to civil and military administration, so efficient a service to trade and commerce that all continental states immediately established a state telegraphic system, an experience of advantage to all'. Coming from a leading member of the commercial world this memorandum probably had more effect than was immediately realized.* (Kieve, 1973, p. 121)

There were also those parties that were strongly opposed to nationalization. Obviously, the telegraph companies themselves were not promoting nationalization, as it was conflicting with their interests. But they did only start protesting when the threat of the Telegraph Bill being accepted became imminent in February 1868 (Kieve, 1973, p. 139).

Surprisingly enough, apart from the principle question of governmental involvement in telegraphy, there was a practical argument. In the period 1840-1864, the *Post Office* had experienced an era of reorganization and rapid expansion of functions; like the introduction of the "penny post", the takeover of the packet service from the Admiralty, the creation of the Post Office Savings Banks. These were some major expansions that had occupied the organization. So, on one hand is the experience that showed the Post Office could certainly well be concerned with an expansion. But due to all the earlier expansions, it was already stressed to its limits; more responsibilities would require more adaptations for the Post Office organization. But it was worth considering and so the Postmaster General

[240] The chancellor of the exchequer is the title held by the British Cabinet minister who is responsible for all economic and financial matters, equivalent to the role of Minister of Finance or Secretary of the Treasury in other nations.

in 1865 initiated a study to be undertaken by Frank Ives Scudamore, an ardent advocate of the cooperative society.

> *By is* [the cooperative society] *he meant a network of public institutions planned and directed by technocrat such as himself so well that social harmony and economic prosperity would inevitably result. One side benefit of such a situation would be that profits in state-run industries would allow a reduction and perhaps even the abolition of the individual tax burden. While it should be made clear that Scudamore continued to believe in a capitalist economy, … he called for sweeping state involvement in a wide array of economic enterprise.* (Perry, 1997, p. 419)

In the report that was presented in July 1866, he criticized the current state of the services provided by the private British companies. In addition, he compared them with the state-run companies in other countries, such as Belgium and Switzerland. For him, the situation was analogous to the postal services of the pre-1840s, when letter boxes were few in number, rates were excessive, and the limits of fee delivery so narrow that many letters were charged extra (Kieve, 1973, p. 133).

> *What were Scudamore's conclusions? Little improvement in the British situation was likely as long as, to employ his phrasing, "wasteful competition" between the firms continued and as long as the directors thought "of the interest of their stockholders rather than of the interests of the whole community" the solution was nationalization under the Post Office, which could provide service that a much larger number of offices, charge a lower tariff of 1 shilling per 20 words, and still return a profit.* (Perry, 1997, p. 420)

Scudamore not only presented a report to the treasury; he did more and started lobbying. Among those he approached were the liberal politicians William Ewart Gladstone[241] (1809-1898) and Edwin Chadwick (1800-1890), a well-know reformer in the mater of public sanitation[242].

> *The same month he submitted his report he wrote Gladstone to remind him of their earlier association on the Savings Banks question and to lobby him concerning the telegraphs. He also forged an alliance with the Utilitarian reformer Edwin Chadwick, who had for years been critical of what he saw as waste and*

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241 Gladstone was a politician who served Britain over sixty years as member of Parliament, prime minister and as chancellor of the exchequer. As an MP, Gladstone supported the electoral reform and disestablishment of the Anglican Church in Ireland. When the telegraph was a political issue, he was chancellor from 1859-1866, and prime minster from 1866-1874.

242 Chadwick made a distinction between different types of legislation and administration: the "competition for the field" (like the postal services) and the "competition within the field" of service. At the request of Gladstone, Chadwick looked into the possibility of a cheap postal telegraph.

> *inefficiency in certain large industries and who, like Scudamore, saw state intervention as the proper remedy. Some of their activities were carried out in public, such as their joint address before the Society of Arts in early 1867. Some of their activities were carried out away from public scrutiny, such as the circulation of petitions favorable to nationalization which would be signed by friends and supporters in provincial towns, sent to the government in London, and then cited as evidence of the nation's outlook on the question. In the end the efforts of Scudamore and Chadwick to mobilize public opinion and to tap into preexisting dissatisfaction with the service offered by the private companies contributed to the growing belief among politicians of Conservative and Liberal persuasion that is was a case where any standing dicta about a minimalist state and the superiority of private initiative to government management should be set aside.* (Perry, 1997, p. 420)

This report would become the basis for new legislation that would soon change the playing field for telegraph companies completely. Yet another financial crises, that of 1866, and an unstable political situation delayed the progress of the Bill to be put into the parliamentary process.

The British Parliament, in its session of 1866-1867, was dominated by debates on the Reform Bill[243]. However, in January 1867, a confidential draft of a bill was drawn up by Scudamore that became the subject of public attention. It resulted in the introduction of the Telegraph Bill on April 1, 1868. The principle of nationalization received parliamentary approval in July 1868, and the following year a Money Bill was passed to implement the purchase.

The Telegraph Act of 1868 gave Her Majesty's Postmaster General the right to acquire and operate the inland telegraph systems in the UK, which had been installed and operated by independent telegraph and railway companies (Figure 161). The expenditure authorized was nearly seven million pounds[244]. The Telegraph Act of 1869 further conferred on the Postmaster-General a monopoly in telegraphic communication in Britain and, on 28 January 1870, the previously privately owned telegraph system was transferred to the state. The newspaper *The Times* voiced, "We have not

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[243] This is the Reform Bill that would result in the Reform Act of 1867. It was the result of a political movement for more democracy and public input in the political system. The debates and votes in Parliament brought down the liberal Russell government. People organized in the Reform League had demonstrated by the hundreds of thousands in cities like London, Manchester and Glasgow. Faced with the possibility of popular revolt going much further, the government rapidly included into the bill amendments which enfranchised far more people. The act doubled the number of people that could vote.

[244] Equivalent to ca 557 million pounds in 2014, calculated on the basis of the real price of a commodity. Source: www.Measuringworth.com.

the slightest doubt that, even at the price paid, the country will find it has made a good bargain. No apprehensions need be entertained for the revenue, but pecuniary profit to the government is the least of the advantages to be expected" (Perry, 1997, p. 421).

Making a profit for a government organization is not too easy, especially when it is growing fast and dissatisfied employees went on strike, as was soon the case. It already started with an overspending due to calculations that had been too optimistic[245]. It would result in the Post Office Scandal of 1873.

> *His [Scudamore's] overspending of £ 812,000 to expand the newly nationalized system precipitated a major scandal in 1873 which had lasting results. Politically, the crisis came at the worst possible moment for Gladstone's government, already weakened by the defeat of the Irish University Bill. The irony of such large-scale*

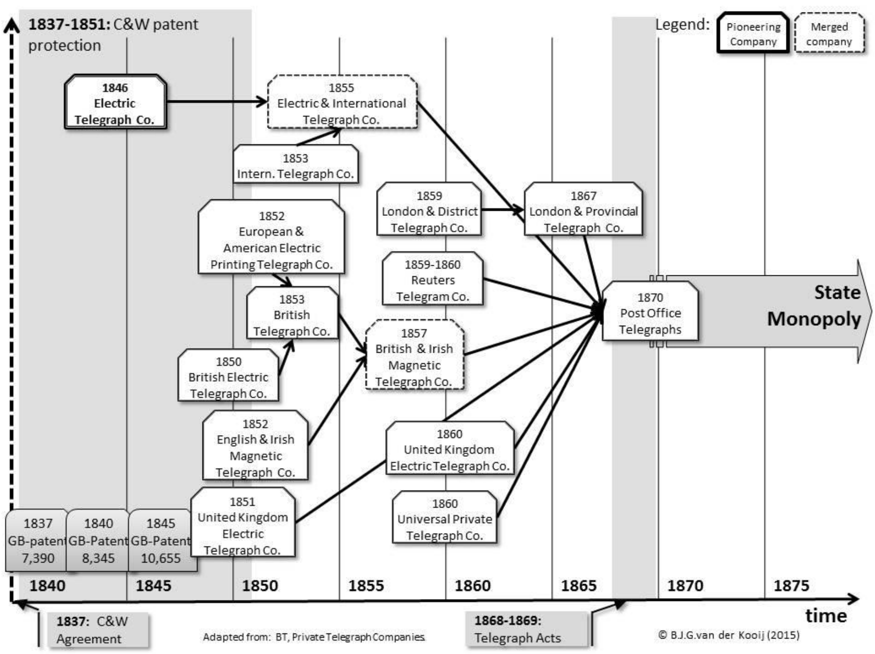


Figure 161: Some of the mergers and acquisitions of telegraph companies resulting the British Post Office Telegraphs.

Source: www.imgkid.com

[245] It had been calculated that an investment of £6.715 million would be needed. The net profit of this investment was expected to be £45,754. The reality was that after some years of profit, from 1886 on, the post office telegraph only made losses (Perry, 1997, p. 423).

> *irregularities in a government which prided itself on administrative efficiency and economy was not lost upon the Opposition. As a result the government was forced to face parliamentary deliberations on the scandal which were, in Gladstone's words, "of a truly mortifying character."' Constitutionally, the crisis was of permanent significance,* … [this] *made the Treasury much less enthusiastic about the prospect of further government expansion into the private economy. This disenchantment helped to delay for a generation the next experiment in nationalization, the takeover of the telephone industry.* (Perry, 1980, p. 351)

Although in Parliament there was a solid majority in favour of nationalization, not everybody was that enthusiastic about the proposed nationalization. One of them was William Fothergill Cooke, the man who started it all after he attended the lecture given by Professor Georg Wilhelm Muncke in 1836. Then he saw a demonstration with a copy of Schilling's single-needle telegraph that sparked his entrepreneurial spirit: communication over a distance by means of that fascinating new medium of electricity. Some three decades later, in 1869, he was knighted for his contributions to telegraphy. The telegraphy that he had started had conquered Europe. He was proud of that fact, but he could not appreciate the nationalization of the Electric Telegraph Company. He wrote to the late Isambard Kingdom Brunel's sister, Mrs. Sophia MacNamara Hawes, to tell her his thoughts about the award just bestowed upon him.

> *I have today had the honour of visiting upon her Majesty at Windsor! I feel the honour I have received quite adequate to my personal deserts - but I am morally convinced, that the country which originated and realized the Electric Telegraph, and the Gov't. which takes possession of it by violence - ie by an Act of Parliament, must hold the national honour very cheap - when a Knighthood given to an old man after 34 years of labour - and a sum of money to shareholders in a Company - are deemed sufficient acknowledgement of the introduction of an invention, now about to be a national Institution , which in its own line can never be surpassed.*[246]

[246] Source: William Fothergill Cooke. Biography. http://ethw.org/William_Fothergill_Cooke (Accessed April 2015)

Telegraphy: A Governmental Affair

The development of British pointer telegraphy, as one of the major trajectories that were followed in the development of the electric telegraph, shows the penetrating power of electricity in fields outside its own development trajectory[247]. Although the original needle telegraphy did not survive, within a couple of decades, pointer telegraphy had grown from its infancy (the early 1840s) into a mature communication infrastructure. It had resulted in a bonanza of industrial activity: the "cluster of innovations" (Figure 153) had resulted in a "cluster of businesses" (Figure 157).

Figure 162: British Tilbury Post & Telegraph Office (1890).

Source: http://gallery.nen.gov.uk/asset77461-.html

Enabled by the Telegraph Act of 1846, a new industry of telegraphic service providers had developed, servicing the public in a nationwide network of telegraph offices (Figure 162). Soon, after rather slow but increasingly enthusiastic adaptation of this new means of communication by business, news agencies and private persons, the same public was faced with the limitations of the new technology, as there were slow transmissions, delays, and queuing as the result of non-compatible systems. And the public was indirectly confronted by the effects of fierce business competition. It was the natural monopoly of the Electric Telegraph Company joined by some other companies (Table 10), the result of business concentration due to a range of mergers and acquisitions (Figure 161).

It created an atmosphere of malcontent in which the privately held telegraph companies were criticized for their performance. The political debate about public interest culminated in the Telegraph Acts of 1868/69, which enabled nationalization of the private companies. It resulted in the

[247] See: B.J.G. van der Kooij: *The invention of the electromotive Engine.* (2015)

monopoly of the British Post Telegraph.

Figure 163: Women working in a telegraph office (1871).

Source: The Illustrated London News Picture Library, http://victoriancontexts.pbworks.com/

In England, in contrast with America, the business development of the telegraph service providers was interrupted by nationalization through the British government in the late 1860s. It was the end of the involvement of the privately owned telegraph lines but the beginning of public ownership with a massive growth of telegraphy that would last till the turn of the nineteenth century. Now government, representing the public interest had to take care of the astronomical development of the maturing telegraph services for the decades to follow (Figure 164).

In another way, the government profited from maturing telegraphy. As telegraphy was bridging the vast distances of the British Empire, it was making its government from London even more effective and powerful. Ultimately, the telegraph would have great impact on British society,

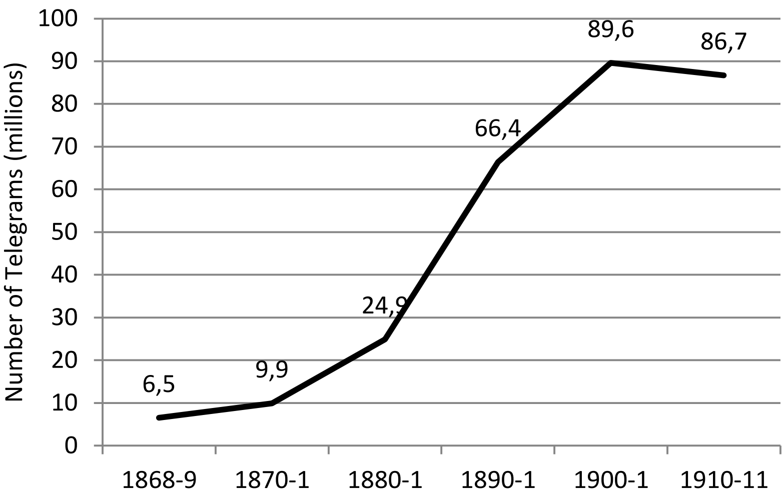
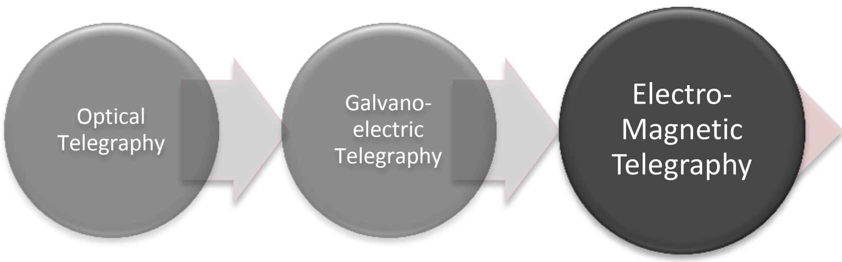


Figure 164: Growth of British Post Telegraphy (1868-1919).

Source: Perry (1997), Table 3, p.422

supporting quite some societal changes. One of those was the employment of woman in the telegraph offices (Figure 163), a phenomenon that could be observed later on also in the telephone services. But—again—that is another story….

The Invention of Electro-magnet Telegraphy



The development of telegraphy in Europe started with the early explorations of Gauss, Weber and Steinheil and was fuelled with the contributions of Cooke and Wheatstone. However in the late 1830s they were paralleled by another—quite independent—development on the other side of the Atlantic Ocean. In the same period of time, there was a completely different development trajectory: the development of the electro-magnet telegraphy, with a similar result. Electric telegraphy became the new way of communication also in United States of America.

As the Old World and the New World were quite interconnected economically, politically and socially, both technical developments soon also became interconnected. Early European electric technology, like Sturgeon's invention of the electro-magnet (S. P. Thompson, 1890), reached America, and American technology (eg Henry's electromagnetic relay) influenced the European development of telegraphy considerably. But the context for the development of the American version of telegraphy was quite different. The young nation, in which the role of the state was perceived differently from the European continent, provided a context dominated by private enterprise: it was capitalism that ruled. The so-recently formed United States had been faced with the disconnection of its political and economic ties from its homeland, Britain, and had even fought with it the 1812-war—its second war of independence. It was still politically maturing, and early industrialization, canalization (eg the completion of the Erie Canal in 1825) and the growing urbanization (as the result of massive immigration) showed all the effects of the first Industrial Revolution in the eastern coastal areas.

In Europe, Napoleon's defeat at the Battle of Waterloo in 1815 had changed the course of history. A period of continuous wars between France and the rest of Europe had ended. It resulted in the post-Waterloo economic recession and following boom in Britain. Free trade with the New World was embraced. Aside from the 1827 Bank Panic, Britain's economy prospered. But France was still going through social-political turmoil. The Bourbon Restoration into the constitutional monarchy had resulted in revolt: the 1830 July Revolution. Again, the geopolitical situation changed in Europe as Belgium declared its independence, revolting from the United Kingdom of the Netherlands. Although the French Revolution initiated some reconstructions of European societies, the influence of parliamentary governments was hardly tangible in those days.

So here we are, again in the 1830s—an interesting time for telegraphic communication, as it would enter a new phase when electricity was applied as carrier for information over distance. It would herald a revolution in communication in which it liberated the actual communication (formerly written text) from the problems of transportation (formerly physical). And now it was about to happen in the US.

Early Days of Telegraphy in America

The semaphore system of communication was used in many American harbours to optically signal the arrival of ships—quite an important occasion in those days, where shipping was the only way to communicate with the Old World. And within in the New World, the postal system was used to spread the news. Early—expensive—semaphore systems that were erected in Novia Scotia and which had primarily a military purpose, were short lived after the Peace of Amiens (1803), in which Britain and France halted—for a short while—hostilities.

In 1800, Jonathan Grout constructed a 104 km long semaphore connection between Martha's Vineyard—an island on the East coast of the USA—with Boston—the premier shipping and trading port of America—to transmit news about shipping. Also the marine semaphore station build in 1821 on the New York Staten Island (formerly known as Staaten Eylandt, named by the Dutch explorers) served this purpose of announcing the arrival of ships from Europe in New York Bay to the station at the Merchants's Exchange in Wall Street, New York (eg the arrival of packet boats like the Sully, sailing from le Havre, France in 1832).

In January1837, a 1,200 mile semaphore telegraph system was proposed to Congress by Captain Samuel Chester Reid, a celebrated naval hero of the War of 1812. The system was to be built between New York and New Orleans[248]. It resulted in the "Report Of The Committee On Naval Affaires, On The Petition Of Captain Samuel C. Reid", on March 4, 1818. The idea of a faster medium of communication was well received by those who were closely involved: government, military and science. The system they had in mind was an optical telegraph similar to the French system of Claude Chappe (John, 1998, p. 197).

Of the eighteen responses that Woodbury, the secretary of state initiating the study, received, seventeen assumed that the telegraph would be optical and that its motive power would be human. One of the eighteen reactions was from an unlikely source: it came from a painter who had just returned from a stay in Europe. (Hochfelder, 2012, pp. 1-2).

> *Among the replies was a protest from a New York college professor named Samuel F. B. Morse, who told the Secretary in effect that it would be unwise to spend a lot of money on visual telegraphs, which would be out of commission at night and in bad weather, and would soon be obsolete, anyhow; for he, Morse, had under way a system of telegraphing by electricity which could be used at any time and in any weather and would sweep the semaphore out of existence. He so impressed some of the Congressmen with the possibilities of his device that governmental interest in visual telegraphs quickly died out.* (Harlow, 1936, p. 32)

Morse concluded his reaction with: "In conclusion, I would say, that if the perfecting of this new system of telegraphs (which may justly be called the American Telegraph, since I can establish my claims to priority in the invention) shall be thought of public utility, and worthy the attention of Government, I shall be ready to make any sacrifice of personal service and of time to aid in its accomplishment. In the mean time I remain, sir, with sincere respect and high personal esteem, Your most obedient, humble servant, "-SAM'L F. B. MORSE (S. Prime, 1875, p. 320).

His reaction had a result; he was invited for a demonstration:

> *In February 1838, Morse exhibited his telegraph to Congress and the Van Buren administration in a room at the U.S. Capitol. He hoped to receive government funding for a large-scale trial. Some congressmen were interested in supporting Morse's device, including the members of the House Committee on*

[248] Petition of Samuel C. Reid, praying the establishment of a line of telegraphs from New York to New Orleans. Source: https://catalog.libraries.wm.edu/Record/2505232. (Accessed June 2015)

Commerce, who reported that, if successful, it would be so powerful that "the Government alone should possess the right to control and regulate it" and advised Congress to "enable the inventor to complete his trial." Most congressmen, however, were less than enthusiastic, and Morse left Washington disappointed and empty-handed. [249]

Overall, that reaction of polictics, although understandable when one realizes that politician are occupied with today's problems and future opportunities, was definitely a downer for Morse. But he did not give up, and it is time we looked at the efforts of this painter—who was not an engineer nor a scientist schooled in electricity—that dared to propose such a revolutionary concept of telegraphy.

Towards the Electro-magnetic Telegraph

As we have saw before, the developments in Europe that resulted in the galvanometer crystallized in the first needle-based telegraphic apparatus. In short it was the scientific trajectory—originating in Volta's chemical battery, Oersted's electromagnetism, Schweiggers multiplier, Summering telegraphs and the contributions of Gauss, Weber and Steinheil—that contributed to the early understanding of electricity as a carrier for information. And it was the property of rotary movement—the rotation of the needle or the coil—that was exploited.

This increasing understanding was certainly followed by the American scientists of that time, who contributed—as we saw before—to the development of the electromagnet. Based of Sturgeon experimenting with electromagnets, it was Joseph Henry who created the different magnets that could exploit linear movement—ie the movement of iron in a coil or the attraction of iron by a magnet—with his quantity magnet and intensity magnet. It resulted in the application of the property of linear movement—the electromagnetic relay—and a completely different development trajectory for the telegraph—a trajectory initiated by one single person: the painter Samuel Finley Morse.

Samuel Finley Morse

Samuel Finley Breese Morse (1791-1872), son of a Calvinist preacher educated in the subjects of religious philosophy, mathematics and science of horses, started during his years at Yale College in New Haven, Connecticut, with painting, although he followed the courses in natural

[249] Source: Telegraph: Early Postal Role. https://about.usps.com/who-we-are/postal-history/telegraph.rtf. (Acessed June 2015)

history given by Professor Sillman and by Professor Day.

> *One day after a lecture on the mysteries of electricity Professor Day announced that he would try a few simple experiments. He told all the members of the class to join hands; then one student touched the pole of an electric battery and at the same instant every boy in the line felt a slight shock, which young Morse described as like a slight blow across the shoulders. This experiment was made to give the students some little notion of the marvelous speed with which electricity travels.* [250]

He went in 1811 to England, studying painting under the tutelage of Washington Allston, one of the top art teachers of his day. He even managed to be admitted to the Royal Academy at the end of 1811. At the academy, he was moved by the art of the Renaissance and paid close attention to the works of Michelangelo and Raphael. After observing and practicing life drawing and absorbing its anatomical demands, he created a clay model of the figure he had in mind, thus helping to conceptualize the creative work to be made. It would become his masterpiece, the Dying Hercules (Figure 170). With the clay model, he won a sculpturing contest, and the painting won popular acclaim: "Flushed with triumph, Samuel Morse was ready to return to the United States to paint great, dramatic scenes of American history" (Helfer, 1952).

Figure 165: Samuel Morse's painting of the Dying Hercules (1812).

Source: Wikimedia Commons, www.nga.gov/exhibitions/2011/morse/morseinfo.pdf

Morse was in London during turbulent times for Europe. Napoleon Bonaparte had been defeated at Leipzig by the allied countries and the French monarchy was being restored after the occupation of Paris in the Battle of Paris/Montmatre of March 30, 1814 (see Chapter Context). The new king was about to leave London to return to France when he was observed by Morse. He wrote home about it:

[250] Source: http://www.heritage-history.com/?c=read&author=perry&book =inventors&story=morse (Accessed June 2015)

> *You will probably, before this reaches you, hear of the splendid entree of Louis XVIII into London. I was a spectator of this scene. On the morning of the day, about ten o'clock, I went into Piccadilly through which the procession was to pass. … I waited four or five hours, during which time the people began to collect from all quarters; the carriages began to thicken, the windows and fronts of the houses began to be decorated with the white flag, white ribbons, and laurel. … soon after the grand duchess, attended by several Russian noblemen, made her appearance on the balcony, followed by the Queen of England, the Princess Charlotte of Wales, the Princess Mary, Princess Elizabeth, and all the female part of the royal family. … I now grew several inches taller; I stretched my neck and opened my eyes. One carriage appeared, drawn by six horses, decorated with ribbons, and containing some of the French noblesse; another, of the same description, with some of the French royal family. At length came a carriage drawn by eight beautiful Arabian creamcolored horses. In this were seated Louis XVIII, King of France, the Prince Regent of England, the Duchesse d'Angouleme, daughter of Louis XVI, and the Prince of Conde. … As the King passed the royal family he bowed, which they returned by kissing their hands to him and shaking their handkerchiefs with great enthusiasm. …*
>
> *I took advantage, however, and got directly before the windows of the hotel, as I expected the King would show himself, for the people were calling for him very clamorously. I was not disappointed, for, in less than half a minute he came to the window, which was open, before which I was. I was so near him I could have touched him. He stayed nearly ten minutes, during which time I observed him carefully. He is very corpulent, a round face, dark eyes, prominent features; the character of countenance much like the portraits of the other Louises; a pleasant face, but, above all, such an expression of the moment as I shall never forget, and in vain attempt to describe. …*
>
> *I saw a monarch who, for five-and-twenty years, had been an exile from his country, deprived of his throne, and, until within a few months, not a shadow of a hope remaining of ever returning to it again. I saw him raised, as if by magic, from a private station in an instant to his throne, to reign over a nation which has made itself the most conspicuous of any nation on the globe.* (E. L. Morse, 1914a, pp. 136-140)

This was also the time of the aftermath of the American Revolution when the United States had declared their independence from Britain. During Morse's time in Britain, the Americans and British were engaged in the War of 1812. Both societies were conflicted over loyalties.

In 1815, he returned to the US, and as he was ready to start a career as a painter, he opened a studio in Boston. In that early period, he was not too successful, travelling the countryside to get orders for paintings. He had no money, he could get no work and his rent and board had to be paid. But that changed when—although having failed to be allowed to contribute to the paintings in the Capitole's rotunda—he painted portraits of many celebrities of that time, such as the presidents Monroe and John Adams (1816), or the societal elite of that time. During the financial Panic of 1819 his commissions declined again. Luckily he was in 1825 commissioned to paint the Marquis de Lafayette (Figure 16), the leading French supporter of the American Revolution. Morse felt compelled to paint a grand portrait of the man who helped to establish a free and independent America. His fee was $1,000, paid by the City of New York. Again the circumstances for Morse had changed. He painted Jonas Platt, a lawyer, politician, judge and member of the US Congress (Figure 166). Rich men who had picture galleries began to think that their collections were incomplete unless they included one or two of S.F.B. Morse's paintings. The life of an artist certainly had its ups and downs.

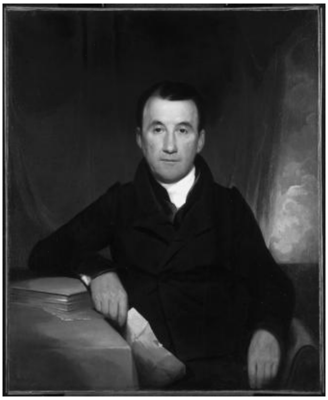


Figure 166: Samuel Morse's painting of Jonas Platt (1828).

Source: Wikimedia Commons, https://www.brooklynmuseum.org/opencollection/objects/1729/Jonas_Platt

Although being a painter of considerable reputation, he was already—like so many people in that time—in his early years highly interested in the developments of electricity. In 1827, he attended lectures on electricity and electromagnetism given by Professor James Freeman Dana at the New York Atheneum, where Morse also lectured.

> *Morse had long had an intelligent interest in the new discoveries in electricity. At Yale, he writes with enthusiasm about Professor Day's experiment in the "Philosophical Chamber," and Professor Dwight's lectures. Later, in New York, he heard Prof. J.M. Dana in public lectures and demonstrations.* [251]

In 1829, after having made something of a name with his portrait paintings, he made again a trip to Europe to do some painting and spend his time among the artists and art galleries of England, France and Italy in 1830-1832. In Paris he undertook to create a painting of the interior of the Gallery of the Louvre, showing some of the exhibited masterpieces in miniature[252] (Figure 167).

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[251] Mather, F.J.; Morse and the Telegraph. Source: http://www.thenation.com/article/morse-and-telegraph/ Accessed July 2015)
[252] Brownlee, P.J.: A new look at Samuel F.B. Morse's Gallery of the Louvre.

> *My anxiety to finish my picture and to return drives me, I fear, to too great application and too little exercise, and my health has in consequence been so deranged that I have been prevented from the speedy completion of my picture. From nine o'clock until four daily I paint uninterruptedly at the Louvre, and, with the closest application, I shall not be able to finish it before the close of the gallery on the 10th of August. The time each morning before going to the gallery is wholly employed in preparation for the day, and, after the gallery closes at four, dinner and exercise are necessary, so that I have no time for anything else* (E. L. Morse, 1914a, p. 422)

He travelled in France to the Riviera, visiting Dyon, Lyon, Marseille, Cannes, Nice and Monaco, and saw along the road towards Avignon the optical telegraph system the brothers Chappe had created. He also traveled Italy, passing Genoa, Sestria, Spezia, Lucca and Florence up to Rome where he visited the Vatican with its St. Peter Cathedral and the Sistine Chapel.

> *At three o'clock went to St. Peter's to see ceremonies at the Sistine Chapel. Cardinals asleep; monotonous bawling, long and tedious; candles put out one by one, fifteen in number; no ceremonies at the altar; cardinals present nineteen in number; seven yawns from the cardinals ; tiresome and monotonous beyond description.* (E. L. Morse, 1914a, p. 345)

Figure 167: Samuel Morse's painting of the gallery of the Louvre (1832).

Source: Wikimedia Commons, www.nga.gov/exhibitions/2011/ morse/morseinfo.pdf

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Source: https://www.nga.gov/exhibitions/2011/morse/morseinfo.pdf (Accessed January 2015)

In his earlier trip in 1811-1815, he had been observing King Louis VIII, who was to return to France to be put on the throne by the allies who conquered Paris in March 1814. And he was confronted with the aftermath of Napoleon's defeat at Waterloo (see Chapter Context).

> *It was Morse's good fortune to have been a spectator, at various times and in different places, of events of more or less historical moment. We have seen that he was in England during the War of 1812; that he witnessed the execution of the assassin of a Prime Minister; that he was a keen and interested observer of the festivities in honor of a Czar of Russia, a King of France, and a famous general (Bllicher); and although not mentioned in his correspondence, he was fond of telling how he had seen the ship sailing away to distant St. Helena bearing the conquered Napoleon Bonaparte into captivity.* (E. L. Morse, 1914a, p. 378)

Now, on his second voyage, he was confronted with the social turmoil of the early 1830s that occurred in Europe, not only in Paris in 1830 but also in Italy where several revolts took place at the time of his visit (February 1830). He witnessed it all from nearby.

> *"Rumors of conspiracy are numerous. The time, the places of rendezvous, and even the numbers are openly talked of. The streets are filled with the people who gaze at each other inquisitively, and apprehension seems marked on every face. The shops are shutting, troops are stationed in the piazzas, and everything wears a gloomy aspect. … It seems to be no longer doubtful that a revolutionary army is approaching Rome from the revolted provinces, and that they advance rapidly…"* (E. L. Morse, 1914a, pp. 380, 383)

On September 12, 1830 Morse was back in Paris, just in time to experience the aftermath of the French Revolution of 1830 when Charles X (the brother of Louis XVIII he had seen in London in 1814) was exiled (see Context). And he met the aristocrat General Lafayette, who he had painted in 1825 (Figure 16):

> *How changed are the circumstances of this city since I was last here nearly two years ago. A traitor king has been driven into exile; blood has flowed in its streets, the price of its liberty; our friend, the nation's guest, whom I then saw at his house, with apparently little influence and out of favor with the court, the great Lafayette, is now second only to the king in honor and influence as the head of a powerful party. These and a thousand other kindred reflections, relating also to my own circumstances, crowd upon me at the moment of again entering this famous city."… "The General looks better and younger than ever. There is a healthy freshness of complexion, like that of a young man in full vigor, and his frame and step (allowing for his lameness) are as firm and strong as when he was our nation's guest. I sat with him ten or fifteen minutes and then took my leave, for I felt it a sin to consume any more of the time of a man engaged as he is in*

> *great plans of benevolence, and whose every moment is, therefore, invaluable.* (E. L. Morse, 1914a, pp. 406, 408-409)

When the autumn of 1832 approached, he decided it was time to return home by packet boat. It would be a memorable trip that changed his life.

> *Morse was now forty-one years old; he had spent three delightful years in France and Italy; had matured his art by the intelligent study of the best of the old masters; had made new friends and cemented more strongly the ties that bound him to old ones; and he was returning to his dearly loved native land and to his family with high hopes of gaining for himself and his three motherless children at least a competence, and of continuing his efforts in behalf of the fine arts.* (E. L. Morse, 1914b, p. 3)

From Flash of Genius to the Sully Idea

Leaving Le Havre October 8, 1832, on his way back from France for a six weeks voyage on the packet boat Sully, Morse was participating in the discussions with other passenger during dinner on different subjects; the topic of the recently discovered phenomenon of electricity was Morse's favorite. One of those passengers was Dr. Charles Jackson who was well informed on the recent developments as he had attended lectures in Paris given by professor Claude M. Pouillet[253] of the Sorbonne and even had acquired an electromagnet and a galvanic battery. Especially interesting was the fact that Faraday's trial had indicated that electricity could pass through miles of wire as fast as lightning.

> *Dr. Charles T. Jackson, a Boston physician who was familiar with the latest European discoveries in electricity and electromagnetism, remarked that electricity passed instantly through long wires, and that its presence could be detected by breaking the circuit and observing the resultant spark. Morse exclaimed that "if this is so and the presence of electricity can be made visible in any desired part of the circuit, I see no reason why intelligence may not be instantaneously transmitted to any distance."* (Hochfelder, 1998a, p. 4).

This remark would later, during the patent war, become known as his flash of insight or flash of genius (A. Mossoff, 2014, p. 19).

During the trip—obviously stimulated by the discussions with the intelligent fellow travelers on board the packet boat—the idea of using electricity to transmit information obsessed Morse.

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[253] Pouillet had experimented with large electromagnets that could lift more than a thousand kilogrammes.

The thought at once greatly absorbed him. He felt within him the thrill of great possibility. The conversation went on, but Morse left the table for the deck, to brood over the conception which had suddenly broken upon him. And while he paced the deck, walking to and fro beneath the well-filled sails that bellied to the October wind, the idea rapidly took form is his mind, that either by the electro-chemical or electro-magnetic effect of a current, marks might be made at distances so great and in such a variety as to render possible the easy communication of and record of an intelligible language. This was, so far as he knew, a new thought. (Reid, 1886, pp. 39-40)

Morse was completely possessed by this new idea. He worked over it that day and far into the night. His vivid imagination leaped into the future, brushing aside all obstacles, and he realized that here in his hands was an instrument capable of working inconceivable good. (E. L. Morse, 1914b, p. 14)

In the remaining period of the voyage, he converted his idea into a concept, which he noted in—as often used by artists—a notebook for sketches. It concerned the conceptual idea of coding messages by making numbers the sign of words (e.g. "56" means "Holland", "161" means "France"). And he developed the functional idea of the registration of incoming signals on moving paper by means of an electromagnetic device (later to be called the *receiver*) (Figure 168). Functionally the apparatus was a complete and right design from that moment in October, 1832, when Morse casually scrawled on pages 25, 26, and 29 of his pocket sketchbook.[254] He considered this work to be his "discovery".

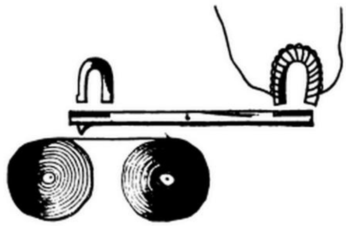

Figure 168: Reproduction of Samuel Morse's early sketches made during the voyage on the Sully (1832).

The sketch shows a balanced lever with a stylus which bears on a moving strip of paper served from rolls.

Source: (Reid, 1886) p.44

During the voyage of six weeks the artist jotted his crude ideas in his sketch-book, which afterwards became a testimony to their date. that he cherished hopes of his invention may be gathered from his words on landing, ' Well, Captain Pell, should you ever hear of the telegraph one of these days as the wonder of the world, remember the discovery was made on the good ship Sully.' (Munro, 1891, p. 52)

[254] Mather, F.J.; Morse and the Telegraph. Source: http://www.thenation.com/article/morse-and-telegraph/ (Accessed July 2015)

When he arrived on November 15, 1832, in New York, he was greeted by his brothers. His brother Richard described that reception later as follows:

> *Hardly had the usual greetings passed between us three brothers, and while on our way to my house, before he informed us that he had made, during his voyage, an important invention, which had occupied almost all his attention on shipboard — one that would astonish the world and of the success of which he was perfectly sanguine; that this invention was a means of communicating intelligence by electricity, so that a message could be written down in a permanent manner by characters at a distance from the writer. He took from his pocket and showed from his sketch-book, in which he had drawn them, the kind of characters he proposed to use. These characters were dots and spaces representing the ten digits or numerals, and in the book were sketched other parts of his electro-magnetic machinery and apparatus, actually drawn out in his sketch-book* (E. L. Morse, 1914b, p. 17)

A Lifetime Nuisance

Jumping ahead from these early days loaded with creative sparks, popping ideas, creative brainstorming, fascination with a new technology and youthful excitement, it was the discussions Morse had with Dr. Charles T. Jackson that would torment him in the years afterwards during the patent litigation to come. About two decades later, Jackson would claim to be the inventor of the electric telegraphy, as he was the one to have suggested the ideas. He declared in court:

> *First, I proposed to count the sparks in a disjoined wire circuit, counting the sparks in time, - that is, counting or noting the sparks, and the intervals between the sparks. Second, by producing colored marks upon prepared paper, the paper being saturated with an easily decomposable neutral salt, and stained with turmeric, or some other easily stained neutral colors. Third, by saturating the paper with a solution of acetate of lead, or carbonate of lead, the paper being moisted while the electric current was passed through it, or over its surface, between points of platina wire. Four, I proposed to make use of the electromagnet, which is formed by coiling copper wire, insulated by being wound with silk, around soft iron, bent in the form of the letter U, the iron being rendered temporarily magnetic by the passage of the galvanic current through the copper wire.* (Prescott, 1866, p. 407)

This declaration to the court was made on May 21, 1850, nearly two decades after the discussions between the two men actually took place. But it was not only a nuisance; Morse would be confronted in other ways with this issue repeatedly:

Morse's contest with Jackson became a lifetime conflict. For instance, when Morse became embroiled in a dispute in the late 1840s with Francis O.J. Smith, one of his business associates to whom was conveyed an ownership stake in his patent, Smith retaliated against Morse by supporting Jackson's claims against Morse. (A. Mossoff, 2014, p. 21)

The Electromagnetic Telegraph

Morse had his idea translated into a concept to apply electricity as a carrier for information. Now he had to translate the concept into a working apparatus. He had a rudimentary understanding of electricity and limited mechanical skills. From his return in 1832 to the first experimental model of his recording electric magnetic telegraph, which he showed publically in 1837, it took him five years. Financially, it was a difficult time; his professorship of the literature of the arts of design in the University of New York hardly allowed him to survive, having to make all the parts he needed himself.

If my nomadic mode of life for two years previous, and he conditions of my pecuniary means, be kept in mind; if, also, it be considered that many of the mechanical facilities in New York, so abundant at the present day, for embodying the invention, did not exist, and therefore were denied to me, it will account for the slowness in completing the instrumentalies of my invention, and the rudiness of the first constructed instrument. (Reid, 1886, p. 53)

A Time of Experimentation

After arriving back home on November 15, 1832, in New York he finished his paintings, among those the Gallery of the Louvre that he sold for $1,300[255] (Figure 167). As he was occupied for a while on other matters (in 1835 he became professor of the literature of the arts and design at the New York City University), he sometime later again started working fanatically on his new idea.

For several years he was on wrong tracks. He experimented with a dictionary code, the signals representing entire words and phrases. His feeling was still that the telegraph would be used only for important and secret business. But as early as the notebook of 1832, he had seen that the letter code must sometimes be used, as in proper names. For a long time, too, he made the signals by notched types which mechanically broke the current. Eventually this plan was abandoned for freehand manipulation of the key. For the key itself, after experiment with a pendulum form, he returned to the simple apparatus sketched in the memorable notebook.

[255] Equivalent to $37,100 in 2014 based on the historic standard of living value of that income. Source: http://www.measuringworth.com/

Before the year 1835 had closed, he had, unaided, carried the machine to the point where he could transmit messages through about forty feet of wire. [256]

He had constructed in 1835 an experimental telegraph made up of an old canvas frame as the register and a port rule for sending the intelligence. It was a rather clumsy and rude apparatus based on the frame on which normally the canvas for a painting was fixed (Figure 169).

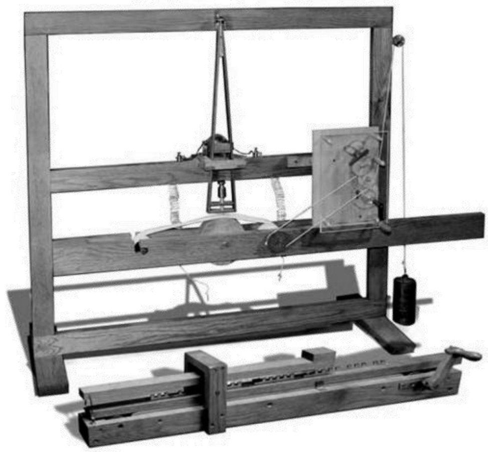

Figure 169: Morse's first experimental telegraph: the Port-rule (foreground) and the Receiver (background).

Source: http://morsecode.voices. wooster.edu/e_telegraph/

> *This machine used a pendulum-type swinging lever on which was mounted the recording pencil and the pole piece of the electromagnet. Directly below the pendulum, paper tape was pulled across the frame by an old clockworks. As the swinging pencil lever was actuated by the electromagnet, the pencil traced a wavy line on the paper that corresponded to the receiving signal pulses. (Coe, 2003, p. 29)*

That about the apparatus itself: the hardware. But Morse did more; he created the software. He also designed a code which could be used for transmitting the letters of the alphabet: the System of Signs. Each letter or number was given a unique code of dots and dashes as described in his in 1846 reissued patent. And he developed a dictionary: a vocabulary of some 5,000 words that each had a number (eg "England" had 252).

> *Claim 6: The system of signs consisting of dots and spaces, and of dots, spaces, and horizontal lines, substantially as herein set forth and illustrated, in combination with machinery for recording them, as signals for telegraphic purposes.* (text of Patent Reisue 117)

By 1837 he had developed—together with professor Leonard Gale—his first battery-powered electric telegraph (now called the receiver). As Gale

[256] Mather, F.J.; Morse and the Telegraph. Source: http://www.thenation.com/article/morse-and-telegraph/ Accessed July 2015)

described it later:

> *From April to September, 1837, Professor Morse and myself were engaged together in the work of preparing magnets, winding wire, constructing batteries, etc., in the University for an experiment on a larger, but still very limited scale, in the little leisure that each had to spare, and being at the same time much cramped for funds* (E. L. Morse, 1914b, pp. 53-54)

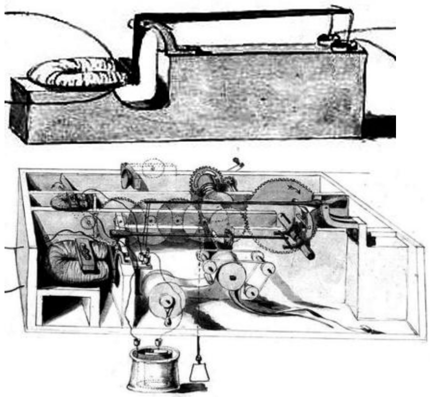

Figure 170: Original Samuel Morse single wire telegraph (1837).

Top: electromagnetic relay; bottom: complete apparatus with clockwork mechanism to move the paper tape. Drawings from French patent October 30, 1838.

Source: Wikimedia Commons, http://distantwriting.co.uk/images/morse%201838b.jpg

The receiver was a device with a pencil writing on a moving paper tape (Figure 170). The pencil drew a zig-zag pattern on a piece of paper. By adapting the pencil in an up/down movement, he could create dots (short activation of the relay) and lines (long activation of the relay) on the paper. Replacing the port rule, on the other side of the cable he designed a key switch for closing the electrical circuit: the Morse key (the transmitter). By tapping on this key, he could send electric pulses to the receiver at the other side of the cable.

He described his invention in a petition to obtain a caveat on December 28, 1837: "Specification Of The American Electro-Magnetic Telegraph." It declared the following:

> *I have invented the following apparatus, namely: 1. A system of signs, by which numbers, and consequently words and sentences, are signified. 2. A set of type, adapted to regulate and communicate the signs, with cases, for convenient keeping of the type, and rules, in which to set up the type. 3. An apparatus called the portrule, for regulating the movement of the type-rules, which rules, by means of the type, in their turn regulate the times and intervals of the passage of electricity. 4. A register which records the signs permanently. 5. A dictionary or vocabulary of words, numbered and adapted to this system of telegraph. 6. Miodes of laying conductors to preserve them from injury.* (S. Prime, 1875, p. 321)

The feasible version of the electromechanical telegraph was born as the *American Electro-Magnetic Telegraph* (see Figure 170) (Huurdeman, 2003, pp. 55-58).

With a Little Help from My Friends

In 1835, when he had a professorship of the literature of arts at the New York University; he there befriended Leonard D. Gale, professor of chemistry, who became enthusiastic about his ideas. Gale then introduced him to the work of other *electriciens,* like Joseph Henry, who had worked on his intensity magnet and experimented with long wires and electric bells.

> *Most importantly, Gale urged Morse to read Henry's 1831 paper in Silliman's Journal, which described these improvements. After using a twenty-element series battery and an electromagnet of several hundred turns, Morse and Gale were able to record messages through ten miles of wire.* (Hochfelder, 1998b, p. 6)

Morse also visited professor Joseph Henry at Princeton and discussed with him his experiments. Henry gave him some technical advice: "During this visit, we conversed freely on the subject of insulation and conduction of wires. I urged him to put his wires on poles, and stated to him my experiments and their results" (Prescott, 1866, p. 415).

> *The receiving magnet was a crucial component of his telegraph, which enabled it to function as a long-distance communications system. Acting as a relay, at great distances from the main battery and sending key, it operated a much shorter local circuit containing a smaller battery and Morse's recording instrument. The receiving and recording magnets were, respectively, little more than Henry's intensity and quantity magnets, which he described in his 1831 paper. Furthermore, the local circuit arrangement was quite similar to Henry's scheme, demonstrated to his classes since 1835, of using an intensity magnet to break the circuit of a quantity magnet supporting a load of weights.* (Hochfelder, 1998b, p. 7)

A Time for Demonstration

With the knowledge he obtained through these connections he also improved his prototype by using a stronger cell and more windings on the magnets. Still, the development of the apparatus was a tedious affair. In his own words he explained them:

> *"In 1836, and the early part of 1837," Professor Morse says, "I directed my experiments mainly to modifications of the marking apparatus, contrivances for using fountain-pens, marking with a hard point through pentagraphic or blackened paper, at one time on a revolving disk, spirally from the centre, at another on a cylinder, by which means' a large, ordinary sheet of paper might be so written upon that it could be read as a commonplace-book, and bound for reference in volumes, and devising modes of marking upon chemically-prepared paper. As my means and the duties of my profession would admit, the spring and autumn of 1837 were employed in improving the instrument, varying the modes of*

> *writing, experimenting with plumbago and various kinds of ink or coloring-matter, substituting a pen for a pencil, and devising a mode of writing, on a whole sheet of paper instead of on a strip of ribbon; and, in the latter part of August or the beginning of September of that year, the instrument was shown in the cabinet of the University to numerous visitors, operating through a circuit of seventeen hundred feet of wire running back and forth in that room. "* (S. Prime, 1875, p. 296)

One of those visitors was the 30-year-old student Alfred Gail, who accidently observed the demonstration and would become instrumental in its further development.

> *I saw this instrument work, and became thoroughly acquainted with the principle of its operation, and, I may say, struck with the rude machine, containing, as I believed, the germ of what was destined to produce great changes in the conditions and relations of mankind. I well recollect the impression which was then made upon my mind. I rejoiced to think that I lived in such a day, and my mind contemplated the future in which so grand and mighty an agent was about to be introduced for the benefit of the world. Before leaving the room in which I beheld for the first time this magnificent invention, I asked Professor Morse if he intended to make an experiment on a more extended line of conductors. He replied that he did, but that he desired pecuniary assistance to carry out his plans. I promised him assistance provided he would admit me into a share of the invention, to which proposition he assented. I then returned to my boarding-house, locked the door of my room, threw myself upon the bed, and gave myself up to reflection upon the mighty results which were certain to follow the introduction of this new agent in meeting and serving the wants of the world. With the atlas in my hand I traced the most important lines which would most certainly be erected in the United States, and calculated their length. The question then rose in my mind, whether the electro-magnet could be made to work through the necessary lengths of line, and after much reflection I came to the conclusion that, provided the magnet would work even at a distance of eight or ten miles, there could be no risk in embarking in the enterprise. And upon this I decided in my own mind to SINK OR SWIM WITH IT.'* (Munro, 1891, p. 57)

So, on September 2, 1837 he had demonstrated his system to colleagues and friends, sending a message through a wire 1,700 feet long (Figure 171).

> *This exhibition of the telegraph, although of very rude and imperfectly-constructed machinery, demonstrated to all present the practicability of the invention, and it resulted in enlisting the means, the skill, and the zeal of Mr. Alfred Vail, who, early the next week, called at the rooms and had a more perfect explanation from Professor Morse of the character of the invention.* (S. Prime, 1875, p. 303)

Soon the improved system worked well with 10 miles (16 km) of cable, and they decided to demonstrate it to a larger audiences, culminating in an exhibition for Congress.

Figure 171: Morse demonstrating his telegraph.
Source: kids.britannica.com

Inventing a concept and building a prototype to prove it works is one thing. To develop it into a working product is a totally different matter. Luckily he found Alfred Vail, the son of a rich entrepreneur with considerable mechanical skills: the help he needed. Vail not only was a skilled mechanic, he brought with him the fortune of the family[257] and was eager to work with Morse.

> *With those and other improvements to his telegraph, Morse, with the assistance of Gale, demonstrated in his classroom on September 4, 1837, the sending of messages via a wire 550 m long. The message he used, was: "Successful experiment with telegraph September 4 1837." That demonstration of the not very reliable device resulted in a joint contract of Morse with Gale and Alfred Lewis Vail. Alfred L. Vail (1807–1859), a member of the Mechanics' Institute, brought with him two advantages: technical aptitude and a rich father, Judge Stephen Vail, the owner of the Speedwell Iron Works in Morristown, New Jersey. Judge Vail agreed to finance further development of the electrical telegraph. On September 23, 1837, a contract was signed committing Alfred Vail to build the instruments and pay the cost of securing patents. Alfred received a 25% interest in the invention"* (Huurdeman, 2003, pp. 57-58).

The cooperation between Alfred Vail and Morse was not pure accidental because Alfred popped in during the demonstration in the lecture room.

> *Alfred and Morse had known each other as college student and professor. They had shared the same boarding house for a time and attended the same Mercer Street Presbyterian Church. Like Alfred, Morse had contemplated the ministry seriously but abandoned it. Like Alfred, Morse had a father, the celebrated*

[257] The Vail family owned the Speedwell Iron Works. In the factory building was a mechanical workshop that Alfred Vail used.

minister and geographer Dr. Jedidiah Morse, who thought that his Yale-educated son had thrown himself away by his choice of career. Both Alfred and Morse were strong believers in American culture; Morse was founder and first president of the National Academy of the Arts of Design. However, the personalities were very different. Morse was artistic in taste and temperament; he was a natural leader and organizer of men, energetic, impetuous and unafraid of controversy. Alfred had what Morse lacked -- mechanical genius, single-minded purpose now that his mind was captured, and loyalty, which would be sorely tried. (Cavanaugh, 1981)

So Morse created a partnership with Alfred Vail, who contributed with his mechanical skills and his father's and brother's money[258] and with Leonard Gale, who contributed with scientific knowhow and his academic network (Figure 172). Having secured the finances with the newly found "angel money", they started to work and expand the concept into another, more reliable, prototype.

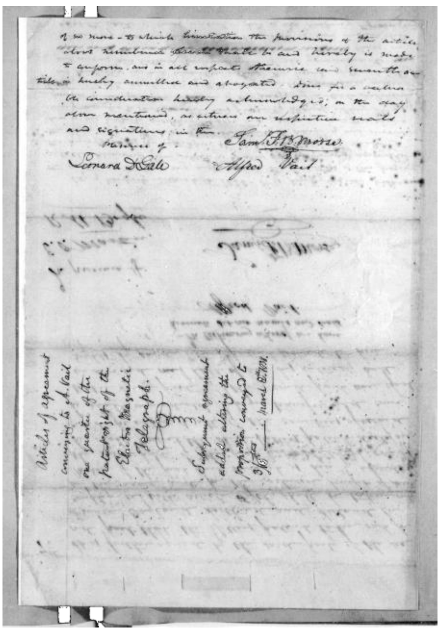

Figure 172: Partnership Agreement between Morse, Vail and Gale (1837).

Source: Samuel Mores paperswww.loc.gov

With Alfred Vail constructing the instruments at Morristown, Gale conducting experiments with stronger batteries and greater lengths of wire, and Morse in New York writing a five dash V-code dictionary of numbers, the work progressed. (Huurdeman, 2003, p. 58)

One has to realize, however, that the state of the art of fine-mechanical technology in those days was different.

It must be remembered that in those days almost everything they wanted had either to be made by themselves or appropriated to their purpose. Their first battery was set up in a box of cherry-wood, parted into cells, and lined with bees-wax; their insulated wire was that used by milliners for giving outline to the 'sky-scraper'

[258] Two thousand dollars were required to procure the patents and construct an instrument to bring before Congress (Munro, 1891). George Vail, the brother of Alfred, became a silent partner, backing the project with money.

bonnets of that day. The first machine made at Speedwell was a copy of that devised by Morse, but as Vail grew more intimate with the subject his own ingenuity came into play, and he soon improved on the original. the pencil was discarded for a fountain pen, and the zig-zag signals for the short and long lines now termed 'dots' and 'dashes.' (Munro, 1891, p. 59)

Ready for the Introduction

The phenomenon of electric telegraphy was becoming a hot item in the public attention. The March 1837 publications in the New York papers—like the *New York Observer* and the *Baltimore Patriot*—that two Frenchmen Gonon and Servell had invented an important system of telegraphs (that proved to be based on Chappe's optical telegraphy), got quite a lot of attention.

Mr. Gronon and his associate, Mr, Servell, have, after many years' application to the subject, invented an important system of telegraphs, which casts into the shade everything of the same kind that has yet been attempted. By their admirable plan, they can communicate every kind of information, word by word, and punctuate the same, without using more signals than words, and with as much rapidity as a person can write or even speak! They have received the most flattering encouragement from those literary and scientific gentlemen to whom they have explained the system, and not a doubt is entertained that it will accomplish the purposes of the inventors, and realize all that has been anticipated for it. Mr. Gonon assures me that he will be able to communicate a dispatch of one hundred words from New York to New Orleans in half an hour! (S. Prime, 1875, p. 297)

The subject of telegraphy also got political interest when the House of Representatives—also stimulated by the earlier-mentioned 1837 petition of Captain Samuel Chester Reid—passed a resolution asking the government to prepare a report upon the propriety of establishing a system of telegraphs for the United States. Morse, as we saw before, had reacted to that investigation.

Also, Morse had already been approached by speculators. It seemed time to become active, and Morse decided to speed up his preparations for a public presentation. Soon they—ie Vail and his assisten William Baxter working on the top floor of the old cotton factory in a big room with good window light, well fitted with tools—had created a working model that was ready for demonstration in January 1838. The first demonstration was at the Speedwell Iron Works for local people on January 6, 1838.

To test the new telegraph, Judge Vail handed his son a message to be sent. Morse received the message at the other end of the bench, and to the relief of them all, *correctly deciphered the famous historical sentence: "A patient waiter is no loser."* (Huurdeman, 2003, p. 58)

Next, on January 24, Morse demonstrated the telegraph in his university lecture room in New York. On February 8, Morse demonstrated the telegraph before a scientific committee at Philadelphia's Franklin Institute. On February 17 and on February 21, Morse demonstrated the telegraph to Mmebers of Congress and President Martin Van Buren and his cabinet. On February 17, 1838, Alfred reported breathlessly from the "Committee Room on Commerce":

> *The labors of the week have cleared and with the most unexpected success. Hundreds have witnessed the operation of the machine and its almost incredible powers...I see members of Congress eager to witness the powers of the machine and ... utter exclamations of wonder and amazement. Some say the world is coming to an end; others -- what would Jefferson think .... Where will improvements and discoveries stop? ... Some members ... bring in a half dozen more, and then they come again and again. Mr. Calhoun after he had seen it ... sent down a dozen other Senators to witness it. And so we go. The President and Cabinet have signified their intention to come.* (Cavanaugh, 1981)

On February 21, President Van Buren and his Cabinet came.

> *I have the pleasure to inform you that they were highly delighted and entirely satisfied. The President proposed the following sentence: "The enemy is near" to Prof. M. silently so that I could not and did not hear it. It was then put up on numbers and written on the register. I send you the actual thing itself which I wish you to preserve for me.* (Cavanaugh, 1981)

Although the demonstrations went well, not everybody was that enthousiastic, though.

> *Despite what Morse and Alfred believed, many Congressmen were dubious, sometimes downright hostile. Cave Johnson, unfortunately later Postmaster General, suggested sarcastically that the appropriation be divided equally between experiments in mesmerism and "the other absurdity." Some constituents agreed with the farmers of Morristown. A Congressman Wallace was defeated at the polls, charged with voting away the people's money on this preposterous scheme.* (Cavanaugh, 1981)

The Committee itself was enthusiastic and proposed a Bill. But the House of Representatives as a whole did not put it on the agenda to vote on it, as other pressing matters absorbed their attention, such as the financial panic of 1837. However, one member of Congress, chairman of the committee, Francis Smith, who had been instrumental in the dealing and wheeling, got quite interested. Morse saw in him the businessman that could complement the partnership with his knowledge of the inner workings of politics. And he would supply cash by paying for Morse's trip to Europe. Morse remained the majority shareholder. Smith's proportion was 5/16. Alfred Vail and George Vail's proportion was lowered to 3/16.

Morse's US Patent № 1,647

In 1837, Morse decided to patent his ideas. He started by applying for a one-year protection (the caveat[259]) on September 28, 1837. He next filed his formal application for a patent for "a new application and effect of electromagnetism in producing sounds and signs, or either" on October 3, 1837.

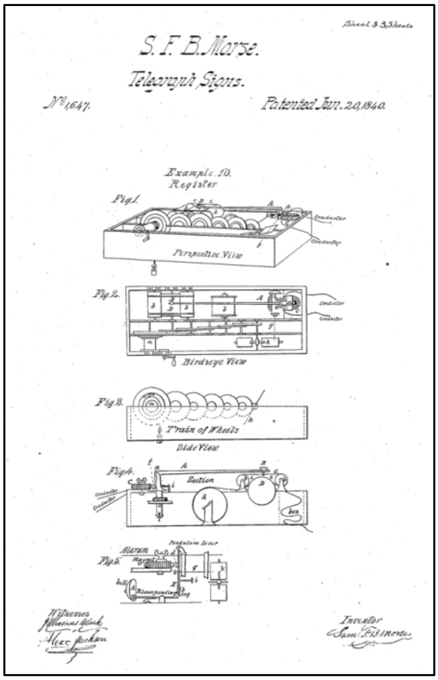

Figure 173: Patent № 1,647 for the Samuel Morse telegraph (1840).
Page shows the description of the receiver.
Source: USPTO

> *Summarizing his patent, he stated: "I specially claim as my invention the use of the motive power of magnetism as a means of operating machinery which may be used to imprint signals upon paper or other suitable material, or to produce sounds in any desired manner for the purpose of telegraphic communication that any distance.*" (Huurdeman, 2003, p. 59)

After some delays caused by both Morse and the Patent Office—some of it related to his trip to Europe to secure patent rights in England, France and Russia—his first patent on the electro-magnetic telegraph would eventually issue on June 20, 1840: US patent № 1,647 A (Figure 173). This patent would be replaced later on by several reissues[260] (Figure 174). It was for both the apparatus as well as for the code system.

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[259] An early legal device for establishing one's right to a patent by detailing some of the relevant information about one's claim to being a first inventor.
[260] Reissues of a patent are possible when the original patent has errors. Manual of Patent Examining Procedure (MPEP), Chapter 1400/1401.

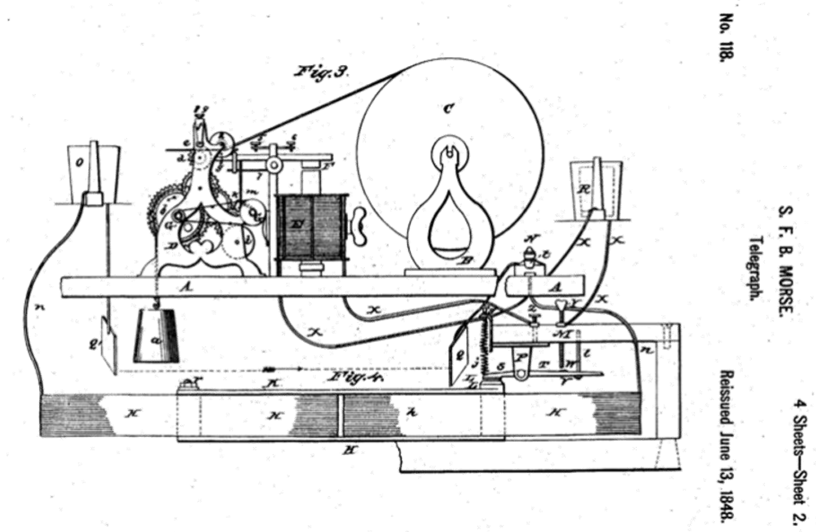

Figure 174: Drawing from Morse US Patent 1.647 Re-issue 118, (1848).
Source: USPTO

US patent № 1,647 contained several claims, among which the famous Nr. 8 claim, in which Morse stated:

> *I do not propose to limit myself to the specific machinery or parts of machinery described in the foregoing specification and claims; the essence of my invention being the use of the motive power of the electric or galvanic current, which I call electromagnetism, however developed, for making or printing intelligible characters, signs or letters that any distances, being a new application of that power, of which I claim to be the first inventor or discoverer.* (Text US Patent)

The "1,647" patent proved to be a pioneering patent, as it was referred to by many other inventors in their own patents. Samuel Morse's telegraph patent (classified in the patent group 178/2R "Telegraphy: Systems") provided the foundation for 807 additional patents related to his original invention.[261] Some of these early patents were US patent № 4,318A, granted to Ezra Cornell on December 20, 1845, for the improvement of cable usage and US-patent № 26,140A, granted to Samuel K. Zook on November 15, 1859, for using earth or water as a natural insulator. Both were early employees of the Magnetic Telegraph Company.

[261] Source: Watson, Jason, O.: A History of the United States Patent Office. [http://www.historical-markers.org/usptohistory3.cgi. (Accessed June 2015). A search in June 2015 gave 811 related patents.

Also, J.E. Smith was granted US patent № 35,571 on June 10, 1862. All these early patents were "improved arrangements". Finally, on October 1, 1867, Elisha Gray was granted US patent № 69,424 for his telegraphic relay instrument. These patents illustrate the developments that resulted in improvements of the telegraph system over the period of three decades.

Patent Monopoly

This broad claim more or less created a monopoly for Morse for telegraph apparatus and systems based on electromagnetism and used for recording or sounding telegraphic signals at a distance.

> *Morse and his supporters contended that his broad claims were perfectly legitimate, since he had not only invented his particular telegraph machine, but had also invented a new process, that of employing electromagnetism to record telegraphic signs or to make sounds. Morse often declared that he "invented a Genus as well as a Species. … Where this claim sustained, Morse would have been able to block the introduction of competing telegraph systems.* (Hochfelder, 1998a).

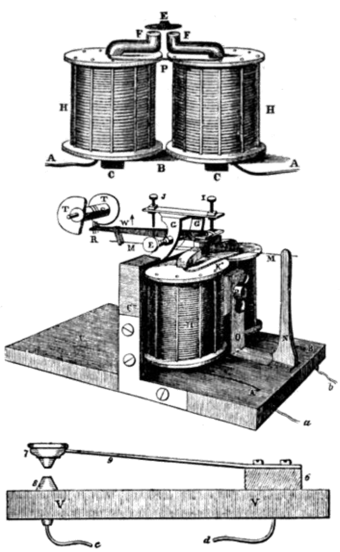

Figure 175: Major components of the Morse electro-magnetic telegraph (1845).

Drawing shows the electro-magnet (top), with the pen lever (middle) and the transmitting key (bottom).

Source: Vail, A.: the American electromagnetic telegraph ... (figure 7 (top), figure 8 (middle) and figure 11 (bottom) (1845).

Later, in 1853, after the Supreme Court's ruling in the *O'Reilly v. Morse* lawsuit, the original patent № 1,647 was adapted. Then the famous claim Nr. 8 was abandoned (Court, 1853). By shear chance, it was in the same month that the issue of his patent in 1840 was preceded by another telegraph patent granted a couple of days before. That was US patent № 1,622, granted on June 10, 1840, to the Englishmen Cook and Wheatstone for their needle telegraph! Morse might not have succeeded in getting a patent in England, but Cook and Wheatstone succeeded in getting a patent for their needle telegraph in the United States.

Morse's telegraph system consisted of several hardware components (Figure 175)—

components that were realizing the mechanical construction of the telegrap, such as the telegraph key as the input device, and the receiver as the output device. The electromagnet was the core of the receiver. And there was the software, the code itself , where combinations of dots and dashes represented letters and numbers. This was the Morse code. The dictionary concept of a vocabulary of words was not used any more.

Connecting these key and receiver by a long wire (and a battery), a message could be sent by tapping on the telegraph key. The electric impulses were received on the other line, where the telegraph receiver (also called the Morse Telegraph Register) would create a paper strip with the dots and dashes written on it. By 1845, it was a well-designed instrument that had no resemblance anymore with 1837 prototype. The ugly duck had become an elegant swan (Figure 176).

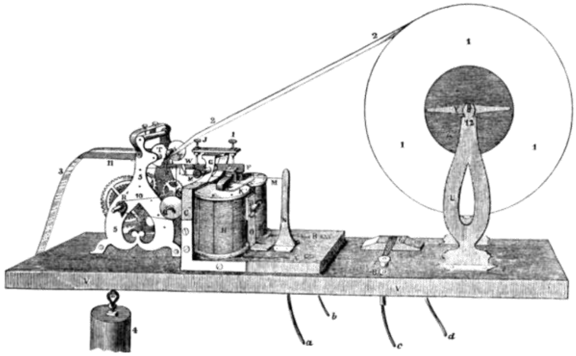

Figure 176: Morse Electro-magnetic Telegraph Register (1845).

Drawing shows the complete telegraph receiving unit with paper roll.

Source: Vail, A.: the American electromagnetic telegraph ... (1845)

Morse Does Europe

Morse wanted to secure his invention in Europe also, so on May 16, 1838, he sailed to England with a model of his telegraph and a second to be sent to France later on. There he met with Wheatstone, learning about Joseph Henry's relay. After taking the necessary steps to file the caveats he applied for the patent, he encountered a totally unexpected problem.

> *At this point I met the opposition of Messrs. Wheatstone and Cooke, and also of Mr. Davy, and a hearing was ordered before the Attorney-General, Sir John Campbell, on July 12, 1838. I attended that the Attorney-General's residence on the morning of that day, carrying with me my telegraphic apparatus for the purpose of explaining to him the total dissimilarity between my system and those of my opponents. But, contrary to my expectation, the similarity or dissimilarity of my mode from that of my opponents was not considered by the Attorney-General. He neither examined my instrument, which I had brought for that purpose, nor did he ask any questions bearing upon its resemblance to my opponents' system. I was met by the single declaration that my '_invention had been published_,' and*

> *in proof a copy of the London 'Mechanics' Magazine,' No. 757, for February 10, 1838, was produced, and I was told that 'in consequence of said publication I could not proceed.'* (E. L. Morse, 1914a, p. 94)

His protests to the attorney general were fruitless, as he was met with British nationalistic feelings.

> *In consequence of my request in this letter I was allowed a second hearing. I attended accordingly, but, to my chagrin, the Attorney-General remarked that he had not had time to examine the letter. He carelessly took it up and turned over the leaves without reading it, and then asked me if I had not taken measures for a patent in my own country. And, upon my reply in the affirmative, he remarked at: 'America was a large country and I ought to be satisfied with a patent ere.'* (E. L. Morse, 1914a, p. 95)

In France he was met by the scientific community with enthusiasm, but he failed nonetheless in obtaining a patent.

> *Arago, one of the grandest man France ever gave to the world, introduced Morse and submitted the Telegraph approvingly to the French Institute at one of their meetings. Some of the brightest men of Europe were present. Its reception was in the highest degree flattering. Guy Lussac gave it his unqualified admiration. Baron Humboldt said that the Morse invention was the best of all the plans that had been devised, and in the presence of the Institute arose, took Morse by the hand, and congratulated him in strong and hearty terms. …*
>
> *But this was all. France could issue a patent only on the invention put in actual operation within two years. To meet this, an agreement was made with the St. Germain Railroad Company to erect a line of telegraph upon their road, but this was made useless by the government interference, the establishment of a telegraph by private parties being regarded against public policy, and that this must be a government policy. Here was tyranny with a vengeance. Thus success and failure went hand in hand.* (Reid, 1886, pp. 92-93)

In other countries, he encountered problems caused by differences in the national patent systems at the time:

> *Tsar Nicholas I of Russia saw in the Morse telegraph potential help for a plot against his regime and us rejected Morse's proposal. In France, Morse obtained a patent but not permission to operate his system. In Germany in 1845, in line with the prevailing antipatent policy, the invention was considered not to be essential.* (Huurdeman, 2003, p. 59)

Returning in April 1839 to America, empty handed after failing to secure his patent right in Europe due to trivial but blocking affairs and regulations, he was quite somber.

All his efforts to introduce the invention into Europe were futile, and he returned disheartened to the United States on April 15, 1839. … Mr. Smith had returned to the political arena, and the Vails were under a financial cloud, so that Morse could expect no further aid from them. The next two years were the darkest he had ever known. …

Towards the close of 1841 he wrote to Alfred Vail: 'I have not a cent in the world ; ' and to Mr. Smith about the same time he wrote : " I find myself without sympathy or help from any who are associated with me, whose interests, one would ink, would impell them that least to inquire if they could render some assistance. For nearly two years past I have devoted all my time and scanty means, living on a mere pittance, denying myself all pleasures, and even necessary food, that I might have a sum to put my telegraph into such a position before Congress as to insure success to the common enterprise. (Munro, 1891, p. 62)

Clearly the period before Congress passed the Bill granting Morse the funding for his experimental telegraph line had been difficult for Morse.

Years afterwards Morse declared that this was the turning-point in the history of the telegraph. 'My personal funds,' he wrote, 'were reduced to the fraction of a dollar ; and had the passage of the Bill failed from any cause, there would have been little prospect of another attempt on my part to introduce to the world my new invention' (Munro, 1891, p. 64).

Morse Gets Funding for the Washington-Baltimore line

Although Morse had already in 1838 demonstrated his early telegraph to members of Congress, it was not before 1843 that he managed to return to Congress with a second demonstration. But the House of Representative was quite reluctant to support Morse's application for the financing of an experimental line.

Morse had come to be regarded as a tiresome 'crank' by some of the Congressmen, and they objected that if the magnetic telegraph were endowed, mesmerism or any other 'ism' might have a claim on the Treasury. The Bill passed the House by a slender majority of six votes, given orally, some of the representatives fearing that their support of the measure would alienate their constituents. Its fate in the Senate was even more dubious; and when it came up for consideration late one night before the adjournment, a senator, the Hon. Fernando Wood, went to Morse, who watched in the gallery, and said, 'there is no use in your staying here. The Senate is not in sympathy with your project. I advise you to give it up, return home, and ink no more about it.' (Munro, 1891, p. 65)

The senator for Indiana, Oliver Hampton Smith, observed after meeting Morse at a demonstration to Congress in 1842:

In a few minutes Senators Linn, Huntington, Merrick, Berrian, Woodbury, and Davis came in. He then proceeded to show us his invention and to point out the mode of operation. I watched his countenance closely, to see if he was not deranged ... and I was assured by other senators after he left the room that they had no confidence in it. (Smith, 1858, p. 413)


LIST OF MEMBERS
OF THE HOUSE OF REPRESENTATIVES OF THE UNITED STATES,
TWENTY-SEVENTH CONGRESS....THIRD SESSION,
COMMENCING MONDAY, DECEMBER 5, 1842.
JOHN WHITE, OF KENTUCKY, SPEAKER.

Figure 177: The annoted list of the members of the House of Representatives of December 1842 (Febr. 23, 1843).

This annotated member list of the twenty-six states may have been used by Morse before, during, or after the vote. the symbol "O" is thought to indicate an assenting vote, "-" a dissenting vote, and ">" no vote.

Source: http://www.loc.gov/collections/samuel-morse-papers/articles-and-essays/collection-highlights/invention-of-e-telegraph/

Although quite a few members were reluctant and wanted to avoid the responsibility of spending public money for a machine they could not understand, a vote was taken. With 70 members being absent, the bill passed by a vote of 89 to 83 (Figure 177). On March 3, 1843, the Bill had passed, after it had been voted on without debate at the very close of the session. Congress had decided to grant $30,000[262] to fund the erection of an experimental line between Washington and Baltimore (distance 64km).

It had taken Congress five years to make a decision to fund an experiment that would change communications in America (to say the least). Now it was Morse's turn to deliver. By August 1843, Morse had some 250 km of wire manufactured by the Stephens & Thomas plant in Belleville, New Jersey. The Ohio Railroad gave

[262] This amount would be equivalent to about $6 million in 2013 using unskilled labor costs as measure. Source: www.measuringworth.com

Morse permission to use the railroad's right of way. Work on the Washington-Baltimore line was started on October 1843. The telegraph lines on poles ran along the railway operated by the Baltimore & Ohio Railroad Company. The telegraph was completed a year later when the line was opened for public business on April 1, 1845 (Huurdeman, 2003).

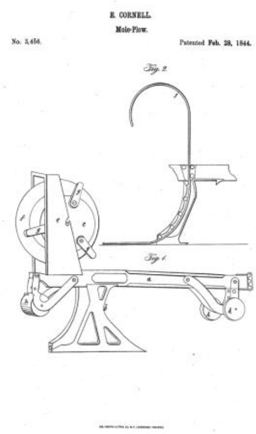

Figure 178: Cornell's patent № 3,456 for his cable-laying machine (1844).

Source: USPTO

The construction of the line had not been without technical problems—problems that had stressed the relations between the partners and the associates they worked with. One of them was related to the construction of the line, a task Smith had been awarded but that he had subcontracted to Ezra Cornell. Cornell was a practical man who had invented "a new and powerful machine for cutting trenches and laying pipes" (US-patent № 3,456 granted Febr. 28, 1844) pulled by donkeys (Figure 178).

> *By means of his ingenious trenching machine, [Ezra] Cornell was soon laying half a mile to a mile of cable a day. … By December [1843], the cable had been laid from the railroad station in Baltimore to Relay, Maryland, about eight or nine miles distant. Tests had by this time confirmed the growing suspicion that the faulty insulation of the wires in the cable was serious enough to require that work be halted. …* (R. L. Thompson, 1947, p. 22)

Figure 179: Telegraph lines installed on poles along the rail tracks.

Source: Wikimedia Commons

All the work done until that moment was lost. What to do as the press was closely watching the progress of the line? It was Cornell, who had put the cables in the ground, who found a solution to both problems. He sabotaged his own machine and suggested, after some deliberation, not to put the cables underground anymore, but to suspend them in the air on poles (Figure 178). Ezra gained Morse's gratitude (Becker, 2010, pp. 50-52), but on a personal level the damage between the partners would prove to be more serious.

The conductor was a five-wire cable laid in pipes; but after several miles had been run from Baltimore to the house intended for the relay, the insulation broke down. Cornell, it is stated, injured his machine to furnish an excuse for the stoppage of the work. The leaders consulted in secret, for failure was staring them in the face. Some 23,000 dollars of the Government grant were spent, and Mr. Smith, who had lost his faith in the undertaking, claimed 4000 of the remaining 7000 dollars under his contract for laying the line. A bitter quarrel arose between him and Morse, which only ended in the grave. (Munro, 1891, p. 66)

Finally the line was completed, and soon the line was used for sending messages (Figure 180, Figure 181). And one specific occasion drew the attention of the public.

An incident now brought the telegraph into instant public recognition. the National Convention to nominate a president was in session in Baltimore; James K. Polk had been nominated president; Silas Wright, then in the Senate, and in Washington, was named for the vice-presidency. Mr. Vail communicated is, over the wires, to Mr. Morse, who immediately told Mr. Wright. In a few minutes the convention was astonished by receiving a message from Mr. Wright respectfully declining the nomination. the presiding officer read the dispatch. the convention could not and would not believe its authenticity, but adjourned to await the report of a committee sent to Washington to confer with Mr. Wright. The committee confirmed the telegraphic message. This led to a conference between the committee and Mr. Wright by the wires. The fact was, of course, soon known, and the fame of the telegraph that once took wing (Reid, 1886, pp. 106-107).

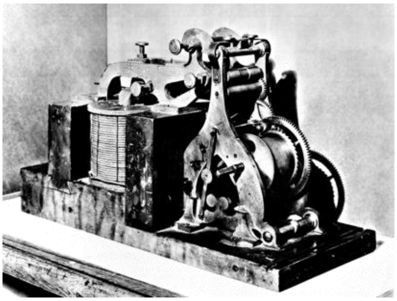

Figure 180: Morse telegraph used for the test of the Washington-Baltimore line.

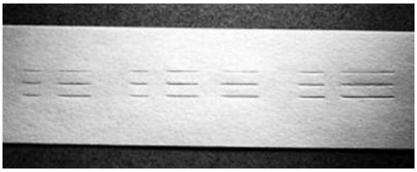

Figure 181: Paper strip with imprints of the dots and dashes.

Top: Vail's Register. Below: A sample of the print from the register. It was produced manually by pulling the paper through while depressing the lever. three letters, " A W A ".

Source: Wikimedia Commons

By now Morse's image had changed. Neglected before, now he became praised. The following year, another line from Philadelphia to Baltimore was built, after many troubles financing the Magnetic Telegraph Company that would be realizing the project and hold the patent rights. Both projects were the beginning of the network that would span America. While Morse was becoming more and more involved in business, he did not like the change from inventor to entrepreneur.

> *After the successful use of Morse's telegraph on the Baltimore-Washington, D.C. line in1844, Morse became a reluctant capitalist. He repeatedly expressed in letters his feelings of inadequacy in and sometimes dislike for commercial dealings. For instance, in a letter in 1839 to Francis O.J. Smith, he expressed appreciation for the efforts of "an energetic businessman like yourself," because, "for poor me I feel that I am a child in business matters." His first passion in life was to be an artist, a profession he actively pursued for decades before his fateful ocean journey in 1832. Although his involvement in the business deals and extensive legal wrangling over his telegraph meant that he never returned back to painting after the 1830s, his never lost his visceral disdain for such things.* (A. Mossoff, 2014, p. 32)

Morse's Entrepreneurial Activities

For Morse came a moment, after the success of the first line from Washington to Baltimore, to decided on what he wanted to do with his invention. He could sell the patent, as he was offered money from private investors for his patent rights, or he could sell the patent to the government. Originally he was inclined to offer his invention to the government and sell it for $100,000[263], but that idea was refused by the Postmaster General. Or he could license the rights on his invention to other entrepreneurs willing to exploit telegraph companies. The idea was to create separate lines radiating from New York to be realized by companies funded with private money. In these companies, 50% of the stock would be given to the holders of the patent rights. He decided to try for the last option.

> *In 1845, Morse hired [president] Andrew Jackson's former postmaster general, Amos Kendall, as his agent in locating potential buyers of the telegraph. Kendall realized the value of the device, and had little trouble convincing others of its potential for profit. By the spring he had attracted a small group of investors. They subscribed $15,000 and formed the Magnetic Telegraph Company. Many new telegraph companies were formed as Morse sold licenses wherever he could. … The first commercial telegraph line was completed between Washington, DC, and New York City in the spring of 1846 by the Magnetic Telegraph Company. Shortly thereafter, F.O.J. Smith, one of the patent owners, built a line between*

[263] This amount would be about $23 million in 2013 using labor costs as measure. Source: www.MeasureingWorth.com

New York City and Boston. Most of these early companies were licensed by owners of Samuel Morse patents.[264]

Morse did both sell the license to his patent (the right to use his system) as well as part of the ownership of the patent. And it was Amos Kendall who was to manage Morse, Gale and Vail's interest in the foreseeable business affairs.

By 1848 Morse had consolidated the partnership to four members. Kendall managed the three-quarters of the patent belonging to Morse, Leonard Gale, and Alfred Vail. Gale and Vail had helped Morse develop the telegraph's technology. F.O.J. Smith, a former Maine Representative whose help was instrumental in obtaining the government grant, decided to retain direct control of his portion of the patent right. The partnership agreement was vague, and led to discord between Kendall and Smith. Eventually the partners split the patent right geographically. Smith controlled New England, New York, and the upper-Midwest, and Morse controlled the rest of the country. (Nonnemacher)

The Magnetic Telegraph Company

As Congress was not interested in playing an active role in the further development nor in committing public funding, Morse had to revert to private capital. In May, Kendall and F. O. J. Smith created the Magnetic Telegraph Company to extend the first telegraph line. It was the beginning of the telegraph boom, as five years later, the new venture would be competing with over fifty other telegraph companies.

*In May, Kendall organized a joint stock association called the Magnetic Telegraph Company—the nation's first telegraph company. The Magnetic took subscriptions for carrying on the Baltimore-Washington line through Philadelphia to New York. Kendal himself served as the salaried president. (*Silverman, 2008)

Morse and his partners decided to create the line between New York and Philadelphia. For this line, they needed $15,000[265], and they wanted to raise this amount by interesting subscribers to invest in the new venture. As the original patentees were Morse, Alfred Vail, George Vail and Leonard Gale, they were soon to be joined with the new stockholders of the Magnetic Telegraph Company to be created. This meant that they had to share the rights in the patents.

But first they had to find those investors. So Ezra Cornell—who had

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[264] Source: http://historywired.si.edu/detail.cfm?ID=324 (Accessed June 2015)

[265] This amount would be equivalent to about $3.5 million in 2014 using unskilled labor costs as measure. Source: www.measureingworth.com

assisted as superintendent[266] in digging the trenches for the Washington-Baltimore line—and his brother-in-law Mr. O. S. Wood went to New York to find the capital they needed. They rented an office, set up the equipment, strung out the wires on the tops of the neighboring houses and waited for interested parties willing to look at their marvelous invention. But that proved not to be that easy.

> *The estimated cost of a line from Fort Lee to Philadelphia was $15,000. It was a very modest sum to ask of the great city of New York. But the men of capital looked over their immaculate collars that the ticking machinery, and into the faces of the hungry exhibitors, and up that the wire straggling among the chimney-pots, and then down that the meagre furniture, and said " No." Each man feared to be the first fool. But what capitalists would not do, humbler men, and the friends of the patentees, did. One of the first men in New York to invest his money in the new device was the keeper of an eating-house in Nassau street, where chicken-pie could be got for ten cents a plate, and who afterward became one of its directors. The money needed was finally raised, but chiefly outside of New York. Mr. Corcoran, of Washington, was the first to contribute* (Reid, 1886, p. 115).

In addition to people like William Corcoran, a banker from the Corcoran & Riggs bank who invested $1,000, people already involved in Morse's work took stock: eg Amos Kendall ($500) and Ezra Cornell ($500). In total they paid $15,000[267] and received shares for a nominal value of $100 for a $50 down payment. Their total share was thus valued in total at $30,000. The value of the patent was placed at $30,000. The value of the capitalization of the company then came to $60,000[268]. From the original agreement in which Morse had given each of his partners (Gale, Vale and Smith) a share in the patent right, now the patentees owned, in addition to the new subscribers, a smaller part in the new company (Figure 182). In the Articles of Association, it was worded as follows:

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[266] Ezra Cornell was hired for the sum of $1,000 a year. But he always took a large part of his pay in stocks, invested in many companies (eg Western Union stock). It made him a rich man.

[267] The subscribers were: Corcoran & Riggs, $1,000; B. B. French, $1,000; Eliphalet Case, $1,000; Charles Monroe, $1,000; Peter G. Washington, $200; John J. Haley, $500; John E. Kendall, $300; James A. McLaughlin, $350; Amos Kendall, $500; Ezra Cornell, $500; Daniel Gold, $1,000; Simon Brown, $500; J.J. Glossbrenner, $500; John M. Broadhead, $1,000; Charles G. Page, $500; George Templeman, $200; Henry J. Rogers, $100; J. W. Murphy, $100; A. W. Paine, $500; F.O.J. Smith, $2,750; J. Black, $200; Keller & Greenough, $500; J.S. Brodhead, $500; T.L. & A.T. Smith, $200; A. Thos. Smith, $200.

[268] Equivalent to ca $ 1,980,000 in 2014, calculated on the basis of the real price of a commodity. Calculated on the basis of income value this would be $ 38,900,000. Source: www.measuringworth.com

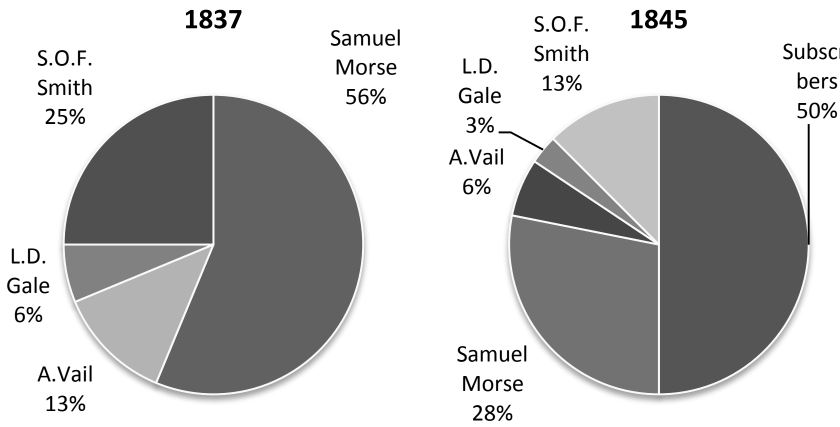

Figure 182: Distribution of the Agreement of 1837 (left) and stock percentages in the Magnetic Telegraph Company of 1845 (right).

The percentages are indicative as no exact data are available

Source: (Reid, 1886) Figures created by author.

> *7. For fifty dollars paid in by subscribers to construct, extend, or improve this line of Telegraph, a certificate for one share of one hundred dollars shall be issued by the Trustees, another share to be added, or another certificate to be issued, for every additional fifty dollars. Cotemporaneously certificates of stock in the same form, and to the same amount, shall be issued to the Grantors of the Patent Right, to each in proportion to his interest, so that the amount of stock issued to them and to the subscribers respectively, shall always be the same. These certificates of stock shall state on their face, that the shares they represent are not subject to future assessment, and also the mode of their transfer.* (Company, 1847)

With the capital being raised, they could start to build the line. But then they ran into unexpected problems.

> *As soon as the line was complete to Fort Lee our sorrows began. The glass knobs as they glistened in the sun were splendid marks for boys and rifle shooters, and they went by the dozen. Sometimes riflemen would try to split the wire. There was much ignorance of the purpose of the structure, and, from many causes, the wires broke. Then came summer, and the wires drew out, became attenuated, and gave much trouble. During the first five months after it was opened for public business, the line was down for thirty-six entire day. …*
>
> *The first great calamity to the new line, which resulted in the hasty removal of the copper wire, was when one night rain fell through a cold atmosphere and froze*

upon the wires. As the sun rose the next morning the sight was beautiful. The wires looked like two magnificent necklaces glistening with fairy sheen in the beauty of the morning dawn. But a change soon came. In an hour or two a sharp breeze came tripping up from the ocean. The wires swayed awhile to the music of the wind and looked more beautiful an ever. The wind stiffened, a moment more, and forty miles of wire went down as by a breath —every length broken short off at the poll (Reid, 1886, p. 121).

Not too surprisingly, all these technical problems resulted in financial problems. When the line was down, no messages could send, so there were no revenues. Also the problems in finding the right managers aggravated the situation. It was William Moseley Swain who turned that negative situation around in 1850 and made the company more successful (Figure 183).

On July 9, 1850, the Magnetic Telegraph Company finally got out of the bush leagues by electing William M. Swain president. He had been a member of the board and a stockholder since the beginning. He tackled the job head on and got all of the departments of the company shaped up. Personnel, public relations and service were all updated. … In 1852 the property of the "Bain Line", the North American Telegraph Company, was surrendered to the Magnetic Telegraph Company when it was proven that they had pirated Morse's invention. This gave the company a shot in the arm, and from then on good dividends with a good surplus in the company treasury were assured. In 1856 the company expanded

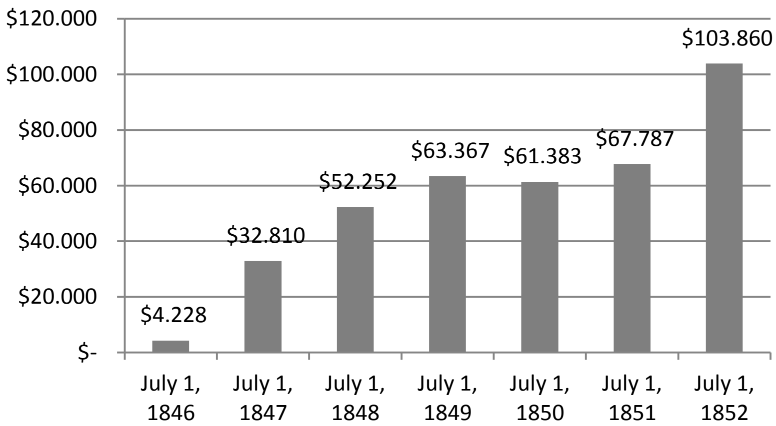

Figure 183: The cash receipts of the Magnetic Telegraph Co. (1848-1852).

One 1850 dollar is about $216 in 2014 (calculated on basis of unskilled labor costs).

Source: http://www.geocities.ws/niarhosjw/magnetictelegraph.htm, Census 1852, p.108, (Company, 1847) *further when the Washington and New Orleans Telegraph Company was leased for a period of ten years. In 1859 the Magnetic Telegraph Company bowed to the larger American Telegraph Company and consolidated with it. So the company was swallowed up and was no more.* [269]

Morse was not the only one who had noticed the business potential of his invention. The potential seemed to be astonishing in the private, corporate and business markets. In fact, nearly every message that was sent by postal mail (ie P-Mail) could be sent by telegram (ie T-mail). And such a potential attracted early investors and businessmen, who organized the new companies needing those investors, such as men like Henry O'Reilly, with considerable business aspirations—the tycoon to be—who we will meet later on.

Figure 184: Telegraph lines and stations in the US (1853).

Map detail shows (thin, straight lines) the telegraph lines erected in the period 1844.

Source: Library of Congress, Geography and Map Division. http://www.loc.gov/item/97683602

[269] Source: Shirley Patocka: *The Magnetic Egg*. Reprinted from 'Insulators –Crown Jewels of the Wire.' June 1978, p.17. http://www.geocities.ws/niarhosjw/magnetictelegraph.htm. (Accessed June 2015)

Soon the telegraph lines following the railroad tracks were used to carry news, share quotes, lottery and race results and "private" messages (Figure 184)—private in that they were non-public, such as in business communication between companies. They were based on mainly three types of systems; the Morse-system, the House system and the Bain system. In 1850, the United States possessed 15,835 miles of line worked under the Morse Syndicate's rights; 2,200 miles under House's patents and 2,012 miles under Bain's.

Patent War

After the failure to sell his patent to the government or acquire public funding, the decision was made to build their own extensions to the Washington-Baltimore demonstration line. Thus part of the business strategy became selling licenses for the use of the Morse system to other syndicates. And that happened, but not without problems of its own. He had to fend off inventors of similar telegraph systems, and he had to oppose those who thought that they could use his patent-protected system without paying royalties.

Patent Infringements

In both cases, Morse soon became involved in lawsuits to uphold his patent rights. His invention was so basic, his patent claims so broad, that many opposed his exclusive rights as granted in patent № 1,647, specially those competitors in the marketplace who were to seek to profit from the unauthorized, free use of the new telegraphic system. They—called the pirates—wanted to avoid paying royalties for using the patented technology. Morse's claim № 8 that he invented a general art—that of telegraphic recording using electromagnetism—and not just his specific transmitter and recording register, was by far the most controversial element of his patent.

> *During the extensive, multi-year litigation over his patented innovation, Morse would be bedeviled by Henry O'Reilly and others who went to great lengths in mischaracterizing the nature of this assistance to try to invalidate his patents. …*
>
> *In fact, Henry O'Reilly was no innocent infringer who just happened to have independently come up with the idea of an electro-magnetic telegraph on his own. O'Reilly was business man, not an inventor, and he was first brought into the telegraph business by Morse's business associates as a licensee of the Morse patents. In fact, in a few scant years O'Reilly went from proclaiming that the telegraph should be called the "Morsograph" and referring to Morse and his business associates as "a band of brothers" to proclaiming that Morse is a*

monopolist who "deserve[s] the 'piratical' reputation of plundering other men. (A. Mossoff, 2014, pp. 19, 31-32)

And then there were those inventors who created competing telegraph systems—inventing around Morse's patent on purpose or by accident. Some of these efforts seemed to infringe on Morse's patent and resulted in lawsuits: *Morse v. O'Reilly*, brought in Kentucky in 1849 against the Columbian Telegraph; *Smith v. Downing*, brought in Boston in 1850 against House's Printing Telegraph; and *French v. Rogers*, brought in Philadelphia in 1851 against Bain's Chemical Telegraph. The Morse interests were successful in *Morse v. O'Reilly* and *French v. Rogers* but failed to obtain an injunction in *Smith v. Downing*; the judge in that case ruled that House's telegraph did not infringe on Morse's patents. In the case against Bain's chemical telegraph Judge Kane and Judge Grier concluded:

> *That he, Mr. Morse, was the first to devise and practise the art of recording language, at telegraphic distances, by the dynamic force of the electro-magnet, or, indeed, by any agency whatever, is, to our minds, plain upon all the evidence. It is unnecessary to review the testimony for the purpose of showing this. His application for a patent, in April, 1838, was preceded by a series of experiments, results, illustrations and proofs of final success, which leave no doubt whatever but that his great invention was consummated before the early spring of 1837. There is no one person, whose invention has been spoken of by any witness, or referred to in any book as involving the principle of Mr. Morse's discovery, but must yield precedence of date to this. Neither Steinheil, nor Cooke and Wheatstone, nor Davy, nor Dyar, nor Henry, had at this time made a recording telegraph of any sort. The devices then known were merely _semaphores_, that spoke to the eye for a moment--bearing about the same relation to the great discovery before us as the Abbé Sicard's invention of a visual alphabet for the purposes of conversation bore to the art of printing with movable types. Mr. Dyar's had no recording apparatus, as he expressly tells us, and Professor Henry had contented himself with the abundant honors of his laboratory and lecture-rooms.* (Boston, 2013, p. 90)

Morse's priority right being established in this case, the most important was the lawsuit that would become known as The Great Telegraph Patent Case. There his monopoly aspirations would become the subject of attention.

The Great Telegraph Patent Case: O'Reilly Versus Morse

The infringement of O'Reilly resulted in the The Great Telegraph Patent Case, starting the O'Reilly versus Morse case in 1847, where the totality of Morse's 1840 patent was at stake. A Rochester man, Henry O'Reilly, had obtained from the Morse syndicate a license to create telegraph lines in a specific area. But he soon came in conflict with Morse, or better, his officers Kendall and Smith.

> *With his authorization to build and operate a telegraph line connecting the Atlantic seaboard with the Mississippi River, O'Reilly embraced with extreme gusto what he called the "Great Enterprise," and his frenetic business activities were soon the basis for conflicts with Morse's business partners. Concerned that O'Reilly was not going to meet his contractual obligations in capitalizing his telegraph company and that he was not doing enough to actually set up the telegraph line that he had committed to build and operate. …*
>
> *In the first of what became many lawsuits over Morse's patented electro-magnetic telegraph, Kendall and Smith sued O'Reilly in 1847 in the Eastern District of Pennsylvania, alleging a breach of contract and requesting an injunction to prevent O'Reilly from continuing his business operations under the 1845 license agreement (A. Mossoff, 2014, p. 37).*

Originally it was about this commercial dispute, but it soon became a case of infringement that enraged O'Reilly, the former paper editor that became a telegraph tycoon. From an infringement case it expanded into a debate over the nature of intellectual property and how best to protect it. In the end it became a broad controversy about monopoly versus competition.

> *With the same boisterous gusto that he displayed in first embracing Morse's telegraph, O'Reilly now began a concerted and multi-front campaign of commercial and legal harassment of the Magnetic Telegraph Company and its licensees. …*
>
> *O'Reilly began constructing and operating telegraph lines far beyond the limited geographic scope of his original license agreement. Moreover, O'Reilly also began actively investing in and using electro-magnetic telegraph devices that were now being invented by other people. …*
>
> *Sometime in late 1847 or early 1848, he renamed his telegraph company "e People's Line." In accord with his new company name, O'Reilly framed his increasingly acerbic dispute with Morse and his business associates as one of free enterprise versus monopoly control, a theme that worked well for him in a time just following the rise of Jacksonian Democracy. In one of his many public pamphlets, he attacked Morse and his business associates as maintaining a "monopoly" that stood in the way of "Equal Rights to all modes of Telegraphing." He announced: "We take the strongest Antimonopoly ground"* (A. Mossoff, 2014, pp. 39, 41).

Not only did O'Reilly violate the regional limitations of the contract, he also started to use other telegraph systems and had installed a telegraph machine called the Columbian *Telegraph* on the People's Telegraph Company on the line Louisville-New Orleans—a telegraph machine that bore a great similarity to Morse' telegraph.

> *The "Columbian" instrument, so called, which, by courtesy, may be stated as the joint invention of Barnes and Zook, was the eeriest plagiarism which two sane or insane men could possibly pass over to the uses of an honest or dishonest service. It recorded the same as Morse's, and by a similar action. The sole difference consisted in the use of permanent magnets alternately polarized, the one making the record and the other acting as the spring as in Morse's first experiment. When these magnets for any cause failed in action, the record was made by a retractile spring and the demagnetization of one of the permanent magnets by the current of a local battery. It was Morse working backwards,…* (Reid, 1886, p. 199)

Now it was no longer a commercial conflict; this was about a monopoly that Morse's patent was alleged to have created. After being sued in 1848 by Morse for infringement, he opposed that Morse was the first inventor of the electro-magnetic telegraph[270]. He also disputed the broadness of the No. 8 claim in the patent.

In September 13, 1848 Morse won the case against O'Reilly. But O'Reilly did not give up. Ultimately, after being brought before the District Court of Kentucky, in 1854 the case ended up before the United States Supreme Court, which decided on January 30, 1854:

> *Professor Morse has not discovered that the electric or galvanic current will always print at a distance, no matter what may be the form of the machinery or mechanical contrivances through which it passes. …*
>
> *And it is the high praise of Professor Morse, that he has been able, by a new combination of known powers, of which electro-magnetism is one, to discover a method by which intelligible marks or signs may be printed that a distance. And for the method or process thus discovered, he is entitled to a patent. But he has not discovered that the electro-magnetic current, used as motive power, in any other method, and with any other combination, will do as well. …*
>
> *In fine, he claims an exclusive right to use a manner and process which he has not described and indeed had not invented, and therefore could not describe when he obtained his patent. The court is of opinion that the claim is too broad, and not warranted by law.* (Text of ruling) (Supreme Court, 1853)

In the judgement, a comparison was made to Robert Fulton, builder of steam boats: "No one, we suppose will maintain that Fulton could have

[270] This claim of being the real inventor was strongly opposed by Amoss Kendall who wrote: "Morse's patent: full exposure of Dr.Chas.T.Jackson's pretentions to the Invention of the American Electro-Magnetic Telegraph" in 1852. To be found at http://babel.haitrust.org/cgi/pt?id=miun.agx3790.0001.001;view=1up;seq=4

taken out a patent for his invention of propelling vessels by steam, describing the process and machinery he used, and claimed under it the exclusive right to use the motive power of steam, however developed, for the purpose of propelling vessels. It can hardly be supposed that under such a patent he could have prevented the use of the improved machinery which science has since introduced, although the motive power is steam, and the result is the propulsion of vessels. Neither could the man who first discovered that steam might, by a proper arrangement of machinery, be used as a motive power to grind corn or spin cotton claim the right to the exclusive use of steam as a motive power for the purpose of producing such effects" (Page 56, U.S. 113). (Supreme Court, 1853)

It was clear, Morse was not the inventor of the "electro-magnetic current" for use in distant writing. So the monopoly part of his patent was invalidated (claim 8), but the basic patent (claims 1-7) stood. The US Supreme Court held that Morse could properly claim a patent right on the system or process of transmitting signals at any distance. In the same verdict, Morse managed to get an extension of seven years for his patent (Phalen, 2015, p. 22). But this apparatus limitation of the patent curbed the potential patent monopoly that could have resulted from Morse's patent.

> *Were this claim [Nr. 8] sustained, Morse would have been able to block the introduction of competing telegraph systems. As a result, rival telegraph inventors and their attorneys argued that Morse's invention was the mere application of Henry's scientific discoveries. As such he was entitled to no more than his specific machinery, a construction of his patent claims which left the field open to other telegraphs* (Hochfelder, 1998a). [271]

Rival telegraph systems could be created, as long as they were different from Morse's system. The ruling made clear though that his invention was prior to that of Royal House, Alexander Bain, Wheatstone or Davy of England (all for a different machine concept, but basically electric telegraphs). The honor of priority was his, but the financial remunerations would be limited; he had no patent protection in Europe.

Although he got his financial reward when the European countries paid him $80,000 in compensation[272], it left Morse frustrated. It was the end of a bitter struggle that started in 1848 when, on April 19, 1848, he wrote in a letter to his brother:

---

[271] Source: http://www.academia.edu/1682289/ _Flash_of_Genius_Samuel_F.B._Morse_s_Telegraph_Patents_ and_e_Legal_Construction_of_Creativity_1832-1854. (Assessed January 2015)

[272] By the time of his death, his estate was valued that some $500,000 ($9.84 million in 2014)

I have been so constantly under the necessity of watching the movements of the most unprincipled set of pirates I have ever known, that all my time has been occupied in defense, in putting evidence into something like legal shape that I am the inventor of the Electro-Magnetic Telegraph!! Would you have believed it ten years ago that a question could be raised on that subject? Yet this very morning in the 'Journal of Commerce' is an article from a New Orleans paper giving an account of a public meeting convened by O'Reilly, at which he boldly stated that I had '_pirated my invention from a German invention_' a great deal better than mine. And the 'Journal of Commerce' has a sort of halfway defense of me which implies there is some doubt on the subject. I have written a note which may appear in to-morrow's 'Journal,' quite short, but which I think, will stop that game here (E. L. Morse, 1914b, p. 283)

At the end of his life, Morse was still engaged in the priority issue. In 1868, he published his account, "Modern Telegraphy", in which he described meticulously all events related to the invention of telegraphy and the contributions he, and others, made to it. (S. F. B. Morse, 1867)

Later Developments in Electro-magnet Telegraphs

As mentioned before, rival telegraphs systems were developed as soon as the concept of telegraphy proved to be viable. Some inventors developed variations on Morse's system after—or even before—his patent rights expired. Some improved upon it, adding to its functionality or usability. Also, earlier in time, rival technologies were developed resulting in different telegraph systems. All this diversity was characterizing the early, pioneering days of the development of telegraphy (Table 11). Inventors like Bain, Royal Earl House and Hughes succeeded. Other inventors perished, and their contributions disappeared in the fogs of history[273]. And others contributed marginally or where very cautious not to claim too much. Like Edward R. Roe, who stated in his description of US patent № 5,612 of May 30, 1848 for an "Improvement in telegraph-manipulators":

I do not claim to have invented a new telegraph, but a manipulator or machine for operating telegraphs now in use and other similar ones; and I do not claim to be the first who has used metal types for the purpose of making and breaking the connection of the galvanic circuit, that having been done by Samuel F. B. Morse, as set forth in his specification on file in the Patent Office, dated December 27, 1845, (see Reissue No. 79;) nor do I claim the use of metallic types as

[273] Just as an example: What happened to the invention of the mechanical telegraph of John Bennett of Indianapolis? (US-patent № 390, 642 granted October 9, 1888).

conductors, forming part of the galvanic circuit, that being an old device heretofore known. … (text of Patent) (Roe, 1848)

As many of the inventors patented their work, their patent shows the trail of the further development of telegraphy, both on the level of rival apparatus, apparatus and components, and the development of the telegraphic system as a whole (Table 11). As in 1852 the telegraph industry was highly competitive between companies using conventional Morse technology and those using printing telegraph systems (House/Bain), it took several trajectories. Among those the most prominent were the following:

Dial telegraphs: This type of telegraph was an early attempt to simplify the use of a telegraph by relating to the alphabet as input and output medium: writing at a distance was getting shaped. The letters and

Table 11: Some random patents granted to other inventors for improvement on the electromagnetic telegraph system: apparatus, components, and network.

Patent №	Inventor	Granted	Description
US 4.464	Royal E. House	April 18, 1846	Improvement in magnetic printing-telegraphs. Recording and printing the Morse code in alphabetic written form
US 5.612	Edward R. Roe	May 30, 1848	Electric circuit closer: Improvement of telegraph key or manipulator
US 14.917	David E. Hughes	May 20, 1856	Improvement of telegraph electromagnet (relay) speed by adding a spring to the armature
US 22.531	David E. Hughes	January 4, 1859	Duplex telegraph, by delaying signals of one operator.
US 26.003	Geo. M. Phelps	November 1, 1859	Printing Telegraph
US 32.854	Alexander Bain	July 23, 1861	Electro acoustic telegraph: Applying an acoustic tube to the operator's ear to prevent the hearing of the messages' sounds and clicks by unauthorized parties.
US 132,931	Joseph B. Stearns	November 12, 1873	Improvement in circuits and apparatus for duplex telegraphy
US 161.739	Alexander Graham Bell	April 6, 1875	Transmitting two or more telegraphic messages on the same line simultaneously using different frequencies
US 388.244	J. M. E. Baudot	August 21, 1888	Automatic telegraph translator of the Morse code signals into alphabetical letters using only one wire
US 480.567	Alexander Graham Bell	August 9, 1892	Quadruplex telegraph: Enables two operators to simultaneously send telegraphic signals over one wire in one direction

Source: USPTO.

numbers or other symbols were placed upon the border of a circular dial plate at each station. Then the apparatus were arranged so that the needle or index of the dial at the receiving station copied the movements at the transmitting station.

Printing telegraphs: Here the developments were also aimed at solving the complexity of usage of the telegraph. By simplifying the data entry (ie by the means of a piano-like keyboard), and by applying readable data-output (paper strip with printed text), the system could be applied by less-skilled operators.

Recorder telegraphs: Here the developments were aimed at improving the telegraphic system as a whole. That included improvements in system components (eg the telegraph key, cabling, isolation) as well as the optimization of the infrastructure. But—as the Morse code required training—it still needed skilled operators.

In the following we will elaborate on some of those inventors along several lines of development: a) the development of the alphabetic telegraphs, b) the development of the printing telegraph, and c) the improvement in Morse telegraph system in terms of capacity.

Dial Telegraphs [274]

Based on Wheatstone's ABC telegraph (Figure 121), which was patented in 1840 in GB patent № 8,345, another simple telegraph system was developed. Using a magneto, a range of pulses were transmitted over the cable. At the receiving end, the incoming pulses were detected by an electro-magnet that moved a pointer to the desired positon, indicating a letter/number. The advancing mechanism was an escapement very similar to what could be found in a pendulum-driven clock. The dial

Figure 185: Brequet's Dial telegraph (1844).

Source: www.liveauctioneers.com/item/21176597_rare-and-unusual-breguet-telegraph-transmitter-and

[274] The dial telegraph in the US is a parallel development to the pointer telegraph in Britain.

telegraphs were not recording; an operator had to write down the letters/numbers on the receiving end. It was an easy to use, but a slow system (ca. 5 words/ minute).

In Europe, many dial telegraphs were developed: in France by Francois Clement Brequet (Figure 185), in Germany by Fardeln (1843), Kramer and Siemens & Halske (1846) (Figure 146). (Beauchamp, 2001, pp. 40-47).

Also, in America, a range of dial-based telegraphs was developed. (Table 12). The Beardslee telegraph in its portable version was used by the American military during the Civil War (1861-1865) in a mobile field telegraph system.

Figure 186: Beardslee's dial telegraph (1863).

Source: Wikimedia Commons US Army Center of Military History

Table 12: Some patents for dial telegraphs (1840-1870)

Patent №	Inventor	Granted	Description
GB 8,345	Cooke & Wheatstone	January 21, 1840	Electrical telegraphs (pointer telegraph)
US 10,292	Davis, J.	Dec. 6, 1853	Dial telegraph
US 14,664	Kirchhof	April 15,1856	Dial telegraph
US 25,718	Bradley, L.	October 11, 1859	Dial telegraph
US 37,997	Bain, A	March 24 1863	Dial telegraph
US 39,376	Beardslee, G.W.	Aug. 4, 1863	Dial telegraph
US 40,324	Chester, C.T.	October 20, 1863	Dial telegraph
US 79,741	Edamnds & Hamblet	July 7, 1868	Dial telegraph
US 97,076	Gilliland,	Nov. 23, 1869	Dial telegraph

Source: USPTO.

Printing Telegraphs

Morse had opened a floodgate of interest in telegraphy, and many—once he had surmounted all the practical obstacles and proven its profitability—jumped on the bandwagon. But they had to circumvent Morse's patent protection, which was done by two telegraphers working in the Cincinatti telegraph office, Edmund Barnes and Samuel K. Zook—a former employee of the Magnetic Company—who created a telegraph apparatus for Morse's former licensee and competitor to be: Henry

O'Reilly. Their system differed from Morse's concept in two ways: it used permanent magnets (and not electro-magnets) and it had galvanometer-like receiving device. Their system became known as the Columbian Telegraph and was used by the People's Telegraph Company on the Louisville-New Orleans line. But other's developed telegraph system that did not infringe om Morse's patent.

Royal Earl House

Another inventor was Royal Earl House (1814-1895) who, already in his forties, after starting to study law, became quite interested in electrical research and telegraphy.

> *[Abandoning the law study,] Returning to his home, he conceived and worked out in his own mind, without the slightest knowledge of what had been done by others, the scheme of an electric telegraph. … In this way he thought out his first printing telegraph, which was adapted work with two independent circuits one of which was made to turn a type-wheel step by step, while the other served to give the impression of each successive letter then presented, precisely as is done in many of the more recent "stock tickers." Having fully completed the design in his mind, House came to New York, and had his machine constructed piecemeal at two or three different shops, afterwards assembling the parts together with his own hands. This apparatus was exhibited in successful operation at the fair of the Mechanic's Institute of New York, in the basement of the City Hall, in the fall of 1844, only a short time after the establishment of Morse's first line between Baltimore and Washington, and long before this had been extended to New York.* (Gish, 1895)

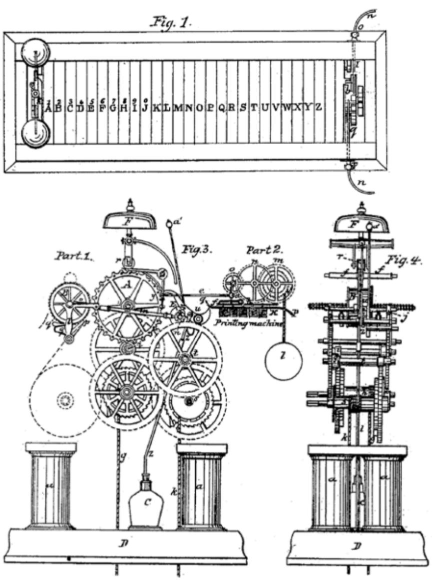

Figure 187: Transmitter and the receiver from House's patent 4,464 (1846).

Shown is the input device or sending station resp. transmitter (Fig. 1, top) and the receiving station (bottom).

Source: USPTO

So he developed and patented a letter-printing telegraph system in 1846 that employed an alphabetic keyboard with 28 keys for the transmitter and automatically printed the letters on paper that the receiver. in April 1846, he was granted US patent № 4,464 for his "Improvement in magnetic printing-telegraphs" (Figure 187). Basically it was a very complex mechanical system. The paper tape was transported by a weight, the dots and dashes were detected by mechanical wheels and the text was printed with a printing wheel. Some of these details are shown in Figure 187.

The House telegraph was first used in 1850 by the New York and Boston Telegraph Company, later known as the Commercial Telegraph Company, and also on a line between New York and Boston, to serve newspapers (Figure 188). Furthermore, the House system was used in the state of New York. A major line was built between Buffalo and St. Louis in 1852. Around 1876, he was granted many patents for improvements he had been working on (Table 13). Despite House's superior technology, his invention lost in the marketplace due to the difficulty of manufacturing the complicated machine on a large scale. But the basic design also caused many synchronization problems, resulting in garbled messages.

Table 13: Some of the patents granted to Royal E. House

Patent №	Granted	Description
US 4.464	April 18, 1846	Improvement in magnetic printing-telegraphs. Recording and printing the Morse code in alphabetic written form
US 9.505	December 20, 1852	Improvement in magnetic printing-telegraphs: steam assisted apparatus
US 180.089	July 25, 1876	Improvement in electric telegraph apparatus (filed February 20, 1874)
US 180.090	July 25, 1876	Improvement in electric telegraph (filed February 20, 1871)
US 180.091	July 25, 1876	Improvement in electric telegraph apparatus (filed February 20, 1874)
US 180.093	July 25, 1876	Improvement in electric telegraph apparatus (filed July 1, 1876)
US 180.094	July 25, 1876	Improvement in telegraph-sounders (filed July 1, 1876)
US 180.097	July 25, 1876	Improvement in electric telegraph apparatus (filed May 3, 1871)
US 180.098	July 25, 1876	Improvement in means and apparatus for joining telegraph-wires (filed October 21, 1871)
US 180.099	July 25, 1876	Improvement in electric telegraph (filed March 19, 1874)
US 180.100	July 25, 1876	Improvement in electro-magnets and relays (filed June 17, 1870)

Source: USPTO

In 1849, Morse's Telegraph Company sued House for infringement. The courts decided, however, that the House Company did not infringe the Morse patent, as the messages using the House system were all printed on a slip of paper, without the use of Morse's code. So House's telegraph could be used by companies competing with Morse[275].

> *June, 1850, in the United States Circuit Court in the District of Massachusetts, Judge Woodbury announced his famous decision, refusing an injunction; a most notable victory for the eminent inventor and his associates, especially relished by House in view of a remark which had once been made by Francis O. J. Smith, one of the principal owners of the Morse patents, that he could drive his old Durham bull from New York to Boston with a message tied to his horns quicker than it would ever be sent by House's printing telegraph.* (Gish, 1895)

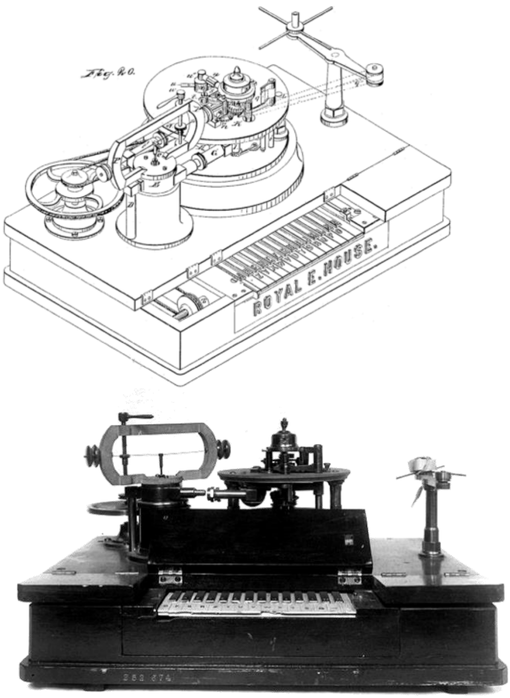

Figure 188: House telegraph (1852): line drawing (top) and model (bottom).

Source: the Smithsonian Institution

House continued developing and was also issued, in December 28, 1852, US patent № 9,505 for steam-assisted receiver: "The third division consists of a pneumatic apparatus connecting the electrical apparatus with the printing machinery, and combining the force of compressed air or steam or other like substance with magnetic force...". He was not the only one to use compressed air, as Hughes also had developed an air-powered system.

[275] Later, the House Co. and the Morse Co. joined and formed the Great Western Telegraph Company.

David Hughes

Another important inventor was David Edward Hughes (1831-1900), born in London into a musical family, who emigrated to the US when he was at the age of seven.

> *At an early age, David Edward Hughes developed such musical ability that he is reported to have attracted attention of Herr Hast, an eminent German pianist in America who procured for him a professorship of music at St. Joseph's College in Bardstown, Kentucky, in 1850. Simultaneously with his musical studies, he appears to have developed a remarkable fondness for physical science and mechanics, and at the young age of 19 was appointed as chair of natural philosophy at that same college where he was professor of music. He diversified into philosophy and particularly in electrical engineering.*[276]

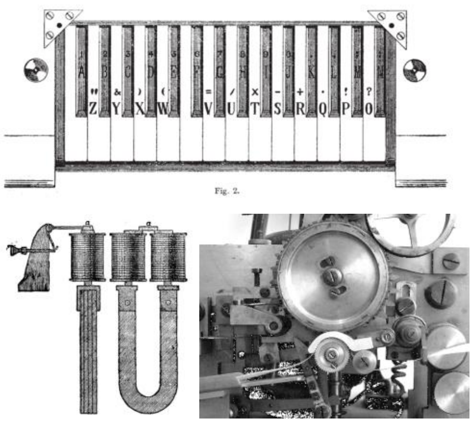

Figure 189: Hughes printing telegraph: keyboard (top), electromagnet (bottom, left) and printing wheel (bottom, right).

Source: Scientific American Supplement. Thompson, S.; www.samhalla.co.uk (printing wheel)

He invented, trying to devise a machine to copy extempore music, a printing telegraph in 1855 (Figure 189). It used a keyboard of 26 keys for the alphabet, an electromagnet to detect the incoming signal, and a spinning type wheel for printing. This printing wheel determined the letter being transmitted by the length of time that had elapsed since the previous transmission. It used a vibrating spring as a governor to synchronize between the sending and receiving apparatus. Basically it was an electromagnet-based telegraph, as it was using an electromagnet—the Hughes electromagnet—to detect the incoming signal. The printing mechanism was a complicated mechanical affair.

In Britain he was granted patent №. 2,085 (Figure 190) in 1855, and in the US he was granted US patent № 14,917 on May 20, 1856.

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276 Davuid Edward Hughes. Source: http://web.archive.org/web/20080422072443/ http://people.clarkson.edu/~ekatz/scientists/hughes.html. (Accessed June 2015)

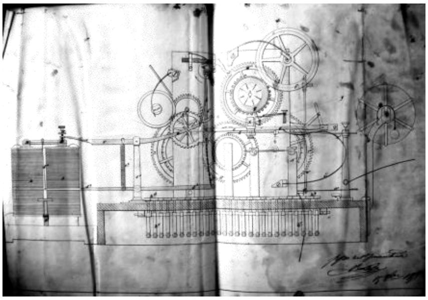
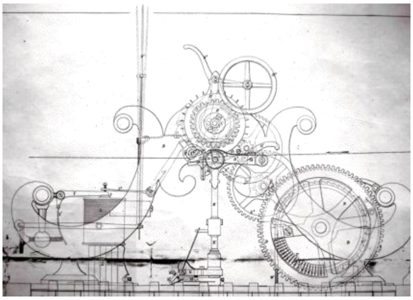



Figure 190: Pages of Hughes British patents for a printing telegraph.
Shown are GB-patent no. 2.058 (1855), (left) and GB-patent no. 938 (1858), (right).
Source: http://davidedwardhughes.com/hughes-telegraph-1/

This telegraph instrument communicated with an identical instrument at a separate telegraph office over a single telegraph wire using a ground return. The two instruments ran in synchronism (a startup procedure ensured they were synchronized) and transmitted data using a form of pulse position modulation (yes in 1855!). Messages were typed in as alpha characters and were printed out on a paper tape that the receiving station. These instruments were full duplex in their operation. The instruments were powered by a weight driven clockwork mechanism. [277]

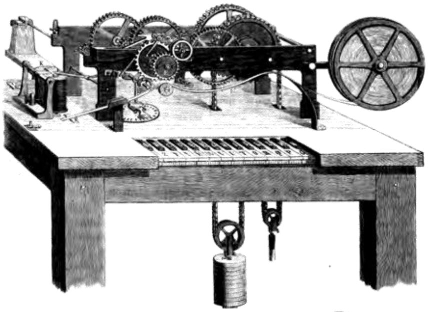
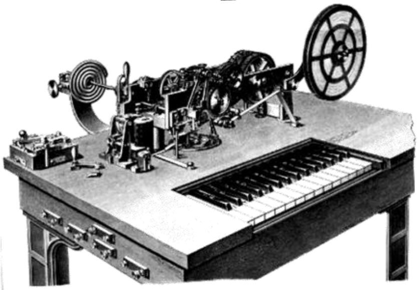



Figure 191: Hughes printing telegraph (1858, top; 1869, bottom).
Source: http://distantwriting.co.uk/

Developing other models—in total he developed four different models—he took, in 1858, British patent № 938 (Figure 190) which was also granted as US patent № 22,531 on January 4, 1859 and US patent № 22,770 on January 25, 1859. For his third development, he was granted British patent № 241 (1863). And finally, his fourth model was powered by an electric motor that replaced the original weight. His system was very stable

[277] Hughes, I and Evans D.E.: *Before We Went Wireless: David Edward Hughes FRS, His Life, Inventions and Discoveries*. Source: http://davidedwardhughes.com/hughes-telegraph-1/

and accurate and became accepted around the world. In Europe, the Hughes telegraph system became an international standard (Figure 191). In America it was used by many companies, such as the American Telegraph Company, later incorporated into Western Union Telegraph Co. His scientific work would later also contribute to the development of the loose-contact carbon microphone, an essential part of the newly developed telephone.

George Phelps

A third important developer was George May Phelps (1820-1888), educated as an apprentice machinist working for his uncle, an instrument maker. He had observed Morse's activities on telegraphy with great interest, as all those inventors needed his mechanical skills. As a telegraph instrument maker, he was considered one of the most eminent electrical mechaniciens of his time.

Phelps contributed to the construction of many telegraph systems invented by others, among which were the telegraphs designed by House, Hughes and Edison. Phelps manufactured many of the House telegraphs. For the construction of House's telegraph, he created House's Printing Telegraph Instrument Manufacturer. This company was in 1856 bought by the American Telegraph Company and became later one of Western Union's manufacturing plants.

Figure 192: Phelps Combination Printer (1859, top) and Electro-motor Printing Telegraph (1875, bottom).

Source: Wikimedia Commons, Edward Henry Knight (1884)

But Phelps also developed, based on the experience he had acquired, telegraph apparatus of his own. Such as the Phelps Combination Printer that was a combination of the House and Hughes printers (Figure 192, top). Phelps used a piano-like keyboard similar to the one on the House printer. It consisted of 28 keys, including a dot and a space key. It used a newly invented electro-magnetic governor for synchronization. He received US patent № 26,003, granted on November 1, 1859, for his invention. Later, he designed a stock ticker, called the *financial instrument*, used to distribute information about the stock markets. In 1875 he created the Phelps Electro-motor Telegraph powered by an electromotor (Figure 192, bottom). It received the award for excellence and superiority at the U.S. Centennial Exhibition in Philadelphia in 1876.

Over time he was granted in total numerous patents for his work on telegraphic equipment (Table 14). His US-patent № 203,369, for example, would be used by Elisha Gray when he patented his microphone in May 21, 1878 (US patent № 204,029). In the 1870s Phelps would also cooperate with the young Thomas Edison, working on his stock printer and quadruplex system. Finally he became involved in the emerging field of telephone, and contributed to its development with his single crown telephone. But that is another story....

Table 14: Some of the patents granted to George M. Phelps

Patent №	Granted	Description
US 26,003	Nov. 1, 1859	Improvement in telegraphic machines (assigned to American Telegraph Company)
US 32,452	May 28, 1861	Improvement in telegraphic machines (assigned to American Telegraph Company) (filed February 1, 1861)
US 89,887	May 11, 1869	Improvement in printing telegraphs (filed September 22, 1868)
US 161,151	March 23, 1875	Improvement in printing telegraphs (filed August 22, 1874)
US 156,942	November 17, 1874	Improvement in magnetic motor (filed October 8, 1874)
US 161,151		
US 161,851	April 6, 1875	Improvement in combined under waist and skirt supporters (filed March 30, 1875)
US 168,919	October 19, 1875	Improvement in printing telegraphs (filed March 25, 1875)
US 186,215	January 16, 1877	Improvement in printing telegraphs (filed October 26, 1876)
US 195,162	Sept. 11, 1877	Improvement in magneto-electric transmitters for printing telegraphs (filed June 27, 1877)
US 203,369	May 7, 1878	Improvement in polarized electro-magnets (filed June 27, 1877)
US 214,840	April 29, 1879	Improvement in speaking telephones (filed December 6, 1878)
US 220,209	Sept. 30, 1879	Improvement in speaking telephones (filed December 21, 1877)

Source: USPTO

That Phelps also applied his ingenuity to other fields of interest is illustrated by his US patent № 161,851 of April 6, 1875, for his "combined under waist and skirt support" (also known as a women's corset)—a fine piece of mechanical construction. His later descendent Mary Phelps Jacob (1891-1970) would invent and be granted US patent № 1,115,674 on November 3, 1914, for the women's underwear known as the backless brassiere.

The telegraph was not only improved upon in the United States but numerous inventors were also active in Germany, England and France.

Emile Baudot

The French engineer Jaen Maurice-Émile Baudot (1845-1903), son of a farmer and having limited education, joined the French postal organization. Based on the Hughes printing telegraph, he developed and patented in 1874 a printing telegraph in which the signals were translated automatically into typographic characters. He created the Baudot code (a digital five-bit code) in 1870 (Figure 193, left) and tried to patent in 1874 but failed because French patent law did not allow concepts to be patented. His telegraph used a keyboard with five keys that created the code (Figure 193, right). For his machine he received French patent № 103,898 *système de télégraphie rapide* (quick telegraphy system) on June 17, 1874[278]. In the US, he was granted patent № 338,244 on August 21, 1888. He also took out a range of similar patents in other countries to protect his invention (Table 15).

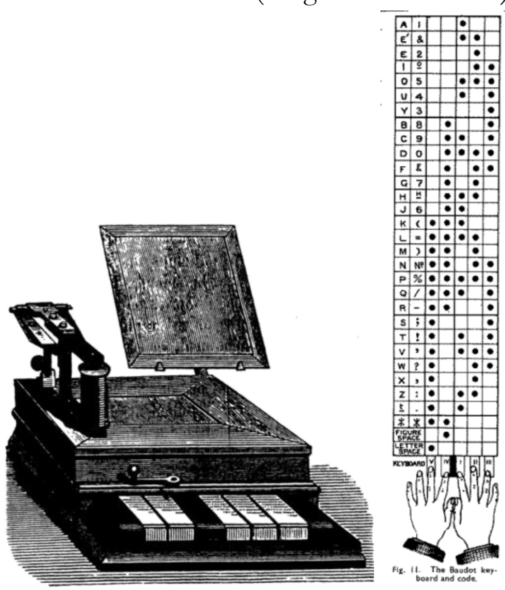


Figure 193: Baudot telegraph (1874): keyboard and code (right).

Source: Wikimedi Commons, Journal Telegraphique vol. 8 Nr. 12 Decembre 1884. Code: www.worldpowersystems.com

[278] Émile Baudot (1845-1903) . Source: http://www.utc.fr/~tthomass/Themes/Unites/Hommes/bau/Emile%20Baudot.pdf (Accessed June 2015)

Table 15: Overview of patents for Baudot's' telegraph system 1874-1888

Patent №	Year	Description
Fr 103,898	June 17, 1874	Multiplex system: 'Quick Telegraphy System'
Fr-146,716	January 6, 1882	Automatic translator for one-line system
GBr-436	January 8, 1882	Automatic translator for one-line system
Ge-20,286	February 4, 1882	Automatic translator for one-line system
Be 58,883	January 25, 1882	Automatic translator for one-line system
US 388,244	August 21, 1888	Automatic translator for one-line system

Sources: USPTO, references in US-patent 388,244

The French patent was challenged by Louis Mimault in 1877, who had developed a telegraph system of his own and obtained French patent № 1,301 on June 5, 1876. The conflict would lead to disastrous consequences.

> *Mimault claimed priority of invention over Baudot and brought a patent suit against him in 1877. The Tribunal Civil de la Seine, which reviewed testimony from three experts unconnected with the Telegraph Administration, found in favor of Mimault and accorded him priority of invention of the Baudot code and ruled that Baudot's patents were simply improvements of Mimault's. Neither inventor was satisfied with this judgment, which was eventually rescinded with Mimault being ordered to pay all legal costs. Mimault became unnerved because of the decision, and after an incident where he shot at and wounded two students of the École Polytechnique (charges for which were dropped), he demanded a special act to prolong the duration of his patents, 100,000 Francs, and election to the Légion d'honneur. A commission directed* by *Jules Raynaud (head of telegraph research) rejected his demands. Upon hearing the decision, Mimault shot and killed Raynaud, and was sentenced to 10 years forced labour and 20 years of exile.* (Froehlich & Kent, 1992, p. 32)[279]

The system Baudot designed was able to let four operators use a single line simultaneously; it was a (mechanical) multiplex system (Figure 195) that increased the capacity of the telegraph lines considerably. The Baudot system was accepted by the French Telegraph Administration in 1875, with the first online tests of his system occurring between Paris and Bordeaux on November 12, 1877.

[279] As we did not have access to the primary source we took the text from Wikipedia.

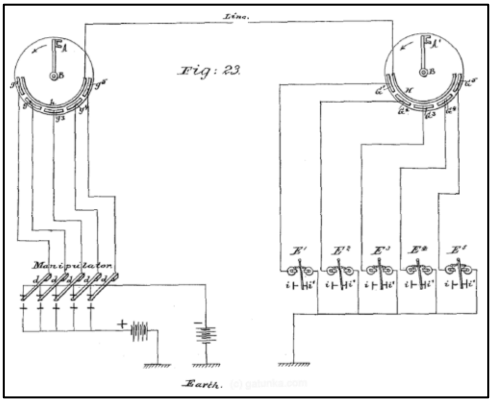


Figure 195: Baudot concept of multiplexing telegraphy.

Schematics from his US-patent 388.244

Source: USPTO

At the end of 1877, the Paris-Rome line, which was about 1,700 kilometers (1,100 mi), began operating a duplex Baudot. The Baudot telegraph system was employed progressively in France and then was adopted in other countries, Italy being the first to introduce it in its inland service in 1887. Holland followed in 1895, Switzerland in 1896, and Austria and Brazil in 1897.

The British Post Office adopted it for a simplex circuit between London and Paris during 1897, then used it for more general purposes from 1898. In 1900 it was adopted by Germany, by Russia in 1904, the British West Indies in 1905, Spain in 1906, Belgium in 1909, Argentina in 1912 and Romania in 1913.

These are a few of the contributions to the development of telegraphy over time. The telegraph systems, whatever the specific methods they used, fulfilled a basic need that clearly existed: communication over a distance.

Improving the Morse system

Telegraphy in its essence is about a telegraph transmitter (the key), a telegraph line, and a telegraph receiver (printing or sounding the dots and dashes)—a system that was based on the doorbell concept: button, cable and bell. And it needed a code system like Morse's code to give meaning to the dots and dashes. To realize this system, a

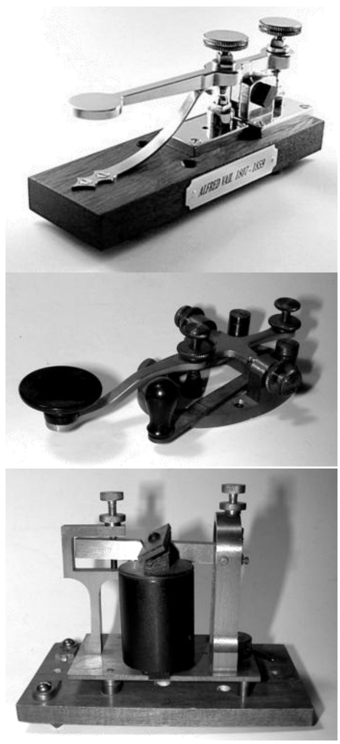


Figure 194: Telegraph Key and Sounder (bottom).

Model made by Vail (top) and Bunell (middle and bottom).

Source: Wikimedia Commons

relatively simple technology was developed by Morse consisting of the telegraph key and the telegraph printer.

Over time, a range of improvements in telegraphy were been made by Morse and by others. Some were related to the equipment (Figure 194), others to the cabling, like the example where Morse hits on a fundamental problem of direct-current systems: the voltage drops over longer distances. In the early days, erecting a telegraph line over a long distance was a technical challenge. As the DC voltage drops when a current travels along a line, at the end of that line the voltage can be too low to activate a coil. By 1837, Morse had developed a set of relays (Morse repeaters) in series to solve that problem (Figure 196).

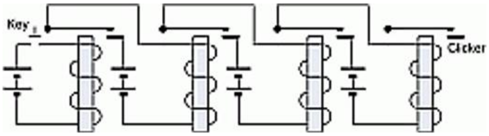


Figure 196: Principle of the Morse repeaters.

Source: Wikimedia Commons

In fact, Morse's telegraph resembled the old postal mail coach system and Chappe's signaling towers in several ways. The mail coach had a relay to refresh the horses. Chappe relied on the tower relays to transmit signals over long distances. The mail coach supplied fresh horsepower. Chappe's relays were human; Morse's relay were mechanic and automatic.

> *French telegraph administrators referred to their human relays as "mutes" which they were, quite literally, since the government employed deaf people to staff the intermediate towers that were located in between the stations at which messages were sent and received.* (John, 1998, p. 195)

Another example of the stream of improvements would be the development of the key to send the signal. Over time, the strait key developed in terms of handling (speed, comfort) (Figure 194), and alternative key concepts also appeared, like the *cootie key,* where the movement of the hand was not up and down but sideways. The input

Table 16: Some patents granted for improvement of the telegraph key

Patent №	Inventor	Granted	Description
US 144,274	W. Hochhausen	Nov. 4, 1873	Self-closing telegraph key
US 178,433	Ch. Greene	June 6, 1876	Improvement in telegraph keys
US 180,669	G.Southead	Aug. 1, 1876	Self-closing telegraph key
US 248,270	Foree Bain	Okt. 18, 1881	Telegraph key
US 258,825	J. Timmerman	May 30, 1882	Circuit closer for telegraph keys
US 267,878	J.T.Guthrie	Nov. 21, 1882	Telegraph key
US 269,321	C. Prosch	Dec. 19, 1882	Telegraph key
US 284,508	S.J. Spurgeon	Sept 4, 1883	Circuit closer for telegraph keys

Source: USPTO. Class H01H21/86

device (the transmitter) soon changed from the simple telegraph key into the special telegraph keys.

> *The early Bunnell model "W" was called the double speed key and was developed to overcome telegrapher's paralysis or "glass arm" (carpal tunnel syndrome according to modern medical parlance). The Bunnell double speed key was patented in 1888 (16 years before the emergence of semi-automatic keys) and sold until the 1920's.*[280]

The nature of these improvements could be called incremental, as they continued the trajectory of the given device (Table 16).

The output devices (the receivers) changed from the pen that produced the dots and dashes on a paper strip (or made the sounds of those dots and dashes), into devices that could be heard: sound telegraphy. The first advancement of the telegraph occurred around 1850 when operators realized that the clicks of the recording instrument portrayed a sound pattern, understandable by the operators as dots and dashes. Soon, in the 1850s, the so-called "sounders" were developed. In the 1870s, many patents were obtained (Table 17). This device allowed the operator to hear the message by ear and simultaneously write it down. It needed a more skilled operator than the original receiver. This ability transformed the telegraph into a versatile and speedy system.[281]

Table 17: Some patents granted for improvement of the telegraph sounder

Patent №	Inventor	Granted	Description
US 140,266	M.W Goudyear	June 24, 1873	Improvement in telegraph sounders
US 141,966	H. van Hoevenbergh	August 19, 1873	Improvement in telegraph sounders
US 153,593	H. Middleton	July 28, 1874	Improvement in telegraph registers and sounders
US 159,894	J.S.Bunell	Febr. 16, 1875	Improvement in telegraph-sounders
US 160,271	D.F. Leahy	March 2, 1875	Improvement in telegraph sounders and recorders
US 180,094	R.E.House	July 25, 1876	Improvement in telegraph-sounders
US 190,191	J.S.Bunell	May 1, 1877	Improvement in telegraph-sounders

Source: USPTO. Class H01F7/1607

[280] Source: http://mtechnologies.com/cootie.htm. (Accessed June 2015)
[281] Source: *History of the Telegraph*, Smithsonian Institution. http://historywired.si.edu/detail.cfm?ID=324. (Accessed January 2015)

Early Activities into Multi-messaging

The moment telegraphy had proven to be feasible, the first lines were build and the "Telegraph Boom" had started; the telegraph concept was going to be improved upon. Originally, telegraphy meant sending one message at a time over the single line. It was based on the concept of the *single-message/single-line system*. However, soon it became clear that the existing telegraph line infrastructure should be used more efficiently. Sending one message at a time, receiving and decoding it, eventually replying it, took a lot of time, in which the line occupancy was marginal. That had to change. The objective was to be able to send several telegrams simultaneously over that single wire: *multiplexing,* as it was called.

Thus it became interesting enough for inventors to pay attention to the *multi-message/single-line* concept. Quite understandably, the motive for multiplexing was economical. The more messages a line could handle, the more revenue for the service providers. It resulted in duplex telegraphy and quadruplex telegraphy.

Duplex telegraphy: The increased use of the electric wire for the simultaneous transmission of telegrams resulted around 1871-72 in an invention by J.B. Stearns. After building up experience in fire-telegraph systems, as president of the Franklin Telegraph Co., he developed the duplexing telegraph and the system of a differential bridge circuit using a special magnet with two windings: the differential relay (Figure 140). Utilizing the apparatus based on this invention, two messages could be sent over the wire simultaneously: one in each direction. His inventions were used widely in Europe—as they were very profitable for the companies—and brought him substantial royalty fees. It made him a rich man when he sold his rights to Western Union for $25,000 in 1872 (Davila, Epstein, & Shelton, 2006, p. 48), and in 1873 he claimed the British Postal Office

Table 18: Some of the US-patents granted to Joseph B. Stearns

Patent №	Granted	Description
US 126,847	May 14, 1872	Improvement in duplex telegraph apparatus
US 132,930	Nov.12, 1872	Improvement in circuits and apparatus for duplex telegraphy
US 132,931	Nov. 12, 1872	Improvement in circuits and apparatus for duplex telegraphy
US 132,932	Nov. 12 1872	Improvement in duplex telegraph instruments and circuits therefor
US 132,933	Nov. 12 1872	Improvement in duplex telegraph apparatus
US 134,776	Jan 14, 1873	Improvement in repeaters for duplex telegraphs
US 147,525	Febr. 17, 1874	Improvement in duplex telegraph apparatus

Source: USPTO

for the amount of $20,000[282].

Quadruplex telegraphy: As business blossomed and demand surged, new devices were developed, like Thomas Edison's quadruplex telegraph, which allowed four messages to be sent over the same wire simultaneously, two in one direction and two in the other (Figure 197). He accomplished this by having one message consist of an electric signal of varying strength, while the second was a signal of varying polarity. Western Union adopted the invention—and paid Edison $10,000 for the patent rights[283]—and had 13,000 miles of quadruplex lines by 1878.

These developments in America were not the only ones trying to improve the capacity of telegraphy. Also on the continent, similar developments took place. An English automatic signaling arrangement, Wheatstone's automatic telegraph with the automatic transmitter of 1883, allowed larger numbers of words to be transmitted over a wire at once, using text that was prepared and coded on a paper strip in advance. It could only be used advantageously, however, on circuits where there was a heavy volume of business. And Baudot's (mechanical) multiplexing system used a time division system to increase the capacity of the lines (Figure 195).

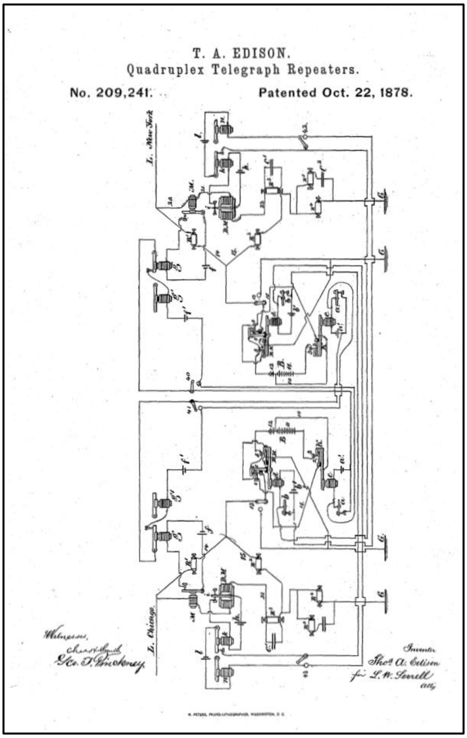


Figure 197: Edison's quadruplex telegraph: patent № 209,241 (1878)

Source: USPTO

[282] Source: BT Archives Catalogue: Adoption of Stearns' duplex telegraph system. POST30/6/1/1/1. www.bt.com/archives (Accessed June 2015). Equivalent to ca $900,000 in 2013, calculated on the basis of the real price of a commodity. Calculated on the basis of income value, this would be $12,400,000. Source: www.measuringworth.com

[283] Equivalent to ca $245,000 in 2013, calculated on the basis of the real price of a commodity. Calculated on the basis of income value this would be $3,120,000. Source: www.measuringworth.com

This frenzy of development activity into high-speed/high-volume communications was caused by the sharp increase in the volume of telegraphic traffic over the increasing numbers of telegraph lines. So, the substantial demand for services—creating profitable returns for the investors—stimulated the technical development, as can be observed from the resulting patent activity.

Patent Activity

As inventors who think their invention has a specific novelty have the habit of applying for a patent, the resulting patent activity in a specific technological field indicates the importance of that field. So it's worth looking at the development of patent activities over time to follow the development of electric telegraphy.

US Patent Activity

All this inventive activity in the field of telegraphy resulted in a stream of patents in the United States. Not only US inventors applied for a patent, also foreign inventors tried to have their inventions patented. The patents were for telegraph systems like the Printing Telegraphs (ie House, Bain,

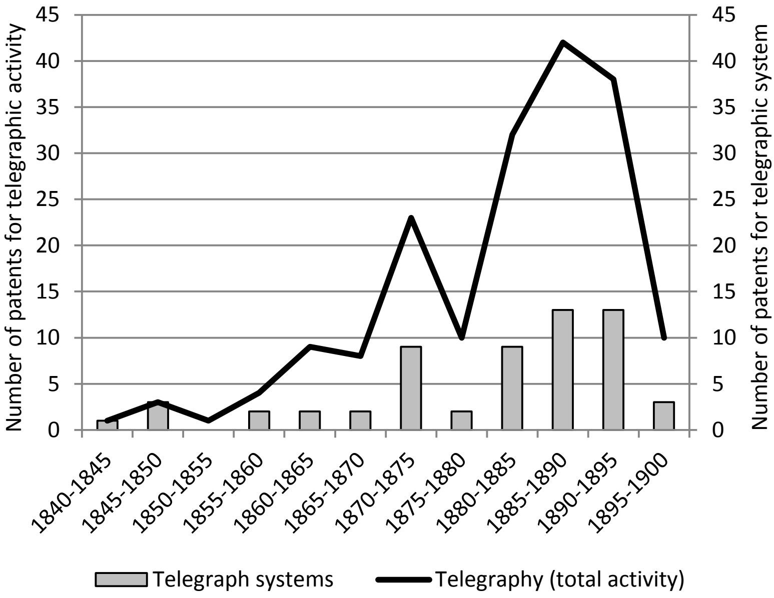


Figure 198: Patent activity in the US for electric telegraphy (1840-1920).

Data from following classes. Telegraph activity: CCL/178/2R or CCL/178/17R or CCL/178/70R or CCL/178/118 or CCL/178/101. Telegraph systems: CCL/178/2R.

Source: USPTO

Hughes) and the Recording Telegraphs, but also for a range of subsystems (eg the telegraph key, the telegraph relay). In Figure 198, this development is shown over a period of time. From the early patent for Morse's 1837 invention, it took a while before patent activity increased. In the 1870-1875 period, the first increase is observable. But it took until the 1885-1895 period to pick up considerably.

French Patent Activity

Obviously the development of telegraphy also spurred inventive activities in other countries. Chappe's optical system had already stimulated French inventors in developing and patenting *telegraphes de jour et nuit* using lanterns. Then both Morse's invention and the system of Cooke and Wheatstone resulted in a stream of French patents (*brevets*) that were issued in the early decade after Morse's invention in 1837 (Table 19).

However, many of the patents were from British inventors like Bain, Highton, Nott, Hughes, Bachhoffner and Brett/Little, or German inventors like Siemens, that were protecting their invention in France. But there were

Table 19: Some patents granted in France for electric telegraphy

Patent №	Inventor	Granted	Description
1BA6869	SFB Morse	1838	système de télégraphe fondé sur l'électro-magnétisme, dit télégraphie de Morse
1BB693	Dujardin	1845	télégraphe électrique
1BB968	Highton, Henry	1845	perfectionnements applicables aux télégraphes électriques
1BB1390	Dujardin	1845	télégraphe électrique semblable au télégraphe aérien employé actuellement en France, sous le nom de système horizontal
1BB3518	Nott	1846	télégraphe électro-magnétique à action directe
1BB3559	Bain	1846	application du fluide électrique aux télégraphes et aux pendules, par un système perfectionné
1BB3595	Brett	1846	télégraphe magnétique ou galvanique pour imprimer des lettres ou caractères
1BB4176	Hebert	1846	système de télégraphe
1BB5385	Brett/Little	1847	perfectionnements dans les appareils dans lesquels se forme le fluide électronique pour mettre en mouvement les télégraphes électriques
1BB8320	Bachhoffner	1849	Système de télégraphie électrique
1BB9762	Siemens	1850	perfectionnement apportés aux télégraphes électriques
1BB11070	Froment	1851	télégraphe électrique à clavier
1BB18610	LFC Brequet	1854	appareil de télégraphie électrique

Source: INPI, Institut Nationalde La Propriété Industrielle. http://www.inpi.fr/

also inventions originating from French scientists like medical doctor P.A.J. Dujardin, who patented a type-printing telegraph, and the scientific instrument maker Gustave Froment, who worked for many professors and copied many telegraph concepts (eg Morse, Hughes) in his workshop.

> *The maker's workshop was also a meeting place between physicists and the technical world. Many builders, like Louis Breguet and Gustave Froment, worked for academics as well as for railway or telegraphy administrations and for industry. Professors studied along with them electromagnetic brakes for trains, various kinds of alarms and triggers, detonators, batteries for telegraphs, electrical synchronisation systems for public clocks, and so on.* (Blondel, 1997, p. 14)

In the 1838-1860 period, some 190 patents[284] related to telegraphy (including railroad telegraphy) were issued in France (Figure 199). As details beyond the first page of the patent are not readily available, it is hard to describe the actual patent. The same problem occurs when we want to investigate the German patents[285].

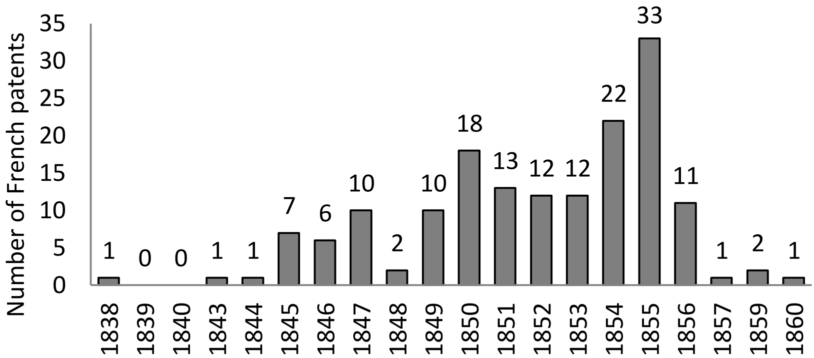


Figure 199: French Patent activity 1840-1860.

Data from following classes: Telegraphe(s), Telegraphigue(s).

Source: INPI

[284] The French patent system was established by law in 1791, later amended in 1800 and 1844. Patentees filed through a simple registration system without any need to specify what was new about their claim. The inventor decided whether to obtain a patent for a period of five, ten or fifteen years, and the term could only be extended through legislative action. Protection extended to all methods and manufactured articles but excluded theoretical or scientific discoveries without practical application, financial methods, medicines and items that could not be covered by copyright. Patentees had to put the invention into practice within two years from the initial grant or face a tribunal, which had the power to repeal the patent unless the patentee could point to unforeseen events which had prevented his complying with the provisions of the law. Source: http://www.eh.net/?s=A+History+of+Mechanical+Invention

[285] As the federal German patent system was not fully developed until 1877, getting an impression of those early German patents is difficult.

The Invention of the Electro-magnetic Telegraph

The invention of the electro-magnetic telegraph—as it was realized in the US—was, next to Cooke and Wheatstone contribution in Britain, also a momentous event in the development of telegraphy. The preceding scientific developments on the application the electro-motive force through a magnet had resulted in electro-mechanical relays. When these electro-magnets—being different from the galvanometer—became used, it started a completely different development trajectory—a trajectory that started in 1832 with a discussion on board the packet boat Sully.

> *Dr. Charles T. Jackson, a Boston physician who was familiar with the latest European discoveries in electricity and electromagnetism, remarked that electricity passed instantly through long wires, and that its presence could be detected by breaking the circuit and observing the resultant spark. Morse exclaimed that "if this is so and the presence of electricity can be made visible in any desired part of the circuit, I see no reason why intelligence may not be instantaneously transmitted to any distance."* (Hochfelder, 1998a, p. 4).

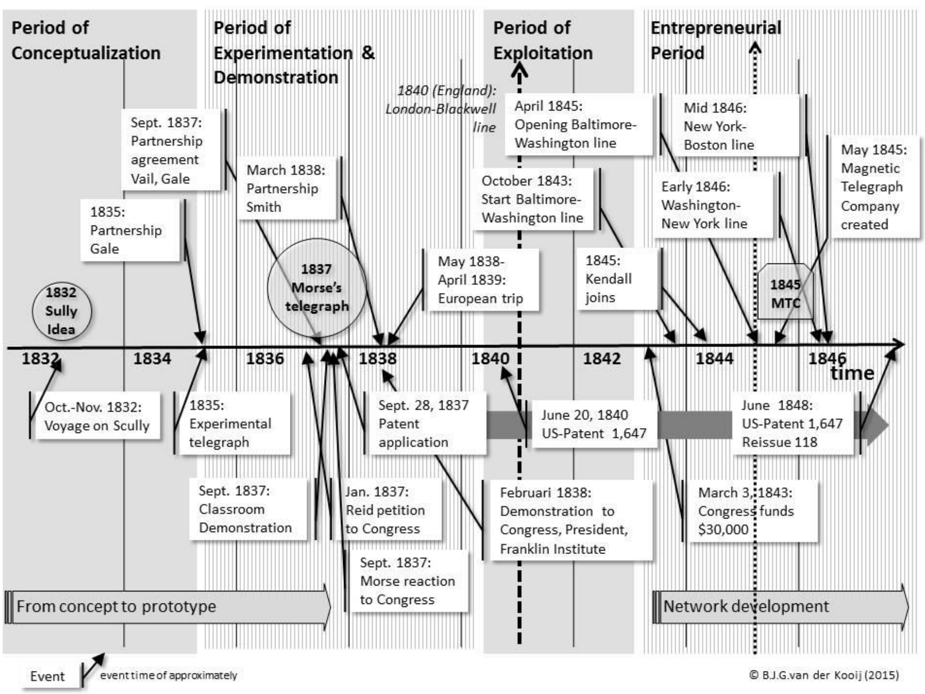


Figure 200: Timeline of events related to Morse's invention.

Source: Figure created by author

When one observes the timeline of Morse's development activities (Figure 200) from the moment of conception (ie the development of the "idea" on the 1832-voyage on the Sully back from France) to the moment of "birth" (ie the 1837 prototype) and the following "infant period" (ie the realization of the Washington-Baltimore line in 1845 after having obtained congressional support in 1843), one cannot fail but to see a very committed person at work. Conceptualization and expanding the idea into the first prototypes in the 1832-1837 period, developing the code-concept and the hardware into the demonstrable apparatus during the 1838-1843 period, and building the first network (ie the Washington-Baltimore telegraph line 1843-45), this all required a very committed person dedicated to realizing his ideas—even more when the circumstances under which this process enfolded, were severe and discouraging. Morse was both creative, as the result of his artistic background, as well as intellectually curious and tenacious in nature.

> *Men of his sort build on the broadest general principles which ordinarily they assume. Their business is with application. Their task is not that of science, but of supermechanics. Morse himself was wholly conscious of his role when he insisted that the telegraph was a machine. He was large-minded enough to distinguish between those who create and enlarge science and those who set it to work. It is a distinction that needs to be repeated and emphasized in an ego that tends to confuse the Morses and Edisons with the Faradays and Kelvins. … Morse's merit was to conceive once for all the apparatus by which electrical telegraphy became practical.* (Mather, 2009)

It was a difficult time; during this creative but non-productive period one also has to earn a living, and one has to keep faith in one's views and convictions. That Morse was at the end of his rope returning from Europe and reaching the limits of his possibilities seems to be quite understandable. Luckily he was able to find people who supported him and who believed in his ideas and his capability to convert them into reality. Both professor Gale and Alfred Vail supported him in his endeavors during the period of conceptualization and experimentation (Figure 200). The result was the first experimental prototype of the Morse telegraph (Figure 169).

Having created the prototype, and having filed the application for a patent protecting his invention, Morse went public. The time was ripe for electric telegraphy, as others (like Congress, which had requested a study on telegraphy) were creating the ambiance for a different approach—ie different from the optical systems then in use—to long distance communication. In both the demonstrations *en petit comité* for colleagues and friends and the more official demonstration before members of Congress, the president and other scientists, he heralded his work.

His efforts to secure patent protection in Europe proved to be disappointing and futile. After returning disheartened, Morse was facing difficulties earning a living. Cooke and Wheatstone were going for a US patent for their invention, and he was considered a nuisance and a tiresome crank by some indifferent members of Congress. Understandably, his mood was low in these dark years:

> *I feel at times almost ready to cast the whole matter to the winds, and turn my attention forever from the subject [of telegraphy]. Indeed, I feel almost inclined, at times, to destroy the evidence of priority of invention in my possession and let Wheatstone and England take the credit for it. For it is tantalizing in the highest degree to find the papers and the lectures boosting of the invention as one of the greatest of the age, and as an honor to America, and yet have the nation by its representatives leave the inventor without the means either to put his invention fairly before his countrymen, or to defend himself against foreign attack* (E. L. Morse, 1914a, pp. 167-168)

It was in December 1842 that he made another effort to obtain the help of Congress—now with more success, as the Bill passed by a marginal majority. With these funds, he was able to start the erection of the first electric telegraph line between Washington and Baltimore in 1843. It was opened for business on April 1, 1845, to the public. In the meantime, the climate had changed.

> *The powers of the telegraph having been demonstrated, enthusiasm took the place of apathy, and Morse, who had been neglected before, was in some danger of being over-praised.* (Munro, 1891, p. 67)

The original idea that the government would—like the earlier optical telegraph system in France—play a dominant role in the future of telegraphy was abandoned, as the government proved to be not interested in procuring Morse's patent. So he went—in the capitalistic America—for private capital to establish the first additional lines.

> *Once it became evident that Congress had no intention of purchasing Morse's patent a swarm of entrepreneurs entered the field, and the American telegraph industry was born. Just as Morse had feared, he had inadvertently unloosed a competitive maelstrom, or what one telegraph historian has termed an era of "methodless enthusiasm." Industry leaders like Hiram Sibley did their best to bring some order to the confusion: first by instituting a series of pooling arrangements in the 1850s; then by cooperating with the Union army during the Civil War; and, finally, by merging several regional firms into Western Union, which emerged in 1866 as the first non-governmental institution to operate truly on a national scale.* (John, 1998, p. 198)

Within a decade, telegraphy conquered the eastern part of America. Morse, looking back in 1855, wrote:

> *The effects of the Telegraph on the interests of the world, political, social, and commercial, have, as yet, scarcely begun to be apprehended, even by the most speculative minds. I trust that one of its effects will be to bind man to his fellowman in such bonds of amity as to put an end to war. I think I can predict this effect as in a not distant future.* (Mather, 2009; E. L. Morse, 1914b)

Morse's invention would start an industrial bonanza in the US of newly formed ventures establishing a telegraphic service. A development—as fitting in the capitalist society of America—was funded by private capital. It was the beginning of the Age of Telegraphy for America, in which a "cluster of innovations" would be accompanied by a "cluster of business"..

Who Invented the Electro-magnetic Telegraph?

The discussion about who had priority in the invention of the telegraph is strongly influenced by semantics: what is a discovery? And what is an invention? Morse was faced with this phenomenon in his time[286]. Much can be said about the exact meaning of the words, but Morse's biographers made their interpretation quite clear.

> *There will always be a difference of opinion as to the comparative value of a new discovery and a new invention, and the difference between these terms should be clearly apprehended. While they are to a certain extent interchangeable, the word "discovery" in science is usually applied to the first enunciation of some property of nature till then unrecognized; "invention," on the other hand, is the application of this property to the uses of mankind. Sometimes discovery and invention are combined in the same individual, but often the discoverer is satisfied with the fame arising from having called attention to something new, and leaves to others the practical application of his discovery. Scientists will always claim that a new discovery, which marks an advance in knowledge in their chosen field, is of paramount importance; while the world at large is more grateful to the man who, by combining the discoveries of others and adding the culminating link, confers a tangible blessing upon humanity.* (E. L. Morse, 1914b, p. 13)

Seen from a conceptual point of view, it was Professor E. N. Horsford, of Cambridge, Massachusetts—a peer of Morse—who specified the requirements for the person who was to transform the concept of the

[286] In our present time, the same discussion between discovery, invention and innovation exists. The modern interpretation (Usher Schumpeter et al., 1929) considers the new combination of insight and skills, realized by the entrepreneur and brought to the marketplace, as the innovation. The discovery of the principle is the invention.

telegraph into reality:

> *There was required a rare combination of qualities and conditions. There must be ingenuity in the adaptation of available means to desired ends; there must be the genius to see through non-essentials to the fundamental principle on which success depends; there must be a kind of skill in manipulation; great patience and pertinacity; a certain measure of culture, and the inventor of a recording telegraph must be capable of being inspired by the grandeur of the thought of writing, figuratively speaking, with a pen a thousand miles long —with the thought of a postal system without the element of time. Moreover the person who is to be the inventor must be free from the exactions of well-compensated, every day, absorbing duties —perhaps he must have had the final baptism of poverty.* (S. Prime, 1875, p. 284) (E. L. Morse, 1914b, p. 16)

Seen from a historical point of view, the question of whether Morse was the inventor of telegraphy—or to be more specific, this version of telegraphy called *the recording telegraph*—has been a subject of much debate over time. Some of the positions taken are quite negative:

> *Prof. Morse, in the opinion of the writer, stands in relation to the electro-magnetic telegraph as a dreamer, and speculator with certain forces, to obtain the desirable end of a "recording telegraph' who never really invented anything important in its composition, and who never, in a practical and useful sense, "combined" any of its parts or forces.* (Greeley, 1974, p. 1242)

Others, already during his lifetime, thought differently. In contrast were the honors bestowed upon Morse after his death on April 2, 1872:

> *His funeral occasioned a national day of mourning. Flags flew at half-mast. Telegraph operators draped their instruments black. The New York Stock Exchange adjourned. … The most imposing ceremony took place on April 16 at the House of Representatives. From its gallery hung an evergreen-wreathed portrait of Morse. Member so f the family sat in a semi-circle facing the Speaker's desk, along with President Grant, his Cabinet, and Justices of the United States Supreme Court.* (Silverman, 2008, p. 442)

Looking at Morse's contribution from a technical point of view, an important criticism relates to the fact that Morse was not a thinker (who has ideas), a scientist (who discovers things), nor an engineer (who creates things). Certainly, a range of scientific contributions created the foundations for the device that would be called the telegraph later on. In this case, it was contributions like Joseph Henry's intensity electromagnet (Figure 83), later to be followed by the combination of the intensity electromagnet and quantity electromagnet that was used in his Yale-experiments (Figure 84). His intensity magnet would become the basis of Morse's repeater (Figure 196), enabling longer distances. "But Henry never sought to commercialize his system, or even to demonstrate it on a larger scale" (Hochfelder, 2010, p. 29). Henry's findings also contributed to the experiments Cooke and Wheatstone in England executed. The electromagnetic relay became the core of their telegraphic receiver, called the ABC telegraph. So, one could say that Henry contributed to the scientific fundaments of both the telegraphs.

> *Henry regarded Morse's machine as "the best" of several telegraphs under development in the mid-1830s, all of them "applying the principles discovered" by himself and others, he denied that Morse had made "a single original discovery, in electricity, magnetism, or electro-magnetism, applicable to the invention of the telegraph. I have always considered his merit to consist in combining and applying the discoveries of others in the invention of a particular instrument and process for telegraphic purposes." Henry summed up his testimony later, that he had "always been careful to give Mr. Morse full credit for his invention, though I cannot award to him the exclusive right to use the scientific principles on which his invention is founded."* (Hochfelder, 2010, p. 30)

Another contributor to Morse's telegraph was the engineer Alfred Vail, whose mechanical skills were essential to its development (ie the sending key, the lever and roller). Vail's refinement of Morse's telegraph was crucial to their efforts to get public funding from Congress in 1838. His mechanical contributions to the system components (eg the Morse key) were undisputed (Figure 194). Even his claim to have developed the Morse code as it was finally used seem to have some merit. But he did not invent the concept as a total, and certainly not prior to Morse's conception.

> *Vail thought Morse arrogant and condescending, and bridled when Morse called him his assistant. Vail wanted Morse instead to acknowledge him as a full partner in the invention, not simply as a hired mechanic. … "I am the sole and only inventor of this mode of telegraph embossing writing. Professor Morse gave me no clue to it… and I have not asserted publicly my right as first and sole inventor, because I wished to preserve the peaceful unity of the invention, and because I could not, according to my contract with Professor Morse, have got a patent for it."* (Hochfelder, 2010, pp. 31, 32)

It was Morse who conceptualized the idea and brought it into practice with the scientific know-how from Joseph Henry and the mechanical skills from Alfred Vail.

> *Thus, the crux of the conflict between Morse and Henry involved the different values and reward structures among scientists and technological entrepreneurs. Henry the scientist regarded basic research as of prime importance and thought of technological advances as the mere application of scientific discoveries. He relied on the open publication of his work to achieve professional respect and success. Morse*

> *the inventor regarded scientific discoveries as abstract and barren things, until someone like himself made them concrete and fruitful. Morse regarded his invention as intellectual property, and relied on the patent laws to protect his rights and to reap a financial reward for his labors. … Put differently, modern technological innovation is the successful combination of scientific discovery, reduction to practice, and entrepreneurship. Morse brought all three of these elements together to create the electrical communications revolution that continues unabated today.* (Hochfelder, 2010, p. 32)

From a legal point of view it is clear that in court Morse had been declared to be the inventor of the electromagnetic telegraph when Judge Kane and Judge Grier concluded in the lawsuit *French v. Rogers,* in Philadelphia in 1851, against Bain's chemical telegraph.:

> *That he, Mr. Morse, was the first to devise and practise the art of recording language, at telegraphic distances, by the dynamic force of the electro-magnet, or, indeed, by any agency whatever, is, to our minds, plain upon all the evidence. … There is no one person, whose invention has been spoken of by any witness, or referred to in any book as involving the principle of Mr. Morse's discovery, but must yield precedence of date to this. …* (Boston, 2013, p. 90)

Also later in time, at the moment the US Supreme Court investigated Morse's priority claims in 1853-1854, this point of view was confirmed. Here is an excerpt from the Morse patent trial before the US Supreme Court:

> *The opinion of Justice Grier, concurred in by Justices Nelson and Wayne, contained these additional points: "I entirely concur with the majority of the court that the appellee and complainant below, Samuel F. B. Morse, is the true and first inventor of the recording telegraph, and the first who has successfully applied the agent or element of Nature, called electro-magnetism, to printing and recording intelligible characters at a distance; and that his patent of 1840, finally reissued in 1848, and his patent for his improvements, as reissued in the same year, are good and valid; and that the appellants have infringed the rights secured to the patentee by both his patents. But, as I do not concur in the views of the majority of the court, in regard to two great points of the case, I shall proceed to express my own."* (Prime, The Life of Samuel F. B. Morse, p. 578).

Looking from a contemporary point of view, the opinion of those involved can be considered. One of them being Joseph Henry, who in the 1830s experimented with electromagnets and who contributed to Samuel Morse's knowledge based on his experiments with the batteries, long wires and electric galvanometers and bells. He certainly claimed a scientific contribution as he describes it himself reflecting on his experiments with electromagnets:

> *It will, I think, be evident to the impartial reader that these were improvements in the electromagnet which first rendered it adequate to the transmission of electrical power to a distance; and I had omitted all allusion to the telegraph in my paper, the conscientious historian of science would have awarded me some credit, however small might have been the advance which I made. Arago and Sturgeon, in the accounts of their experiments, make no mention of the telegraph, and yet their names always have been and will be associated with the invention. I did not refer exclusively to the needle telegraph when, in my paper, I stated that the magnetic action of a current from a trough is at least not sensibly diminished by passing through a long wire.* (J. Henry, 1857, pp. 104-105)

> *In order to guide myself, I instituted a series of preliminary experiments on the conduction of wires of different lengths and diameters, with different batteries. … This was the first discovery of the fact that a galvanic current could be transmitted to a great distance with so little diminution of force as to produce mechanical effects, and of the means by which the transmission could be accomplished. … In arriving at these results, and announcing their applicability to the telegraph, I had not in mind any particular form of telegraph, but referred only to the general fact that it was now demonstrated that a galvanic current could be transmitted to great distances with sufficient power to produce mechanical effect adequate to the desired object.* (J. Henry, 1857, pp. 110-111)

Again, depending on definitions of the concept of invention and innovation[287], one could wonder where the start of a discovery trajectory of electro-magnetic telegraphy is. Would it be Henry's implicit conception of the electromagnetic relay when he used his intensity magnets? Or would it be the electro-magnet itself (Sturgeon, 1825)? Or would it be the mechanism of magnetic induction (Oersted, 1820)? Or, even more extreme, would it be the discovery of voltaic electricity (Volta, 1800)? Was it the observation itself or was it the formulation of the idea of a concept (ie electromagnetism), that constitutes the discovery? Or was it the experiment associated with the conceptualization that created the discovery?

The next consideration is the relation between discovery (of the electromagnet) and the invention (of the electro-magnet telegraph). As Alfred Vail had failed to mention Henry's contributions in a 1845 book about telegraphy, it started a dispute between Henry and Morse themselves. In the controversy that followed, they became engaged in a bitter dispute

[287] The definition of discovery/invention in the early twentieth century and the definition of invention/innovation at the end of the twentieth century have much in common. Both invention and innovation have the element of realization: the combination doctrine that includes the market and the entrepreneur. Over time, the invention paradigm shifted into the innovation paradigm. We will analyze this paradigm shift later on in the invention series.

over the issues of scientific and technological priority. Henry stated, in his reaction on the acquisitions made by Morse in the magazine *Schaffner's Telegraph Companion* related to the infringement case:

> *"I am not aware that Mr. Morse made a single original discovery, in electricity, magnetism, or electro-magnetism, applicable to the invention of the telegraph. I have always considered his merit to consist in* combining and applying the discoveries of others *in the invention of a particular instrument and process for telegraphic purposes."* (J. Henry, 1857) (Emphasis by me, BK)

In today's terms, he is referring to the innovation that Morse realized: the conversion of the scientific concept into a commercially viable product by the combination of the "Act of skills" and the "Act of Insight", a process he could not have realized without the contributions of others.

> *It will be correct to state that Joseph Henry provided the theoretical basis, Morse had the vision of the system, Gale made valuable contributions on the electrical design, and Alfred Vail constructed reliable apparatus and developed the dash-dot Morse code and the Morse key.* (Huurdeman, 2003, p. 141)

Morse was the one who conceptualized the telegraphic concept using the electro-mechanical relay. Seen from that point of view, he certainly was the inventor.

> *Morse's initial conception of his electro-magnetic telegraph represented a seminal breakthrough, because, just as with the mechanical typewriter and the sewing machine, it represented an important conceptual leap: the recognition that machine motion cannot replicate human motion in performing the same activity. Other telegraph systems invented around the same time as Morse's telegraph made similar types of conceptual leaps, but they ultimately failed because they did not go as far as Morse did in fully embracing the utter simplicity in a machine operated by a single circuit transmitting a binary code.* (A. Mossoff, 2014, p. 22)

The impact of Morse's invention is illustrated by the fact that his code system was adopted in 1851 as the standard for European telegraphy.

The Cluster of Innovation for the Electro-magnetic Telegraph

Morse was not—as pointed out before—a scientist thinking and tinkering with the new phenomenon of electricity, contributing to the knowledge about its characteristic behavior of its invisible properties (such as Michael Faraday), experimenting with its linear and rotative power (such as Joseph Henry). He was neither an engineer, nor as an *electricien* tinkering with electricity, nor a *mechanicien* with a mechanical background and experience in instrument making. No, Morse was an artist: someone who conceptualizes, starting with a simple idea, developing and visualizing it in his/her mind and then converting the abstraction into an artistic medium like a sculpture or a painting—someone who mastered his artistic skills over the years and built up an artistic reputation.

An artist is someone having the artistic skills to transform an abstraction into a visual object, be it it a drawing on paper, a statue from clay, or a painting using oil paints. Morse was not only quite able to create his paintings (Figure 165, Figure 166, Figure 167), he also got recognition by others as he was successful in selling his work. He was able—with different success—to make a living out of it after his father supported him in his education in his early professional years (ie his first trip to England in 1811-184). Morse certainly was an artist for the first part of his life: he was educated, had experience and could create amazing art that was appreciated enough to be bought. He was even commissioned by Congress to paint famous people like the Marquis of Lafayette (Figure 16). Morse was able to realize his art in the context of his time; he moved around in the higher classes of his society of that time. He was acquainted with the custom of patronizing, in which an artist was supported by a Maecenas of arts.

From a struggling artist to a struggling inventor

This combination of the act of artistic skills and "the act on insight" is exactly what happened in the turning point of Morse's life, after the period in which he professed the arts, socialized in the French upper classes and now was ready to voyage back to America.

He had travelled again to England, but also to France, where he saw Chappe's semaphore towers while travelling to Avignon. He went to Rome, Florence and Venice, experiencing the revolutionary turmoil of that time, but also the beautiful arts created by Italian artists and artisans. Then came that trip on the packet boat: a time consuming means of weather dictated travelling in which there was ample time for reflection—time for discussing modern developments with educated people, like the magical new technology of electricity—a new technology that seemed to be able to travel with the speed of lightning—a technology that could create instant movement at a distant, thus communicating without delay to a distant point.

It is obvious that he—going through that artistic process of creation—was then able to conceptualize a new way of communication. Like an artist creating detailed sketches and pre-studies of a painting to be created, he visualized the details of his new idea, and he transformed the abstract in his mind and conceptualized it in sketches in his notebook (Figure 168). But this time it was not an artistic work like a painting; this time it was a technical system. Like an artist bursting with energy to create his artistic work, he was obsessed with this idea and wanted to get started in creating the artistic artefact in the time after his arrival. He ran directly into the obvious problems of life: one had to make a living. Daily life presses the creative mind back in the usual habits, patterns and problems. And he was faced with the limitations of his technical skills that were not too impressive. He was confronted with a functional concept that had to be realized in a mechanical and electrical technology he did not master. The only thing he could do was—using the materials at hand like a painters canvas frame and a mechanical clock (Figure 169)—create an object that represented his idea. And it was not without the help of others like the intellectual Leonard Gale and mechanic Alfred Vail. He had to give up part of the intellectual ownership for it though (Figure 172).

No Contributing Innovations for Morse's basic innovation?

The conceptualization of electro-magnetic telegraphy (ie the use of an electro-magnet to detect the incoming communication) is basically different from needle telegraphy (ie the use of a galvanometer to detect the incoming communication). Both have in common that they were realized in a creative process by creative minds. In Morse's case, realizing this creative process as described before, it is understandable that no direct contributing innovations can be found around Morse's basic invention as patented in 1837 (Figure 170). Certainly there had been the minimal knowledge Morse acquired about electrical phenomena (ie based on the electromagnet that the experimental scientist Sturgeon and Henry experimented with) and the conceptual impressions of optical communication systems (ie the slow working communication of Chappe's system). It could even be that he had heard about the European development in electrical telegraphy (ie the experiments of Schweigger, Schilling, Gauss, Weber and Steinheil (Figure 79)), but that was all. There were no direct innovations that contributed to the moment he presented his artefact in 1837. Depending on the definition of the words *invention* and *innovation*, one could consider Sturgeon's and Henry's experimental work—that was not commercialized in any way—as contributing inventions to Morse's basic invention.

Morse's contribution to telegraphy certainly has the characteristics of a basic innovation. Its impact on the American economy—and later the European communication networks—even on society as a whole, is undisputed. It resulted in massive economic and business activity. It also initiated a range of technical developments that matured electrical telegraphy over the decades to come—a development that followed two trajectories: the trajectory of printing telegraphy and the trajectory of improvements in the "Recorder telegraphy", as the Morse-telegraphy was called (Figure 201). The former would lead to the telex, the latter would

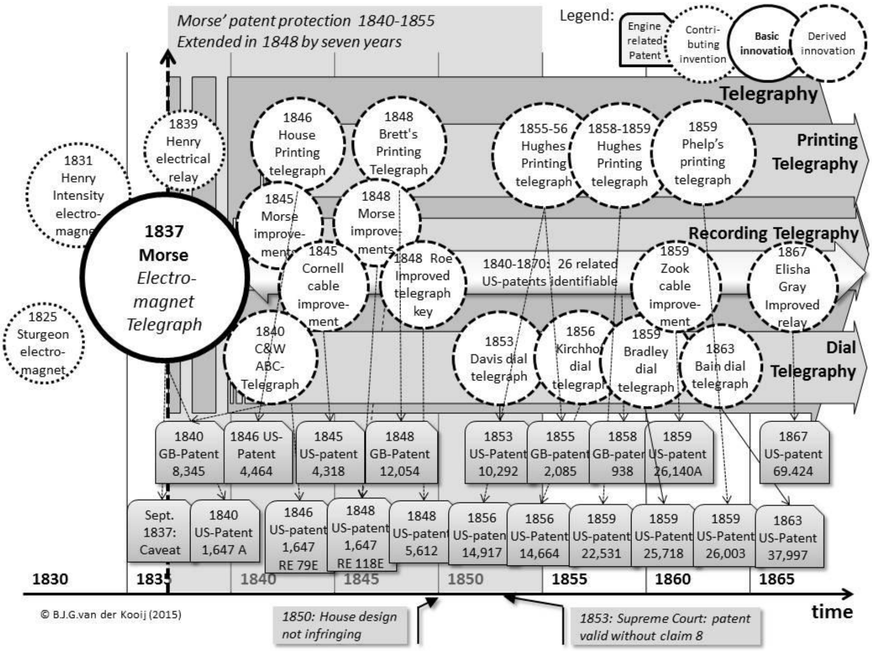


Figure 201: The cluster of innovations around Morse's 1837 electro-magnet telegraph.

Source: Figure created by author

lead to the marine application of Morse's system, as we will see when we look at the development of wireless telegraphy.

Industrial Bonanza: Telegraphy Providers and Manufacturers

As mentioned, the cluster of innovations in telegraphy that started with Morse contributions in 1837, would result in massive business development. Telegraph lines were erected by a multitude of enterprises: the telegraph service providers (*syndicates* as they were called). They created employment not only because the telegraph lines had to be erected; it created also more permanent employment as their telegraph offices had to be manned, creating employment for telegraphists. And telegraph equipment had to be made by equipment manufacturers. Not surprisingly, it created the US Telegraph Boom.

The US Telegraph Boom

Not long after Morse had proven the technical feasibility with the Baltimore-Washington telegraph line, the United States was seized by telegraph fever. A new technology, offering new and exciting possibilities, was attracting many entrepreneurial types. Also, now investors began to see the opportunities for investments offered by the new technology. So telegraph companies were formed and lines erected all over the eastern USA (Figure 202). Before the decade ran out, there were dozens of telegraph lines started—telegraph lines that often were competing along the same high-traffic commercial routes.

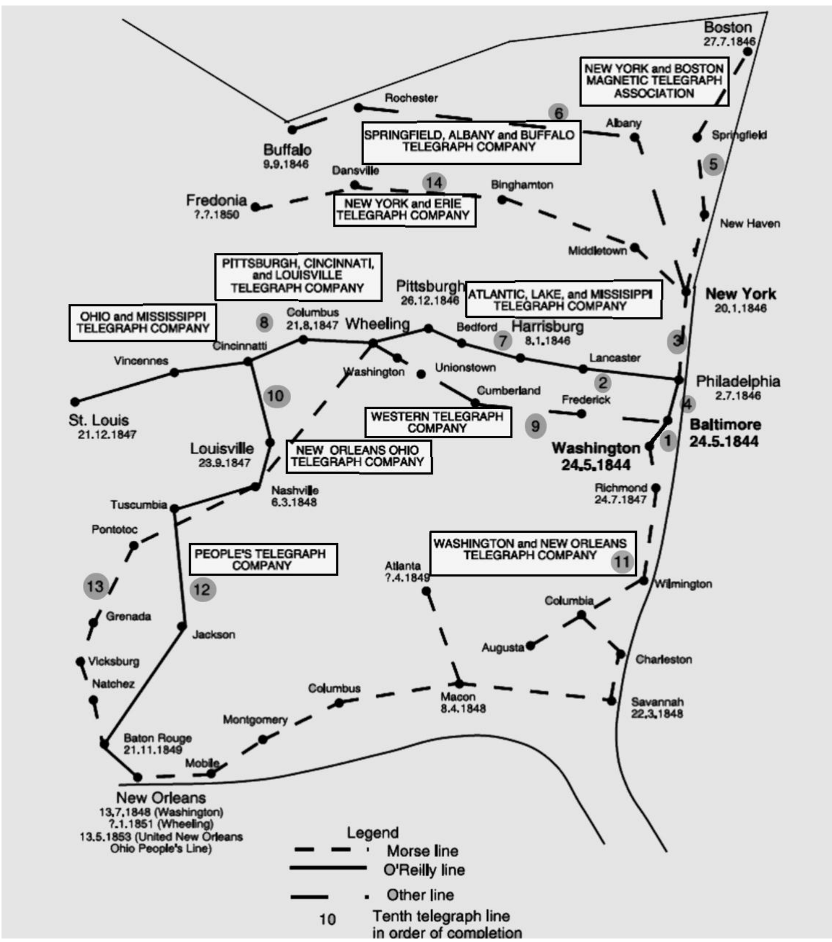


Figure 202: First electrical telegraph lines in the United States (1845-1850).

Source: Adapted by author from Figure 6.7, Huurdeman, p.64

In the press, the Telegraph Revolution was widely heralded. In one characteristic 1847 commentary, *The Republican* of St. Louis, a city then becoming the nucleus of the western lines, editorialized:

> *The Magnetic Telegraph has become one of the essential means of commercial transactions. Commerce, wherever lines exist, is carried on by means of it, and it is impossible, in the nature of things, that St.Louis merchants and business men can compete with those of other cities, if they are without it. Steam is a means of commerce – the Magnetic Telegraph now is another, and man may as well attempt to carry on a successful trade by means of the old flatboat and keel, against a steamboat, as to transact business by the use of the mails against the telegraph.* [288]

In the papers, the electric telegraph was considered to be a wonder. Indeed it was a wonder for their own news collecting—heralded as "the news by telegraph"—as the telegraph made the distribution of news possible (compared with the news distribution by traditional Pony Express and steam ship). In October 1848, under the heading "Telegraphic Wonders," the *New York Herald* reported it had received "interesting intelligence last night by electric telegraph from eight cities comprehending an aggregate distance of 3,000 miles" (4,800 km)[289].

So there was this entrepreneurial explosion of commercial telegraphy. As the cost of entrance was low[290], many new companies emerged offering telegraph services to railroad companies, banks, the press, the financial sector, general business and private people. That the mood had changed from scepticism to enthusiasm was also notable in the behavior of the professional investors: the businessmen with money. They—after being quite reluctant in the years 1844-1845—now were eager to finance new ventures.

> *Convinced of the virtues of the telegraph by the late 1840s, businessmen were now providing substantial financial support for new lines, westward in particular. Not only did they perceive their own growing needs for telegraph service, but they could also see the potential, if not actual profitability, of investments in telegraphic enterprises.* (Boff, 1980, p. 475)

The result of the increasing demand, the availably of venture finance

[288] "The Magnetic Telegraph," in *The Republican*, September 18, 1847; O'Rielly Documents, First Series, I. Source: (Boff, 1980, pp. 471-472).

[289] Source: http://ns1763.ca/ponyexpress/ponyex01.html. (Accessed May 2015)

[290] Capital outlays (largely installation of poles and wires) depended on terrain, climate, availability of supplies, number of wires per line and the incidence of vandalism; throughout the 1850s and 1860s they averaged $150 per mile for a one-wire line but ranged between $50 and $300 per mile (Boff, 1980, p.462).

and the more-than-eager entrepreneurs resulted in a boom of start-up companies that wanted to create telegraph lines.

> *Responsible for the extraordinary spread of the telegraph after 1846 was the prevailing system of small competitive enterprise and independent merchants, wholesalers, and speculators, who were quick to grasp the opportunities the new means of communication offered. Telegraph technology, after all, represented a breakthrough without precedent. … Of course, there was an initial period of apprehension and skepticism, during which high risk premiums, timid financial support, technical difficulties, and ill-defined markets discouraged all but the more daring capitalists. But in the case of the telegraph this period lasted barely two years (1844-1846).* (Boff, 1980, pp. 461-462)

The Telegraph Boom in the late 1840s and early 1850s was the result of this mania. In December 1852, the superintendent of the census Jos. C.G. Kennedy reported in the annual census that until 1851, a total of 89 lines had been created with a length of 16,735 miles in the United States alone (Kennedy, 1853, p. 113). These figures illustrate that O'Reilly and Sibley, who we meet later on, were not the only ones who wanted to jump on the bandwagon of this new technological development.

> *The turning point for the telegraph in terms of public recognition came with the completion of lines between Washington and Boston in June 1846; instantaneous communication was now assured all the way along the east coast population axis. Significantly, the first link in this chain was the Magnetic Telegraph Company's New York-Philadelphia line, which began operations in March 1846 from the Merchants' Exchange in the Quaker City. Almost immediately, it was used not only by the press but also by brokers for "speculating" in stocks and bonds.* (Boff, 1980, pp. 475-476)

So, telegraphy—the lightning wires—was "hot" in the 1850s, both for its manufacturing potential as well as for its use. Telegraph lines had to be installed, operated and maintained. Telegraph equipment had to be manufactured. The potential use for railroad communication, distribution of stock market information, newspaper information, business communication and private messages was so overwhelming that everybody wanted a part of the action (Figure 203).

> *… the road and canal building mania of the 1830s and 1840s was supplanted by a feverish cycle of railroad construction, which was shortly competing with the telegraph for funds. Whereas in 1845-1846 the new means of communication was going through a struggling probation, in the years 1847-1852 it was accorded full public approval. With boundless enthusiasm, but little knowledge of telegraph construction, dozens of promoters now entered the communications field to exploit the eagerness of all sections of the country for the telegraph. In common*

with other empire builders of the age, these impetuous promoters had little time to look ahead and plan. Throughout the country, people were clamoring for telegraph lines. A random network of unsound lines, therefore, shortly bore evidence of the zeal with which the telegraph promoters sought to satisfy the public demand. …

So unbridled a construction program as that which occupied the telegraph industry during the next few years, could have but one conclusion - a bitter struggle for survival among the numerous small companies. Rival lines contended fiercely for business over every important route. Both the House printing telegraph and a newcomer, the Bain chemical telegraph, contested the right of the Morse patentees to monopolize the telegraph business. A host of pirates, respecting no patent and using all, hastily erected lines. Dozens of lawsuits were commenced. Telegraph fortunes rose to dizzying heights only to collapse, … [in] this mad era of methodless enthusiasm. (R. L. Thompson, 1947) [291]

As the economy in the newly admitted state of California at that time was booming (as a result of the California Gold Rush from 1848-1850), a small telegraph network developed in California. With companies such as

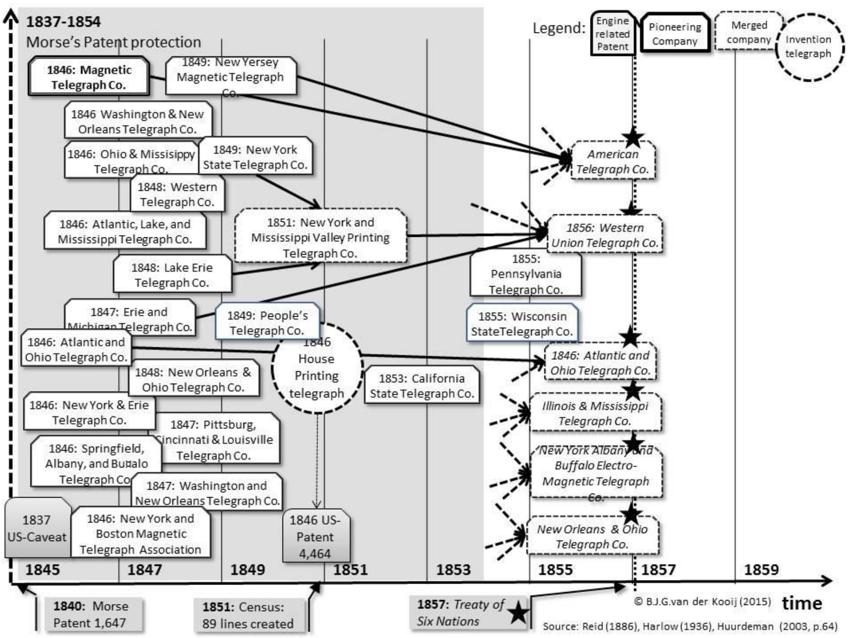


Figure 203: Cluster of business of telegraph companies (service providers) in the United States.

Source: Figure created by author

[291] Source: http://www.myinsulators.com/acw/bookref/ telegraph/ (Assessed January 2015).

the Pacific Telegraph Company, the Overland Telegraph Company and the California State Telegraph Company. In 1861, the first transcontinental telegraph was realized, just a few months after the onset of the Civil War. It connected the network on the east with that in California. The side effect was that the famed and legendary Pony Express discontinued its service.

Because the telegraph—as the communication engine that enabled the flow of information more rapidly and economically over the "lightning wires"—became so popular, the penetration of the telegraph technology occurred with lightning speed. It took the United States a decade to implement the first waves of local, regional and interstate networks, with enormous economic consequences.

> *The birth and diffusion of the telegraph took place in a highly favorable external demand setting as well - the long economic boom of 1843-1857. But it was not demand resulting from surging national income and a growing population that "induced" this historic invention. The telegraph possessed autonomous cost-saving and internal control features that made it particularly suitable for business purposes. These features gave rise to intensive business use of telegraph services and led to the interplay between customer demand patterns and supply adaptation within the telegraph industry, which by 1866 became the first major monopoly in the United States and a portent of things to come.* (Boff, 1980, p. 479)

This increasing business activity, both by the providers of telegraph services, as well as by the users of telegraph services, obviously resulted in a lot of side effects. High traffic resulted in queuing; smaller lines could not connect to major lines that were reserving their transmission capacity for preferred customers. Many lines were faced with the limits of wire capacity.

> *In concrete terms, telegraph users in smaller towns often found that the lines were tied up by heavy volumes of messages travelling between and within major cities. The situation was aggravated by the priority status given to government, police, and some press dispatches. In 1848 a business reply sent in New York state from Troy to Rochester took more than twenty-four hours to be transmitted to Rochester.* (Boff, 1984, p. 580)

Telegraphy Providers: Tycoons and their Empires

As indicated before, quite a few entrepreneurial persons saw in the telegraph an opportunity to create companies. Some of these companies expanded into large organizations with many telegraph lines, others stayed limited in size, struggled and withered and finally disappeared from the scene through mergers and acquisitions. Although they may have each had their own peculiar characteristics, they had one thing in common: they were headed by some colorful people.

Henry O'Reilly

One of the entrepreneurs who got a license from the Morse patentees was Henry O'Reilly (1806-1886), an Irishman who had come as a ten year old boy to the United States in 1816. There he was in New York apprenticed to Baptiste Irvine, the editor of the *New York Columbian*.

> *The articles of apprenticeship were for a term of eight years, and for the greater part of the period O'Reilly was to serve without pay. He was to be given sufficient meat, drink and clothing; and he was to be instructed in the mysteries of the art of printing, in reading, writing and arithmetic, and in the rudiments of the "latin and french languages." In exchange for these manifest advantages O'Reilly agreed "not to waste his master's goods, not to commit fornication or contract matrimony, not to play at cards, dice or any unlawful game, not to absent himself day or night from his master's service without leave, and not to haunt alehouses, taverns, or play houses."* (Perkins, 1945, p. 2)

After working for several newspapers, he became editor in 1826 of a newspaper in Rochester: *The Rochester Daily Adviser*. He became involved in local politics and journalistic controversies and campaigned for Andrew Jackson, running for presidency.

> *Amongst the objects of O'Reilly's activity during his ten years' continuous residence in Rochester none was more important than the enlargement of the Erie Canal. The canal had been finished in 1825, and had, of course, been the major factor in the astoundingly rapid growth of the city on the Genesee. Constructed at a cost of around $ 10,000,000, it had been amazingly profitable, and it had been possible for the state to retire a loan of seven and three quarter million dollars from the revenues of the first ten years.* (Perkins, 1945, p. 7)

This was the time of canals and railroads that characterize the First Industrial Revolution. So, in the late 1830s, O'Reilly became involved in the funding efforts for the enlargement and improvement of the canal. Also he became journalistically and politically involved in the improvement of public schools. In 1838, he became postmaster in Rochester, made the wrong political choices, and had to leave Rochester in 1842.

> *By this time he was thoroughly familiar with the mixing of business and politics, and had, indeed, almost continually held some office such as was dealt out in the thirties to deserving members of the party.* (Perkins, 1945, p.15)

It was in that period of time that Morse—helped by Amos Kendall, the former Postmaster-General— was looking to exploit his invention through private investments. O'Reilly, as former postmaster and knowing Kendall, became involved in the new field of telegraphy ventures. It was the opportunity to make money in a big way.

He had certainly been conspicuously unsuccessful up to 15 L this time; he had left Rochester in debt; he had not demonstrated any extraordinary business capacity at any time ; but perhaps these very facts tempted him to some kind of scheme for easy and rapid accumulation; his temperament made it easy for him to see immense possibilities for the future in a new invention; and the year 1844 was the year of the first American telegraph. (Perkins, ,1945, pp. 15-16)

Then he was offered a contract to create telegraph lines in the most rapidly growing part of the country: the booming middle west.

On June 13, 1845, O'Reilly obtained a contract from Amos Kendall giving him the right to "raise capital for the construction of a line with the Morse telegraph from Philadelphia to Harrisburg, Pittsburgh, Wheeling, Cincinnati, and such other towns and cities as the said O'Reilly and his associates may elect, to St. Louis, and also the principal towns on the Lakes." The Morse patent owners were to receive one-four of the capital stock and not "connect any Western cities or towns with each other which may have been already connected by said O'Reilly." With this contract, Kendall had intended to give O'Reilly the right to build some lines west from Philadelphia. O'Reilly, however, regarded this contract as authority to organize, build, and manage lines for numerous companies and to establish his own telegraph empire. (Huurdeman, 2003, p. 14)

O'Reilly indeed became quite active. He started the organization of a whole series of companies, independent of one another, and extending over—and finally beyond—the great area in which the contract gave him the right to operate. He interested private investors by selling stock.

The funds raised by the sale of stock were used for the construction of the lines. The companies which O'Reilly organized were apt to begin business with a large part of the money which had been raised to set them off already expended. (Perkins, 1945, p. 18)

He organized telegraphy providers such as the Springfield, Albany, and Buffalo Telegraph Company, founded on July 16, 1845; the Atlantic, Lake, and Mississippi Telegraph Company, organized on September 14, 1845; and on March 20, 1847, the Washington and New Orleans Telegraph Company.

His organization of separate companies was directly contrary to the desires of Kendall and of the patentees. In addition, F. O. J. Smith managed to persuade his associates virtually to hand over to him the control of the patent interests, and by this time Kendall, concluding that O'Reilly was not to be trusted, went over to the opposition. The patentees began to construct competing lines ; they sought to close the lines they did construct to O'Reilly business. Though a temporary injunction restraining O'Reilly was denied them in 1847, they went ahead making more and more trouble for him. Efforts at compromises were blocked by

> *the dominating personality of Smith. The struggle waxed hotter and hotter.* (Perkins, 1945, p. 19)

Twenty telegraph companies existed in 1850, about half of them in the state of Ohio. A race started among these companies to operate the most profitable telegraph lines. All this activity resulted in a fierce competition, resulting in dropping prices for the telegrams as new firms entered the market.

> *By 1851, ten separate firms ran lines into New York City. There were three competing lines between New York and Philadelphia, three between New York and Boston, and four between New York and Buffalo. In addition, two lines operated between Philadelphia to Pittsburgh, two between Buffalo and Chicago, three between points in the Midwest and New Orleans, and entrepreneurs erected lines between many Midwestern cities. In all, in 1851 the Bureau of the Census reported 75 companies with 21,147 miles of wire.* [292]

In 1853, his infringement on the Morse system and the violation of the contract resulted in a US Supreme Court decision that ended his involvement with telegraphy.

> *It is difficult to avoid the conclusion that he had strayed into fields in which his talents were not conspicuous, and, indeed, in the years that followed, he was to be a rather pathetic figure, never attaining success, from time to time seeking once again to capitalize his talent for popular controversy, and for popular causes, but rarely doing so with any profit to himself. 21*

> *O'Reilly became the greatest of all pioneer line builders. He constructed over 15,000 km of lines and was the first person to promote the use of social and seasonal greeting telegrams. Unfortunately, O'Reilly increased his debt with each line that he built. He ended his career as a New York Custom House storekeeper and died in poverty [in Rochester] at the age of 80 on August 7, 1886.* (Huurdeman, 2003, p. 63)

Cyrus West Field

Another entrepreneur who should be mentioned was Cyrus West Field (1819-1892). Although he attended the local school, already at a young age, he was working in New York as an errand boy. After three years in the employ of A.T. Stewart and Company, he returned to Stockbridge and began a career in the paper industry. He became a bookkeeper for his brother Matthew D. Field, who was a partner in a paper mill at Lee, Massachusetts. He became a successful paper salesman and made trips to Boston, Philadelphia, Washington and New York. Through the depression

[292] Source: http://www.tfo.upm.es/ImperialismoWeb/CosasTelegrafo/TelegrafoUSA.htm

of 1837, he became involved in the paper business as a manufacturer. In 1842, he established the partnership of Cyrus W. Field & Company, and by 1853 he had built up a successful business. At the age of 34, he was already quite wealthy, possessing some $250,000[293].

In the early 1850s, he had become interested in the new phenomenon of electric telegraphy that had outgrown its infancy in both the US and the European continent. The feasibility of uniting the two vast systems of Europe and North America was exciting, not only for the scientists and engineers, but also the entrepreneurs. Imagine all the business that could be generated with fast news. And technology was maturing, as underwater cable lines had already been successfully laid around England and Ireland.

Field decided to invest, and bought in 1852 the ailing Electric Telegraph Company of Newfoundland. This company was started by Frederic Gisborne in 1852, but financial problems had made it a failure, and it bankrupted in 1853. In 1854, Field, together with some other investors, created the New York, Newfoundland, and London Telegraph Company.

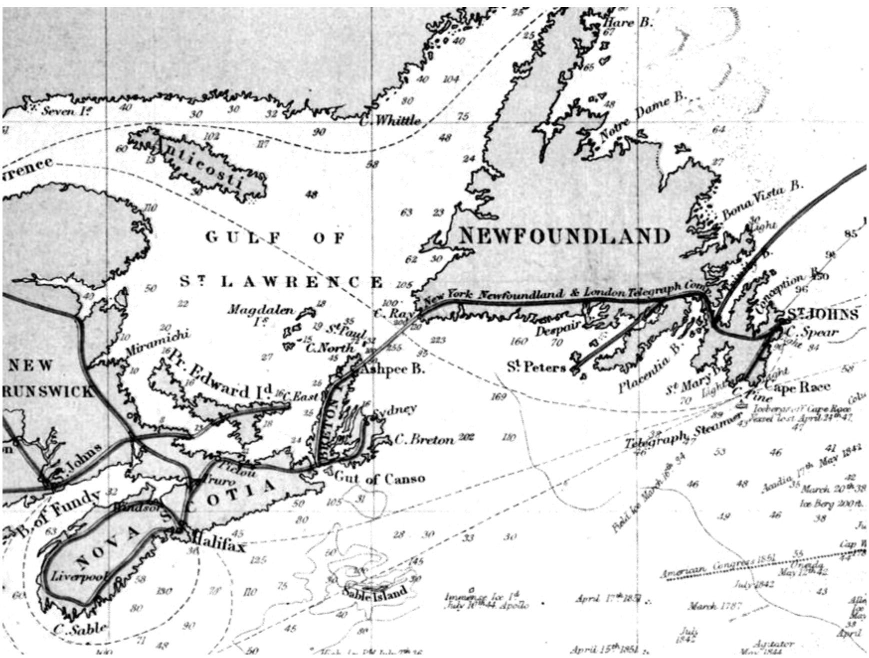


Figure 204: North-American side of the transatlantic cable project (1856).

Source: http://atlantic-cable.com/Ephemera/Broadsides/1856-Atlantic-Cable-Map_D1.jpg

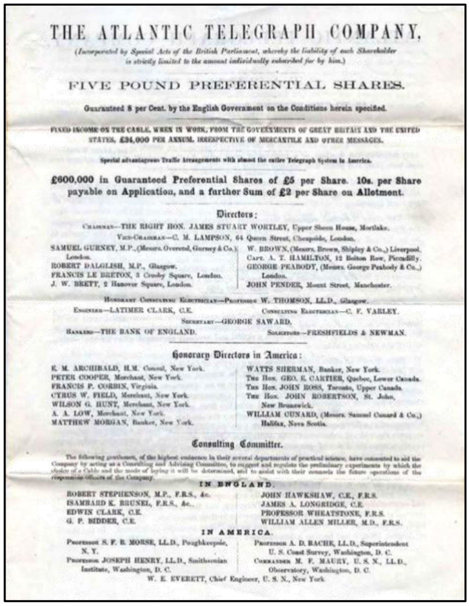
[293] Equivalent to ca £25 million in 2014, calculated on the basis of the real price of a commodity. Source: www.measuringworth.com

This company, created by the "Five Immortals" Cyrus West Field, Peter Cooper, Moses Taylor, Marshall Owen Roberts and Chandler White, raised a capital of $1.5 million[294].

The first thing they did was to create a telegraph line that crossed the Gulf of St. Lawrence (Figure 204). They met with failure, and it was only the second attempt that, in the summer of 1856, realized the Cabot Strait cable between Newfoundland and Cape Breton Island. Now St. John's, Newfoundland, was connected with the North American electric telegraph system. It would become the first link in the chain of telegraphy that connected the Old World with the New World.

Having invested quite some money, they considered the next step.

> *The great question then came up, What could we do about an ocean cable? After getting a few subscriptions here, which did not amount to much, we sent Mr. Field across the ocean, to see if he could get the balance of the subscriptions in England; and he succeeded, to the astonishment of almost everybody, because we had been set down as crazy people, spending our money as if it had been water. Mr. Field succeeded in getting the amount wanted, and in contracting for a cable. It was put on two ships which were to*



THE ATLANTIC TELEGRAPH COMPANY.

(Incorporated by Special Acts of the British Parliament, whereby the liability of each Shareholder is strictly limited to the amount individually subscribed for by him.)

FIVE POUND PREFERENTIAL SHARES.

Guaranteed 8 per Cent. by the English Government on the Conditions herein specified.

FIXED INCOME ON THE CABLE, WHEN IN WORK, FROM THE GOVERNMENTS OF GREAT BRITAIN AND THE UNITED STATES, £34,000 PER ANNUM, IRRESPECTIVE OF MERCANTILE AND OTHER MESSAGES.

Special advantageous Traffic Arrangements with almost the entire Telegraph System in America.

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Consulting Committee.

The following gentlemen, of the highest eminence in their several departments of practical science, have consented to aid the Company by acting as a Consulting and Advising Committee, to suggest and regulate the preliminary experiments by which the choice of a Cable and the mode of laying it will be determined, and to assist with their counsels the future operations of the responsible Officers of the Company.

IN ENGLAND.

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ISAMBARD K. BRUNEL, F.R.S., &c.
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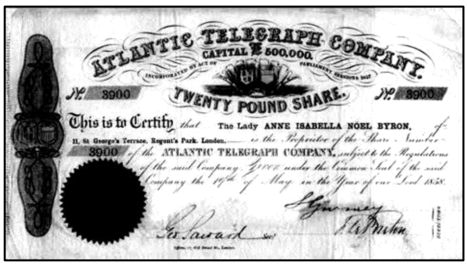

Figure 205: Prospectus for shares in the Atlantic Telegraph Company (top, 1859) and share certificate (May 19, 1858, below).

Share owned by Anne Isabelle Noel Byron, widow of the poet Lord Byron, bought for £100, sold for £35, and worthless after the failure.

Source: http://atlantic-cable.com/stock.htm

[294] Field, Cooper, Taylor, Roberts and Wilson G. Hunt are known as the "Five Immortals": the men who first risked £500,000 in 1854 and paid up the balance of the million sterling to keep up the connection with Newfoundland until the Atlantic cable was completed in 1866.

> *meet in mid-ocean. They did meet, joined the two ends of the cable, and laid it down successfully. We brought our end to Newfoundland, where we received over it some four hundred messages. Very soon after it started, however, we found it began to fail, and it grew weaker and weaker, until at length it could not be understood any more.*[295]

In July 1856, Field, together with the Englishmen J.W. Brett, and Charles Bright, organized the Atlantic Telegraph Company. The capital needed at the outset—£350,000[296]—was raised in England from merchants and ship owners who saw the value of such a connection (Figure 205). So Field launched his transatlantic cable project, which would become the Victorean equivalent of the twentieth century Apollo project[297]—a project that, after some failures in 1857 and 1858 and new attempts in 1864 and 1866 with a newly designed cable, resulted in the bridging of the Atlantic Ocean.

A new company, the Anglo-American Telegraph Company, had to be raised to finance the £600,000[298] of fresh capital. That was not easy during the aftermath of the Civil War that had raged in the US and stressed the political relations between the US and Great-Britain. But Field, with some diplomacy, succeeded in involving the suppliers like the Telegraph Construction and Maintenance Company and its subcontractors. Now the cable contractors replaced the wealthy New Yorkers from the 1850s. This commitment was not enough, but Field managed to have the rest financed by his friend Junius Morgan, of the J.S. Morgan & Co. bank. The agreement was sealed just before the financial crash of Black Friday on May 10, 1866, that would start the British Panic of 1866[299].

With the finances organized, the project was restarted. Luckily, not only did the 1866 attempt succeed, the 1864 cable was also repaired. Now two working telegraph lines existed. The interest in using the Atlantic telegraph

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295 Peter Cooper's Autobiography. Source: http://ns1758.ca/tele/telegraph02.html#pcooperautobio

296 Equivalent to ca £30 million in 2014, calculated on the basis of the real price of a commodity. Source: www.measuringworth.com

297 The Apollo program, also known as Project Apollo, was the third United States human spaceflight program carried out by the National Aeronautics and Space Administration (NASA), which accomplished landing the first humans on the Moon from 1969 to 1972

298 Equivalent to ca £50 million in 2014, calculated on the basis of the real price of a commodity. Source: www.measuringworth.com

299 The 1866 Panic began with the collapse of the City of London's oldest bill brokerage firm and discount company, Overend, Gurney, and Company. It's director, Samuel Guerny, had been director of the Atlantic company, which financed the first attempts to create the transatlantic telegraph connection.

connections was so great that Field was able to pay off all his debts by 1867 (Kieve, 1973, pp. 106-115)[300]. Field became a hero: the "Columbus of our time" as he was proclaimed. Congress minted a gold medal in his honor. He got a grand reception in Great Barrington, Mass. It was a glorious time for him, but bad investments left Field bankrupt at the end of his life in 1892.

These transatlantic telegraph connections, with all those other submarine cables that were laid in 1850-1860 (Table 20) and the thousands of miles of land lines, would create a vast telegraph network circling the world. Together they would create the Victorean Internet (O'Hara, 2010; Standage, 1998).

Table 20: Some of the principle submarine cables (1850-1870)

Year	Route	Leng (km)	Company	Promotor
1851	Dover-Calais	44	Submarine Telegraph Co.	J.W. Brett
1853	Portpatrick-Donaghadee	64	English& Irish Telegraph Co.	C. Bright
1854	Sweden-Danmark	58	Glass Elliot & Co.	W. Thompson
1855	Cape Breton-Newfoundland	137	Electric Telegraph Co.	J.W. Brett
1857	England-Netherlands		Electric Telegraph Co.	R.S. Newall
1858	England-Hannover	45	Glass Elliot & Co.	R.S. Newall
1859	Toulon-Corsica		Glass Elliot & Co.	R.S. Newall
1861	Malta-Alexandria	2471	Glass Elliot & Co.	L. Gisborn
1866	Valentia-Newfoundland	4495	Anglo American Telegraph Co.	J. Pender
1869	Brest-St.Pierre	5300	French Atlantic Cable co.	E. d'Erlanger
1870	Falmouth-Gibraltar-Malta	5632	Falmouth, Gibraltar & Malta Telegraph	J. Pender

Source: Beauchamps, K. (2001); Table 5.1 pp 144-145

Hiram Sibley

As a last example, we touch on the efforts of Hiram Sibley (1807-1888). Hiram came from a family of fifteen children. He had no formal education when he became apprentice to a local shoemaker. He was mechanically gifted and opened up a sawmill and a machine shop. At the age of thirty-six, he was elected sheriff of Monroe County (1843-1846). He met with Royal Earl House, Samuel Morse, Alfred Vail and Ezra Cornell, and became involved in the creation of the Washington-Baltimore telegraph line in

300 In 1866, the first 20 words of a telegram to Great Britain would cost $100. In today's money that would be equivalent to $1,540 (based on the historic standard of living. In 1866, that had dropped to 40 cents/word. Source: www.measuringworth.com

1843. And he knew Judge Samuel L.Selden, one of the largest owners of the House patent.

> *At the time of Judge Selden's acquisition of his interest in the House patent, Hiram Sibley was Sheriff of the county of Monroe. He was a man of decided personal qualities, imperious, rugged, of ready practical discernment, self-confident, and whose early life had made him thoroughly wide-awake and earnest. To him Judge Selden went with a project to organize a telegraph company, under the House patents, to operate in the vast regions west of Buffalo, and endeavored to enlist Mr. Sibley in the scheme. These gentlemen had long and frequent interviews with each other, discussing the features of the project. Judge Selden saw in Sibley the aggressive element which insists on and compels success, and was anxious to secure his co-operation.* (Reid, 1886, p. 463)

So, in 1851, Hiram Sibley, Hugh Downing and Samuel L. Selden organized the New York and Mississippi Valley Printing Telegraph Company (NYMVPTC) in Rochester, New York, to construct a line from Bufallo to St. Louis. The company used the House telegraph to realize telegraph lines. But, as it was hard to compete with the existing New York, Albany, and Buffalo Telegraph Company, they decided upon another strategy—a strategy that encompassed the acquisition of the small existing companies that were struggling to survive and unifying them into a single unified system.

> *In 1854 there were two rival systems of the NYMVPTC in the West. These two systems consisted of thirteen separate companies. All the companies were using Morse patents in the five states north of the Ohio River. This created a struggle between three separate entities, leading to an unreliable and inefficient telegraph service. The owners of these rival companies eventually decided to invest their money elsewhere and arrangements were made for the NYMVPTC to purchase their interests.* (Harding, 1986, p. 4)

Creating the idea was not that difficult; putting it into reality proved more difficult.

> *However, the financial support needed to achieve that vision would prove very difficult to obtain, and the large number of small companies controlling the telegraph lines connecting different cities presented additional challenges. To unify the country's telegraph system, it was therefore necessary to create large companies able to purchase the smaller ones controlling the different telegraph routes. With this idea, by 1857, Western Union (the new name of Sibley's company) gained control of the telegraph lines in the Western territories in the same way that the American Telegraph Company controlled the Eastern territories. This situation of two companies trying to control the territory culminated in the Treaty of the Six Nations, in which the six most important telegraph companies reached an*

agreement to interconnect the lines of their members and try to discourage competitors. (de Adana, 2010, p. 2)

So, Sibley and consorts, after a period of negotiating, managed to consolidate the telegraph companies from Ezra Cornell, House, Morse, O'Reilly, Speed and Wade into one company called the Western Union Telegraph Company in 1856.

The Morse patent was the most valuable item in the entire conveyance. It gave the basis of immense control, not even then fully comprehended, in connection with a new project for railroad uses and cooperation, for which no other patent had any practical or intrinsic value. This became more and more evident in after years, and has proved the chief element in the great success which since that period has followed telegraphic extensions. (Reid, 1886, p. 469)

Sibley became its president and started to extend Western Union Telegraph Company into an electrical telegraph network in cooperation with the railroad companies. That was the beginning, and Sibley became one of the great consolidators of the telegraph industry and created the Western Union monopoly. Together with early investors like Ezra Cornell, it was the start of their fast fortunes, as they were its major stock holders.

More about that development later on. But let's first look at all those people that became employed by the companies these tycoons created: the telegraphers in their telegraph offices.

Telegraphers and Telegraph Offices

When telegraphy became more popular, the number of lines grew, and the employment for people who could operate the machines also grew. These *telegraphers* as they were know, earned a better salary and had exotic careers on the front of advanced technology (of that time). The messages they transmitted originally were not ordinary chit chat. Telegraphy was serious business.

Except for press, which was for general public consumption anyway, most of the communications were of a private nature, many extremely secretive. The operator was under bond and had no right to disclose any information or report any wrong doing observed in the contents of a telegram. Even the police had no right to demand reading a telegram except by court order. It is doubtful whether the mails would have contained as much information if opened, yet the telegrapher was up front witnessing all of this take place.[301]

[301] Source: Arthur W. Grumbine: the *Era of Morse Telegraphy*, series of articles in "Dots and Dashes" in 1985. Part I. (Accessed May 2015)

Telegraphy was used for a range of communications: business transactions between companies, stock information from brokers to clients, official governmental communications and newspapers who wanted to cover out of town events as soon as possible:

> *... election returns, World Series games, prize fights, etc., were transmitted by Morse code to large public gatherings in front of newspapers, in city squares, auditoriums and clubs, where results were posted on huge blackboards or other devices, making changes as things progressed. There was no other means of communication then, except the newspapers, and even they too had to depend upon telegraphy to get their out of town news. Morse code was used then like television and radio are used today to cover all important events.* [302]

Figure 206: General Operating Department, Western Union Telegraph Building, New York, NY, c. 1875.

Source: http://gallery.nen.gov.uk/asset77461-.html

Over time, the nature of the messages changed. When members of the general public also started using the telegraph to send social messages, it became an alternative for short mail.

> *In early years delivery of a telegram to a private residence was always dreaded for it usually announced the death of a loved one. Introduction of singing telegrams and prepared stock greeting suggesting soon overcame that belief, and use of telegrams for all social occasions became extremely popular. During the Christmas and Easter Holidays the lines were swamped with greeting messages requiring extra help and overtime to handle the load.* [ibidem]

http://www.telegraphlore.com/telegraph_tales/grumbine/grumbine_1.html

302 Source: Arthur W. Grumbine: the *Era of Morse Telegraphy*, series of articles in "Dots and Dashes" in 1985. Part II. (Accessed May 2015)
http://www.telegraphlore.com/telegraph_tales/grumbine/grumbine_1.html

Telegraph offices popped up everywhere (Figure 206). Here people could bring their messages for transmission. Or here the transmissions were relayed to other telegraph offices. After the period of consolidation, the telegraph offices of Western Union and the offices of the Postal Telegraph Company spread all over America.

Figure 207: Berlin Telegraph Office.

Source: http://davidedwardhughes.com/wp-content/uploads/2014/05/25.-Berlin-Telegraph-office.jpg

> *Telegraph offices were virtual beehives and as commonplace to everyone as the post office. Western Union, through railroad wire connections, reached more than 20,000 communities. The Postal Telegraph Company served over 1,000 cities. Many branch offices were scattered in the larger cities and suburbs.*[303]

It was not only in America that the institution of the Telegraph Office became widely known. This also happened in Europe; where numerous electric telegraph lines were erected, the telegraph offices appeared. Some small, some quite large (Figure 207).

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[303] Source: Arthur W. Grumbine: the *Era of Morse Telegraphy*, series of articles in "Dots and Dashes" in 1985. Part III. (Accessed May 2015) http://www.telegraphlore.com/telegraph_tales/grumbine/grumbine_1.html

Entrepreneurial Activities: Equipment Manufacturers

Alfred Vail wasn't the only one to work on prototypes, building the two Vail's registers that were used for the Washington-Baltimore line; other technicians also contributed. A diversity of subcontractors had already worked for Morse (eg Thomas Hall and Daniel Davis, making the relays) (Figure 208). As the number of lines grew—very soon exponentially—the number of manufacturers also grew, not only in New York, but also in the cities of Troy, Rochester and Utica (upstate New York). In 1871, some twenty-nine companies were organized. Table 21 shows some of these companies.

Figure 208: Advertisements from Thomas Hall and Daniel Davis.

Source: http://www.telegraph-history.org/manufacturers/#24

Table 21: Some early manufacturers of telegraphy-related equipment

Name	Place	Manufacturing (as advertised)
A. S. Chubbuck,	Utica, N.Y	Telegraph instruments and supplies: Registers
S. J. Burrell,	New York, N.Y.	Printing telegraph instruments
Knox & Shain	Philadelphia, Pa.	high grade telegraph registers
Chester, Partrick & Company	Philadelphia, Pa.	Registers, keys, relay magnets, sounders, switches, lightning arresters, and every variety of apparatus, batteries
Hicks and Shawk	Cleveland, Ohio	Automatic repeater, electrical and telegraphic apparatus
F. L. Pope & Company	New York, N.Y.	Morse telegraphic instrument, batteries, chemicals, insulated wire
Charles T. and John N. Chester	New York, N.Y.	Instruments, batteries, repeaters, insulators, insulated wires
Partrick, Bunnell and Company	Philadelphia, Pa. & New York, N.Y.	Morse sounders, batteries, wires, relays, registers, switches, repeaters
Charles Williams Jr.	Boston, Mass.	Repeaters, switch-boards, relays, registers, sounders, keys, rheostats, galvanometers and batteries
E. S. Greeley & Company	New York, N.Y.	Telegraph and general supplies

Source: John Casale: Telegraph History. http://www.telegraph-history.org/manufacturers/index.html (Accessed January 2015)

J.H.Bunnel was a delivering telegraph messages at the age of thirteen.. In April 1861, Jesse, not yet eighteen, joined the Union Military Telegraph Service (UMTS) and became a telegraph operator. At the war's start, telegraph operators were the Army's Cinderellas. They were, and remained, civilians. Their value was not appreciated and they were given very little support and $60 per month, less than that of a quartermaster clerk. The operators were often under fire, as their main duty was to relay troop movement observations and orders, in part replacing military couriers. After he had left the army, in 1878, Jesse created J. H. Bunnell and Co. And in 1879, he hired Charles McLaughlin as a partner in charge of sales and administration, while Jesse concentrated on manufacturing and innovations. He received a patent on February 15, 1881, for his steel lever key. Bunnell manufactured and supplied telegraphy and other electronic equipment for the military from the time of the Spanish American War through the present (Figure 209). Bunnell also made keys for Great Britain's military.[304]

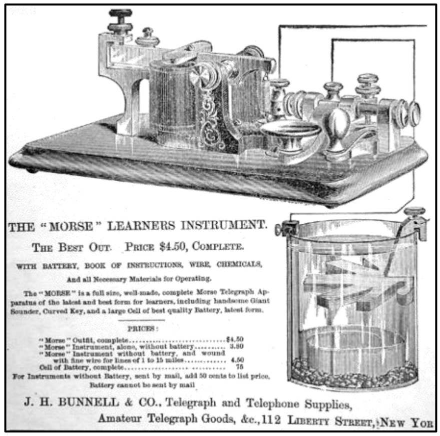

Figure 209: Advertisements from J.H.Bunell & Co.

Source: http://www.telegraph-history.org/manufacturers/#24

Hicks & Shawk resp. its successor the Telegraph Supply and Manufacturing Company in Cleveland was founded in 1869 by George B. Hicks. Hicks had invented the Hicks Repeater that was used on long telegraph lines(1873-price $100). After Hicks died in 1873, George Stockly took charge of the company. In 1876, Stockly hired his childhood friend, Charles F. Brush, and facilitated his work on the arc light and electric dynamo. In addition to telegraphic instruments, the company was also active both in telegraphic fire alarm and burglar alarm system. And they started to make carbon electrodes for the arc lights. In 1880, following the success of the public lighting demonstration, the name of the

[304] Source: http://jhbunnell.com/bunnellcohistory.shtml (accessed January 2015). the company still exists

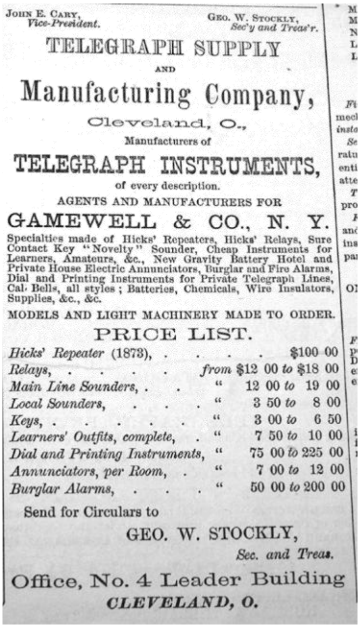

Figure 210: Advertisements for Telegraph Supply & Manufacturing Co.

Source: http://www.telegraph-history.org/manufacturers/#24

company was changed from the Telegraph Supply Company to the Brush Electric Company[305], both to better reflect the business in which it was engaged and to capitalize on the Brush name recognition.

In the 1850s, Boston had become a center for the manufacturing of telegraph equipment as well as a center for telegraph developments that were created by a range of inventors. Many of those improvements were not implemented by the inventor's themselves. They might have designed the prototypes, but they left the fabrication to the more skilled instrument makers of those days: people like Charles Williams, Thomas Hall, Daniel Davis, M. Wightman, N.B. Chamberlain, Moses Farmer and E.S. Ritchie. And quite a few over time grew into the manufacturing side of the telegraph equipment. Take for example Charles Williams, an early significant telegraph instrument maker.

Charles Williams was a telegraphy instrument maker who had a shop at 318 Washington Street in Boston (Figure 211). In 1874, Alexander Graham Bell rented space for his experimenting in the attic of the building , where he worked with Thomas Watson. In his shop, Williams worked for many inventors and made a range of standard products.

> *Williams had an electrical shop that manufactured among other items, telegraph instruments. Types of telegraph instruments known to exist from Williams are keys, sounders, registers and KOBs (key and sounder on wood base). It is likely he also made relays. Some of the first fire alarm telegraph equipment was made in Williams' shops. …Williams supplied parts and apparatus to Thomas Edison, Joseph Stearns (who perfected duplex telegraphy, et. al.), Alexander Graham Bell and other inventors. The advertisement …testifies to the nature of Williams' business as a supplier. Edison, as a young inventor, leased space in a corner of the building from Williams before he had his own laboratory. In the December 1868*

[305] See: B.J.G. van der Kooij *The Invention of the Electric Light.* (2015)

Figure 211: Advertisement for Charles Williams's products.

Source: http://www.telegraph-office.com/pages/Charles_Williams.html

issue of the Telegrapher, Edison announced his address as "Care of Charles Williams Jr., Telegraph Instrument Maker, 109 Court Street, Boston." It was here, with the aid of one of Williams' employees that Edison built a working model of his first patented (1869) invention, a vote recorder. Moses Farmer, the most prominent telegraph inventor (repeater, call box, et.al.) of the mid nineteen century, had his instruments built in Williams' shop. (McEwen, 1998)

The telegraphy business started to phase out from the 1870s as the telephone business grew. Williams manufactured all of the Bell Telephone equipment until the spring of 1879. The demand for telephones exceeded the capacity of the Williams' shop, so other makers were licensed.

The US Telegraph Monopoly

The early years of the telegraphy services were offered by a range of small companies operating a telegraph line, mainly in the east of the United States. But soon there was a wave of consolidations.

> *The supply response, in turn, created conditions favoring a weeding out of smaller telegraph companies and successive rounds of consolidation within the industry. During the first decade of telegraph development, 1846-1856, competitive lines sprang up in many sections of the nation, as the message market consisted of many decentralized users and entry costs for telegraph entrepreneurs were low. … By the early 1850s the need for interfirm cooperation that terminal stations and for standardization of dispatch and delivery procedures was self-evident.* (Boff, 1980, p. 462)

So the infancy stage of telegraphy in the U.S was characterized by many startups by private parties, some of them as a licensee of Morse's system. But also, many pirated by working with Morse-like equipment (eg the Columbian telegraph that O'Reilly used). Major agglomerations were the first to be connected, as they were the ones that promised a good return. And many rival lines were established in parallel. But this was to change when the technology matured. Then there were only three surviving technologies: the Morse system, the House system and the Bain system, each having its own techniques, standards and patent protection.

> *The methodless enthusiasm which marked the birth of the telegraph industry in the United States reached its peak in the early 1850s. Within the Morse family itself were to be found three rival groups, all claiming the exclusive right to use the Morse instruments on the main arteries of the nation. Four Bain and three House companies operating over main routes -- to say nothing of the many organizations operating on subsidiary lines -- further complicated the situation. All the ills of multiple management and duplicating service were apparent. Inability to fix responsibility for errors in transmission, and high costs when messages passed over the wires of more an one company, made the public reluctant to use the telegraph for long-distance communication. Contradictory rules of operation, poorly constructed lines, and inexperienced and inefficient operators, contributed to the general dissatisfaction with the service. Under the circumstances, telegraph companies were impoverished. Of the twenty-three leading organizations that the opening of the decade, only a few were making substantial profits; a number were barely managing to pay expenses; the majority were sinking deeper into debt each month.* [306]

Between 1853 and 1857, regional monopolies formed and signed the Treaty of Six Nations, a pooling agreement between the six largest regional firms (Figure 212). It proved to be a profitable operation.

> *Yearly conventions were decided upon by the telegraph companies, and they drifted slowly towards a closer rapprochement, finally resulting in 1858 in the formation of the North American Telegraph Association. But before that date, a new colossus had arisen among their members, one destined eventually to engulf them all.* (Harlow, 1936, p. 249)

> *The windfall profits enjoyed by the members of the North American Telegraph Association depended in large part on the lack of competition in telegraphy, an advantage in danger of disappearing when the Morse patent expired in June 1861, six years ahead of the recently renewed patent on the telegraph receiving magnet.* (Wolff, 2013, p. 74)

That new colossus started—as described earlier—as a small cooperative action of Judge Samuel L. Selden and Hiram Sibley, who created the Mississippi Valley Printing Telegraph Company. The new company was one of the many telegraph providers and found it difficult to grow. However, Sibley had observed that many of the small existing telegraph companies were struggling to survive. That was a problem, but it also could be an opportunity, certainly for Hiram Sibley.

[306] Based on: Thompson, Robert Luther. *Wiring a Continent: the History of the Telegraph Industry in the United States, 1832-1866*. Princeton, NJ: Princeton University Press. Copyright 1947. LOC HE7775.T5. Source: http://www.myinsulators.com/acw/bookref/telegraph/ (Accessed January 2015)

> *When the House machine was patented, Judge Selden bought rights for the northwestern territory, and suggested to Sibley that they organize a company to operate under it from Buffalo westward. Sibley's reaction to the idea was a suggestion that they buy some of the weak Morse and O'Rielly lines in the territory to westward, and weld them into a system. Isaac Butts, a third Rochester man, joined with them in the project, and in 1851, the New York and Mississippi Valley Printing Telegraph Company was organized, with a board of directors on which Rochester citizens predominated. … Sibley accordingly planned his reorganization of the New York and Mississippi Valley in 1854 with the intention of accumulating more capital and beginning to absorb the sickly wires which were fighting each other westward from New York State and Pennsylvania.* (Harlow, 1936, pp. 250, 251)

Finding capital for such an operation in a market where every investor—already conservative by definition—saw the struggling companies, proved not to be easy. Sibley only managed to raise a mere $100,000. With that he started to buy the struggling telegraph lines (Figure 212). Among them was the Lake Erie Telegraph Company and the Erie and Michigan Telegraph Company. Its owner, Ezra Cornell, a former associate of Samuel Morse, constructing and stringing the telegraph poles between Washington and Baltimore in 1844, insisted on the Western Union Telegraph Company for the name of the new company (Harlow, 1936, p. 253).

Next were added the Atlantic & Ohio Company, a telegraph line first build by O'Reilly between Pittsburgh and Philadelphia in 1846, and the Pennsylvania Telegraph Company, founded in 1855 (Branch, 1938, pp. 28, 29). Soon, Sibley's idea proved profitable, and in December, the first dividends of 8% were paid out to the investors, who saw the value of their investments rise astronomically.

> *By May 1, 1864, the capital was $10,066,900, and Western Union had become the most popular of extravaganzas, a dream world come true. The stock rose to 200, despite its frequent dilution, and then to 225. … Such fantastic success brought its inevitable consequences. Promoters and capitalists, with chops dribbling for a taste of such rich gravy, were organizing more telegraph companies, and because of the shining example of the Western Union, were readily finding money with which to do it.* (Harlow, 1936, p. 256)

All these mergers and acquisition had made the company quite valuable. The dividend payout was attractive. The stock market had a frenzy time in a pandemic of telegraph fever.

> *A share of Western Union with the par value of $100 in 1860thus had a par value of $678 in May 1864—and was worth nearly $1,500 at market prices.*

> *A shareholder who bought stock in 1860 and held it until 1864 would have seen his annual cash dividend payment grow nearly seven times larger , while inflation had increased consumer prices in the North by only 75 percent during the same period.* (Wolff, 2013, p. 73)

After Hiram Sibley and his consorts had created the Western Union Telegraph Company on April 4, 1856, similar consolidations took place in other areas of the country between 1857 and 1861 (Figure 212). It resulted in the American Telegraph Company (covering the Atlantic and some gulf states), the mentioned Western Union Telegraph Company (covering states north of the Ohio River and parts of Iowa, Kansas, Missouri and Minnesota), the New York Albany and Buffalo Electro-Magnetic Telegraph Company (covering New York State), the Atlantic and Ohio Telegraph Company (covering Pennsylvania), the Illinois & Mississippi Telegraph Company (covering sections of Missouri, Iowa, and Illinois) and the New Orleans & Ohio Telegraph Company (covering the southern Mississippi Valley and the southwest). All these companies worked together in a mutually friendly alliance, the Treaty of the Six Nations of 1857, and other

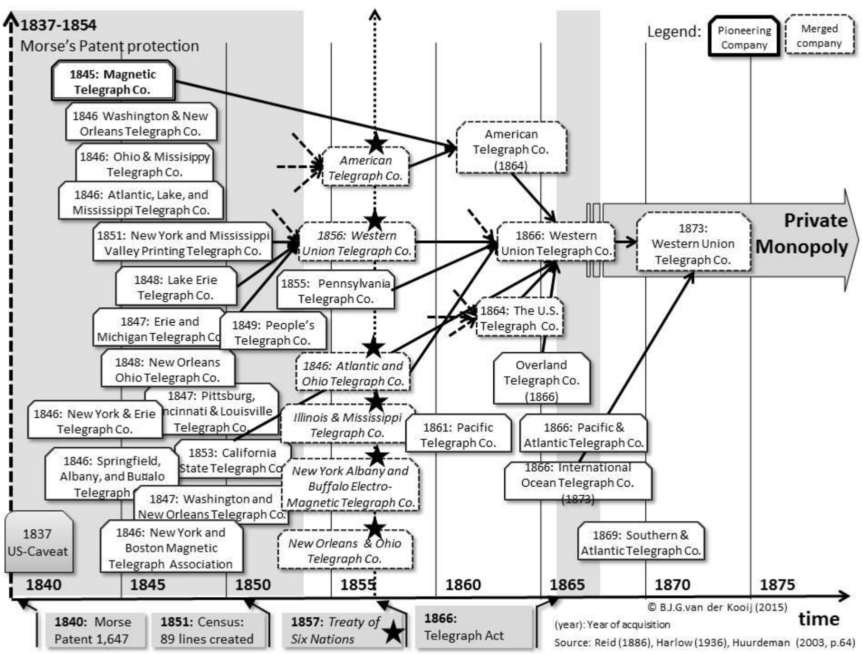

Figure 212: Some new US telegraph companys and their Mergers and Acquisitions.

Source: http://atlantic-cable.com/Ephemera/Broadsides/1856-Atlantic-Cable-Map_D1.jpg small companies cooperated with the Six Nations, particularly some on the west coast. [307]

Not fortuitously, the telegraph industry became the first industrial monopoly in the United States when the Western Union Telegraph Company swallowed up its last two rivals in 1866; the American Telegraph Co. and the US Telegraph Co.[308]. From then on it dominated the telegraphy market.

> *The period from 1866 through the turn of the century was the apex of Western Union's power. Yearly messages sent over its lines increased from 5.8 million in 1867 to 63.2 million in 1900. Over the same period, transmission rates fell from an average of $1.09 to 30 cents per message. Even with these lower prices, roughly 30 to 40 cents of every dollar of revenue were net profit for the company. Western Union faced three threats during this period: increased government regulation, new entrants into the field of telegraphy, and new competition from the telephone.* (Nonnemacher)

The Telegraph Acts of 1866

Like in England, in the United States this emerging monopoly caused concern in political circles. Telegraph consolidation meant that an overwhelming majority of locations in the United States were served by a single company: Western Union. The political concern resulted in the National Telegraph Act of 1866, the beginning of a three-decade battle between Western Union and the federal government that acted in the public interest that wished to regulate the telegraph industry.

> *The rise of Western Union did not go uncontested. Troubled by its high rates and limited geographical scope, industry critics lobbied to bring it under federal control. Though these efforts proved almost entirely unsuccessful, they did hasten the pas sage of the Telegraph Act of 1866, which granted Congress the authority to purchase, at a mutually agreeable price, the assets of every telegraph company in the United States that agreed to be bound by its terms. In return, the law gave consenting firms the right to erect telegraphic lines on any postal route in the country, a valuable privilege in an age in which the individual states continued to exercise a broad range of powers over their internal affairs. This agreement proved acceptable to most of the leading firms in the industry, including Western Union, whose officials came to hail it as a contractual guarantee that its shareholders' rights would be duly respected.* (John, 1998, p. 199)

[307] Source: http://historywired.si.edu/detail.cfm?ID=324 (Accessed June 2015)
[308] One of the company's Morse operators was Thomas Edison, whose early inventions were completed under the auspices of Western Union.

The political discussions resulting in the National Telegraph Act marked the first time telegraphy was seriously on the agenda of Congress since Morse's first attempts to get Congress interested in 1837. The seven months beginning with the introduction of John Alley's House resolution in December 1865 proved to be one of the most pivotal periods in telecommunications history. The discussion if there should be a state-run public telegraph system—in this case in competition with the private telegraph companies—had already simmered for a longer time, but finally in 1866 it went in a different direction than in Britain.

> *While committees in both houses pondered the National Telegraph Company Bill, the question remained whether a publicly operated telegraph was feasible or desirable; neither Congress nor the Postmaster General had considered the question since Postmaster General Cave Johnson issued a report favoring a public telegraph in 1845. … With some help from the telegraph industry, Postmaster General William Dennison issued his report on June 2, 1866.. … He concluded that the total cost of a government network would be $6,8 million plus maintenance and depreciation. … His conclusion, however, suffered from no ambiguity: it would not be "wise" for the government to sponsor a postal telegraph, not only because of the poor financial prospects, but also because he doubted its "feasibility" in the "American political system". The sources of Dennison's report undoubtedly had significant influence on his conclusion.* (Wolff, 2013, p. 97)

When the Bill finally reached Congress to be voted upon, it passed the Senate with a three-vote margin. After passing the House, it was signed into law on July 24, 1866. Despite Western Union's heroic efforts to block the bill, some form off regulation would be exercised over the great monopoly of the telegraph industry. Basically, it came down to opening the telegraph business to more competition.

> *Although the 1866 act did not regulate telegraphy directly, taken as a whole it created a quasi-regulatory environment that encouraged competition and restrained Western Union from using the full force of its monopoly.* (Hochfelder, 2012, p. 57)

In the 1870s, it was the Bostonian businessman Gardiner G. Hubbard who would continue to fight the monopolistic behavior of the telegraph industry by proposing a postal telegraph plan to Congress. As the father in law of Alexander Graham Bell, who was working on the "speaking telegraph", he had a good reason to do so. But that is another story....[309]

[309] This topic is covered in: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telephone'.* (2015)

Telegraphy: A Societal Affair

From the preceding analysis emerges a picture of the growing importance of telegraphy. After its pioneering days, it soon picked up and became an important means of communication. In America and Britain telegraphy was seen from the outset as a public affair, other European countries had a different perspective. There it often was an affair where telegraphy was reserved for governmental and military use.

Telegraphy encompassed the rapid transmission of information created and used by the public: corporations, financial and news institutions and private persons. It was expected to be more than just a replacement for the earlier communication systems. Or, as *The Daily Chronicle* of November 16, 1847, stated: "[Telegraphy was] facilitating Human Intercourse and producing Harmony among Men and Nations" (Boff, 1984, p. 571).

Corporate use: For business, the use of telegraphy meant speedier communications. This improved doing business, and companies—wanting to keep their communication secret from others—used elaborate code systems. The growing corporations were able to run regional operations—and even overseas subsidiaries—from a central office.

Distribution of news: Newspapers—known to distribute information about affairs of public interest—welcomed the telegraphy with open arms. Now they could acquire news from more sources at greater distances at greater speed. Replacing the old postal mail based system of the Pony Express (and the homing pigeons), the telegraph system improved the dissemination of information by wire agencies dramatically. It resulted in a news explosion.

> *By 1848 two associations were formed in New York City: the Harbor News Associations, dedicated to obtaining foreign News, and the New York Associated Press, an organization concerned with gathering domestic news.* (Phalen, 2015, p. 128)

In Europe the telegraph networks also made the dispersion of news much quicker and available to a wider audience, like the news that the war correspondents like William Howard Russell reported back to Britain about the situation at the Crimean War in 1854. It was about the carnage of Sevastepol and about British soldiers who went down with cholera and typhus. It would create the fame of Florence Nightingale as the "Lady with the Lamp".

> *His reports revealed the sufferings of the British Army during the winter of 1854-1855. These accounts upset Queen Victoria who described them as these*

> *"infamous attacks against the army which have disgraced our newspapers". Prince Albert, who took a keen interest in military matters, commented that "the pen and ink of one miserable scribbler is despoiling the country." Lord Raglan complained that Russell had revealed military information potentially useful to the enemy.* (Simkin, 1997)

Stock information and trading: One of the earlier uses of telegraphy to distribute information was to be found in the financial and trading markets. The stock ticker was used to transmit stock information over telegraph lines. In trading, where time was money, telegraphy was eagerly welcomed.

> *The telegraph undoubtedly had a major impact on the structure of financial markets in the United States. New York became the financial center of the country, setting prices for a variety of commodities and financial instruments. Among these were beef, corn, wheat, stocks and bonds. As the telegraph spread, so too did the centralization of prices. For instance, in 1846, wheat and corn prices in Buffalo lagged four days behind those in New York City. In 1848, the two markets were linked telegraphically and prices were set simultaneously. The centralization of stock prices helped make New York the financial capital of the United States. Over the course of the nineteenth century, hundreds of exchanges appeared and then disappeared across the country. Few of them remained, with only those in New York, Philadelphia, Boston, Chicago and San Francisco achieving any permanence.* (Nonnemacher)

Private communication: The general public, using the multitude of telegraph offices, used the new medium of communication for personal and urgent communication. The telegraphic dispatch—or *telegram* as it soon would be called—became the messages of joy and sadness, sorrow and success.

And the US government? Did it start using telegraphy? Well, it took a while, but after the international network developed, they started to use telegraphs for diplomatic purposes. European foreign ministries first used telegraphy during the early 1850s, but it did not become an important tool in the diplomacy of the United States until the completion of a successful transatlantic cable in 1866. It also heralded the first encrypted telegrams when on November 23, 1866, the US State Department sent its first encrypted message via submarine cable (Nickles, 2009, p. 169).

> *Telegraphy increased the centralization of foreign ministries. When ambassadors were months away from their political superiors, they were often forced to take pressing and important decisions before they could receive their instructions. In such circumstances, they exercised enormous power, sometimes even acting as policymakers in their own right. In contrast, telegraphy circumscribed the*

> *independence of diplomats. It reduced the pressure of difficult decisions, which diplomats had previously faced without ready access to advice from their superiors. Yet, it also diminished the prestige and the power of diplomatic representatives. Their function changed. Whereas diplomats had once received autonomy because the sending of instructions to respond to every eventuality was slow and cumbersome, they now, in the age of the telegraph, were prized in part for their inefficiency. They provided an extra layer of expertise and slowed the policymaking process, thereby reducing the chances of a catastrophic error.* [310]

There were also other side effects of the maturing telegraphy, like in the 1870s the emerging—and often highly fraudulent —bucket shops[311], where common people could speculate in stocks or currency or just gamble on horse races (Figure 213). Although quite popular with the public, they were opposed by brokers and the stock exchanges and were even raided by the police (Hochfelder, 2006, p. 354).

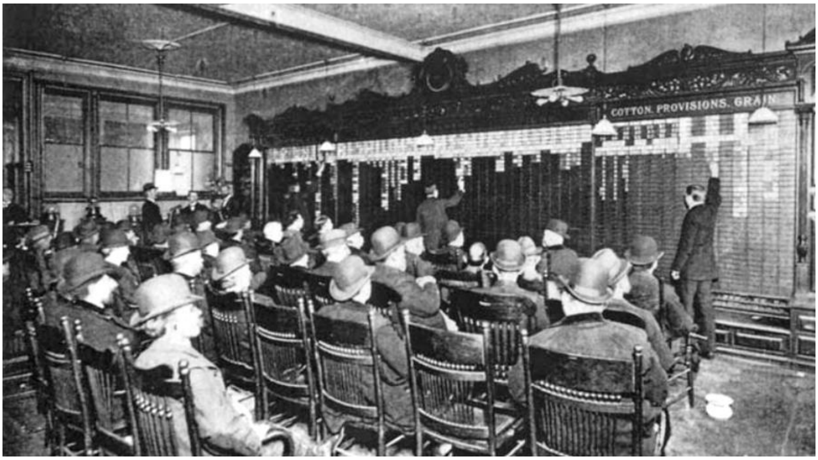

Figure 213: Interior of bucket shop (ca. 1890).

Source: www.livermoresecret.com

[310] Milestones: 1866-1898. US Diplomacy and the Telegraph, 1866. Office of the Historian, US Department of State. Source: https://history.state.gov/milestones/1866-1898/telegraph

[311] Shops where customers could wager on the price movements of stocks and commodities. Bucket shops leased tickers from telegraph companies on the same terms as brokers did and used real-time quotations from exchange floors as the basis for customers' wagers. However, bucket shops did not place customers' transactions on any of the stock and commodity exchanges, nor did bucket shop transactions affect the actual prices of stock shares or agricultural products. Such transactions were fictitious and did not result in delivery of stock certificates or commodities to their patrons.

> *The twenty-five-year war between the exchanges and the bucket shops brought out the dangers as well as benefits of instant telegraphic communication. Court rulings regarding their property rights over quotations, negotiations with the telegraph companies, and widely-held assumptions about speculation and gambling all defined the boundaries within which the major exchanges sought mastery over their informational destiny. In their struggle exchange leaders came to realize that control over the legal, business, and cultural environments were absolutely necessary to solve the dilemma in which the telegraph and the ticker had placed them.* (Hochfelder, 2001, p. 6)

Telegraphy had made quite a few people very rich. Not so much the original inventors, although, although Samuel Morse became quite well off at the end of his life[312]. Neither Leonard Gale nor Alfred Vail profited that much from his invention[313]. Alfred even died a poor man. No, it was the early investor-entrepreneurs in the emerging telegraph lines, the shrewd business men like O'Reilly, that profited. And the businessmen who saw telegraphy—and its companion the railroad lines—as an entrepreneurial opportunity not to miss (eg Ezra Cornell, the trenching man who saved the Washington Baltimore line; Andrew Carnegie, the telegraph clerk who went into railroads; Jay Gould, the railroad monarch who went into telegraphy; and the telegraph operator Theodore Vail (cousin of Alfred Vail), who created the telephone monopoly of the American Telephone & Telegraph Company) [314]

The development of the US recording telegraphy, one of the major trajectories that followed the development of the electric telegraph, shows the penetrating power of electricity in application fields outside its own development trajectory. Like its counterpart, the development of needle telegraphy resp. pointer telegraphy that originated by the Cooke and Wheatstone conceptions, it grew within a couple of decades from it's

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[312] Later in life Morse depended on dividends from telegraph companies. In 1858, several European countries combined to pay him a gratuity of 400,000 francs as compensation for their use of his system. Morse spent most of his life as a poor man, but at the time of his death in 1872 his estate was valued at around $500,000 ($10 million in 2014). Source: http://www.samuelmorse.net/ (Accessed June 2015).

[313] Vail left the telegraph industry in 1848 because he believed that the managers of Morse's lines did not fully value his contributions. His last assignment, superintendent of the Washington and New Orleans Telegraph Company, paid him only $900 a year, leading Vail to write to Morse, "I have made up my mind to leave the Telegraph to take care of itself, since it cannot take care of me. I shall, in a few months, leave Washington for New Jersey, ... and bid adieu to the subject of the Telegraph for some more profitable business." Source: Morse, Edward L., ed. Samuel F. B. Morse, His Letters and Journals. New York, 1914

[314] For more details: Josephson, M.: The Robber Barons. Hartcourt, Brace & Company, New York, 1934.

infancy in the late 1840s into a mature communication network. It also resulted in a bonanza of entrepreneurial activity: the "cluster of innovations" (Figure 201) thad resulted in a "cluster of businesses" (Figure 212).

In Europe and the United States, telegraphy was—next to the still extensively used postal mail—conquerring the business world, its communication network covering the distances of oceans and continents. Telegraphy had affected the Western society in unexpected ways, not only by the fact that it made communication over large distances possible but also by its usage, such as the way one communicated over distance doing business. Telegraphy affected the trading in commodities when actual market prices were available at distant markets. Telegraphy changed the way news was brought by the printed news media to the people. News was not "old" anymore when it arrived at the readers doorstep. In America, the concentration of the telegraph service industry through a range of mergers and acquisitions had resulted in the private monopoly of Western Union Telegraph Company. One of its profitable services was the information of financial data distributed by the stock ticker.

The telegraph would have great impact on society. It fascinated many entrepreneurs, many of which were similarly obsessed with the new phenomenon in the Victorean Internet (Figure 214), as later others would be, with the Internet of the twenty-first century.

Figure 214: Mr. Merger Hogg is taking a few days much needed rest at his country home.

Cartoon depicting the obsession investors had with the stock ticker communicating information about the trade at the stock exchanges.

Source: Charles Dan Gibson. The Gibson Book: A Collection of the Published Works of Charles Dana Gibson (New York, 1907).

When necessity is the Mother of Invention,
Human Curiosity, Ingenuity and Creativity
should be its Father.[315]

Conclusion (Part 1)[316]

For somebody living today—anno 2015—in a world flooded with local and international news, personal contact by telephone and instant access to almost any information source, times without modern communication are hard to imagine. But there was a time without television, smartphones and Internet. In the early nineteenth century, writing letters as communication in a written form was limited. To make an appointment, one scribbled a short letter. To share something more important with somebody, one wrote a long letter in a graceful handwriting with a fountainpen on embossed paper. Getting a response could take weeks or even months when the recipient was located far away. Communication over distance was something quite special in those times.

In today's world, communication is nothing to get too excited about. Now electronic mail (E-mail) replaces paper mail (P-mail). Every day, many E-mails clutter the inbox of our personal computer, tablet or smartphone—our modern computing engines—most of them being "junkmail" or "spam". That is just part of modern communication. The news of the world bombards us through a range of communication channels daily. From the classical newspapers and magazines through the modern media of radio and television, commination between organizations (B2B), businesses and their clients (B2C) and between individual people themselves is supported by advanced means of communication. Computing engines in networks, connected through the present-day Internet have become part of daily life, both for the professional as well as the private person. Modern

[315] Adaptation of English proverb.
[316] This conclusion will be complemented with Part II. There we add the conclusion for another communication engine: the telephone. To be published in B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telephone'.* (2015)

communication engines like the mobile (smart)phone and computer tablet, are an essential part of individual communication with the rest of the world one is connected to. Today, in the twenty-first century, everybody one moment or the other is connected and "online"—connected to the communication infrastructure to conduct business, to take care of private affairs and to interact with other people.

Not many people realize that this modern, high-technology based way of communicating started in the nineteenth century with a relatively low-technology development. The—then—old ways of communication (from homing pigeon to postal services: the classic P-mail) were replaced by new, technology-based developments. It was the General Purpose Technology of electricity[317] that created the basis for a new way of communication called "electric telegraphy". In a period of three decades—from the first patents granted to Cooke and Wheatstone, and Morse in the late 1830s—to the governmental regulations with the Telegraph Acts in the late 1860s, the foundations for the Victorian Internet were created. Electric telegraphy changed the world (Figure 215).

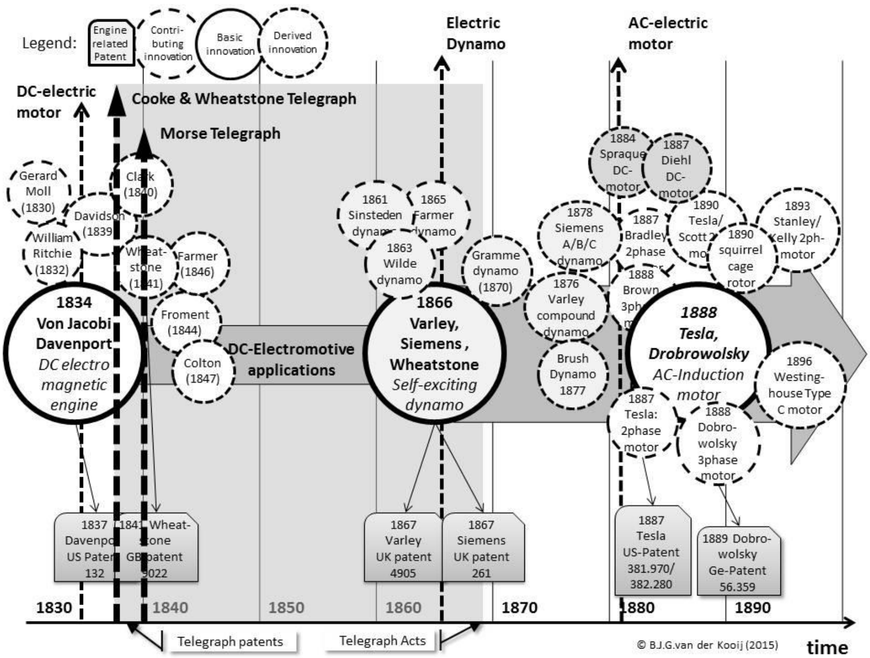

Figure 215: Telegraphy related to the cluster of electro-motive engines.

Source: Figure created by author, adaptation of figure published *in The Invention of the electro-motive engine.* (2015)

[317] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015)

In the preceding analysis, we identified the two majors developments in early telecommunications—developments that resulted nearly simultaneously in two conceptually different telegraph machines (Arrows on left side of Figure 215):

1. *Cooke and Wheatstone's inventions: the cluster around the basic innovation of the needle telegraph and the pointer telegraph, and,*
2. *Morse's invention: The cluster around the basic innovation of the electro-magnetic telegraph.*

Both occurred in the early development of electricity, as it was still the electro-chemical battery that was the source of electricity, and the electric dynamo had yet to be invented. It is the combination of these two clusters that is often referred to as the invention of electric telegraphy.

In this analysis, we looked at how the General Purpose Technology of electricity is pervading the world we are living in, such as in the form of communication over distance, originally called *distant writing*. We tried to find an answer to the question of how it was that the basic innovations that created telegraphy could revolutionize the world we are living in today, pervading over a short period of some decades into society, creating the foundations for the world of telecommunications we are living in today. Basically we wanted to know "What was the Invention of the telegraph?"

We observed how the development of electric telegraphy initiated the Communication Revolution—a period in time where communication over distance was transformed from the classical means and methods—such as the optical semaphore—into communication with modern "engines": the electric telegraphic instruments. A development that was realized through the contributions of many people, from the tinkering and thinking engineering scientists to the entrepreneurs creating business activities large and small.

Reflecting on the massive social changes that originated from the contributions of so many people willing to devote their creative and entrepreneurial efforts in changing the world, we will try and wrap up this case study with an interpretation of our observations.

Human Curiosity, Ingenuity, Creativity, and... Competition

One observation stands out among the many that can be found. It is an obvious but easy to miss observation that innovation is about human activity. The creative and entrepreneurial behavior of people that resulted in all these individual contributions—contributions that created the "clusters of innovations" and the "clusters of businesses". It is curiosity—one of the dominant characteristics of human nature—that is the driving force behind that behavior. It is the curious nature of man that has led him to wonder, ponder and then learn. Curiosity is the building block of our common knowledge structure—the key that opened new vistas of thought. It is curiosity in man's nature that drives him to understand different phenomena in life. But being curious is not enough. More is needed to realize innovation. After obtaining knowledge and insight, there is the creative act, where ingenuity[318] creates the new combination: the moment the invention is born. All this curiosity, ingenuity, creativity and entrepreneurship takes place in the context of its time. And that context dominates the developments to come, as a world in turmoil (as in the American and French Revolution, but also other times of madness) has a different influence on human behaviour than a world at peace.

This case clearly showed how this human curiosity, ingenuity and creativity resulted in the contributions of so many people towards the development of electrical telegraphy in the nineteenth century.

Technical Contributions in Electrical Telegraphy

As described elsewhere[319], the development of the insight in the phenomenon of electricity started in the eighteenth century when the curious and inquiring minds of the electro-physicists wondered what the nature of lightning exactly was (Figure 79). The discovery of the electro-chemical battery (the "wet cell") by Alessandro Volta marked the breakthrough of curious electric experimenting in the early nineteenth century . Their experimental work was complemented by the contributions of the theoretical scientists, from Ampere to Faraday and Maxwell—people who created insight in the phenomenon electricity with their—often mathematical—concepts and models. And then we have those people who focused on the application of electricity in communication: the engineering scientists (Figure 216)

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318 The ability to invent things or solve problems in clever new ways (Oxford Dictionaries).

319 See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015)

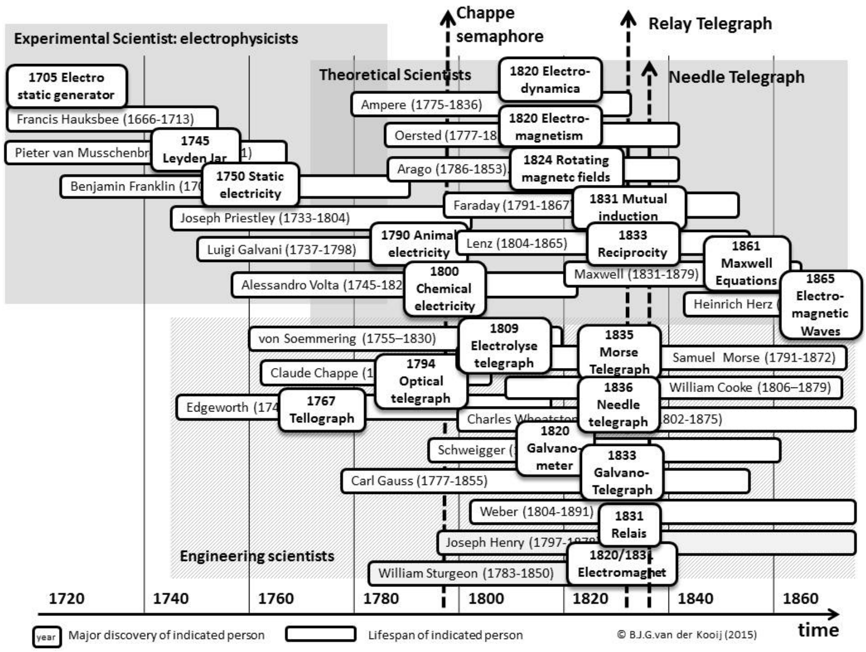

Figure 216: Experimental, theoretical and engineering scientists contributing to the application of electricity in communication.

Source: Figure created by author

Based on this cumulated knowledge, in the same period of time, we find those engineering scientists who, by creating their often quite crude artefacts, tried to explore the possibilities of electricity as a carrier of power. The heavy quantity magnet was born, complemented by the first electro-motive engines that supplied rotative power: the DC motor (Figure 215). This was soon to be followed by the explorations to use of electricity as a carrier of information; it resulted in the small intensity magnet. Its usefulness as a communication device over longer distance became clear with Henry's bell experiments (Figure 95). The same development took place with another device—the galvanometer. Elsewhere, the multiplier was born (Figure 80). Both constituted the beginning of the development trajectory of the use of electricity in distant writing.

Earlier along another development trajectory, communication over distance had evolved. From the crude ancient tools of beacons of fire to the —then—more modern means of postal communication by courier, coach or homing pigeon; soon optical communication networks developed. The optical communications increasingly bridging longer distances. This concept of communication networks was maturing in the semaphore systems: optical transmission systems that used a code system to transmit information.

Ingenuity and Creativity in Combining

One can observe that in the first half of the nineteenth century the following situation existed:

Cabled Network: There had evolved a system of transmitting coded information over a communication infrastructure, and,

Electricity: There had evolved a news means to carry that—eventually coded—information very fast over a long distance.

Then these two development trajectories came together (Figure 217). First in the crude experimenting with static electricity generated by a friction machine: the electro-static telegraphy. Then followed by experimenting with the electro-chemical process of electrolysis in a

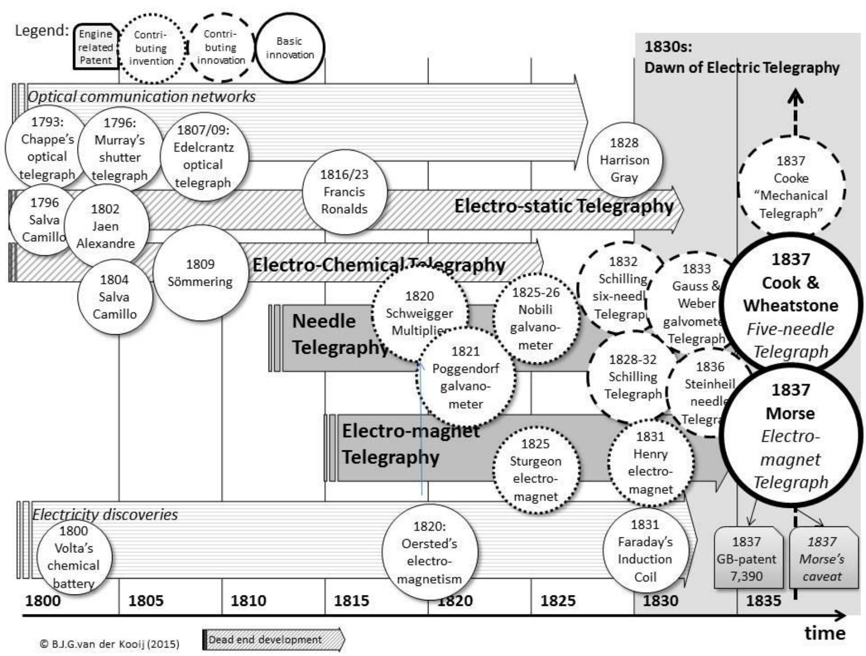

Figure 217: Technical contributions from science and engineering to electric telegraphy in different development trajectories.

Source: Figure created by author

communication system: electro-chemical telegraphy powered by chemical electricity. Both proved, although quite interesting for other developments, to be not workable in a communication network. They became dead-end technologies.

In the end, the galvanometer and the electrical relay proved more successful. They both would lead to a different development trajectory of electric telegraphy in the 1830s (lower part of Figure 217). The galvanometer and the electro-magnet resulted into two trajectories that created the parallel development of Morse's electro-magnet telegraph and the needle telegraph of Cooke and Wheatstone.

All the activities in the different trajectories were the result of contributions with a technological nature: the *technical contributions from science and engineering*. Both successful trajectories were the result of the more fundamental contributions in the basic artefacts—identified as the *contributing inventions*—as well as the more engineering-oriented contributions on a system level identified as the *contributing innovations*. It was the same pattern every time: the combination of two—or more—different streams of thought. It was the result of the human ingenuity of combining the opportunities offered by the new phenomenon of electricity with the needs that were present in society—needs like the need for communication It was the combination of the pushing technology (also known as "technology push"- effect) with the demanding needs (also known as the "demand pull"- effect) that would create the breakthrough effect of the basic innovation.

Sometimes the state of the technology was not good enough to meet the need. Some technologies proved to be a dead end but could very well develop further in other directions, like the electro-chemical telegraphy that proved to be a dead-end technology, but the process of electrolysis would follow its own successful course of development in chemistry and manufacturing. In other cases, there was a fit between technology and need: it resulted in the needle telegraph and the electromagnet telegraph.

Competing for Survival

As soon as a concept for electric telegraphy had proven to be viable, other inventors contributed to the further development of electric telegraphy—improvements that in turn followed different improvement trajectories. In Figure 218 (based on Figure 153 and Figure 201) is shown what happened after the basic inventions of Cooke and Wheatstone and Morse were created.

In the case of Cooke and Wheatstone's five-needle telegraph, it resulted in two major trajectories: first the improvement in needle telegraphy by

Cooke and Wheatstone themselves, followed by Highton and Henley's contributions. Needle telegraphy was workable and became applied in railroad telegraphy, but needle telegraphy faded out soon due to its slow speed and complexity of use. The needle variant of the moving-coil telegraphy as initiated by Bain—a development that even reached America—did not survive that long either. Next there were the developments of the alphabetic telegraphs and the universal telegraph that resulted in the trajectory of dial/pointer telegraphy—a development that became quite popular because of its simplicity.

In the case of Morse's invention, there seem to be two distinguishable trajectories. As the use of Morse's telegraphs required skilled operators, soon improvement were made that simplified the transmission of telegrams. It resulted in the development trajectory of printing telegraphy—a development that involved data entry by a keyboard and printing the readable message on a strip of paper. Next to that, Morse's system itself was improved upon at the component level (the key, the cabling, the recorder) as well as at the system level (the network). Part of the improvement activities were geared at the development of the

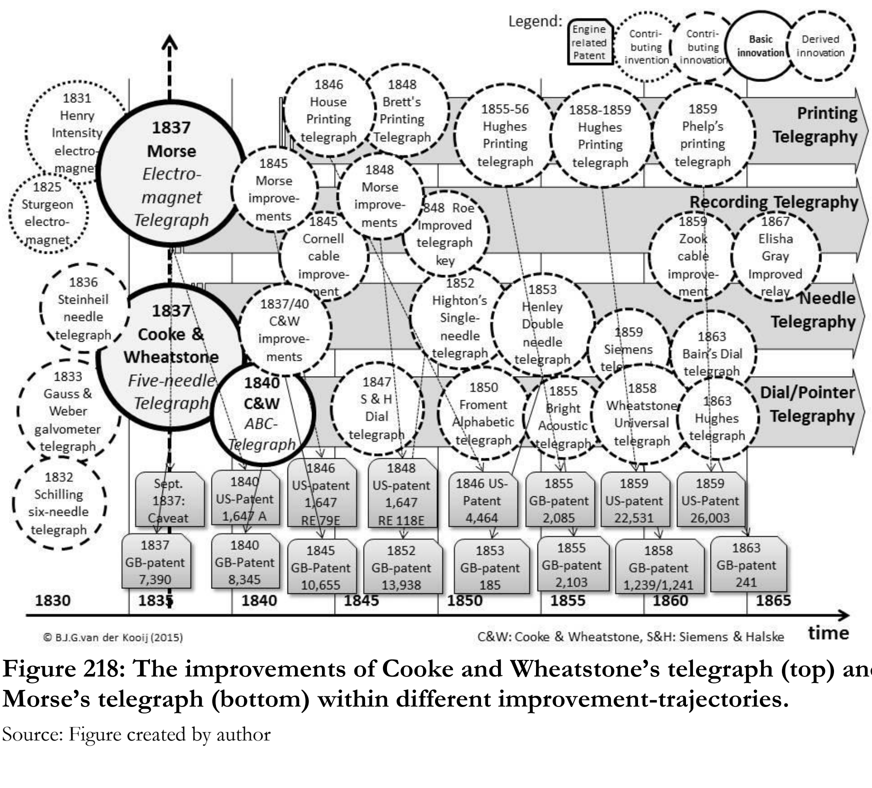

Figure 218: The improvements of Cooke and Wheatstone's telegraph (top) and Morse's telegraph (bottom) within different improvement-trajectories.

Source: Figure created by author

network capacity: duplex and quadruplex telegraphy. Amazingly enough, that development would also lead to the acoustic telegraph, a development that would result in the "speaking telegraph", also called the telephone[320].

The Morse System, the concept of the transmitting key, the code and recording receiver, would become the dominant design for telegraph systems in the second half of the nineteenth century. After the patent protection expired—or when no protection was available at all, like in some European countries[321]—the Morse recording telegraphic receiver became a source of inspiration for many engineers, like Werner Siemens and Georg Halske, who we met before, who improved upon Morse telegraphy.

> *Taking advantage of the situation that Morse's telegraph was not patented in Germany, Siemens was invited to construct and produce an improved version of the Morse telegraph. In recognition of his valuable inventions, Morse received a golden tobacco box from King Friedrich Wilhelm in December 1850. Halske made a number of mechanical improvements to the Morse telegraph. … The improved version became the standard for Prussia and later for the member countries of the Austrian-German Telegraph Union.* (Huurdeman, 2003, p. 81)

The Morse code was later also used in wireless telegraphy. But that is another story....

In the first instance, both these technologies (ie needle telegraphy and electromagnet telegraphy) showed a fitness to survive, each in its own environment: Britain was involved in the growing effects of Industrial Revolution with its Railway Mania, Amercia was dominated by its capitalistic entrepreneural environment. The first environment proved a breeding ground for railway telegraphy, soon to give way to public telegraphy. The latter environment was shaped by a fierce competitve climate where, not without a struggle, the lesser fit concepts did not survive the competiton. In the battle of the survival of the fittest, the Morse system became the ultimate survivor.

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[320] To be published as: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telephone'* (2015)

[321] In Germany, following the prevailing anti-patent policy, the Prussian patent commission decided in 1845 that Morse's invention was not important enough to be patented.

The Cluster of Innovations

The story of the electric telegraph is a story of invention—inventions created by the contributions of a multitude of creative, ingenious and entrepreneurial persons—people sprouting a stream of innovations. From the mechanical-based innovations that were improving the apparatus to the electrical-based inventions that were improving both components and the communication network as a whole. There were improvement in reliability and speed but also improvements to handle the increasing volume of messages.

In the total clusters of innovation around the basic innovations of Morse and Cooke and Wheatstone (Figure 219), two major innovation streams—also described as technologies—can be recognized in the early development of electric telegraphy leading up to the basic innovations: the contributions to needle telegraphy that emerged in Britain and the relay-telegraphy that emerged in the United States. In Britain, it was the needle telegraph—followed later by the pointer telegraph—that became originally the dominant technology.

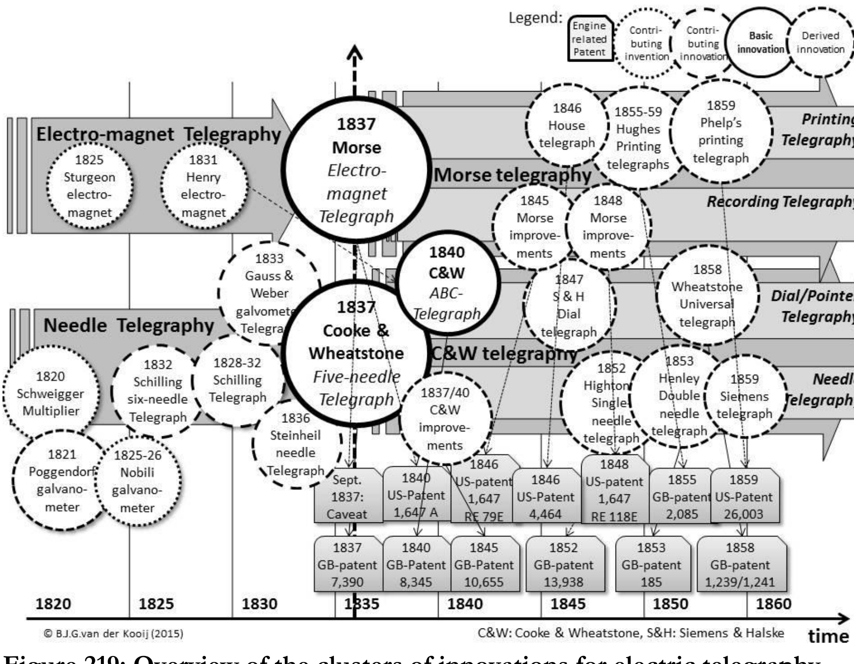

Figure 219: Overview of the clusters of innovations for electric telegraphy.

Source: Figure) created by author

The needle-indicating electric telegraph was a peculiarly British innovation. It required an operator to read the movements of the needles and another to write down the received message. Atmospheric disturbances could cause the needles to indicate spurious signals, or to become demagnetized. The simple Morse key and sounder system developed a few years later in the USA was cheap and practical and its adoption there was swift. Yet because the needle telegraph was the first practical system in the world and was ideally suited to the regulation of railway movements on a congested network, it became an established method of communication in Britain. (Liffen, 2010, p. 294)

In the US, the Morse system with the electromagnetic telegraph became the dominant technology. Other, quite mechanically complicated, telegraph systems (such as the Bain's, House's, Hughes' and Phelps' telegraphs) were used but did not survive in the long run.

Several trajectories developed after the basic innovations of Morse and Cooke and Wheatstone, from the needle telegraph and the dial/pointer telegraph (bottom of Figure 219) to what became known as trajectories in the Morse system of telegraphy: printing telegraphy and recording telegraphy (top of Figure 219). In the long run, the trajectories of the British needle telegraphy and dial/pointer telegraphy were—except for some special applications, as in the military—not as long lived, as the Morse system became the mainstream of electric telegraphy. The Morse code itself was adopted as the European standard in 1851, allowing direct connections between the telegraph networks of different countries. (Britain chose not to participate, sticking with needle telegraphs for a few more years.) The Morse receiver was copied throughout the world.

In 1871, Samuel Finley Breese Morse was recognized for his basic contribution to telegraphy.

In a dramatic ceremony in 1871, Morse himself said goodbye to the global community of telegraphers he had brought into being. After a lavish banquet and many adulatory speeches, Morse sat down behind an operator's table and, placing his finger on a key connected to every telegraph wire in America, tapped out his final farewell to a standing ovation. By the time of his death in 1872, the world was well and truly wired: more than 650,000 miles of telegraph line and 30,000 miles of submarine cable were throbbing with Morse code; and 20,000 towns and villages were connected to the global network. Just as the Internet is today often called an "information superhighway", the telegraph was described in its day as an "instantaneous highway of thought". [322]

[322] Source: http://www.economist.com/node/183572#Oiy2ud77lvEM1P88.99. (Accessed July 2015)

The technology of the Morse system had proved to be the technology that survived in the battles of the survival of the fittest.

Business contribution to electrical telegraphy

We talked about human curiosity, ingenuity and creativity that focused on the technical aspects. But there had to be more to convert all those creative ideas into workable artefacts; machines that could—more or less reliably—perform certain tasks in the communication network. Needed were complementary contributions with an organizational nature: the entrepreneurial contributions. Just having the scientific curiosity and creating some sparkling ideas in one's mind does not realize a tangible artefact that can be applied in the real world. And even being able to create a prototype that can be demonstrated to the public is not enough. More is needed, like the task of organizing the formal business aspects, finding the money to finance further development, and getting people who are willing to contribute their specific capabilities to the task at hand. In short, we talk about those many organizational contributions related to creating a businesses.

Entrepreneurial Contributions

In both cases—the case of the invention of the Cooke and Wheatstone telegraph and the case of the invention of the Morse telegraph—next to the technical contributions mentioned before, there is an additional aspect to consider: the act of bringing it all together—the new combination of different technical elements into one functional concept—and the act of bringing that functional concept to life. It is about the person who is able to realize the conversion of the conceptualized idea into usable artefacts that can be used in real life. Having the idea of communication with lightning speed was the beginning of a path that ended in the realization of a working telegraph. We are talking about a type of contribution that can be considered as the *entrepreneurial contribution*.

In Figure 220 are shown—on a timeline—the major events and related activities that were needed to realize the telegraph of Charles and Wheatstone and Morse's telegraph. The accumulation of these activities are found in three major results: the idea, the patented prototype and the enterprise. In short, the lower timeline (based on Figure 200) shows how Morse converted his idea of a future telegraph on the packet boat Sully (the 1832 Sully idea), with several partners into the patentable prototype (the 1837 Morse's telegraph) and started realizing telegraph lines with the creation of an enterprise called the Magnetic Telegraph Company (1845, MTC). In the case of Cooke and Wheatstone, the upper timeline (based on Figure 152) shows how Cooke converted his idea of a future railroad

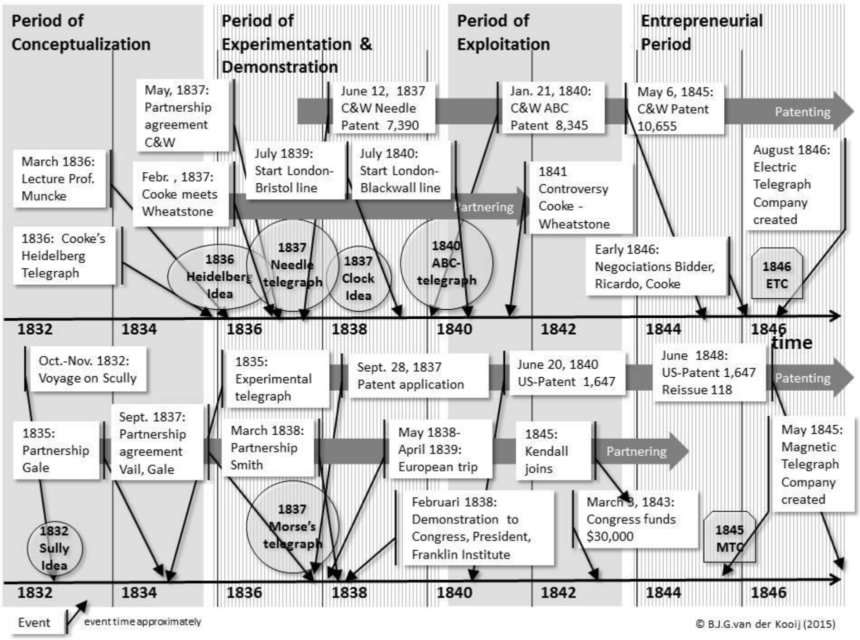

Figure 220: Combined timeline of events related to Cooke and Wheatstone's invention (top) and Morse's invention (bottom).

Source: Figure) created by author

telegraph created in Heidelberg (1836, the Heidelberg idea), in a relativly short time in the patentable needle telegraph (1837, the needle telegraph). It also shows that the rather complex needle telegraph was soon to be replaced. It was the idea of using a magnet-powered dial to indicate letters and numbers (1837, the clock idea) that was converted in the patentable pointer telegraph (1840, the ABC telegraph). To commercialize their patents, the Electric Telegraph Company was created (1846, ETC).

The developments shown illustrate clearly the simultaneously and parallel development in Britain and the US of the electric telegraph. Each concept went through a period of conceptualization, experimenting and demonstration, and exploration, to be finalized in the entrepreneurial period. Although based on different technical concepts, the parallel between the activities, the partnerships, the patenting and the creation of a company is remarkable.

Competing for Survival

After 1845/1846, the continuing technical development was accompanied by the development of the telegraph industry: both the providers of telegraphic services (Figure 221) as well as the manufacturers of telegraphic instruments. In Britain it was the start of the Electric Telegraph Company that heralded the industrial bonanza of telegraph providers all over England (Figure 157). In America, it was the start of the Magnetic Telegraph Company that soon created a bonanza in new telegraph companies (syndicates) establishing telegraph lines in the eastern part of the United States (Figure 203).

The cost of entry to create a new business was low, and the market for telegraph services was large. It resulted in a bonanza of new entrepreneurial activities by new service-providing companies and instrument makers that started manufacturing telegraph equipment. Different technical systems were competing with each other, the reliability and quality of the services hampered by immature technologies. Price levels were high but dropped rapidly once completion started to pick up. Soon many of those early pioneering service providers were struggling to survive. Fierce business competition resulted in a range of mergers and acquisition that created the private monopoly for the Western Union Telegraph Company in 1873 (Figure 221, bottom). In England a similar business development took place, and all of England became covered with telegraph lines. In two decades, a range of mergers and acquisitions concentrated the industry (Figure 221, top).

It soon became clear that regulation was needed. In the US, a natural monopoly had regulated the industry when, between 1853 and 1857, regional monopolies formed and signed the Treaty of Six Nations, a pooling agreement between the six largest regional firms. But the government, concerned with emerging Western Union's monopoly, opened up the telegraph business with the Telegraph Act of 1866 (Figure 221, bottom). In Britain, the concerns about the public interest resulted in more drastic measures: nationalization of the telegraph companies functioning in Britain. The involvement of the government resulted in a state monopoly when the five major companies where nationalized in 1870 into the Post Office Telegraph (Figure 221, top).

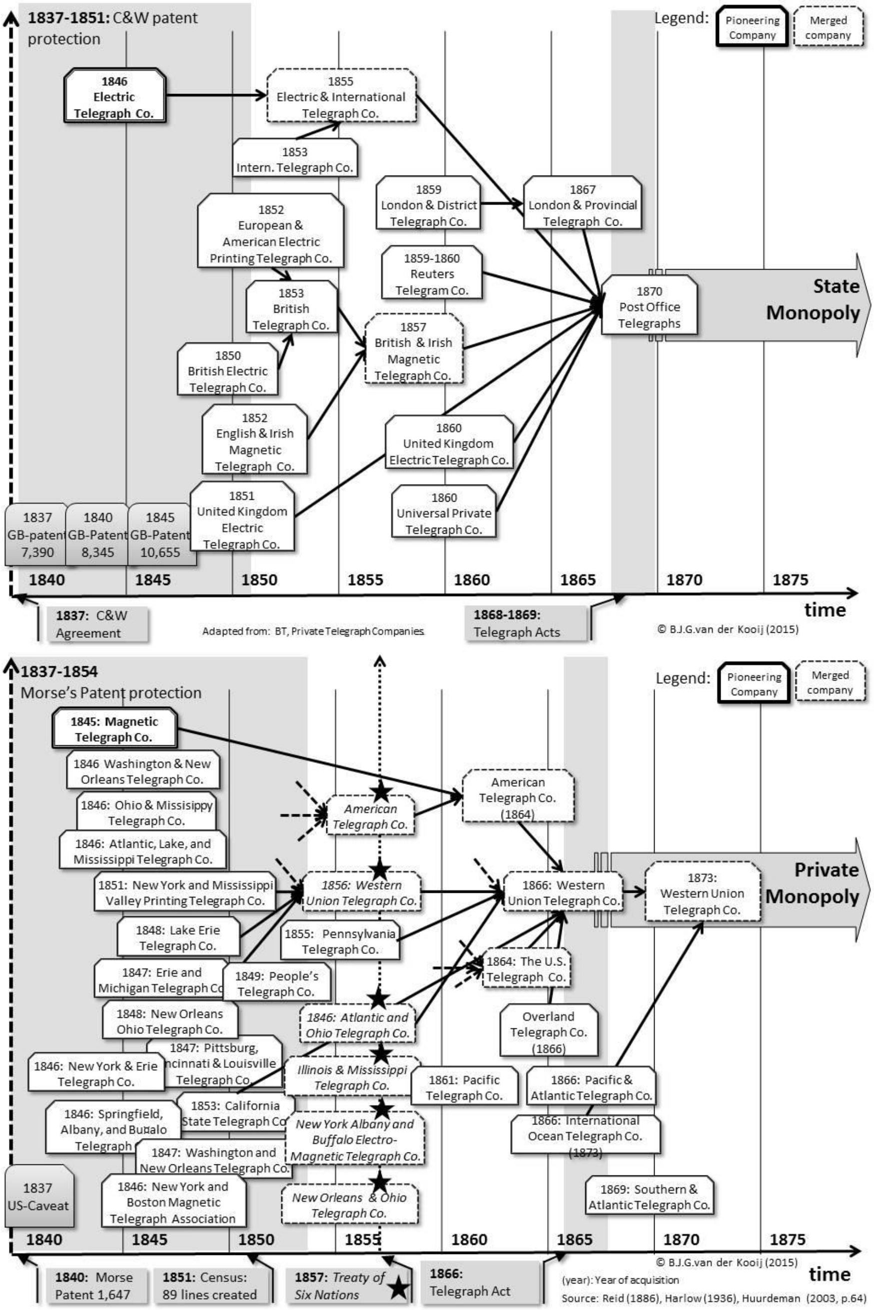

Figure 221: Clusters of businesses: the development in England (top) and the US (bottom).

Source: Figure created by author

The Cluster of Businesses

It is clear that both basic innovations of Morse's telegraph and Cooke and Wheatstone's telegraph initiated a development that soon exploded in worldwide use. Telegraphic technology had met a need, that was sure. From the early entrepreneurial initiatives in the late 1830s to the monopolies in the early 1870s, it was just only three decades that started the Age of Communication that used the communication engine of the telegraph. It was the telegraph industry, both the providers of the services as the manufacturers of the equipment, that responded to the telegraph fever of that time. Everywhere, in Europe and America, the telegraph lines dotted the countryside along the railways, crossed along the streets and the rooftops in the cities. Telegraph offices were manned with telegraphists and used the telegram boys for the last miles of the communication connection. Small manufacturers, often the original instrument makers, soon grew into manufacturing factories. It was a cluster of business that was the result of the basis innovations in telegraphy.

The dynamics of enterprise influenced the telegraph industry in the following decades after the pioneering company was established: the Magnetic Telegraph Company in the US in 1845 and the Electric Telegraph Co. in Britain in 1846. The many mergers and acquisitions resulted in fewer and larger companies dominating the market in both countries. It resulted in comparable monopolies (Figure 221).

To conclude

The invention of electric telegraphy—as we might combine the work of both Morse and Cooke and Wheatstone for the ease of discussion—was in a period of time that much of the Old World was in the aftermath of periods with considerable turmoil, as we have described extensively with the case of the French Revolution. The question arises if our assumption that social change precedes technical change that results again in social change has any merit at all and can be concluded from our observations.

Social Change Precedes Technical Change

The development of electric telegraphy took place in a multidimensional context. The context was shaped by the First Industrial Revolution, creating the different contextual dimensions (Figure 222). The social, economic and political context was shaped by the social revolutions. In the US, the shackles of mercantilism had been loosened, in the meantime forcing the early forms of industrialization. In Europe, royalty and nobility had lost much of its power and the monopoly of the guilds was broken, to mention just two of the many changes—changes that were initiated by the American Revolution and the French Revolution. The financial context was shaped by the rising capitalism. From the wealth of the few owners of most of the land (the royalty, church and aristocracy), it had become the wealth of the merchants, traders, entrepreneurs and industrialists that as a class had demanded and obtained their place in society.

For many European countries, and also for the US, the first half of the nineteenth century was a time of massive social changes. The resulting turmoil disrupted the lives of many, be it with the emigration to the new land of hope and freedom or facing the democratic struggles of the Old World. As described in the beginning, the Old World was in turmoil in the first half of the nineteenth century. The French Revolution, with its massive disruptions of the fabric of society, had a widespread influence in the whole of Europe. It's predecessor, the American Revolution, had also created a new context for the changes to come. It was a time of revolts and revolutions, that characterized the context for the development of electric telegraphy. It was within this context that the inventors lived and worked.

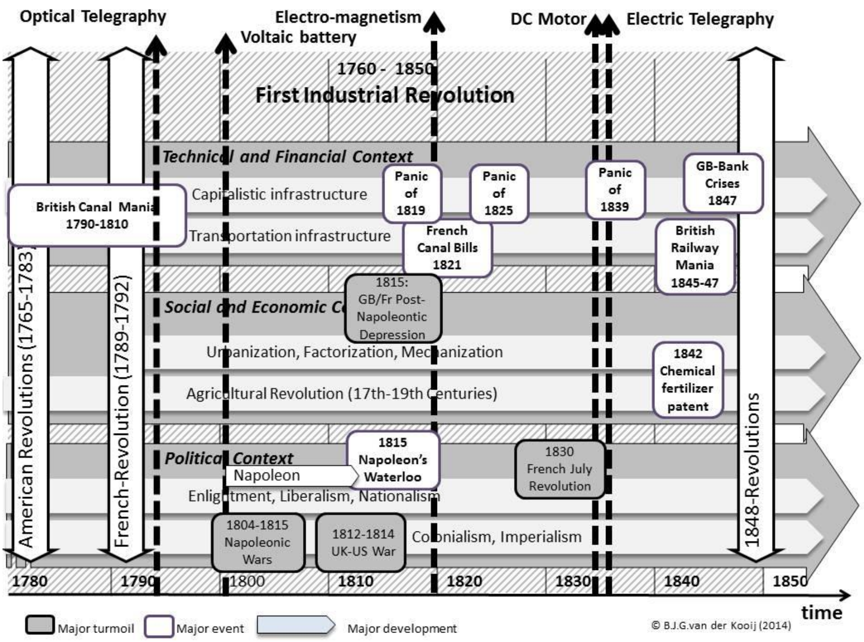

Figure 222: The context related to the invention of electrical telegraphy (First Industrial Revolution).

Source: Figure) created by author

The birth of the technology of electric telegraphy in the late 1830s was the result of clusters of innovations with the contributions of many curious, ingenious and creative minds living in those times: the scientists and engineers tinkering with electricity creating their clusters of innovations. The genesis of telegraphy in the real world was the result of the clusters of business that erupted from their inventions. The telegraph industry—both the telegraphic services as well as the equipment manufacturing efforts—were the result of contributions from a different breed of people: the entrepreneurial types that initiated, struggled—sometimes even fought, cheated and manipulated—and created the enterprises within the context of their specific societies.

The electric telegraph was conceived in a world where an early form of telegraphic system already existed. Chappe's optical telegraph was well established in mainland Europe; the principle was simple and accepted by politicians, soldiers, scientists and the broader public. Electric telegraphy operated on an entirely different principle to the existing optical telegraphy and promised to be faster and more reliable. It was in no way a modification of existing telegraph technology (save, perhaps, the use of codes in creating a large corpus of relatable information from a relatively small base of possible signals, if that could be considered a technology). Nor was the electric telegraph really a modification of any other technology; later telegraphs used metal wires, galvanometers, needles and voltaic piles (and, much later, generators and induction coils). Sure, the electric telegraph used existing (fine mechanical) technologies within its construction, but arguably was not a modification of any of them (Bowman, 2005).

> *The understanding that an electrical current through wire can affect magnets lead to a new group of prototype electrical telegraph systems, principally working through using the relayed current to move a magnetic needle or armature. This allowed for greater reliability in conveying messages, and greater simplicity in the design of electric telegraph systems; the pioneering patented systems being reliant upon knowledge of the principle. …*
>
> *The invention of the electric telegraph was made possible by many scientific and technical developments in electricity in the years leading up to the 1830s and beyond. The earliest electrical experiments concerning signals over distance in the 1740s were considerably different from the broadly similarly intended experiments of the 1830s. Over that period of time new understandings of several of the processes involved in sending electricity through a wire: conduction, resistance, electromagnetism, current, charge and voltage to name a few, drastically altered the understanding of experimenters, scientists (including the recently minted Physicists) and the general public. Improved understanding of the nature of electricity allowed better inventions and innovations to be made within the field of*

electrical telegraphy, which sought to replace the existing proven but flawed system of long-distance communication. …

Technological and scientific innovation, however, were not the sole mothers of invention. The experiments, trial-runs, funding (state and private), implementation and eventual institutionalization of electric telegraphy wouldn't have been possible without changes in public opinion, political consensus, or military thinking. Part of these changes were themselves brought about by the publication of scientific discoveries, but broader sociological and political changes in Europe and America certainly contributed towards the invention and development of the electric telegraph. (Bowman, 2005, pp. 8, 9)

And those broader sociological and political changes were certainly related to the American Revolution and to the French Revolution and its aftermath.

Social Change Follows Technical Change

So *Social Change* certainly created the scene for *Technical Change*. But then the new electric telegraphy would in its turn influence society. *Technical Change* would result in *Social Change*.

Electrical telegraphy changed the way people communicated, did business and became informed. It made the elements of time and distance less dominant in communication. As a side effect, all those different local times became synchronized by telegraphic signals, creating "railway time" using electric clocks. News travelled the world faster than ever: news supplied by war correspondents at the war front, reporting of the atrocities of the Crimean War, and that news was distributed by telegraph to newspapers like *The Times*, and the news agency Reuters. News was widely available to the British public, influencing public opinion. In the US, stock markets and other commodity trading became more transparent. As the electric light was going to change the way people lived, telegraphy would change the way people communicated. People were fascinated by it, as they *en masse* visited the Great Exhibitions in the second half of the nineteenth century that followed the successful Great Exhibition in Britain in 1851 (Figure 154).

Within that turmoil, electric telegraphy was one of the basic inventions that originated from the general purpose technology of electricity that proved to be very pervasive in new application areas such as the electric light and electric communication. It was to become one of those many contributions that—taking place in the First Industrial Revolution—heralded and initiated the Second Industrial Revolution (Figure 223)—a period in time that saw the Belle Epoque (1871-1914) in France, the Gilded

Age (1865-1905) in the US and the Great Victorian Boom (1850-1873) in Britain. It was the time of imperialism and colonialism but also the time in which the Enlightenment and liberalism got settled in society—a time that saw great changes in the geo-political situation, one of them being the Germany we know today that was trying to find its shape. The other was France, still shuffling between republic and monarchy. It was a period in time where the powers in Europe would shift, changing the political context[323].

The social impact of telegraphy was already recognized when Charles Briggs and Augustus Maverick concluded in 1858:

> *The completion of the Atlantic Telegraph may be garded as the crown and complement of all past inventions and efforts in the science of Telegraphy ; for great and startling as all past achievements had been, so long as the stormy Atlantic bade defiance to human ingenuity, and kept Europe and America*

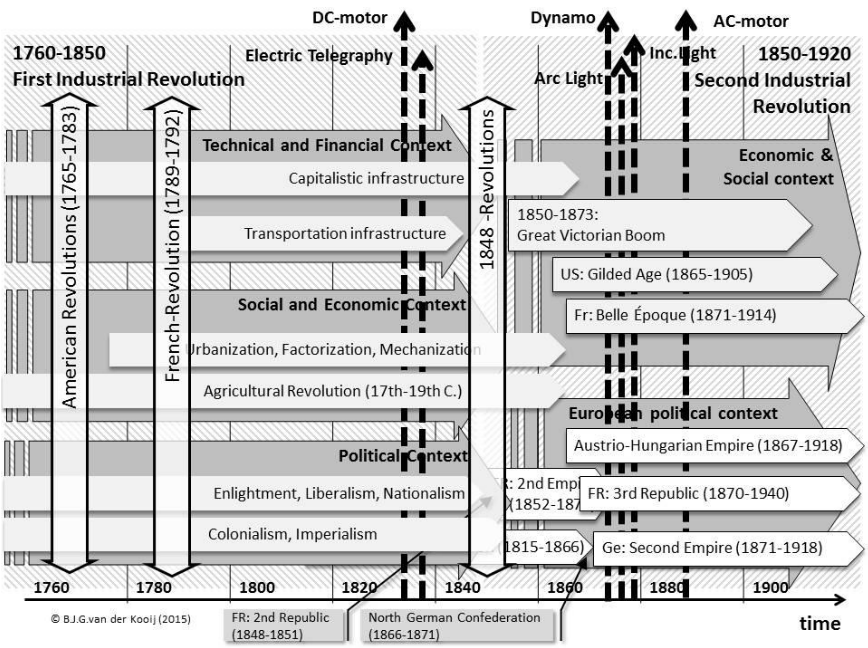

Figure 223: The context related to the invention of electrical telegraphy (First and Second Industrial revolution).

Source: Figure) created by author

[323] See : B.J.G. van der Kooij : *The Invention of Electric Light.* (2015). pp.4-10.

dissevered, the electric Telegraph was deprived of the crowning glory which its inventor had prophesied it should one day possess. But now the great work is complete, and the whole earth will be belted with the electric current, palpitating with human thoughts and emotions … Of all the marvelous achievements of modern science the electric telegraph is transcendentally the greatest and most serviceable to mankind. It is a perpetual miracle, which no familiarity can render commonplace. …

How potent a power, then, is the telegraphic destined to become in the civilization of the world! This binds together by a vital cord all the nations of the earth. It is impossible that old prejudices and hostilities should longer exist, while such an instrument has been created for an exchange of thought between all the nations of the earth. Such is the vista which this new triumph of the might of human intelligence opens to us. (Briggs & Maverick, 1858, pp. 12, 13-14, 22)

Future to Come

It is time to wrap it up. We illustrated that within the clusters of innovations, both in Britain and the US, a range of contributing and derived innovation had taken place around the basic innovations of Morse and Cooke and Wheatstone. Over time, in the second half of the nineteenth century, the Morse System had gained dominance and was used widely all over the world. But that dominance was also coming to an end.

But by the 1890s the Morse telegraph's heyday as a cutting-edge technology was coming to an end, with the invention of the telephone and the rise of automatic telegraphs, precursors of the teleprinter, neither of which required specialist skills to operate. Morse code, however, was about to be given a new lease of life thanks to another new technology: wireless.[324]

It had started with the basic innovations of Morse and Cooke and Wheatstone that occurred at the end of the 1830s. In the relatively short time of a decade, these basic innovations already showed in their early development the enormous impact they would have on society in general. By the end of the first half of the nineteenth century, the world had started to change. People visiting the Great Exhibition of 1851 in London, seeing the magic of distant writing created by the exhibitors of the Crystal Palace, were flabbergasted by the new marvel of electrical telegraphy. They were—without even realizing it—facing the Communication Revolution. The basic innovations of telegraphy were soon to be followed by another basic-innovation: the communication engine of the telephone.

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[324] Source: http://www.economist.com/node/183572#Oiy2ud77lvEM1P88.99. (Accessed July 2015)

> *The major achievement of electrical telegraphy, apart from making news a valuable commodity, and substantialyy improving the security and reliability of railway transportation, has been the creation of an international telecommunications infrastructure: a prerequisite for the development of worldwide communications.* (Huurdeman, 2003, p. 88)

The social changes may have been rooted in the Age of Enlightenment, but this was the dawn of the Age of Communication. A period with Technical Change and the resulting Social Change that started with the electric telegraphy in the second half of the nineteenth century—a time in which the new phenomenon of electricity would progress on its development paths ever further into other fields of application: the electric light, wireless communication and the speaking telegraph. It was electricity that brought power to people and that—in more than the literary sense as we look at the changes in society that would be induced by it—was the brink of the Second Industrial Revolution.

Electric light, speaking telegraphs and wireless communication: those stories are going to be told next. They will show a great similarity with the contributions we described in this case study. The General Purpose Technology of electricity was starting to show its powers to penetrate in all areas of our daily life.

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About the author

Drs.Ir.Ing. B. J. G. van der Kooij (b. 1947) obtained his MBA in 1975 (thesis: Innovation in SMEs) at the Interfaculteit Bedrijfskunde (nowadays part of Rotterdam Erasmus University). In 1977, he obtained his MSEE (thesis: Microelectronics) at the Delft University of Technology.

He started his career as assistant to the board of directors of Holec NV, a manufacturer of electrical power systems employing about 8,000 people at that time. His responsibilities were in the field of corporate strategy and innovation of Holec’s electronic activities. Travelling extensively to Japan and California, he became well known as a Dutch guru on the topic of innovation and microelectronics.

In 1982–1986, he was a member of the Dutch Parliament (Tweede Kamer der Staten Generaal) and spokesman on the fields of economic, industrial, science, innovation, and aviation policy. He became known as the first member to introduce the personal computer in Parliament, but his work on topics like the TNO Act, Patent Act, Chips Act, and others went largely unnoticed.

After the 1986 elections and the massive loss for his party (VVD), he was dismissed from politics and became a part-time professor (Buitengewoon Hoogleraar) at the Eindhoven University of Technology. His field was the management of innovation. In 1986 he also started his own company, Ashmore Software BV, as developer of software for professional tax applications on personal computers.

After closing these activities in 2003, he became a real estate project developer, and in 2009 a real estate consultant until his retirement in 2013. Innovation being the focus of attention of all his corporate, entrepreneurial, political, and scientific life, he wrote three books on the subject and published several articles. In his first book, he explored the technological dimension of innovation (the pervasive role of microelectronics). His second book focused on the management of innovation and the human role in the innovation process. And in his third book, he formulated laws of innovation based on the Dutch societal environment in the 1980s.

In 2012 he started studying the topic of innovation again. In 2013 he was accepted at TU-Delft by Professor Dr. Cees van Beers as a PhD candidate. His focus is on the theory of innovation, and his aim is to develop a multidimensional model explaining innovation. For this he creates extensive and detailed case studies observing the inventions of the steam engine, the electromotive engines, the communication engines, and the computing engines. He studies their characteristics from a multidisciplinary perspective (economic, technical and social).