The Invention of the Communication Engine ‘Telephone’

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
The Invention of the Communication Engine 'Telephone'

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 'telephone'. It is based on a large number of historic and contemporary sources. As we did only conduct limited 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 (eg Wikipedia) 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. For those that are not 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 Figure 7 of Bell's First Telephone Patent (US Patent № 174,465) and Figure 1 of Bell's Second Telephone Patent (US Patent № 186,787) (courtesy USPTO).

Version 1.1 (January 2016)

ISBN-10: 151966656X
ISBN-13: 978-1519666567

Contents

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, also 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 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

[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.

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?'

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 the series. That is not to say there was no technological innovation before that 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, product, 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 —of synthesis— 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.

As a great part of our research is related to *product innovation*, we define a product as an artefact (from the latin 'arte"—by or using art—and factum—something made) that, through its product-function, fulfils a need. Just imagine the product-function of timekeeping, realized by the timepiece 'clock', that can be considered as an answer to the need for timekeeping. Or take the product-function of speech transmission; it fulfilled the need for communication over distance. Those needs to fulfil are ultimo related to basic human needs. From the basic need for shelter (the need for keeping warm creates the need for clothing) to its derived needs (as in 'keeping the clothing closed') and esthetical needs (as 'keeping the clothing elegantly closed'). There is a hierarchy in needs where the invention of the button certainly would fulfil a specific 'cloth fixing need'. The concept of the product function thus can be quite abstract (as in the 'transportation-function') to quite detailed (as in the 'short haul person and load-transportation' function realized by a horse powered cart). Innovation takes place in those product functions when the artefacts change. Take the timepiece, evolving over time from those early hourglasses and sundials into the pendulum clocks, ships chronometer, and pocket watches. Their product-function is 'timekeeping'. It is the mechanical implementation as a wristwatch that realizes the function of 'easy portable timekeeping'. Nearly a universal need in our days implemented in many ways. The realization of a certain implementation of that product-function is realized by people who know 'how to make it', people that have the knowhow of the 'fine mechanical watch technology'. Such as those nineteenth century Swiss with their fine-mechanical skills. This all leads us to the link between product innovation and technology.

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 'Weltanschaung' (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).

The concept of the *General Purpose Technology* (GPT) uses as definition: "A GPT is a single generic technology, recognizable as such over its whole lifetime, that initially has much scope for improvement and eventually becomes widely used, to have many uses, and to have many spill over effects." (Lipsey, Carlaw, & Bekar, 2005, p. 98). We see a GPT as (a) cluster(s) of innovations of which the fundamental new combinations, the basic innovations, have considerable impact on society. We call these basic innovations the General Purpose Engines. More narrowly we define a

General Purpose Technology '*as the collection of 'general purpose engines' appearing in a range of interrelated clusters of innovations.'*[3]. In other words, it is a range of clusters of innovations around the General Purpose Engines (GPE's). Others defined it more by its effects: "the pervasive technologies that occasionally transform a society's entire set of economic, social and political structures" (Lipsey et al., 2005, p. 3). Thus we refined Richard Lipsey, who also described 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" (ibidem, p. 133), by focussing on the General Purpose Engines themselves.

In popular terms it is the meta-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—and it is the engine of creative destruction. 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)" (ibidem, p. 97). These examples of engines are our General Purpose Engines.

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 trajectories of the electric light, telegraph and telephone are a GPT on their 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.

Finally a word about the use of the notion of *revolution* as in 'Industrial Revolution'. Revolution can be used to denote major social and political upheavals (ie the French Revolution) resulting in a major restructuring of society or government (regime change), the replacement of a former elite with a new one (governing change), often with a lot of violence and casualties. In that sense a *political revolution* is an internal war—in contrast to the external wars between nations—that attempts to alter state policy, its rulers and its institutions. The resulting *societal revolutions* are the changes in the structure of society—often originating from the oppressed classes—that are related to the concept of Social Change we will explore. The

[3] This definition is more precise than the one we used in the preceding case studies as the result of new insights developed in the micro-foundations of a GPT during those studies.

companion concepts of Scientific Change related to *scientific revolutions,* and Technical Change related to *technological revolutions*, are discontinuities outside the political and societal spheres. In a technological revolution the ruling meta-technology is replaced, or complemented, by another meta technology: the new General Purpose Technology. The technological revolution restructures the material conditions of human existence and results in *socio-economic revolutions.* These drastic changes in the societal and social structures are caused by such major technological changes, creating a broad spectrum of technical and organizational novelty. The combined socio-techno-economic disruptions we call the *Industrial Revolution*s. Although the violence aspect is not that obvious, the casualties of those socio-economic revolutions certainly can be identified as the victims of Schumpeter's creative destruction (eg business cycles).

About our research

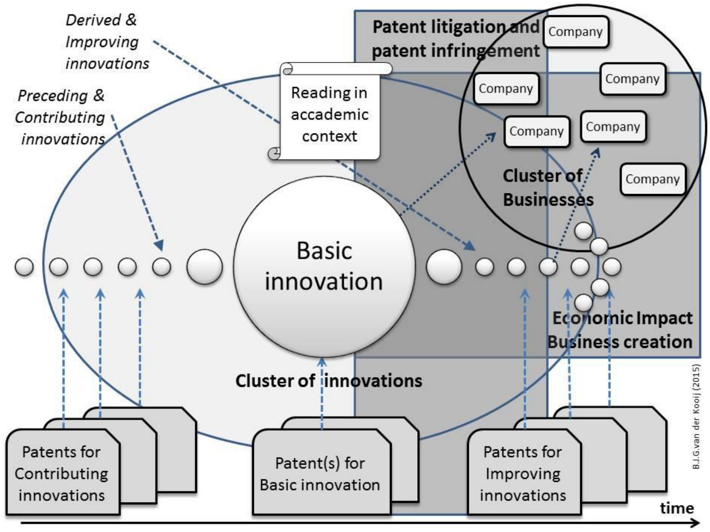
This book is the fifth manuscript in the *Invention Series*, a series of books on inventions that created the world we live in today. In the first manuscript, *The Invention of the Steam Engine*, we explored a methodology to observe and investigate the complex phenomena of technological innovation as part of a General Purpose Technology (GPT). In that case, it was about the steam technology that fuelled the First 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 throughout the structure of the manuscript.

The case study is the result of a specific scholarly view to observe the phenomena as they occurred in the real world. This 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 was Alois Schumpeter, who related the clusters of innovations to business cycles under the influence of creative destruction: "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); "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). The dominant design 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 fifth study, we focus on the application area where communication technology based on electricity was applied.

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 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.



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

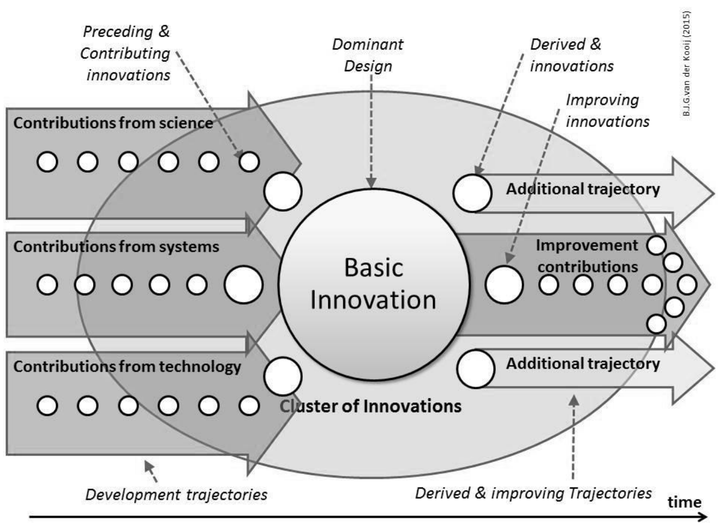
Our *perspective* was the identification of patterns that are related to the cluster concept. Can coherent clusters of innovation be identified within a specific general purpose technology? If so, how are they related, and how are the clusters put together? The first pilot case showed that it could be 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 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



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

or an interconnecting network; a complex whole' (Oxford Dictionary). In this case the system being the total network-infrastructure, their subsystems and their entities. But systems can also be entities by themselves. People who contributed to that totality created the system contributions.

Example: Sometimes these are contributions that are harder to classify. Let's 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 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 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.

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.

Example: Further on we will give ample examples of improvements in telephony

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.

Example: 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

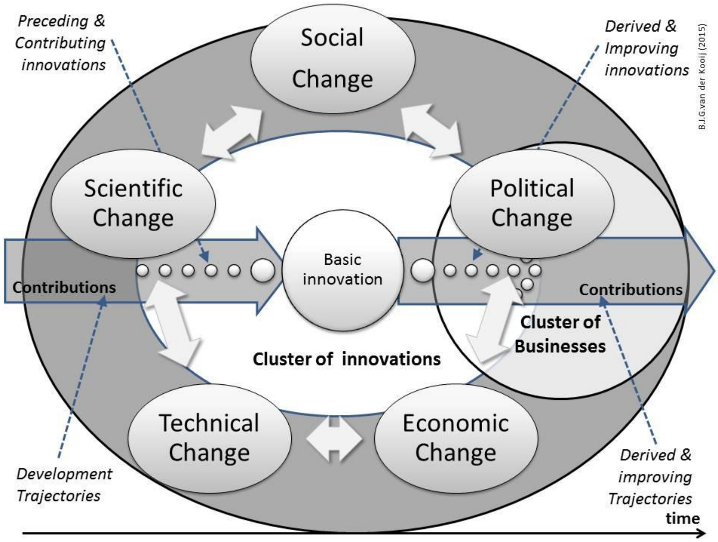
As mentioned before, case studies are about content and context. Our specific case studies are about the *content* of Technical Change—they cover technological innovations—and we look at change from the perspective of the development of technological innovations themselves: the clusters of innovations. 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 autonomous the 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. It can be incremental or sometimes even disruptive. We talk about the Industrial Revolution as a drastic form 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)

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



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

technologies prove to be 'a dead end'. They were not fit enough[4]. When the environment proves to be fertile—for example in business terms—many technology-induced innovations and their artefacts will prosper[5].

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.

Our analysis for patterns of change in the different contexts is quite abstract, one could say we take a helicopter view. No so much the larger 'satellite view', nor the more detailed 'birds eye view', this helicopter view enables us to alter between pattern and detail by zooming in or out.

---

[4] 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.

[5] 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).

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 mostly our sources. They use the words in the context of their time—a use that can be different from our time. For example: 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[6].

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—, and the application of electricity—in light and power applications—, 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. The research started with the communication engine created for 'distant writing' (Part I)[7]. This case study about the telephone focusses on communication as it was realized in 'distant speaking' (Part II).

Context for the discoveries: We will begin with a thorough look at the events that created the general context for the developments of the telephone. Although this type of events are not directly related to the invention of electric communication itself, the social, economic and political turmoil—followed by relative peace—created the general context for the scientific discovery, invention and innovation to come. The telephone originating from America, we zoom in on the New World of America to examine the history of a new nation being born. From the early settlements up to the moment the Industrial Revolution reached the United States in the first half of the nineteenth century. We describe extensively the American Revolution that separated the new nation from its former colonial master Britain. In rough brushstrokes we paint a picture of the political and social evolution (political change and social change) that created the settings for the technological inventive activities. Next to that general context, we describe the early efforts where curious people started to try and apply the new phenomenon of electricity, as

[6] See: B.J.G. van der Kooij: Innovation Defined: a Survey. Source: http://repository.tudelft.nl/view/ir/uuid%3A6a5624c9-e64e-4426-98e9-f239f8aaba18/. (Accessed June 2015)

[7] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015)

they were trying to understand the 'nature of communication'. Just as they earlier tried to understand the 'nature of lightning' and the "nature of heat' before[8].

The invention of the electric speech: This segment is about the 'speaking telegraph' itself. Given the development of *distant writing* (telegraphy) in the first half of the nineteenth century, this is in essence quite a logical development as one could as easily think about *distant speaking*. Therefore, we examine the efforts of those early contributors who tried to apply electricity in distant speaking. We than go and describe the contribution of one specific person, the teacher of deaf Alexander Graham Bell. It was his invention of *electric speech* that would be the breakthrough for the practical implementation of distant speaking. His efforts, that took place within less than a decade, would add distant speaking to the foundations of the Era of Communication. For him, the Scottish immigrant, this was the decade in which he grew from zero to hero. We explore in detail the crucial time in which Bell's idea of the 'undulatory current' grew into the new-born baby of the telephone, and how he just in time managed to obtain his pioneering patent. We also analyse what happened after his artefact proved to be viable: the start of the entrepreneurial activities. Describing the commercialization of Bell's idea under the protective umbrella of Bell's patents, we explore how the Bell Monopoly came into existence. We also describe how the most valuable patents were defended over time within a web of legal entanglements not seen before. And we finalize our exploration by describing the later—technical and entrepreneurial—contributions of so many to help the growing up of telephony into a mature phenomenon that conquered the world within decades.

This again is a story about the *General Purpose Technology* of 'electricity' with its 'clusters of innovations' and 'clusters of businesses' that created the Era of Communication and changed the world we live in.

B. J. G. van der Kooij

[8] See: B.J.G.van der Kooij: *The Invention of the Steam Engine* (2015); *The Invention of Electro-motive Engine* (2015); *The Invention of the Electric Light* (2015).

The Invention of the Communication Engine 'Telephone'

Context for the Discoveries

Figure 1: Chatting women washing clothes by a stream.

Source: Daniel Ridgway Knight (ca 1898). Wikimedia Commons.

For someone living in the pre-electric era, it would have been hard to image verbally communicating over long distances the way we do today. In those times person-to-person communication was local. The world was small. For the most people, living on the countryside near and in the many hamlets, it was person-to-person communication with people they knew quite well. Only the occasional traveller and maybe the people from the manor—the Lord and his heavily armed Knights—were passing by. People knew their place, the bowed and took of their caps for the powers that ruled them.

Most conversations took place around the village water flow or local water source (Figure 1), where the women did their washing, laughing and gossiping, and exchanged the latest news, which was predominantly local. In the few small villages the people had more social interactions. The local market attracted the people from the neighbourhood, who travelled with their horse-powered cart to the towns to sell their surplus. There they communicated with other people, heard the last gossips. And they traded their surpluses of food and goods. The pace of live was quite slowly. For news that was relevant to the broader public, another medium was used: the town crier. Public proclamations and announcements were done by the local town crier—also called the 'bell man'—who would walk around the village and loudly shout his message so everyone could hear it. This as an example of the one-to-many communication (Figure 2).

Figure 2: Town Crier reading a declamation.

Source: http://blogs.hud.ac.uk/subject-areas/historians-at-work/2014/03/21/tricorn-hats-bells-breeches-town-criers-invented-tradition/

Verbal communication over great distances—what today we call telecommunication—was non-existent, as sound had a limited reach. Over longer distances, only the written communication would do. And that form of communication took time. Time needed to transmit the message and that sometimes could have grave consequences. Take for example what happened to one of those people who would be important in the development of communication over distance: Samuel Morse:

> *It was while working on the portrait of Lafayette that Morse suffered the personal tragedy that changed his life forever. In Washington, D.C., for the commission, Morse received a letter from his father–delivered via the standard, slow-moving horse messengers of the day–that his wife was gravely ill. Morse immediately left the capital and raced to his Connecticut home. By the time he arrived, however, his wife was not only dead—she had already been buried. It is believed that the grief-stricken Morse, devastated that it had taken days for him to receive the initial notification of his wife's illness, shifted his focus away from his art career and instead dedicated himself to improving the state of long-distance communication.*[9]

Clearly, early techniques of long-distance communication were limited in their usefulness. This situation improved with the development of telegraphy, which allowed messages to be transmitted with the speed of light along wires. Nobody, however, dreamed that one day there would be 'communication engines' such as the telephone. Except, as we will see, one person, who was teaching deaf people…

[9] Source: http://www.history.com/news/six-things-you-may-not-know-about-samuel-morse (Accessed June 2015).

Communication: from 'No-Line' to 'On-Line'

Now let's jump ahead in time from those days without any communication lines, to the time the telephone appeared by the end of the century.

In the 1880s the telephone was a local device used to be connected to a few people, those belonging to the same local or regional network of the telephone provider (from some dozens to maybe a couple of hundred). Person-to-person communication by telephone was limited to people living in the same village, as people on the countryside did not even have a telephone. Till the mid-twentieth century, the 1910-1920s of our grandparents, long-distance 'person-to-person' communication was only possible using the old fashioned (cabled) telephone, a medium available only to the few who could afford the high cost. At home this device was often located in the hallway to create some privacy. The telephone was exclusive and to be used only for short conversations. Therefore, standing before the telephone was not a problem (Figure 3). One had only to speak loudly into the microphone.

Figure 3: Party Wire by Norman Rockwell (1919).

Several subscribers connecting to the same 'party line' made any privacy hardly possible.

Source: http://www.best-norman-rockwell-art.com/norman-rockwell-leslies-cover-1919-03-22-the-party-wire.html

Imagine the 1950-1960s of our parents. The telephone was moved to the living room, next to the comfortable chair, and consequently, longer telephone conversations could be conducted in comfort. From an exclusive communication tool for business, the telephone had become a social tool. The person-to-person talking around the washbasin was replaced by the social chatting over telephone. It was not only the woman who used the telephone, as sometime later in the 1980s, a small 'home' network even made the telephone available in the kitchen, study, bedroom and kids rooms. But one still had to share—for example, with the teenage daughter who could gossip for hours with her friends—that single landline ('*Can you get of the line, dear. Mommy needs to make a call.*').

Now look at the present day. People today can hardly comprehend a world without the modern communication engines. Today the youngest generation is literally growing up with the most modern communication engine ever devised: the wireless 'smartphone'. Gone is the phone cord; the cell phone is connected wirelessly to the network, both for speech and data. Each person has his/her own connection and is constantly 'on-line'. This advanced telephone has a range of applications—called apps—that enhance its functionality (camera, agenda, timer, calculator, browser, etc), along with a host of other, not-so-obvious applications. One of these other applications is the pacifier function, which is used to placate the crying toddler, keeping the youngster quiet for a while as he/she swipes and presses the screen at random. Thus, for many a parent, the smartphone is a tool used for getting the kids out of their hair. But in the meantime, by playing, the kid gets acquainted with modern communication facilities.

For a young person, say a teenager, in the second decade of the twenty-first century, being glued to his smartphone, twittering and tweeting, using social media (like Twitter, Facebook) for hours a day, is an indispensable social tool (Figure 4). Even for grownups, who exchange photos, stories (blogs) and music through 'the cloud', and who use mobile internet facilities and numerous other websites offering their services (YouTube, Flickr, Whatsapp, etc), it has become hard to imagine what a world without internet communication would be like.

Figure 4: Chatting girls using mobile phones.

Source: http://www.leaderpost.com/business/aims/10875991/story.html

Figure 5: Senior person using a mobile phone.

Source: Shutterstock. Fair use is claimed.

Even the older generation has discovered internet communication, using their tablets as modern—and quite expensive—photo books to proudly show their offspring, fanatically playing games (Bookworm, Wordfeud, etc) over the internet, sending emails, and chatting for hours to maintain their family network (Figure 5). For modern people of all ages—and not only the wealthy and privileged, or those living in the developed countries—, the smartphone is an indispensable tool. One has to be 'online'. The device is always close by, even during dinnertime, while driving to work, or when having professional meetings. To be connected is important, but it comes at a price. The fear to be not-connected leads to socially rude behaviour, unsafe driving and unwanted integration of work and private life 24/7: '*Sorry, I have to take this, it's my boss'* is not an uncommon thing to hear during an off-day meeting with friends. That the burnt-out manager is still working—by telephone—within the first days of his holiday is not too rare either *('Just checking the business, dear.'*).

The age of communication by smart devices—communication engines—has arrived without people really realizing it. It started in the early nineteenth century when 'Electricity' came about. In hindsight, the enormous impact of the introduction of electricity in society is undeniable. Even more so, the application of electricity in the fields of communication had massive consequences. This first became clear in the first half of the nineteenth century when 'Telegraphy' came about and conquered the communication field in a couple of decades, starting the Communication Revolution. And it became even more clear in the late-nineteenth century when 'Telephony' revolutionized private and professional communications. In the twentieth and twenty-first centuries, the Communication Revolution has continued up until today, where the massive effects of modern communication media are clearly visible in society.

But these effects took some time to develop, requiring the curiosity necessary for scientific discoveries, a lot of ingenuity and great engineering effort for all this to happen. Let's go and look what happened…

Change: Technical, Social, Political, Economic and Scientific

We used the words 'Communication Revolution' to indicate the massive social changes that resulted from the development of the 'communication engines', eg the telegraph and the telephone. Their origin—as we will see further on—lies in the nineteenth century. In the first half of that century the *General Purpose Technology* of 'Electricity' came into existence when the phenomenon of electricity was slowly unravelled by scientists and engineers. The experiments of many curious and ingenious people with the 'voltaic battery' resulted in a number of applications: the electromagnet, the DC electric motor and early spark lights. These were soon followed by the invention of a totally new device: the communication engine called the telegraph. The secrets of electricity were slowly discovered by experimental scientists, applied by engineering scientists, and then explained by theoretical scientists.[10] Telegraphy was born (Figure 6).

One has to realize that all these efforts took place in the societies of their day, societies in which the remnants of earlier times still existed. These were former absolute monarchical societies with feudal heritages that

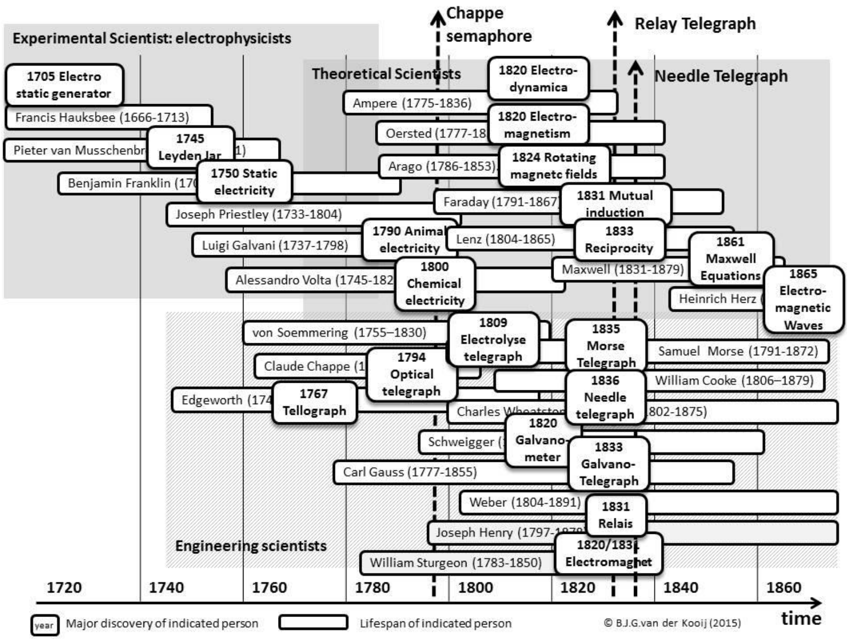


Figure 6: Science discovers electricity and telegraphy.

Source: B.J.G. van der Kooij: *The Invention of the Communication Engine Telegraph.* (2015) p.446

[10] See for more details: *The Invention of the Electric Light*. pp. 24-69 (2015)

developed into the eighteenth and nineteenth century empires (the British Empire, the French Empire, etc) with their imperialism, colonialism, mercantilism[11] and protectionism. These societies saw mass disruptions caused by social revolutions, including the American Revolution, the French Revolution and the European Revolutions of 1848. They all underwent the 'madness of times'—war and revolt at sea and on land—sometimes locally in regional wars and sometimes on a broader scale as wars between nations.

These societies created the context for the discoveries, inventions and innovations that we are going to investigate and that contributed to the Second Industrial Revolution. The relationships of these societies to the technological developments that occurred within them are complex, with many interrelations that we will try to unravel. Interrelations such as the connections between social changes and technical changes, economic changes and political changes, and technical changes and scientific changes. And—not to forget—the climatic affairs to be labelled as Climate Change.

Technical Change and Social Change

Before we zoom in on the different aspects and specific related contexts of the technological developments themselves, let's make a tour d'horizon and explore from a bird's eyes perspective the totality of changes as they occurred in the real world. Starting with the specific changes in society that were caused by technical change and followed by those changes where technical change was influenced by social change.

From Technical Change to Social Change

As we have seen before[12], the new ways to apply 'mechanical rotative power', such as the steam engine, resulted in quite a societal change in the seventeenth century. Labelled as the (first) Industrial Revolution[13] (starting somewhere after the 1760s), the early technological developments of that time heralded formidable change in the society. *Industrialization* became the

---

[11] Mercantilist policies were aimed at creating overseas colonies, excluding them from trading with other nations, monopolizing markets with staple ports and forbidding trade to be carried in foreign ships. Thus, governments protected their merchants —and kept others out— through trade barriers, regulations and subsidies to domestic industries in order to maximize exports from and minimize imports to the realm. This system created a massive redistribution of wealth from the colonies to the motherland. The goal of mercantilism was to run trade surpluses so that gold and silver would pour into London.

[12] See: B.J.G. van der Kooij: *The Invention of the Steam Engine.* (2015)

[13] Historians are still debating the exact nature of the developments classified as the Industrial Revolution. For some, it was a unique turning point in the societal development; for others it was a gradual transformation. As a consequence, the indicated starting point is highly arbitrary and can differ geographically.

word for new processes of mass-production (eg textiles). The *factory system* of mass manufacturing goods came into use, resulting in different working conditions. *Urbanization* was the result of the massive migration into the cities of people looking for work and fleeing the impoverished country sides. Quite a few of these people ended up in the slums of the bigger cities. Later, the effect of the availability of electricity to create 'mechanical rotative power'—the technologies of the electric motor and electric dynamo—would be even more drastic, creating the (second) Industrial Revolution[14]. This is especially true with respect to the application of electricity in communication—which we address in this volume—and lighting[15].

The economic consequences of the *Industrial Revolutions* were enormous. But the Industrial Revolutions were more than—as so many economists evangelized in their theories[16]—just the rise in productivity, real incomes, investment and the 'residual component'. The revolutions also freed mankind from physical labour as the 'prime mover' to create mechanical energy. Now coal could be used to fire the steam engines—such as with the early, highly energy-inefficient Newcomen's steam engine—replacing the animal powered, wind powered and water wheel powered mills. Consequently, the Industrial Revolution started in Britain in those areas with an abundance of coal and a newly developed infrastructure: the canals. Examples of this, in England, were the areas around Manchester (later in time nicknamed the 'Cottonopolis' [17]), Birmingham, Leeds, and Sheffield. In these places, the first steam powered engines—Savery's pump, known as the 'Miner's Friend', followed by Newcomen's engine—solved the water and foul air problems of mining. Then when the technology advanced with Watt's steam engine, the application spread over larger areas, changing the way people worked in the manufacturing industries, including in wood, textile and grain mills. And finally, when Trevithick's steam engine was available, the technology found its way into transportation applications such as steam ships, steam locomotives and steam carriages, changing the way goods and materials were transported and the way people travelled. A change that took place over quite a period of time: some hundred years.

---

[14] See: B.J.G. van der Kooij: *The Invention of the Electromotive Engine.* (2015)

[15] See: B.J.G. van der Kooij: *The Invention of the Electric Light.* (2015)

[16] For example: Smithian growth after Adam Smith (1750s), Schumpeterian growth after Alois Schunpter (1930s), Solovian growth after Robert Solov (1950s).

[17] 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.

Thus, to cut a long story short, changes in the technical systems in the period of the First Industrial Revolution started to induce changes in the socio-economic system we call society[18]. It was the Britain of the eighteenth century, the cradle of the technologies that created the Industrial Revolution, that started it and that profited enormously from it. It was a technological revolution that—similar to the political ideas of the French Revolution—spread through Europe and America. Where some societies were not too adaptive in picking up the possibilities offered by new technical developments (eg France and Russia) and lagged behind, others such as Britain and the US, the latter already being freed from historical political shackles and social obstacles, were more receptive and embraced, even enhanced, the new technical developments (Mokyr, 1990, 2003, 2011). Whatever the pace of acceptance and change, the Industrial Revolution was a European affair in which Britain took a leading role.

> *It is clear by now that far from being a "traditional" and "static" society, Britain on the eve of the Industrial Revolution was a country of sophisticated markets, in which profit-hungry homines economici did what they are supposed to do to help a country develop. But Britain was of course not alone in this: the Low Countries, Northern Italy, large parts of Germany, Iberia and Scandinavia at some time or another displayed unmistakable signs of rapid economic progress.* (Mokyr, 2003, pp. 13-14)

From Social Change to Technical Change

Technical Change (more abstractly: change in the technical system) resulted in *Social Change* (more abstractly: change in the socio-economic system), as we certainly will observe further on. However, Social Change also prepared the way for Technical Change. As we will see, up to the nineteenth century, societies changed due to reasons of their own. These changes we now label the Scientific Revolution (seventeenth-eighteenth century) and the Enlightenment (eighteenth century), and they ultimately resulted in the First Industrial Revolution.

> *We may call this the Industrial Revolution, but the sources of these changes go back to the institutional changes we associate with the enlightenment. We do not usually associate the enlightenment and the scientific revolution that preceded with it (and overlapped with it) with a particular nation or region in Europe, though there were differences in style and intensity. Europe, from Edinburgh to St. Petersburg, participated in these historical phenomena, no matter how we define them.* (Mokyr, 2003, p. 47)

[18] We recommend reading the case study of the *Invention of the Steam Engine* to get a better understanding of the topics mentioned here. B.J.G. van der Kooij: *The Invention of the Steam Engine.* (2015)

> *The technology that created the Industrial Revolution, then, was not exclusively British: it was European. … Although Britain pulled ahead of the rest of Europe for a while between 1760 and 1820, its technology relied heavily on epistemic bases developed elsewhere in Europe, especially in France, but also in Germany, Scandinavia and Italy.* (Mokyr, 2003, p. 50)

Europe in the eighteenth century was in the grip of Enlightenment (French: *Illumination, Siècle des lumieres*, German: *Aufklärung*) from the 1650s up to the 1780s; cultural and intellectual forces in Western Europe emphasized reason, analysis and individualism rather than traditional lines of authority and inequality. Views developed by the philosophers of that time proclaimed new ideals that challenged the existing social institutions of royalty, aristocracy and clergy: the Ancien Regime as it was called in France[19].

Among the philosophers, we find the Enlightenment thinker, philosopher, and Englishman John Locke (1632-1704), also called the father of classical liberalism. His views on the natural rights of man and the role of government were published in *Two Treatises of Government* (1689). Addressing the origin of society and the legitimacy of authority of the state over the individual, he opposed absolute monarchy and advocated individual consent as the foundation of political legitimacy, arguing that the will of the people should be the basis of the system of government.

> *To properly understand political power and trace its origins, we must consider the state that all people are in naturally. That is a state of perfect freedom of acting and disposing of their own possessions and persons as they think fit within the bounds of the law of nature. People in this state do not have to ask permission to act or depend on the will of others to arrange matters on their behalf. The natural state is also one of equality in which all power and jurisdiction is reciprocal and no one has more than another. It is evident that all human beings – as creatures belonging to the same species and rank and born indiscriminately with all the same natural advantages and faculties – are equal amongst themselves. They have no relationship of subordination or subjection unless God (the lord and master of them all) had clearly set one person above another and conferred on him an undoubted right to dominion and sovereignty.* (Locke, 2013, p. 70)

Locke's conception of natural rights influenced societal development in England, just as the ideas of the Frenchmen Voltaire and Rousseau in turn influenced the French Revolution. A century after Locke's Two Treatises, the totality of liberal thinking in turn influenced the thinking of those

[19] See for more details about France at the end of the eighteenth century: B.J.G. van der Kooij: *The Invention of the Communication Engine Telegraph*. Chapter: The Changing Social Context. pp. 75-168 (2015)

American revolutionaries who created the United States Declaration of Independence. They were the founding fathers of the United States of America.

Another philosopher was David Hume (1711-1776), who heralded in his *Treatise of Human Nature*, published in 1739-40 (Hume, 2012), the naturalistic science of man.

> *It is evident, that all the sciences have a relation, greater or less, to human nature: and that however wide any of them may seem to run from it, they still return back by one passage or another. Even Mathematics, Natural Philosophy, and Natural Religion, are in some measure dependent on the science of man; since they lie under the cognizance of men, and are judged of by their powers and faculties. It is impossible to tell what changes and improvements we might make in these sciences were we thoroughly acquainted with the extent and force of human understanding, and could explain the nature of the ideas we employ, and of the operations we perform in our reasonings. And these improvements are the more to be hoped for in natural religion, as it is not content with instructing us in the nature of superior powers, but carries its views farther, to their disposition towards us, and our duties towards them; and consequently we ourselves are not only the beings, that reason, but also one of the objects, concerning which we reason.* (Hume, 2012, pp. 7-8)

He reflected on the origin and association of mental perceptions: 'All the perceptions of the human mind resolve themselves into two distinct kinds, which I shall call IMPRESSIONS and IDEAS' (Hume, 2012, p. 1). From this he constructed his view that reason governs human behaviour. Hume reflected on his concepts and theories from a historical background, as illustrated by his publication *The History of England* (Hume, 1789).

His work contributed to the intellectual change that was arising in those times in the more permissive societies, where creating ideas, concepts and theories about the 'nature of heat' and the 'nature of lighting'—to give two examples covered in other cases[20]—was not considered to be heresy or apostasy[21]. In addition, his views on private property, inflation and foreign trade contributed to economic thought. This all made the tinkering and experimenting of those early 'gentlemen of science' be seen as a respectful and desirable activity.

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

[21] The term heresy is usually used to refer to violations of important religious teachings, but is used also of views strongly opposed to any generally accepted ideas. The term apostasy is used by sociologists to mean renunciation and criticism of, or opposition to, a person's former religion.

> *Above all, it [Enlightenment] was a movement that believed in social progress and the improvability of mankind, the belief in growth and improvement, and the specific notions that innovations and the growth of useful knowledge were the way to bring them about and thus the source of hope and excitement, were central to the Enlightenment movement. … in the century of Enlightenment, the word 'innovation', traditionally a term of abuse, had become a word of praise* (Mokyr, 2011, p. 33)

These enlightened views on the relation between the individual and the state, the relation of science to man, and of economic novelty and change, contributed to the changing social structures, norms and values in different societies. These changes were more or less gradual, but many were often disruptive, such as the American Revolution and the French Revolution. Whatever their nature, they created a different context for the *homo economicus*, who was to become the *homo inventicus*.

Subsequently, Enlightenment played a considerable role in the events that occurred in Europe at the end of the eighteenth century. But even more, they played a role in the development of the British colonies of the United States that would culminate in the American Revolution. Enlightenment advocated the freedom of man and religious tolerance that the new inhabitants of America were craving.

> *The Enlightenment was crucial in determining almost every aspect of colonial America, most notably in terms of politics, government, and religion. Without the central ideas and figures of the Enlightenment, the United States would have been drastically different since these concepts shaped the country in its formative years. Both during and after the American Revolution many of the core ideas of the Enlightenment were the basis for monumental tracts such as the Declaration of Independence and the Constitution. Concepts such as freedom from oppression, natural rights, and new ways of thinking about governmental structure came straight from Enlightenment philosophers such as Locke and forged the foundations for both colonial and modern America. All aspects of life, even religion, were affected by the Enlightenment and many key figures from American history such as Thomas Jefferson were greatly influenced by the movement.* (N. Smith, 2011)

Part of the overall views of the Enlightenment were oriented toward scientific and economic progress. The *Industrial Enlightenment*, for instance, was an aspect of eighteenth-century society that '… refers to that part of the Enlightenment which believed in material progress and economic growth could be achieved through increasing human knowledge of natural phenomena and making this knowledge accessible to those who could make use of it in production' (Mokyr, 2011, p. 40).

Economic Change, Political Change and Social Change

The development of our western society over the centuries was the result of a process of change. Sometimes it was a gradual change, hardly noticeable and creating a state of equilibrium for many. Other times the change was brute, destructive and influenced the lives of many. But 'change' was always there.

From political change to social change

To state it quite bluntly, human beings are by nature political animals. That is to say, political behaviour is part of the existence of men. Men, at first, lived in small organized units, followed by small hamlets, and later in city-states that rose to great power (eg Florence in the Middle Ages). And during that development, basically, some people always dominated by exercising physical and economic power. Their subjects followed in exchange for protection and livelihood. Undoubtedly, people have needs to survive, physical needs, safety needs and social needs. Needs that are different from person to person, but that determine their behaviour and their place in the group. These needs result in the creation of coalitions of cooperation, in interdependence among people. And, as people are living in an environment that constantly changes, their needs are affected by those environmental changes. However, next to those external changes related to human's basic needs (such as climate changes threatening their physical survival and safety), there occur also other changes in the social structures. Those social structures change over time as the result of influences of an independent, non-technical-nature.

That is to say, social behaviour in societal system are in a state of constant dynamics. Dynamics that change the societal structures. Sometimes, the changes are dramatic, as in social revolutions, and sometimes, they are gradual, as in the social movement of *democratization*, which was the process where the old social structure of monarchical absolutism[22]—with many ups and downs over a long period of time—was replaced by a new structure: democracy (ie the parliamentary democracy[23]). Democratization 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.

[22] Absolutism: used for the monarchical form of government in which the monarch has absolute power among his or her people.
[23] 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.

Just imagine Europe in in the seventeenth century as it had developed over centuries. At that time only a few (ie the so called 'landed class' of landowners, from Junkers to Barons[24]) decided on taxation, created legislation (eg punitive laws), and carried out the rather harsh law enforcement. They ruled by distributing favors (eg patronage), distributing royal charters[25] and establishing monopolies[26]. They maintained their power base 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. 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 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)

From economic change to political change

That power base of society was about to change in the course of the nineteenth century. The economic importance of land ownership was—now that international trade and early industrialization had slowly taken effect—no longer the dominant factor. The British *Agricultural Revolution*[27]

---

[24] 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.

[25] 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.

[26] 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.

[27] 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.

increased food production, leading to a drastic increase in populations. As more children survived and only one could inherit the farm, more adolescents had to create a living outside farming. Going into trade was one option. Colonial 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 (London, Bristol, Liverpool) and also far into the hinterland. It made many merchants rich, often richer than the landed gentry. And that a new class in society—the emerging middle class of industrialists, mercantile traders, 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 trade and industrious[28] production—and its related *Demographic Revolution*[29]—encompassed 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, the struggle of these classes was about their right to exercise their representation in the societal power structure of the evolving democratic system. Moreover, a big part of that struggle was about so-called male suffrage[30].

From social change to political change

Next to these autonomous developments was the previously mentioned Enlightenment movement and its consequent Liberalism, which was based on liberty and equality of people under the credo 'all men are created equal'. Liberalism 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. As described, early English philosophers like John Locke[31] (1631-1704) and David Hume (1711-1776) had already developed their views that each man has his 'natural rights to life, liberty and property'. And in this view, government was obliged to facilitate and

[28] 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).

[29] 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.

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

[31] 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.

safeguard those rights. This view was the 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.*[32]

In nineteenth-century Britain, the liberals generally formed the party of 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. Liberalism 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. Consequently, 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. Nevertheless, 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.

[32] Source: Biography John Locke. The European Graduate School. http://www.egs.edu/library/john-locke/biography/ (Accessed June 2015).

To wrap this short analysis of independent social change up: we have just 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 from the 1650s up to the 1780s, in which the old power structures were to be challenged seriously. Enlightenment that, next to new arising ideas about the 'social contract[33]', saw the encouragement of arts and sciences[34], although at different moments in time and in different forms at different places.

Scientific Change and Technical Change

One of the changes from the agricultural society to the industrious society was related to the way people looked at the world around them. From the former Aristotelian view of the physical world (with philosophic views relating to the elements Earth, Water, Air, Fire and Aether) that influenced the physicals sciences up to the Renaissance, people started to look different at the world around them. People like Copernicus, who reflected on the universe and published in 1543 *De revolutionibus orbium coelestium* ('On the Revolutions of the Heavenly Spheres'). It became the time of scientific experimentation in which different views on the natural world we are living in, started to develop.

In the Europe of the eighteenth century, the effects of the Scientific Revolution were noticeable. Developments in mathematics, physics, astronomy, biology and chemistry had transformed the scholarly views of society and nature. Stimulated by the work of Nicolaus Copernicus (1473-1543) the scientific revolution took place over the next two ages. The experimental scientists of that time, men such as the Italian Galileo Galilei (1564-1642), who lived in Pisa and Florence, contributed substantially to that change. Galileo's experiments have to been seen in the context of his time:

---

[33] 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.

[34] 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.

Galileo started by using materials and tools ready at hand, off the shelf, including what was available in his Tuscan environment as he was growing up. And his "practice" only evolved or matured in the course of his investigations (Settle, 2001, p. 832).

Over time the views he developed and expressed brought him in conflict with the Roman Inquisition, and in 1633 he had to defend himself and was placed, for the rest of his life, under house arrest (Figure 7). Nevertheless, the views that resulted from his experiments were published in 1638 in Holland (!), where the writ of the Inquisition was of less consequence. It resulted in his scientific testament *Discorsi e Dimostrazioni Matematiche Intorno a Due Nuove Scienze* ('Discourses and Mathematical Demonstrations Relating to Two New Sciences').

Galileo studied the nature and laws of motion throughout his scientific career, eventually formulating in the Discourses and Mathematical Demonstrations (Leyden, 1638) an entirely new dynamics, based on mathematical reasoning and innovative experiments. In this ground-breaking work, the Aristotelian concept of motion is replaced by a vision founded on new principles: the acceleration of natural motion and its proportionality to time from rest, the parabolic trajectory of projectiles, the infinite force of impact. For Galileo, the radical reform of Aristotelian dynamics opened the way to the definitive affirmation of the Copernican system…

Figure 7: Galileo before the Holy Office, facing the Roman Inquisition (1633).

Source: Wikimedia Commons, painting by Joseph-Nicolas Robert-Fleury.

> *… The affirmation of the experimental method in the 17th century and the development of new instruments stimulated significant progress in the investigation of natural processes, helping to discover the laws that governed them and to unveil invisible phenomena. The barometer was used to reveal the effects of atmospheric pressure and to measure variations in it caused by changes in the weather. The graduated thermometer was used to measure temperature objectively and even more precisely. The microscope and the telescope enormously enhanced the powers of eyesight, revealing hitherto unknown phenomena of the micro cosmos and the macro cosmos. Lastly, combinations of lenses, prisms and mirror led to the progress in the science of optics.* [35]

The Scientific Revolution was to culminate in Isaac Newton's (1642-1726) grand synthesis expressed in his book *Philosophiæ Naturalis Principia Mathematica* ('Mathematical Principles of Natural Philosophy', 1687). He presented a new view of the universe, a synthesis of the work of Copernicus, Kepler, Galileo and Descartes. His views on classical mechanics—that were later to be called the Newtonian mechanics—resulted in a system of physics that predicted the behaviour of particles, pendulums, machines, etc., with his three Laws of Motion[36]. Moreover, his famous Law of Universal Gravitation[37] predicted the behaviour of bodies in the universe. Using the language of mathematics, he made the movement of bodies predictable: from the orbit of comets to the apple falling from a tree.

The Scientific Revolution was a departure from the ancient Aristotelian Physics[38]. The philosophy of using an inductive approach to nature—to abandon assumption and to attempt to simply observe with an open mind—was in strict contrast with the earlier, Aristotelian approach of deduction, by which analysis of known facts produced further understanding. It was a new view of nature in which science became an

---

[35] Text originating from the exhibition in the Florence Galileo Museum (visited October 2015). I am indebted to Professor Emeritus Thomas B. Settle, who was graciously willing to share his insights with me and to educate me in the history of science, especially Galileo's role in the Tuscan context of that time. (see also: http://www.imss.fi.it/~tsettle/index.html.

[36] Law I: Every body persists in its state of being at rest or of moving uniformly straight forward, except insofar as it is compelled to change its state by force impressed. In formula: $\sum F=0$. Law II: The alteration of motion is ever proportional to the motive force impress'd; and is made in the direction of the right line in which that force is impress'd. In formula: $F=ma$. Law III: To every action there is always opposed an equal reaction: or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts. In formula: $F_A = -F_B$

[37] The law of universal gravitation states that any two bodies in the universe attract each other with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between them.

[38] The Aristotelian Physics relate to the general principles of change as developed by the philosopher Aristotle. It was based on concept that the terrestrial spheres are made up of the fundamental elements air, water, earth, and fire.

autonomous discipline, distinct from philosophy and technology:

> *Among the most conspicuous of the revolutions which opinions on this subject have undergone, is the transition from an implicit trust in the internal powers of man's mind to a professed dependence upon external observation; and from an unbounded reverence for the wisdom of the past, to a fervid expectation of change and improvement.* (Whewell, 1858, p. 318)

Natural Philosophers started studying the physical universe by looking at 'The Nature of…' (ie the nature of heat) and the 'Power of…' (ie the power of heat). It was the study of nature on a grand scale: astronomy and cosmology as observed through a telescope. In addition, it was also the study of nature on a small scale: the micro-cosmos as observed through a microscope.

The scholarly efforts of all those involved in mechanistic natural philosophy—like those 'gentlemen of science' who met, discussed and studied the physical world and wondered about 'The Nature of Matter' (Figure 8)—created quite different views of the world. In the field of chemistry, the ancient art of alchemy was replaced by the modern views on chemical matter. Studies on the 'Nature of physics' resulted in the discoveries of gasses (eg oxygen and hydrogen). Their existence was observed by many scholars (eg Lavoisier, Davy) and explained in Lavoisier's

Figure 8: Boyle's Chemical Club meeting at London's first coffeehouse opened by the apothecary Tillyard (1655).

Source: http://www4.ncsu.edu/~kimler/hi322/coffeehouse.jpg, painting by unknown artist.

Oxygen Theory of Combustion. The nature and behaviour of matter was explained and theorized. Such as the behaviour of gasses in relation to pressure and volume (eg. Boyle's Law[39]).

> *With the Oxygen Theory of Lavoisier, the theory that the world is composed of the four elements reached its end. As Foucault has said of this transition period, "Modern medicine has fixed its own date of birth as being in the last years of the eighteenth century", at the time that the Oxygen Theory revolutionized science and political revolutions convulsed France and the American colonies.* (Bray, 1994, p. 187)

All those scholarly efforts resulted in insight into the 'Nature of Heat', the understanding of the mechanism of thermodynamics, with the steam engine as the pinnacle of its concrete results[40]. The study into the 'Nature of Lightning' resulted in the discovery of electricity. The observation of the behaviour of electricity—studied by men such as Faraday and Ampère—resulted in the theories of electromagnetism. With electromotive engines as the pinnacles of its concrete results [41].

Concluding

So far, we have painted in rough brushstrokes a picture of the changing society under influence of specific developments now labelled the Enlightenment and the Scientific Revolution. The first resulted in a changing societal structure that constitutes what we call Social Change and Political Change. The latter resulted in the scientific approach to observe and interpret the natural world around us. With the Science of Physics ultimately leading to the development of new technologies. This all resulted in what we call Technical Change. As a consequence there were the changes in the economies, to be called Economic Change.

Having explored from a bird's eye perspective some of the historical relationships between social, technical, political and scientific change, it is now time to look at what happened in the 'real world' in more recent times. The 'real world' that created the context for the technical developments that would change society by setting the social 'scene for change'. Especially the world of the American society up to the period we call the Industrial Revolution.

---

[39] Boyle's law is a gas law, stating that the pressure and volume of a gas have an inverse relationship, when temperature is held constant.

[40] B.J.G. van der Kooij: *The Invention of the Steam Engine.* (2015) pp.19-38

[41] B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015) pp. 31-62.

The American Revolution

What is today called the United States of America started as a British trade settlement that, by 1770, had grown into thirteen British Colonies on the East Coast of North America. The colonies were the result of a massive European colonization in the preceding years. In competition with the Spanish and Portuguese, the Dutch and the French, the Brits created their colonial empire: the (first) British Empire (1583-1783). And a big part of that Empire declared itself independent in 1783—after the American Revolution.

Early Settlement and Colonial Trade in North America

In the *Age of Discovery*, Spanish, Portuguese, French, Dutch and British ships roamed the seas to discover the world. Christopher Columbus' discovery in 1492 of America spurred maritime exploration. When that was well underway, and the stories about the riches—with gold and diamonds everywhere to find—reached the home courts, ships again roamed the world. But now the nations were interested in the trade of gold, exotic spices, dyes, timbers and ivory. Trade that was later complemented by sugar (Caribbean islands), coffee (Brazil), tea (India), tobacco (America) and slaves (Africa). The slaves became the workforce on the plantations in the American colonies. The traders were the British, Spanish, Portuguese and Dutch.

The British already had a long history of maritime conflicts, especially with the Dutch, as the Dutch had commercial and maritime supremacy over the routes to the New World and Further East in the middle of the seventeenth century. Everywhere they sailed, the English found the Dutch in their paths.

The Virginia Venture

As was done by all the sea exploring nations of that time, when a promising region was discovered by exploration expeditions, serious attention would be paid to exploring that region. If the outcome was positive, an expedition would be sent to create a settlement. Such as the 1607 expedition organized by the *Charter of Virginia Company of London*. The company was established in 1606 by four founders, one of whom was Captain Edward Maria Wingfield, a soldier by profession. They received the Royal Charter from King James I with the purpose of establishing colonial settlements in North America. In that *First Charter of Virginia*, King James I (who reigned 1603–1625) guaranteed to the colonists and their posterity all of the 'liberties, franchises, and immunities' possessed by anyone born in England (the so called 'liberties of Englishmen'). Every subsequent colonial charter included similar provisions.[42]

> *And do therefore, for Us, our Heirs, and Successors, GRANT and agree, that the said Sir Thomas Gates, Sir George Somers, Richard Hackluit, and Edward-Maria Wingfield, Adventurers of and for our City of London, and all such others, as are, or shall be, joined unto them of that Colony, shall be called the first Colony;*
>
> *And they shall and may begin their said first Plantation and Habitation, at any Place upon the said-Coast of Virginia or America, where they shall think fit and convenient, between the said four and thirty and one and forty Degrees of the said Latitude;*
>
> *And that they shall have all the Lands, Woods, Soil, Grounds, Havens, Ports, Rivers, Mines, Minerals, Marshes, Waters, Fishings, Commodities, and Hereditaments, whatsoever, from the said first Seat of their Plantation and Habitation by the Space of fifty Miles of English Statute Measure, all along the said Coast of Virginia and America, towards the West and Southwest, as the Coast lyeth, with all the Islands within one hundred Miles directly over against the same Sea Coast…*[43]

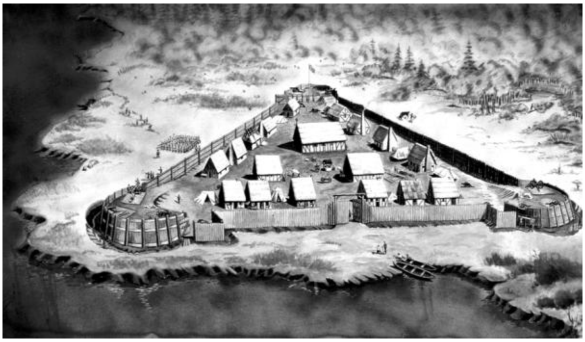


Figure 9: The Jamestown settlement in 1607.

Source: http://www.rutgersprep.org

In December 1606 the three ships *Susan Constant*, *The Discovery* and *The God Speed* sailed from England with one hundred and four would-be colonists on board, along with the only stockholder capable enough for the expedition: Edward Maria Wingfield. After their arrival in the Chesapeake Bay in April 1607, and after some skirmishes with natives, they built a fort defendable against land, canoe and sea attack (by the French and Spanish) some fifty miles upstream on a swampy island, amidst brackish waters (Figure 9). The

[42] Source: http://loc.gov/exhibits/magna-carta-muse-and-mentor/rights-of-englishmen-in-british-america.html. (Accessed June 2015)

[43] Source: The First Charter of Virginia; April 10, 1606. The Federal and State Constitutions Colonial Charters, and Other Organic Laws of the States, Territories, and Colonies Now or Heretofore Forming the United States of America. http://avalon.law.yale.edu/. (Accessed June 2015)

fort was completed in one month in which Wingfield drove his men hard to 'working, watching and warding'. Life was hard, food scarce, the climate hot and dry, and mosquitos—and soon natives—attacked constantly. In the first years forty-six colonists died of fever, starvation, or Indian arrows during foraging trips. When supply ships arrived with new settlers and fresh provisions in January 1608, they found only thirty-eight survivors. Wingfield, blamed for the failure, was sent back to England on the supply boat.

In 1609, some four hundred new settlers arrived with the Third Supply mission, but the conditions were so severe that in the spring of 1610 only sixty persons had survived. One of the aggravating conditions was the period of extreme drought, which led to crop failure (for both the settlers and the Indians) and lack of fresh water. The settlement was considered a failure, and the surviving colonists were shipped back to England.

However, the arrival of another relief fleet on June 10, 1610, turned the tide. New settlers worked their plots (some 20 hectares that they received after paying for their voyage or that they received after seven years of indentured service). Now with more success as the period of drought had ended, and economic progress was made as the growth of a new kind of tobacco proved successful. The marriage of the settler *John Rolfe* with Pocahontas, the daughter of an Indian Chief of the Powhatan Indians (Figure 10), brought several years of peace between the English and natives. The settlement of Jamestown survived and was the beginning of British colonization in that part of America. Pocahontas even went to England, where she was presented at the court to King James. The English aristocracy, who had never seen a native Indian, turned up in masses to meet her.

Figure 10: The marriage of Rolfe and Pocahontas in 1607.

Source: Boyd Smith, The Story of Pocahontas and Captain John Smith. http://www.gutenberg.org/ files/24487/24487-h/24487-h.htm#landing

From New Amsterdam to New York

Not only Britain, but also all the sea dominating countries had created mercantile companies. Next to the Brits, who had created the *British East India Company* (1600), the Dutch had created the *Vereenigde Oost-Indische Compagnie* (VOC: the East India Company) in 1602 and the *Geoctroyeerde West-Indische Compagnie* (West-India Company) in 1621[44]. After their 'Get-rich-quick' days, in which they captured the silver fleets of the Spanish[45], the Dutch started to create their settlements. Soon the settlements grew into small cities where the goods that were to be exported were checked, weighed and packaged for sea transport. On the Hudson River in North America, this process was happening around forts like *Fort Orange*.

The basis for these first settlements was the Dutch 'patroonship', a title and grant to the invested members for a specific area (16 by 16 miles, 26 by 26 km) of land to be colonized. It was based on the *Charter of Freedom and Exemptions* that established the patroonship and gave it powerful rights and privileges. A 'patroon' (feudal chief) could create civil and criminal courts, appoint local officials and hold land in perpetuity, with exclusive fishing and hunting rights. In return, he had the obligation to establish a settlement with at least fifty families within four years. These families would have to pay rent for the land they worked. The settlements were purely commercial ventures that took place in a time when the feudal system was still in place in Europe.

These first settlers were the tenants working for the patroon, who created their own villages. For example, *Rensselaerswijck*, owned by the Rensselaer family, was established when one of the directors of the *Dutch West India Company,* the diamond and pearl merchant Kiliaen van Renseselaer (1586-1643) of Amsterdam, obtained the estate in 1630 on the Hudson River. This wealthy Amsterdam businessman who controlled vast tracts of lands in and around the area that is now Albany, New York, had brought with him several families from the religious village of Nijkerk in the Netherlands.

> *Of the early Dutch colonial families the Van Rensselaers were the first to acquire a great landed estate in America under the "patroon" system; they were among the first, after the English conquest of New Netherland, to have their possessions erected into a "manor," antedating the Livingstons and Van Cortlandts in this*

[44] Later in time a particular case was the (first) *Royal African Company*, created in 1660 with a monopoly on the African slave trade and led by James, Duke of York (King Charles II's brother). This company was heavily into debt during the war with the Netherlands, in which the Brits attacked Dutch African trading post.
[45] In 1628 privateers like Piet Hein brought in a bounty of over $115 million, the following year $18 million (today's equivalent would be a thousand times these amounts).

> *particular; and they were the last to relinquish their ancient prescriptive rights and to part with their hereditary demesnes under the altered social and political conditions of modem times. So far as an aristocracy, in the strict understanding of the term, may be said to have existed under American institutions—and it is an undoubted historical fact that a quite formal aristocratic society obtained throughout the colonial period and for some time subsequently, especially in New York—the Van Rensselaers represented alike its highest attained privileges, its most elevated organization, and its most dignified expression. They were, in the first place, nobles in the old country, which cannot be said of any of the other manorial families of New York, although several of these claimed gentle descent. Thus in becoming patroons and later manorial lords in America, the Van Rensselaers but enjoyed an extension in kind (though scarcely in degree) of aristocratic dignities which had already been theirs for generations.* (Spooner, 1907, p. 1).

For two hundred years the patroonship of the estate would stay in the Rensselaer family. When the estate was split up in 1839 after the Anti-Rent War, it made the actual owner Stephen van Rensselaer III (1764-1839), Lieutenant Governor of New York, the tenth richest man in America, with a net worth of $10 million[46]. The patroonship ended in 1840.

In the late 1630s, not only the Dutch lived in the settlements; many other nationalities were also represented, such as Germans and Englishmen (ie Quakers). Originally, the settlements were fortified trading posts, buying furs from Indians and hunters, that later added farming around the fort. The Dutch colonists kept in close contact with their cultural background from the Republic of the Low Countries at the sea (today's 'Holland'). In a way, these settlements were melting pots, but many of the colonist held to their original religions (eg the Dutch Reformed Church, the Quakers). As a free-trade zone, the area of Dutch settlement was rife with economic activity. This all resulted in a plural, multi-ethnic, many-faithed society that was governed by a company: the *Dutch West Indies Company*.

In the 1640s a young and adventurous university-educated lawyer, *Adriaen van der Donck* (1618-1655), became 'schout' (ie sherrif) on the estate of the Dutchman Killian Van Rensselaer. His job was to make sure the settlers worked the land for the 'profit of van Rensselaer'. But van der Donck had higher aspirations.

> *Being the schout of Rensselaerswyck turned out to be more than just a job of enforcing the law and maintaining peace. The job essentially involved managing the estate for Killian Van Rensselaer, who liked to run his New Netherland*

[46] Equivalent to $104 billion in 2014, based on the calculation of economic power. Source: http://www.measuringworth.com/uscompare/relativevalue.php. (Accessed June 2015)

estate from the safety of Amsterdam with a lot of close direction to his agents in New Netherland. It soon became clear that Van der Donck and Van Rensselaer did not always see eye-to-eye, and some of Van Renssealaer's directions were not always carried out by Van der Donck. Whereas Van Rensselaer wanted to run a strict regime, Van der Donck would often side with the tenants against the directions of Van Rensselaer. It was a relationship that was bound to fail, and fail it did. [47]

During those years he scouted the environment, befriended the Indians and learned their languages. After leaving the Van Rensselaer employment in 1644, he became involved in the brokering of peace with Indians after Governor Willem Keift made war with them over the sale of the land (Figure 11). For his efforts, van der Donck was awarded a piece of land (some 97 km^2) by the Dutch West Indies Company (DWIC). He thus became a considerable landowner himself and became a prominent colonist.

Figure 11: Negotiating peace with the Indians (1642).

Lenape Indians and New Netherland officials meeting in 1642 at the home of Jonas Bronck, negotiating a truce in a conflict often called Keift's War.

Source: www.nps.gov

In 1649, Van der Donck was appointed by the then governor general Peter Stuyvesant to be a member of the Council of Nine, a group of advisors and legislators in New Amsterdam. Since Van der Donck was by far the best educated member of the Council of Nine, he quickly became its leader. He then ran into conflict with Stuyvesant about running the colony. The conflict ended up in a stand-off and it was decided that the government in Holland would have to resolve the conflict. Van der Donck then left for Holland where he argued to the States General for making the governor general of New Netherland solely responsible to the States General in Holland and not to the DWIC. *(ibidem)*

[47] Source: Adriaen van der Donck [1620-1655], Early Founder/Historic Leader: http://www.newnetherlandinstitute.org/history-and-heritage/dutch_americans/adriaen-van-der-donck/. (Accessed June 2015)

In 1650 he published a pamphlet addressed to the Dutch *Staten-Generaal* about the colony, called 'Remonstrance'. The pamphlet described the life in the colonies in such way that many people were suddenly eager to immigrate, and ships were forced to turn away paying passengers. Although the Staten Generaal originally agreed to establish a governmental role in the colony to replace the company rule, the First Anglo-Dutch war threw a spanner in the works. The plans were cancelled, the DWIC was again in full power, and van der Donck was declared a 'persona non grate' for the company. Promising not to meddle in the affairs of the company, van der Donck was allowed to return. Not long after his return from Holland in 1653, van der Donck died. Having no children, his estate was sold to Oloff van Cortlandt (1600-1684), the founding father of the van Cortlandt dynasty that would become quite powerful in New York's politics when his son Jacobus van Cortlandt (1658-1739) became mayor of New York[48].

Figure 12: The Settlement of New Amsterdam in 1660.

The street next to the Wall on the right site of the settlement is called Wall Street. A name that still exists in New York.

Source: Wikimedia Commons, Castello Plan

[48] Later, after New Netherland was taken over by the British, they would apply their system of 'Lords of the Manor' in accordance to this concept. It would result in other manors; such as the Manor of Livingstone and Manor of Cortlands.

The New Amsterdam settlement (Figure 12) was a thorn in the side of the English, and was entangled in illegal trade—smuggling—and colonial conflicts between the Dutch and Brits. As the Dutch more or less neglected the settlement, finally, in 1664 Colonel *Richard Nicolls*, Groom of the Chamber[49] to the Duke of York, planned to occupy it. It was an action planned by a narrow segment of the British aristocratic elite headed by *James*, Duke of York, brother of King Charles II and later King James II, and powerful aristocrats like his personal friends Sir *Edward Hyde*[50], Earl of Clarendon, Sir *George Carteret*[51] and Lord *John Berkeley*[52], 1st Baron Berkeley of Stratton and a prominent member of the Privy Council. Obviously, these gentlemen, sharing so many societal interests with the other Lord Proprietors, were in the position to forward any action in their own self-interests.

The conspiracy made quick progress. The Royal Charter was quickly created in two weeks. The King agreed to give a grant of £4,000 [53] and only wanted a yearly payment of forty beaver skins as compensation: 'And the said James Duke of York, doth for himself, his heirs and assigns, covenant and promise to yield and render unto our heirs and successors, of and for the same and every Year, forty beaver skins when they shall be demanded, or within ninety days after.'[54]

The king was not the only one aware of the Dutch influence and effect on the British trade. Soon the House of Commons authorized a study into the causes of the decay of trade[55]. Now all that was needed was to show some muscle. It was early 1664.

---

[49] Groom of the Chamber was a position in the Royal Household. Grooms ranked below Gentlemen of the Chamber, usually important noblemen, but above Yeomen of the Chamber.

[50] Edward Hyde was a prominent politician in that time who sided with the king during his reign. As a Chief Minister (1660-1667), he gave his name to the Clarendon Code, a range of Acts designed to preserve the supremacy of the Church of England.

[51] Vice Admiral George Carteret served in the Clarendon Ministry as Treasurer of the Navy.

[52] Charles II had already in 1660 granted colonial land —the later Province of Carolina, todays North and South Carolina— to the eight Lords Proprietors in return for their financial and political assistance in restoring him to the throne in 1660. Berkeley was one of them, just as Carteret and Hyde.

[53] Equivalent to £94 million in 2014, calculated as the economic power value. Source: www.meausingworth.com. (Accessed June 2015)

[54] Source: Charles II's Grant of New England to the Duke of York, 1676. The Federal and State Constitutions Colonial Charters, and Other Organic Laws of the States, Territories, and Colonies Now or Heretofore Forming the United States of America, June 30, 1906. http://avalon.law.yale.edu/18th_century/nj14.asp (Accessed April 2015)

[55] The Commissioning of a Report is still in today's Parliament a proven method when the Parliament is indecisive about what to with the subject at hand. It buys time and can be used as a solidification when someone (person, group, people, country) is to blame.

> *On April 2, James commissioned Richard Nicolls, groom of his bedchamber, to be lieutenant-governor of the yet unconquered territory in America… The king opposed war with Holland, but believed that the Dutch were the aggressors and that he had a legitimate complaint against the Dutch East and West India companies, particularly in America, for, he said, New Amsterdam "did belong to England heretofore, but the Dutch by degrees drove our people out of it."… A month later, though England and Holland were at peace, Nicolls and his fleet of four vessels started for America to conquer the territory thus summarily disposed of. A more unprincipled series of secret actions against a friendly nation, whose only offence was greater success in commerce, can hardly be imagined. …*
>
> *[Arriving in July for the New England coasts and three weeks later at the mouth of the Hudson] the city fell an easy prey to the fleet. Stuyvesant wished to fight. When he received from Nicolls the letter demanding the surrender of the city he tore it in pieces and in a storm of wrath stamped upon the torn fragments, and declared to the members of the council that he would never yield. But the phlegmatic burghers refused to support him, and, gathering the pieces of the letter, they read the communication and answered it with a flag of truce.* (Andrews, 1904, p. 80)

That day, September 6, 1664, when Peter Stuyvesant surrendered New Amsterdam, was the end of the Dutch settlement in this region (Figure 13). New Amsterdam became *New York*, in honour of the Duke of York, who was now the proprietor of the new colony. Carteret and Berkeley got a large

Figure 13: Peter Stuyvesant refuses to surrender New Amsterdam to the English in 1664.

Source: Wikimedia Commons. Painting by Jaen Leon Gerome Ferris.

piece of land previously named New Netherlands (that they renamed New Jersey). Clarendon fell out of grace with Charles II, and he lived his final years in exile.

> *The capture of New Amsterdam by the English was one in a series of events which issued into the first Dutch war of the Restoration. The war itself grew out of the struggle for trade which was bequeathed to the two countries by the war of 1652. That contest was most intense on the African coast, and a descent upon New Amsterdam was not considered until Dutch hostility had ruined the Royal African Company. … The news of the fall of New Amsterdam arrived in Europe when war seemed inevitable, and thus was in no sense a cause of the conflict. The war was the contest of two nations struggling for the commerce of the world, and the fall of New Amsterdam was but one of many expressions of that commercial antagonism.* (Schoolcraft, 1907, pp. 692-693)

Although the traitorous capture of the Dutch colony contributed to the start of the first Anglo-Dutch War (1652-1654), it was not until 1673 that the Dutch retaliated, when a fleet destined for the Caribbean arrived at New York during the third Anglo-Dutch War (1672-1674). The Dutch admiral *Cornelis Evertsen*, with his Zeeland squadron, and the Dutch admiral *Jacob Benckes*, with his Amsterdam squadron, recaptured the settlement (then called New Orange). But it was not for long.

Figure 14: The Four Days Fight during the Second Anglo-Dutch War (June 1666).

Source: Wikimedia Commons, painting by Abraham Storck

The combined fleet arrived at the English colony of New York in July 1673. The English had taken over New Netherland in 1664, and the sight of the impressive armada with Dutch flags fluttering awoke the smoldering loyalty of many of the inhabitants. While the fleet was lying at anchor off Sandy Hook a contingent of disgruntled Dutchmen went aboard. They grumbled about life under the English, and provided valuable intelligence about the shabby state of the city's defenses and the poorly garrisoned Fort James. They also indicated that Governor Lovelace was absent from the city. All this kindled the interest of Cornelis and Benckes, and gave them a crazy idea: what if they were to actually retake New Netherland? …

Following a brief exchange of fire and the landing of 600 marines under Captain Anthony Colve, the English surrendered. … For all the efforts of Cornelis and Benckes, the new Dutch rule at New Orange was short-lived, and in November 1674 the colony reverted to England under the Treaty of Westminster, a bargaining chip in the peace process, and the Dutch empire in the New World finally came to an end. (Douglas, n.d., pp. 3-4)

The Great Migration

With the Dutch out of their way—at least in America, as soon the Second Anglo-Dutch War (1665-1667) would erupt in Europe (Figure 14)—the colonies began to receive new groups of settlers. Settlers such as the Quakers, a dissenting Protestant group that broke away from the Church of England, and the Presbyterians, the Baptists and the Methodists. These were the religious British colonists known as Puritans, who were looking for religious freedom. Which is to say, they mainly wanted freedom for *their* religion, not for other religions. Between 1630 and 1640, more than twenty thousand Puritan men, women and children took part in the 'Great Migration' from the East Anglian parts of England to their new home. British religious groups were not the only ones to immigrate, as from Germany, France and Switzerland, came the Amish, Moravians, Huguenots and Mennonites.

An interesting case is the creation of the colony of Pennsylvania. It was the result of a Charter the English king Charles II had given to *William Penn* (1644-1718). The king owned his father—an admiral in the English Navy—a large debt of more than £16.000[56]. To settle that debt, he gave in 1681 a large piece of land (120.000 km^2) in the territory between Lord Baltimore's province of Maryland and the Duke of York's province of New York. Soon the legislative foundation for the Quaker Province had been created and religious immigrants from England,

[56] Equivalent to £2,110,000; calculation based on historic opportunity costs. Source: http://www.measuringworth.com/ukcompare/relativevalue.php. (Accessed June 2015)

Scotland, Germany and Ireland arrived in the new colony of Pennsylvania.[57]

Far from the principles established in the first Royal Charter that created the colony of Virginia, and some decades later, it is clear that the colonies had become primarily business ventures for the British King and the aristocracy around him. The king, as we have seen before, was always in need of money.

> *James, whether as duke or king, had no appreciation of the term "liberties of Englishmen," and he endeavored to destroy the corporations in New England, in the interest of his revenues, with the same indifference he showed in manipulating corporations in England in the interest of a Tory majority in Parliament.* (Andrews, 1904, p. 268)

In order to protect British business interests, in 1651 the *Navigation A*ct forbade the colonists from using foreign ships for trade between Britain and its colonies, or from trading directly with other countries like the Netherlands, Spain and France, or their colonies, for certain "enumerated' goods like sugar, cotton and tobacco. The Act was designed to keep the successful Dutch merchants at bay.

Not only for adventurous settlers, soon were the colonies also a place for England's surplus and unwanted population, such as the previously mentioned people in fear of religious persecution who fled England, the Puritans. The new colonies were also the first penal colonies that received many convicts (their 'crime' being often that they were poor and could not pay their debts) from England, Scotland, Wales and Ireland. So, the inhabitants of the New World had a mixed background, from farmers to convicts and from the religiously oppressed to the politically deviant. However, they had one thing in common: their status was one of *servitude*, and their station in life was *unfreedom*. That was already the case in their country of origin, and for many that was still the case when they went to the colonies under the system of *indentured servitude*.

> *The system provided opportunities for improvement to many who voluntarily chose to make a go of it in the New World. For many, the system was comparable to servitude and apprenticeship in England. The terms of service were longer in America, and the labor was generally more arduous, but the incentives via freedom dues were greater than in Britain, and those ex-servants who set up as small planters probably did better than if they had stayed at home. In fact, when falling real wages and bad harvests in mid-seventeenth-century England made the overseas option more attractive, and when indenturing oneself to pay transportation costs was the only way to cross the Atlantic, then the indentured*

[57] The name is referring to the family name Penn and the word sylvania : latin for woods.

> *servant system actually offered opportunities. Moreover, until about 1660 the chances were high that a young man who completed an indenture in the Chesapeake could achieve a comfortable position in society.* (Fogleman, 1998, p. 47)

Most of the early immigrants were so poor that they could not even pay for the voyage, about six pounds per person[58]. At first the colonial companies provided the cost of the voyage in return for a servitude contract, but later the 'Headright System' was implemented to attract new colonists. In this system, to stimulate the immigration of new workers in Virginia and Maryland around 1620, the plantation owner was awarded 50 acres (200,000 m^2) of land for each new settler who would work as an indentured servant. So, the owner of a plantation paid for the settler's voyage in return for a labour contract of five years. At the end of the contract, the 'indentured servant' would receive his 'Freedom dues': some land, money, clothes or food. It was a system that in practice encountered many problems, especially as by 1660 the best lands were claimed by the large landowners. The former servants were pushed westward, where the mountainous land was less arable and the threat from Indians constant. The system contributed to the first rebellion in the American colonies where white settlers opposed the ruling governor: *Bacon's Rebellion*. The rebellion occurred in 1676 when a thousand Virginians of all classes rose up in arms against Governor William Berkeley—brother of the before mentioned John Berkeley, 1st Baron Berkeley of Stratton—and torched Jamestown.

The Era of Settlement

The seventeenth century saw the establishment of a range of settlements on the American coast, most of them based on a Charter from the British monarch, the Dutch Republic or, occasionally, another European monarch. Examples include the previously mentioned British *Saybrook Colony* created in the late 1630s by the Providence Company under Charles I. This company was created by the aristocrats William Fiennes (Earl of Saye and Sele), Robert Greville (Earl of Brooke) and Robert Rich (Earl of Warwick), and the Broughton Castle circle of puritan entrepreneurs, among whom were nine members of Parliament. Or take the region *Rensselaerswijck*, owned by the Dutch Rensselaer family, that started in 1630 when one of the directors of the *Dutch West India Company,* the diamond and pearl merchant Kiliaen van Renseselaer (1586-1643) of Amsterdam, obtained the estate on the Hudson River. Another example is the previously mentioned settlement of *New Amsterdam* that was created by the Dutch West India Company under a charter from the Dutch Republic and where in 1624 the

[58] Equivalent to £1,019 based on the historic standard of living. Source: www.measuringworth.com. (Accessed June 2015)

first group of Dutch families settled. On the southern coast—now Florida—the Spanish also created settlements. On the northern coast of Newfoundland, the French expanded their trading posts—like the one that would become Quebec—into the French Canadian colonies in a constant struggle during the *Beaver Wars* and the *French and Indian Wars* (aka the different *Intercolonial Wars*).

The Northern Americas, as well as the Caribbean, were the primary scene where the imperialistic expansion from Spain, France and Britain were conducted. Over a period of a century, this expansion would result in several wars: the *First Intercolonial War* (1688-1697), the *Second Intercolonial War* (1702-1713), the *Third Intercolonial War* (1744-1748), and the *Fourth Intercolonial War* (1754-1763). In the end, the British were the winners who took it all.

The Thirteen Colonies

By the mid eighteenth century, the British had chartered two dozen American colonies (eg Newfoundland, Nova Scotia, Bermuda). Among these were the thirteen colonies on the Atlantic coast of North America (Figure 15), founded between 1607 (the colony of Virginia) and 1731 (the colony of Georgia).

The Northern New England colonies were dominated by agriculture and attracted British settlers. The fertile grounds of the Middle colonies attracted immigrants from all over Europe. The Southern colonies were less cosmopolitan, had large plantations which produced tobacco, rice,

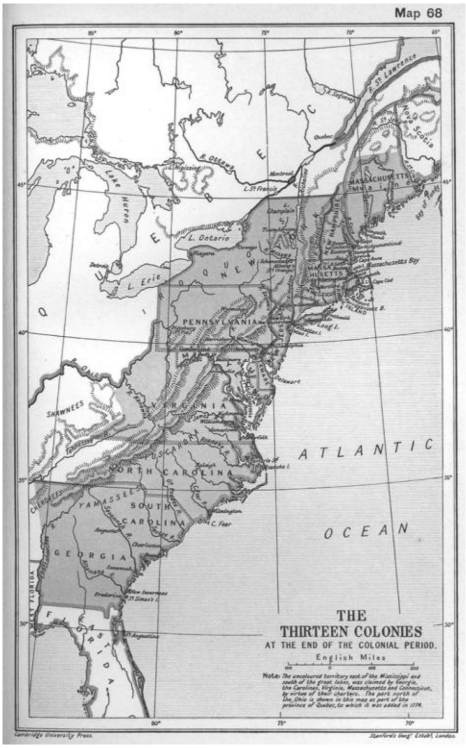


Figure 15: The thirteen British colonies in North-America (1763).

Source: Cambridge University Press; Stanford's Geog. Est. London and indigo, and needed a workforce. Here it was that slavery would find its roots.

The growth of population was rapid, from about 466,000 colonial inhabitants in 1720 to 2.5 million in 1775. Partly this was due to natural increase (birth rate versus death rate), but it was also the result of massive immigration.

> *By 1750, more than one million people, representing a population increase of significant proportions, were living in the thirteen colonies along the Atlantic coast. Disease, which had threatened the survival of many of the early settlements, was much reduced. Infant mortality rates in the colonies were much lower than those in England, and life expectancy was considerably higher. Women married earlier, giving them the opportunity to have more children, and large families were the norm. It was not uncommon at all for a woman to have eight children and more than forty grandchildren.*[59]

Among all those people were many who were attracted by the religious freedom the colonies offered. A large number of the European immigrants were Quakers—aka Society of Friends—a Christian religious group that rejected social hierarchy. By 1750 they were the third largest religious denomination in the American colonies.

> *By 1760 the immigrants—slaves, convicts, indentured servants of all sorts, and free passengers—had become quite visible as part of a colonial world characterized by a hierarchy of ranks and degrees of dependency. Slavery flourished in the colonies, challenged only by the Quakers and a few others, and convicts arrived in record numbers. Both the English and the Americans considered indentured labor (including that of apprentices and of adults who bound themselves out in exchange for a lump sum) as a normal form of voluntary labor. Indeed, until the eighteenth century, most labor in England and the colonies was bound, and workers were normally referred to as "servant".* (Fogleman, 1998, p. 57)

Most people lived in rural conditions. The cities of that time (1760) were small; Boston had 16,000 inhabitants; Newport Rhode Island: 7,500; New York City (Figure 16): 18,000; Philadelphia: 23,000; Charlestown: 8,000 inhabitants. Those cities all had the civic problems of garbage disposal, sewer drainage, fire hazards and crime prevention.

[59] Source : Colonial Society and Economy, Cliffnotes. http://www.cliffsnotes.com/ (Accessed April 2015)

Figure 16: New York City (1767).

Source: http://www.old-maps.com/NY/ny_townmaps/ nyc/manhattan/nyc_1767_Ratzen_web.jpg

In total, by 1775 about 2.5 million white people had settled in the Thirteen Colonies[60]. Some 85% were of English, Irish, Scottish or Welsh descent, 9% were German and 4% Dutch. Most of them were farmers working the fertile lands; they created the *rural economy*. The small cities and seaports linked the colonial economy to the larger British Empire; they were trade-dominated and created the *mercantile economy*.

Although the regional circumstances for the Colonies were quite different, they had one thing in common. There was no European aristocracy nor was there one dominant established church, and there was no long tradition of powerful guilds as in Europe. People worked in their own interests.

> *Two of the most fundamental factors in the growth of the thirteen colonies were the character of the people and the nature of the land and resources to which they applied their labor. The connecting link between the two that gave the thirteen colonies their unique character was the system of small individual holdings that came into being, usually at the start of settlement. It provided a strong incentive to labor and was therefore a major factor in their development. Crevecoeur spoke of "that restless industry which is the principal characteristic of these colonies," and observed: "Here the rewards of . . . [the farmer's] industry follow with equal steps*

[60] Source : http://www.history.com/topics/thirteen-colonies

> *the progress of his labor; his labor is founded on the basis of nature, self-interest, can it want a stronger allurement .. . ? As farmers they will be careful and anxious to get as much as they can, because what they get is their own."* …
>
> *Such immigrants were, to a large extent, industrious, progressive, and energetic. Their productivity was stimulated by the climate of freedom in which they lived-a climate that was made possible in good measure by the indulgence of the government.* (Nettels, 1952, pp. 107-108)

As result of the mercantilist policy, the British did what they could to prevent the rural nature of the colonies from changing from home manufacturing into industrial manufacturing. They created Acts like the *Hat Act* (1732) that forced Americans in the colonies to buy British-made goods, and this artificial trade restraint meant that Americans paid four times as much for hats and cloth imported from Britain than for local goods.

> *British statutes restrained the American woolen, iron, and hat industries. The colonies could not impose protective tariffs on imports from England. They could not operate mints, create manufacturing corporations, or establish commercial banks institutions that are essential to the progress of manufacturing* (Nettels, 1952, p. 113)

Colonial Self-Government

In the thirteen colonies, the population was governed in a totally different political 'climate' than in good old England. Sure, the British Empire installed in each Colony a governor who ruled on behalf of the British government and who represented the Crown. Legislation was based on the *Rights of Englishmen*, the traditional and basic rights all the subjects of the English monarch were understood to be entitled to. Rights of Englishmen that should also apply to the colonists. The Royal Chapters allowed for the establishment of self-government and elections of the Governor's Council (a body of senior advisers to the appointed royal Governor). The council had to approve new laws, which usually originated in the legislature. It also decided on tax issues, budgets and other civic concerns.

Next, there were—over a period of time—established Assemblies whose members were elected annually. As many settlers were—by definition, as they were granted land when they arrived—land owners (also called 'freeholders', like in England), the number of eligible voters (the franchise[61]) was large. Generally speaking, the colonies were used to a form

[61] The franchise was the number of eligible white males who had a long-term economic stake in the society. This franchise could be different from county to county.

of self-government in which many participated. That was the 'official' structure implied in different forms regionally and locally, including the local flavours of dominant—and even fraudulent—landowners, vote bribery, abuse and election fraud, and all else that is part of human nature.

> *In general, both social prestige and political power tended to be determined by economic standing, and the economic resources of colonial America, though not as unevenly distributed as in Europe, were nevertheless controlled by relatively few men. …*
>
> *Like in the south the planter class who, joined by a few prominent merchants and lawyers, dominated the two most important agencies of local government—the county courts and the provincial assemblies. … New England society was more diverse and the political system less oligarchic than that of the South. In New England the mechanisms of town government served to broaden popular participation in government beyond the narrow base of the county courts.*
>
> *… The social and political structure of the middle colonies was more diverse than that of any other region in America. New York, with its extensive system of manors and manor lords, often displayed genuinely feudal characteristics. The tenants on large manors often found it impossible to escape the influence of their manor lords.*[62]

Take, for example, the region that would become the State of New York after it had been obtained from the Dutch. The rising inequality in the social fabric of the colonies resulted in social discontent between the landlords and small farmers. It resulted in revolts such as the *Prendergast Rebellion* of 1766. This turmoil related to the colonial land distribution that was exploited by some shrewd landlords who fraudulently/semi-legally obtained large tracts of lands, often from Indians.

> *For, discerning eyes could catch glimpses of transactions that were not without taint of fraud. Huge grants were inspired by bribes, family connections, and fee hunger. Colonial governors made many of these illegal sales in violation of colonial statutes or British instructions that limited the size, or prohibited the making, of land grants. Where these limitations on the transfer of land were not boldly violated, they were subtly circumvented by the use of "dummy" grantees or of fictitious names. Nor were land-hungry governors averse to these illegal and corrupt practises where they themselves were the chief beneficiaries. Vaguely defined metes and bounds, and Indian grants wrested from drunken or credulous natives afforded opportunities to the unscrupulous for swelling their landed estates. Overlapping grants and Indian claims arising from these circumstances were a*

---

[62] Source: Beeman, R.R. Imperial Organization. http://www.britannica.com/EBchecked/topic/616563/United-States/77690/Imperial-organization. (Accessed February 2015)

source of colonial violence and litigation. From all these seeds came the bitter fruit of controversy. (Mark, 1942, pp. 111-112)

The result was that some very large estates—called Manors—were established (Figure 17). On these lands lived the tenants who rented their tenancy, often paying for it in kind and labour, under laws that protected the landlord, not the tenant. It was England copied all over again.

Such were Cortlandt Manor's 86,000 acres[63] *and Philipsborough's 205,000 acres in Westchester County; Philipse Highland Patent's 205,000 acres in that part of Dutchess which subsequently became almost the whole of Putnam County; Livingston Manor's 160,000 acres in that part of Albany County which later became the southern third of Columbia; and, again in Albany County, Rensselaerswyck's 1,000,000 acres which exceeded the total acreage of Rhode Island by over 200,000 acres. …*

For, although feudal manors had become obsolete, their lords still retained considerable economic and political power over the tenants. Whether on the manors or on the patents, the tenants were oppressed by onerous obligations such as perpetual rents, tax burdens, or alienation fees. … For the law covered the landlord, though not the tenant, with the mantle of security of tenure. Statutes made dubious titles certain: a recording system, which was of special concern to the large landowner, kept the titles clear. Furthermore, the law of inheritance for intestacy, through entails and primogeniture, encouraged the maintenance of a landed aristocracy. …

Figure 17: Hudson River Valley manors and patents.

Top indicates Manor of Rensselaerwijck, middle right Livingstone Manor and bottom right Cortlandt Manor

Source: (McCurdy, 2001) p.3

[63] An acre is about 0.4 hectare. So 86,000 acres would be 34,400 hectares/344km^2. Livingston's 160,000 acres equal to 650 km^2.

> *Against such an array of landlord power, what prospect of improving his lot did the small farmer have in an appeal to executive, legislative, or judicial remedies? … The closing of all peaceful avenues forced the small farmer to resort to violent action to better his state of economic and political dependence.* (Mark, 1942, pp. 112-116)

In the system of Manors, low class farmers were trapped. It is not too surprising that in the mid-eighteenth century a major turmoil of agrarian disturbances broke out. The Manors were stormed, and the disturbances became an anti-rent war. The tenants sought legal justice at first, but as their cases were before a council of great landowners indirectly interested in the outcome, there was but one conclusion: the tenants lost. However, 'The discontent did not confine itself to litigation. It flared into serious peasant rebellions that appeared in 1766 in disaffected areas in the eastern part of Hudson Valley from Cortlandt Manor to Rensselaerswyck' (Mark, 1942, p. 116).

The uprisings spread, and more and more people protested in different places. A governmental proclamation issued on April 30, 1766, offered a reward for the seizure of specifically named leaders of the farmers' movement, including William Prendergast. By the end of June 1766, the movement involved approximately 1,700 tenant farmers, armed with firearms. They were known as 'Levelers' because they believed that their equitable claim to the land should be recognized and their leases converted into fee simple titles.

> *To meet this many-headed danger, the provincial authorities launched a vigorous counter-attack. At the end of June, the Twenty-eighth Regiment landed at Poughkeepsie. Under Major Thomas Brown, it engaged in a skirmish which resulted in the dispersal of the anti-renters and the capture of eight of them. … 'The Nineteenth Infantry, a company of the Twenty-sixth Regiment, with a detachment of the artillery train and three field pieces embarked for Claverack where the Van Rensselaers experienced disorders.* (Mark, 1942, pp. 125, 126-127)

On Wednesday, August 6, 1766, William Prendergast was brought to trial on the charge of high treason. The jury found him guilty with a recommendation of mercy, but the court sentenced 'that the Prisoner be led back to the Place whence he came and from thence shall be drawn on a Hurdle to the Place for Execution, and then shall be hanged by the Neck, and then shall be cut down alive, and his Entrails and Privy members shall be cut from his Body, and shall be burned in his Sight, and his Head shall be cut off, and his Body shall be divided into four Parts, and shall be disposed of at the King's Pleasure' (Mark, 1942, p. 129). Again, it seemed like the rule of good old England.

> *The widespread sympathy for Prendergast left the Sheriff unable to secure anyone to assist in the execution of the sentence notwithstanding his advertisement that the helper "will meet with a good reward, he shall be disguised so as not to be known, and secured from Insults."* (Mark, 1942, p. 130)

Prendergast was not executed. Instead, he received, due to his wife's efforts, a royal pardon six month later.

The landlords prevailed, and many settlers moved to other areas. But quite some decades later, during the Anti-Rent Era (1839-1865), when thousands of tenant families rose again against the manor system and refused to pay rents, the system collapsed (McCurdy, 2001).

Apart from these regional exceptions, basic to the colonies' social fabric was something additional, something that was in the 'nature of the situation'. In the majority of the colonies—with the exception of the examples given before—due to the absence of the old British 'landed gentry' and their land-based power of manorialism[64], the former power holders of a feudal society—the British aristocracy—were to a large extent absent. In general, there were no—with the exception of the New York manors—former landholders, as there had been for centuries in Europe. The former landholders were the local Indians, and they were not considered relevant as a power factor. Also, the power of the clergy that had ruled all over Europe for centuries was absent. Not that religion did not play a role in the daily life of the colonists, but there was no landowning church that dominated the peasantry like in Europe. Over time, as many colonists adhered to different religions (eg Roman Catholic, Jewish, Lutheran, Protestant, Anglican, Quakers and Presbyterians), the colonies' religious diversity created a religious tolerance.

Colonial Economy into the 1780s

Every man was his own, and it was he, himself, who could improve his station in life. Many colonists were small landowners, giving them title in the legislative structure of those days. The effectiveness of that title was limited, but they possessed something more important. They supplied 'labour', and that would prove to be essential in the colonies, where land was available in abundance, but where labour was scarce.

Throughout the colonies, people relied primarily on small farms and self-sufficiency. Households produced their own candles and soaps, preserved food, brewed beer and, in most cases, processed their own yarn to make cloth. In the few small cities and among the larger plantations of

---

[64] The Lord of the Manor had legal rights over the people under the jurisdiction of his manor, and his fiefs have obligation to him, under the principle of 'nulle terre sans seigneur'.

North and South Carolina and Virginia, some necessities and virtually all luxuries were imported—in return for tobacco, rice and indigo exports—, which produced large profits in England's London, Bristol and Liverpool markets. In these areas, trade and credit were essential to economic life.

Early colonial industrial activity was closely associated with trade. A significant percentage of Atlantic shipping was on vessels built in the colonies, and shipbuilding stimulated other crafts, such as the sewing of sails, milling of lumber, and manufacturing of naval stores. Supportive industries developed as the colonies grew. A variety of specialized operations, such as those sawmills and gristmills, began to appear. Shipyards opened to build fishing fleets also, in time, started to build the basic merchant marine. Oak, which had become relatively rare in England, was easily available in New England. Iron manufacturing also gradually began to develop in the colonial era. [65]

The colonies depended on Britain for many finished goods, partly because laws prohibited making many types of finished goods in the colonies. These mercantile laws achieved the intended purpose of creating a trade surplus for Britain. As Britain was in nearly a state of constant conflict with France in the eighteenth century (eg the European *Seven Years' War* of

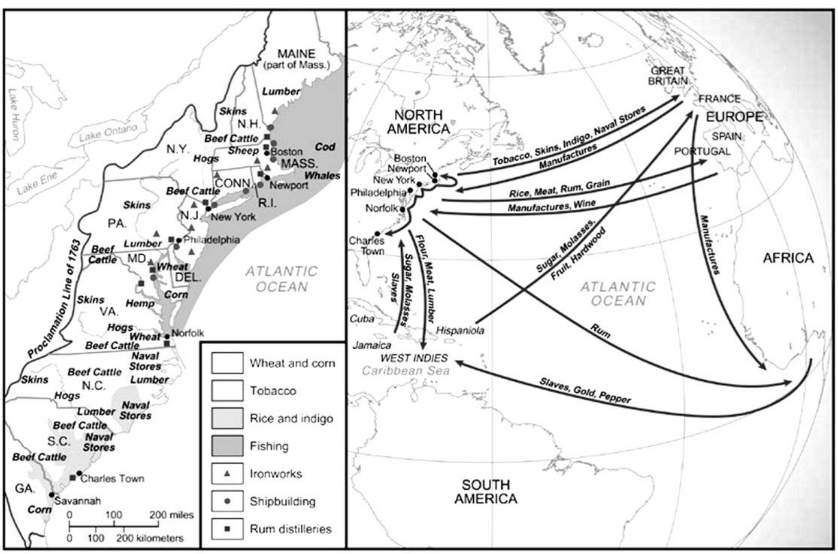


Figure 18: Colonial products and their trade (1750).

Source: US History Maps, http://jb-hdnp.org/Sarver/Maps/us_history_maps.htm

[65] Source: http://www.let.rug.nl/usa/outlines/economy-1991/a-historical-perspective-on-the-american-economy/colonial-economy.php (Accessed June 2015)

1756-1763), this had its effects on the colonial trade. For both countries, the Americas were the promised lands of undreamed wealth and fortunes. And as the colonies grew, they were to become a captive market for the surplus production of the mother countries as well as a source of basic materials (eg cotton, rice) and luxuries (eg tobacco, sugar) (Figure 18). The essence was in creating a surplus in the Balance of Trade, and the richness would flow to the imperial power. But only the British managed to fulfil that dream. For the French, the Americas were a constant drain on the royal purse. This drain resulted—after the American *Fourth Intercolonial War*, aka French and Indian War (1754-1763)—in the dissolution of New France; Canada went to Great Britain, and Louisiana went to Spain. In 1803 Louisiana was sold to the United States by Napoleon Bonaparte.

The American Revolution (1765-1783)

In the mid-eighteenth century the British colonies were alive and kicking, a result of population growth, better living conditions and the blossoming local economy. Colonial trade—although restricted by the Navigations Act—flourished. The Virginia tobacco sold well (from planter to English merchant), and was taxed upon arrival in England (before 80% could be sold to the rest of Europe). The enumerated products, like flour, rice, fish, wheat, indigo and corn, contributed largely to the export. Again, they could only be sold to British merchants. British manufactured goods (knives, guns, cloth, pots & pans) were brought to Boston. Other imports were not allowed, as the *Staples Act* of 1663 forbade the colonists from buying any products grown or manufactured in Africa, Europe or Asia. It was mercantilism at is pinnacle.

Boston grew into the largest port outside Britain. The Northern colonies, due to the rocky soil, focused on building ships, had a thriving fishing industry and manufactured shoes, candles, coaches and leather goods. The Middle colonies produced flour, cereals and lumber. The Southern colonies produced rice, tobacco, cotton, naval stores (tar, hemp) and indigo for British consumption (Figure 18). Much was on credit as a result of the financing system that was applied:

> *Out of a total of nearly £ 3,000,0000*[66]*, debtors in the Southern plantation colonies had claims against them of nearly £ 2,500,000, or 84 per cent; as compared with £ 475,000, or16 per cent, against those owing in the commercial colonies in New England and the Middle Atlantic region.* (Sheridan, 1960, p. 167)

[66] Equivalent to $ 90,800,000 in 2014 when calculated as wealth based on of the historic standard of living. Source: www.measuringworth.com.

With the rise of a class of large planters it became customary for the planter to consign his crop to a merchant in London or the outports. The merchant, on a commission basis, sold the crop and purchased goods on order to ship to the planter by return vessel. When the proceeds of the crop were less than the cost of the goods ordered, as was often the case, the merchant charged the difference, together with other orders sent during the year, to the planter on open account. The debit balance was in effect a credit which was customarily granted for twelve months without interest and thereafter at five per cent on the unpaid balance. (Sheridan, 1960, p. 168)

This shows that the policy of Protectionism adopted by the British with respect to colonial America was designed to protect British workers and British businesses. To the detriment of the colonists, trade was controlled and facilitated by laws (eg the *Hat Act* of 1732, the *Molasses Act* of 1733, and the *Iron Act* of 1750), and all trade was taxed. It was all about protection, but only protection of the British interest, not the colonists.

Passing a Law might be easy, but upholding it was more complicated due to 'colonial evasion'. To avoid the duties that were to be paid, a complete smuggling industry arose that easily bypassed the meagre British customs control. Ships from the colonies often loaded their holds with illegal goods from the French, Dutch and Spanish West Indies. American shippers soon became quite skilled at avoiding the British navy. To uphold the Acts that were part of the British mercantilism[67], the British government chose to apply 'salutary neglect'; they pretty much left the colonies alone, allowing customs officials to take bribes in exchange for looking the other way. Smuggling soon became part of American free trade and was seen as a natural right.

For example, in 1756 and 1757, some 400 chests of tea were imported into Philadelphia, but only sixteen were imported legally. Indeed, three-quarters or more of the tea consumed by Americans was illegal. In 1763, the British government estimated the value of commodities smuggled into the colonies at 700,000 pounds annually, an enormous sum[68] at that time. (G. H. Smith, 2011)

In 1763 the British decided to uphold the trade laws (eg the *Navigation Act*), and eight warships and twelve armed sloops were sent to patrol American waters and pull in smugglers. In addition, new laws were implemented adding new taxes, regulations and rigorous methods of

[67] The basic idea behind this 'mercantile system' or 'mercantilism' was fairly simple. The colonies were to produce raw materials, many of which could be shipped only to Britain, and Britain, in turn, would produce finished products to sell to the colonies.

[68] Equivalent to £9,249,000,000 in 2014; calculation based on economic cost. www.measuringworth.com.

enforcement. The effect of the *Sugar Law* was not so much tax revenues—although duties were increased on non-British goods shipped to the colonies—as the law was intended to make custom enforcement more effective. Now custom officers were absolute in their legal powers, and any ship-owner would probably be guilty of some violation. The tables of power were turned totally as the government did not have to present evidence of fraud, and the charged party had to pay the cost of the process in advance. The owner was presumed guilty and had to prove his innocence. It was a shock for the colonists.

> *…, Americans who had grown accustomed to decades of "salutary neglect" deeply resented the post-war efforts of the British government to impose taxes—especially when those taxes were raised for the express purpose of maintaining 10,000 British troops in the colonies.* (G. H. Smith, 2011)

In Britain at that time, the economy blossomed. It was the Era of Steam Power, as James Watt's steam engine had begun to be used in mining and manufacturing[69].

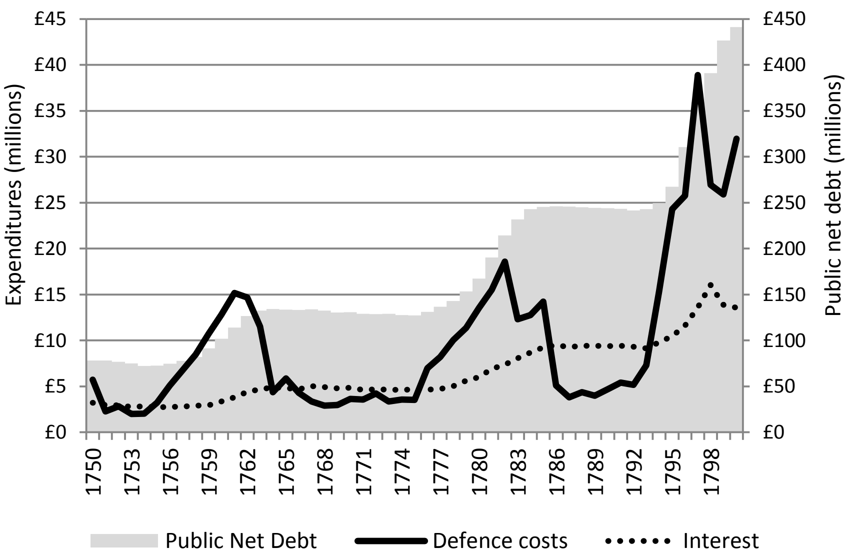


Figure 19: British governmental expenditures and public debt 1750-1800

The graph shows the sharp increase in public debt in the early1760s, the early 1780s, and the late 1790s. It was the result of the costs of the Seven Years War (1754-1763, the American Revolutionary War (1775-1783) and the French Revolutionary Wars (1793-1802).

Source: http://www.ukpublicspending.co.uk/

[69] See: B.J.G. van der Kooij: *The Invention of the Steam Engine.* (2015). pp. 36-71

> *In Great Britain the years from the mid-sixties to the early seventies were characterized by a remarkable expansion of manufacturing, mining, and internal improvements which is the well-known story of the early Industrial Revolution. Capital was relatively cheap, and its market was widened by the aid of merchants and bankers. The expansion was by no means confined to the home island, for colonial planters and merchants shared in the movement. By 1769 the credit boom was underway and reached a dizzy height before its collapse in mid-1772.* (Sheridan, 1960, p. 162)

However, as the economy was intensively related to war, it had its ups and downs due to all that warfare. In periods of war, public expenditures rose considerably, causing an increase in the public debt. And, as the bankers wanted repayment of the loans and a hefty interest, the cost of this debt was enormous. The result was that two subjects dominated governmental expenditures: the 'cost of defence' and the 'costs of interest' (Figure 19).

Life in the colonies was quite 'socially dynamic'. Sure, there were the societal problems among hot-headed colonists, power struggles between groups of settlers, and conflicts between landowning settlers and those without land. Sometimes even the local natives dared to complain about their treatment. In addition to these problems, there were also the struggles

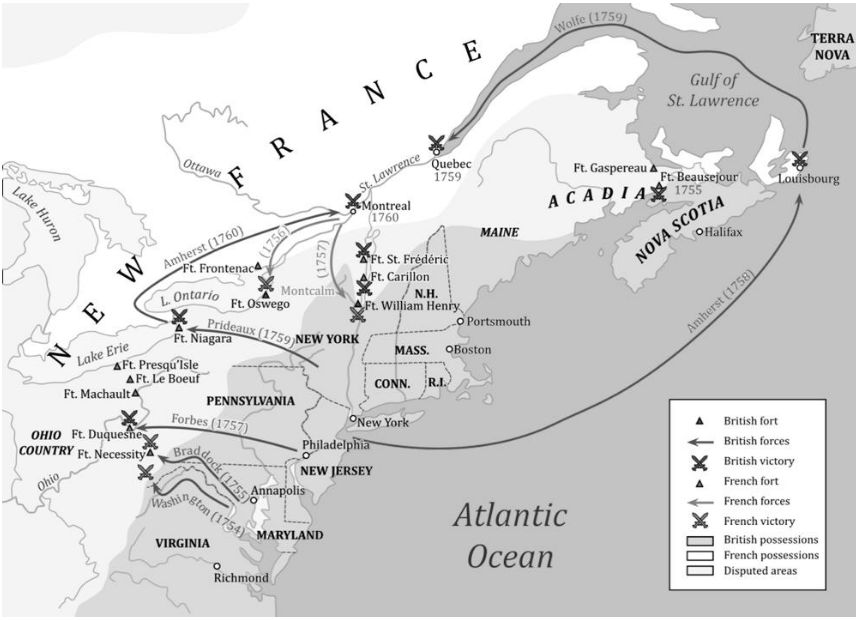


Figure 20: French and Indian War (1754-1763).

Source: Wikimedia Commons

with other colonial countries (like France) and the Indians tribes outside the colonies. The land claims of the French North American colonies (New France) brought them into territorial conflicts with the American colonies. The continuing westward colonization brought conflicts with new tribes, resulting in the *French and Indian War* (1754-1763) (Figure 20). This was a quite costly affair for Britain, which was facing a doubled national debt. To recoup the costs of war, British Parliament decided—for the first time—to tax the colonies to contribute to the colonial defence by introducing the *Stamp Act*. This was a total reverse in the British Policy towards the American colonies.

> *The Stamp Act of 1765, which Parliament imposed on the American colonies, placed a tax on paper, legal documents, and other commodities; limited trial by jury; and extended the jurisdiction of the vice-admiralty courts. The act generated intense, widespread opposition in America with its critics labeling it "taxation without representation" and a step toward "despotism."* [70]

The result was widespread public protests, and even the creation of underground organizations like the *Sons of Liberty*. The argument was again 'no taxation without representation'; as the colonies did not have any delegates in the British Parliament's House of Common who could represent their interests. The *Sons of Liberty* were particularly adept at employing intimidation and violence to hamper the distribution of stamps; they frequently burned tax collectors in effigy and ransacked the homes of British officials.

> *Arthur Lee of Virginia asked rhetorically whether any member of [the British] Parliament actually "know us, or we him? No. Is he bound in duty and interest to preserve our liberty and property? No. Is he acquainted with our circumstances, situation, wants, etc.? No. What then are we to expect from him? Nothing but taxes without end."* [71]

The Stamp Act also resulted in the *Stamp Act Congress* in 1765, which unified the individual colonies in a common cause and resulted in the *Stamp Act Resolves*. Colonial leaders channelled popular opposition to the tax by way of petitions to the king and Parliament. The protest was about much more than the repeal of the Stamp Act. It was about the power to decide on colonial affairs. Now the issue at hand became the right to taxation. All the colonists declared that, due to 'No taxation without representation', any law affecting the colonists—such as the Sugar Act and the Stamp Act—were illegal. This was a view already supported by the political scholar Nicolas de

---

[70] Source: http://loc.gov/exhibits/magna-carta-muse-and-mentor/no-taxation-without-representation.html (Accessed April 2015).
[71] Source: http://www.taxhistory.org/www/website.nsf/Web/THM1756?OpenDocument (Accessed April 2015).

Caritat, marquis de Condorcet, who wrote in 1795, waiting to being arrested as a traitor to the French Revolution[72]:

> *They [the colonists] understood, more perfectly perhaps than Europeans, what were the rights common to all the individuals of the human race; and among these they included the right of not paying any tax to which they had not consented. But the British Government, pretending to believe that God had created America, as well as Asia, for the gratification and good pleasure of the inhabitants of London, resolved to hold in bondage a subject nation, situated across the seas at the distance of three thousand miles, intending to make her the instrument in due time of enslaving the mother country itself. Accordingly, it commanded the servile representatives of the people of England to violate the rights of America, by subjecting her to compulsory taxation. This injustice, she conceived, authorized her to dissolve every tie of connection, and she declared her independence.* (Condorcet Caritat, 1795, p. 209)

The Brits reacted by repealing the Stamp Act, but they replaced it with another act, the *Declaratory Act*, in 1766. This act asserted British Parliament's authority to pass laws that were binding on the American colonies. It was a direct copy of the *Irish Declaratory Act*, an Act which had placed Ireland in a position of bondage to the crown, implying that the same fate would come to the Thirteen Colonies. Also in 1768 some 4,000 new British troops arrived in Boston in response to the social unrest. Together, these events created even more unrest, and in 1770 the turmoil resulted in the *Boston Massacre* (Figure 21), an incident in which British soldiers killed five civilians. This event fuelled the opposition against British rule. And the British already had quite a few problems of their own, such as the Bank Crisis of 1772, when hundreds of banks went bankrupt.

Figure 21: The Boston Massacre (1770).

Source: blog.encyclopediavirginia.org

[72] He wrote 'Esquisse d'un tableau historique des progrès de l'esprit humain' (Sketch for a Historical Picture of the Progress of the Human Spirit), one of the major texts of the Enlightenment and of historical thought. See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'. (2015)* p.174

> *Bankruptcies in England, which had averaged 310 in the eight years preceding the panic, rose to 484 in 1772 and 556 in 1773. From London the panic spread to other parts of England and Scotland where a number of banks, including the one at Ayr, were forced to suspend payments. A fresh outbreak occurred on the continent of Europe in late 1772 and early 1773, when there was such "an extensive crash, that there seemed to be an universal wreck of credit. …*
>
> *Meanwhile the crisis had spread to British colonies and spheres of influence in India and America. One manifestation of credit stringency was the curtailment by the Bank of England of advances to the East India Company and a demand for debt repayment. By July of 1772 the Company was so "overwhelmed with debt and burdened with the cost of a disastrous war against Hyder Ali" that it had to confess its inability to carry out its engagement.* (Sheridan, 1960, p. 172)

To help the financially ailing British East India Company to get rid of their massive surplus of tea stocked in the warehouses, the *Tea Act* was introduced on May 10, 1773. Intended to block the parallel import of tea by Dutch smugglers to America, the act allowed East India to ship its tea directly to America and be taxed there. Immediately, a coalition of merchants, smugglers and artisans, similar to that which had opposed the Stamp Act of 1765, mobilized opposition to delivery and distribution of the tea.

The ensuing turmoil culminated in 1773 with the *Boston Tea Party*, which was basically a protest about tea tax and the tea monopoly of the East India Company. The cargo of three tea ships anchored in the Boston Harbour

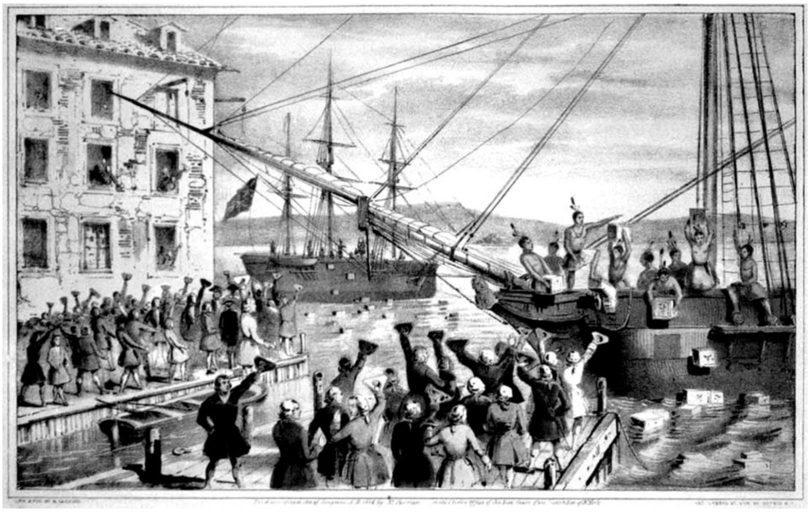


Figure 22: The destruction of tea at the Boston Harbor (1773).
Source: Wikimedia Commons, Nathaniel Currier

was thrown in the sea (Figure 22). As punishment, the Brits reacted with the *Intolerable Acts (*aka *Coercive Acts)* of 1774, which included the *Boston Port Act* that effectively shut down *all* commercial shipping in Boston harbour. Boston Harbour was now completely blocked by the British Royal Navy, whose warships patrolled the entrance. British troops joined in enforcing the blockade. This shutdown hurt not only the local Bostonians, but also the inhabitants of the whole of Massachusetts and neighbouring colonies. The colonist reacted with the *Declaration of Rights and Grievances* that declared that taxes imposed on British colonists without their formal consent were unconstitutional:

> *'That the foundation of English liberty, and of all free government, is a right in the people to participate in their legislative council: and as the English colonists are not represented, and from their local and other circumstances, cannot properly be represented in the British parliament, they are entitled to a free and exclusive power of legislation in their several provincial legislatures, where their right of representation can alone be preserved, in all cases of taxation and internal polity, subject only to the negative of their sovereign, in such manner as has been heretofore used and accustomed'* (text of Declaration).[73]

In an increasingly revolutionary atmosphere, in the colony of Virginia, a series of political meetings—the *Virginia Conventions*—were held to discuss the colonial relationship to the motherland. The colonists were ready to defend themselves 'against any form of despotism'. In the fifth convention on May 15, 1776, they declared independence from Britain by way of three resolutions: one called for a declaration of rights for Virginia, one called for establishment of a republican constitution, and a third called for federal relations with whichever other colonies would have them and alliance with whichever foreign countries would have them. De facto, they wanted to end the relationship with Britain. The text read:

> *We, his Majesty's dutiful and loyal subjects, the delegates of the freeholders of Virginia, deputed to represent them at a general meeting in the city of Williamsburg, avowing our inviolable and unshaken fidelity and attachment to our most gracious sovereign, our regard and affection for all our friends and fellow subjects in Great Britain and elsewhere, protesting against every act or thing which may have the most distant tendency to interrupt, or in any wise disturb his Majesty's peace, and the good order of government, within this his ancient colony, which we are resolved to maintain and defend at the risk of our lives and fortunes, but at the same time affected with the deepest anxiety, and most alarming apprehensions of those grievances and distresses by which his Majesty's American subjects are oppressed, and having taken under our most serious deliberation the*

[73] Source: http://avalon.law.yale.edu/18th_century/resolves.asp (Accessed April 2015)

> *state of the whole continent, find that the present unhappy situation of our affairs is chiefly occasioned by certain ill-advised regulations, as well of our trade as internal policy, introduced by several unconstitutional Acts of the British Parliament, and at length attempted to be enforced by the hand of power; solely influenced by these important and weighty considerations, we think it an indispensable duty which we owe to our country, ourselves, and latest posterity, to guard against such dangerous and extensive mischiefs, by every just and proper means.*[74]

In twelve points, they declared a ban on the import of British goods, the import or purchase of slaves, and the import of tea and other goods of the British East India Company (honouring their Boston compatriots). Also, the export of tobacco and other commodities would be halted.

Other colonies had also contemplated a reaction, as in 1774 the delegates from twelve colonies met in the first *Continental Congress*. On October 20, 1774, the *First Continental Congress* (Figure 23) adopted the *Continental Association* in which delegates agreed to a boycott of English imports, an embargo of exports to Britain, and the discontinuation of the slave trade. The discussions were about economic counteraction to the British, not about abandoning the British governmental system. Among the delegates, there were those who sought legislative equality with Britain and those who instead favoured independence and a break from the Crown and its excesses. On May 10, 1775, the *Second Continental Congress* met, and the discussions continued. That resulted in the *Articles of Confederation*, the document signed by the thirteen colonies that established America as a confederation, which was finally ratified in 1781.

Figure 23: Debate at the First Continental Congress (1774).

Source: www.history.com

[74] The Association of the Virginia Convention; August 1-6, 1774. Niles, Hezekiah (1777-1839). Principles and acts of the Revolution in America, … http://avalon.law.yale.edu/ 18th_century/ assoc_of_va_conv_1774.asp (Accessed April 2015)

The American Revolutionary War (1775-1783)

By that time the *American Revolutionary War* had already started with the *Battle of Lexington and Concord,* in April 19, 1775. This military conflict was the result of the local opposition against the Boston blockade, which had caused the British Government to declare the colony of Massachusetts 'to be in a state of rebellion' in 1775. Some 4,000 British troops had already been sent to occupy Boston. They controlled the city, but could not control the countryside where the colonists had organized militia. In this type of defence, the colonists were well experienced as they had often had to organize against Indian attack.

As the militant colonists had stored munitions out of reach of the British to supply the growing militia[75] in Massachusetts, the Brits were planning a counter action. Leaving Boston on the night of April 18, 1775, they intended to go on secretive mission to seize the militia's supply stores in nearby Concord and imprison the rebellion's leaders. However, the plan was discovered by Doctor Joseph Warren, and the militia warned during the night by the silversmith Paul Revere and William Dawes (aka the 'Midnight Ride'). The forewarned militia quickly restocked their supplies, and when the Brits first reached the town of Lexington, the 77 militiamen were facing 700 British troops.

> *The heavily outnumbered militiamen had just been ordered by their commander to disperse when a shot rang out. To this day, no one knows which side fired first. Several British volleys were subsequently unleashed before order could be restored. When the smoke cleared, eight militiamen lay dead and nine were wounded, while only one Redcoat was injured. The British then continued into Concord to search for arms, not realizing that the vast majority had already been relocated. They decided to burn what little they found, and the fire got slightly out of control. Hundreds of militiamen occupying the high ground outside of Concord incorrectly thought the whole town would be torched.… After searching Concord for about four hours, the British prepared to return to Boston, located 18 miles away. By that time, almost 2,000 militiamen—known as minutemen for their ability to be ready on a moment's notice—had descended to the area, and more were constantly arriving. At first, the militiamen simply followed the British column. Fighting started again soon after, however, with the militiamen firing at the British from behind trees, stone walls, houses and sheds. Before long, British troops were abandoning weapons, clothing and equipment in order to retreat faster.* (Staff, 2009)

[75] Under provincial law, all towns were obligated to form militia companies, composed of all males 16 years of age and older, and to assure that the members were properly armed. The militias were formally under the jurisdiction of the provincial government, although in New England, the militia companies elected their own officers.

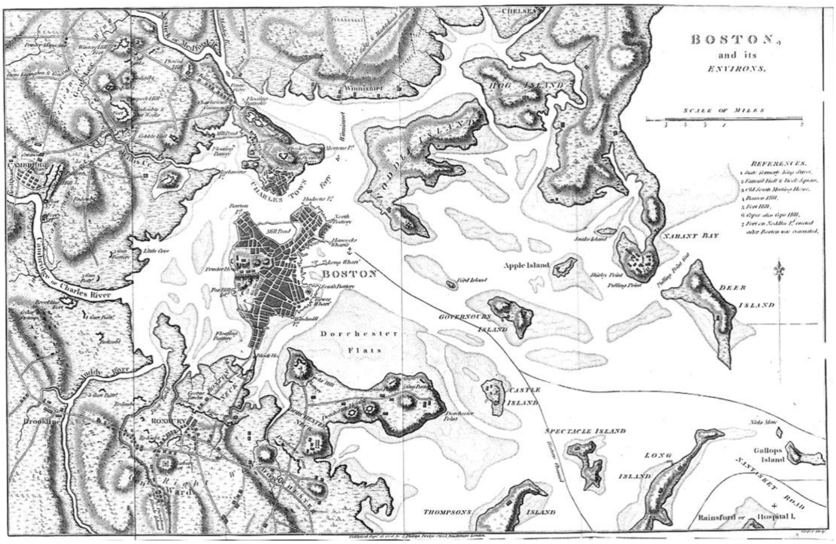


Figure 24: Boston and vicinity during Siege of Boston (1775-1776).

Bunker Hill is located north, and Dorchester Heights southeast of Boston

Source: Wikimedia Commons. "Marshall's Life of Washington" (1806)

The American militia's tactics (we would it today guerrilla tactics) were completely different from the ones the British troops were using. They were—because of the individualistic nature of the colonists—not that well-coordinated as a group, but everybody took more or less his own plan. The British regulars where well-organized, highly trained and battle hardened. Still, the British barely escaped defeat on the way back to Boston and left much of their weaponry behind in order to reach Charleston. The next day the militia army grew as the surrounding colonies sent men and supplies.

Soon more than 15,000 Patriots[76] set siege to Boston, and the Continental Congress formed a Continental Army from the militia. The *Battle of Bunker Hill* followed on June 17, 1775, where the inexperienced militia was defeated by the trained British troops. Next the militia managed to install cannons taken from a captured fort on the Dorchester Heights, a hill overlooking the harbour of Boston, and threatened the British fleet (Figure 24). This threat caused the British troops to withdraw from the city on March 17, 1775, with 120 ships and more than 11,000 people on board (of which 9,906 were troops, the others being women and children). The Boston blockade had ended.

[76] The name given to those colonists who rebelled during the American Revolution against the British control. Also the terms Patriot Whigs is used.

In the meantime, on June 8, 1775, the *Second Continental Congress* made a final attempt at reconciliation: the *Olive Branch Petition* to the British Crown. This was to no avail, however, and George III responded with the *Proclamation of Rebellion* on August 13, 1775, and a *Speech from the Throne* on October 27, 1775. It was clear that positions had hardened on both sides, and finally, on July 4, 1776, the *Declaration of Independence* severed the ties between the American colonies and the British Empire. The Declaration expressed the following:

> *When in the course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation.*
>
> *We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain unalienable Rights, that among these are Life, Liberty and the pursuit of Happiness.--That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed, --That whenever any Form of Government becomes destructive of these ends, it is the Right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles and organizing its powers in such form, as to them shall seem most likely to effect their Safety and Happiness. Prudence, indeed, will dictate that Governments long established should not be changed for light and transient causes; and accordingly all experience hath shewn, that mankind are more disposed to suffer, while evils are sufferable, than to right themselves by abolishing the forms to which they are accustomed. But when a long train of abuses and usurpations, pursuing invariably the same Object evinces a design to reduce them under absolute Despotism, it is their right, it is their duty, to throw off such Government, and to provide new Guards for their future security. –Such has been the patient sufferance of these Colonies; and such is now the necessity which constrains them to alter their former Systems of Government. The history of the present King of Great Britain is a history of repeated injuries and usurpations, all having in direct object the establishment of an absolute Tyranny over these States* (text of the Declaration of Independence).

The Declaration described all the grievances the colonists had experienced and it concluded as follows:

> *We, therefore, the Representatives of the united States of America, in General Congress, Assembled, appealing to the Supreme Judge of the world for the rectitude of our intentions, do, in the Name, and by Authority of the good People of these Colonies, solemnly publish and declare, That these United Colonies are,*

and of Right ought to be Free and Independent States; that they are Absolved from all Allegiance to the British Crown, and that all political connection between them and the State of Great Britain, is and ought to be totally dissolved; and that as Free and Independent States, they have full Power to levy War, conclude Peace, contract Alliances, establish Commerce, and to do all other Acts and Things which Independent States may of right do. And for the support of this Declaration, with a firm reliance on the protection of divine Providence, we mutually pledge to each other our Lives, our Fortunes and our sacred Honor (text of the Declaration of Independence).

The American Revolution was clearly the replacement of a government dominated by the old powers—in this case the British Royalty and the Aristocracy—by a new form a government in which people would be represented and hold a democratic power. The colonies revolted against the country that had the world's largest Navy, a highly trained Army and a highly efficient system of public finance to fund a war.

So the British returned in force in July 1776 with 22,000 men (among them 9,000 Hessians). Soon they crossed the colonies in several military campaigns, such as the *New York and New Jersey Campaign* (1776-1777) where the British troops tried to get control of state of New Jersey (Figure 25). Defeating the continental army, they took control of New York on July 13, 1776, and used that as a base for their expeditions until the end of the war in 1783.

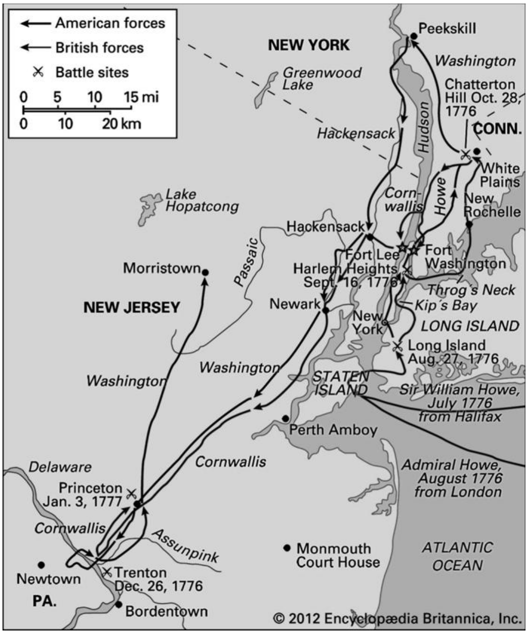


Figure 25: New York-New Jersey Campaign (1776-1777).

Source: Encyclopedia Brittanica

Next came the *Philadelphia Campaign* (1777-1778), with a range of battles, as well as the *Saratoga Campaign* (1777), in which the several *Battles of Saratoga* were fought that gave the Americans a decisive victory over the British, marking a turning point in the

Revolutionary War. But in the meantime, several wars and conflicts were fought on the 'Western Frontier' with the raiding Indians armed by the British. The battles were not only fought on land; naval engagements also took place. The early Continental Navy, authorized in 1775, was no match for the mighty British naval force. The American privateers, though, were more successful and captured hundreds of British vessels and their British sailors, especially in the West Indies theatre.

Over time others countries also became involved, starting with the French in 1778 (the Franco-American Treaty), the Spanish in 1779, and the Dutch in 1780 after the British had declared the *Fourth Anglo-Dutch War* (1780-1784), paralyzing the Dutch Republic. Mostly, the support was in the form of supplies, ammunition and guns traded for American colonial wares, but in some cases also troops. The French also financed the colonial military efforts. Take, for example, the *Siege of Yorktown* in 1781, where the colonial Continental Army beat the British:

Figure 26: Territory ceded to the US at the Treaty of Paris (1783).

Source: wiki.wooster.edu/display/greatlakes/Brant's+Town

There, the majority of George Washington's 15,000 man Continental Army were French soldiers. Washington's men were clothed by the French, the rifles they used were French, and French gold paid their wages. Nor must we forget that it was the French Navy that trapped Cornwallis's soldiers at Yorktown by preventing English ships sent from New York from rescuing the British army. Perhaps the final irony of the French monarchy's assistance to America (and proving once again that no good deed goes unpunished) is that it led to the financial collapse of the French ancien regime. And the bankruptcy of Louis XVI was one of the major causes of the French Revolution. …

The British in 1783 decided to make peace with America. It would do so for both political and military reasons. Attacked in Parliament and spread thin by

> *attacks in all parts of its empire, the British ministry decided to cut its losses in America and grant independence to its former colony. It did so primarily in order to consolidate its own military forces and fight the French and Spanish. The British went on to defeat both European powers and preserve what would come to be called the Second British Empire.* (Carp, 2015)

The participation of France, Spain and the Netherlands was decisive as they contributed crucial land and sea power to the war and forced the British to divert a large portion of their resources away from North America. After the financial arrangement stipulated in the *Versailles-contract*[77] of July, 1782, the *Treaty of Paris* (signed September 3, 1783) ended the war and recognized the sovereignty of the United States over the territory bounded roughly by what is now Canada to the north, Florida to the south, and the Mississippi River to the west (Figure 26). The rebelling colonists of the New World had attained their objective: freedom from British oppression. The British promised to evacuate the colonies and the Western forts, but that took a while. It would take another treaty, *Jay's Treaty* of 1794, to facilitate a peaceful trade between the United States and Britain in the midst of the French Revolutionary Wars that had started in 1792.

The Critical Period (1783-1788)

The Revolutionary War left the colonies in a wretched state. For many Americans, the war brought hardship and suffering even if they were not fighting; more died of disease than from enemy fire. In addition to that, some 60,000 Loyalists[78] left the United States. Many settled in Canada. The wealthy—royal officials, rich merchants and landed gentry—returned to England. In many cases, they had their property confiscated. This changed the social cohesion of the former colonies, a cohesion that had found its roots in the British culture of that time.

> *Any position that came from any source but talent and the will of the people now seemed undeserved and dependent. Patrimonialism, plural office holding, and patronage of all sorts—practices that had usually been taken for granted in a monarchial society—came under attack. … it is in this context that we can best understand the revolutionaries' appeal to independence, not just the independence of the country from Great Britain, but, more important, the independence of individuals from personal influence and "warm and private friendship". …* (Wood, 2011, pp. 177, 178)

---

[77] In the 'Contract Between the King and the Thirteen United States of North America', signed at Versailles on July 16, 1782, the United States agreed to pay to the British King the enormous amount of 18 million French Livres ('Livres Tournois'). This was a repayment for the King's assistance at war during the years 1778-1782.

[78] Colonists who remained loyal to the British monarchy during the American Revolution (about 500,000 persons, 20% of the white population). The term Tories is also used.

Now that the British monarchical power was more or less gone, the new American state formed by the thirteen colonies was on its own (in terms of governance). As many of the leading revolutionaries who had played an important rule during the military period went home, the *Confederation Congress* was more or less paralyzed. People were politically divided. Within the individual States, there were the *Federalists*, who pressed for a strong central government, and *Antifederalists*, who stressed preservation of individual liberties protected by strong state sovereignty. The two groups disagreed fundamentally about the governmental structure, the type of legislature, and the division of power between the individual states and the confederate state. They also disagreed about taxation, the funding of the army, and the regulation of trade and interstate commerce, as well as on how to pay back the states' debts incurred during the Revolutionary War. These disagreements resulted in a political division that culminated in the *Constitutional Convention* of 1787.

In other words, after the American Revolution had ended in 1783 with the Treaty of Paris, America's critical period arrived with the growing pains of a confederate state in the making. And in the meantime, in the 'real world' of the colonies, the common people faced problems of their own. In a rural society where the majority of people laboured in a subsistence economy and were hardly surviving, the after-war depression was felt hard. It resulted in civil unrest, but now the unrest did not oppose the British rule, it opposed the rule of the new states themselves.

The *Continental Army* was in uprising about payments to the military, both actual salaries they had not received and payments promised by Congress in 1780, resulting in the *Newburgh Conspiracy* in March 1783.

> *Most officers were apprehensive about returning to civilian life. Many had been impoverished by the war while friends at home had grown fat on wartime prosperity. For all the long absence meant breaking back into a society that had adjusted to their absence, and in traditionally antimilitary New England, a society that would accord none of the advantages or plaudits that returning veterans normally expect. During those long, boring months of 1782, a growing feeling of martyrdom, an uncertainty, and a realization that long years of service might go unrewarded-perhaps even hamper their future careers-made the situation increasingly explosive.* (Kohn, 1970, p. 190)

The petition to Congress, drafted up by a number of officers of the Continental Army, came at a moment in time when there were political debates about financing the new Nation. It was the Nationalists against the Federalists, and the army's claim became part of the political machinations of these two groups. In the meantime, a 'coup d'état' by the military threatened. It was George Washington's personal intervention that turned the tables; soldiers were given a partial remuneration in the form of government bonds.

> *The Newburgh incident was a case of outside pressure on the normal political process similar in its operation to modern lobbying. What distinguished it, however, was the threat of more direct intervention. Furthermore, it could have led to more serious events. … It would have been a passive mutiny, a declaration of independence from the nation by the military, and it would in all probability have precipitated a major political and constitutional crisis.* (Kohn, 1970, p. 219)

In Massachusetts, civil unrest erupted in *Shays' Rebellion* from 1786-1787. The cause was simple: the money problems of businesses, the state and the people. The European business partners of Massachusetts merchants refused to extend lines of credit. It was cash on delivery. Soon the colonial merchant did the same with local business partners, who passed it on to their customers. The manufacturers—often the farmers with limited funds who bought on credit—fell into debt, and when they did not meet their obligations, they lost their land. These problems were compounded by the fact that the State of Massachusetts had to pay off its war debt. Despite the hard times, the state implemented an aggressive taxation policy—with payment only in gold or silver. Tax collectors were authorized to seize property, a policy that proved disastrous. In addition, veteran soldiers, who had never been paid for service, found themselves in court for non-payment of debts. These policies resulted in uprisings, public demonstrations, mob actions and blockades shutting down court houses.

Soon the insurgents, called the Regulators, with Daniel Shay as leader, engaged in battle with the state militia in January 1787. The governing elite, mostly Boston merchants who stood much to lose, reacted in a classical way: by force and law making. The 125 Bostonian merchants funded a private army, and the rebellion was crushed. In 1787 the *Disqualification Act* pardoned many of the insurgents, including their leader Daniel Shay. In 1786 the *Riot Act* was passed, which forbade gatherings of more than twelve armed persons, empowered sheriffs to kill rioters and allowed people to be imprisoned without trial. In 1792 the *Militia Act* was passed, which called for the execution of any militia officer or soldier who had taken up arms against the state.[79]

Along with these real-world problems was still the issue of the governing of the United States. To address this issue, the *Constitutional Convention* was convened to revise the Articles of the Confederation. The weakness of the federal government was apparent to many, and many plans

[79] Source: http://shaysrebellion.stcc.edu/shaysapp/person.do?shortName=samuel_adams

were proposed to fix this: the Virginia Plan, the New Yersey Plan, the Hamilton Plan, etc. The topic of slavery was especially crucial and divided the Northern and Southern colonies.

On May 25, 1787, the Convention met in Philadelphia and drafted a new *Constitution*. The most contentious disputes revolved around the composition and election of the Senate, how 'proportional representation' was to be defined (whether to include slaves or other property), whether to divide the executive power between three persons or invest the power into a single president, how to elect the president, how long his term was to be and whether he could stand for re-election, what offenses should be impeachable, the nature of a fugitive slave clause, whether to allow the abolition of the slave trade, and whether judges should be chosen by the legislature or executive. All these issues were settled by the *Connecticut Compromise*: a bicameral legislature with equally weighted representation for the states in the upper house and proportional representation in the lower house.

The draft was sent to the separate states for ratification. In some states, ratification was effected only after a bitter struggle in the state convention. Most ratified the draft, and on September 18, 1788, the Congress set a date for the presidential election and a date the new Constitution would become effective. It was ratified as the *United States Constitution* on September 11, 1788, when forty delegates signed. Not every delegate signed, though; some thirteen delegates left without signing, and three delegates refused to sign

Figure 27: Scene at the signing of the Constitution of the United States (1788).

Source: Wikimedia Commons, Howard Chandler Christie.

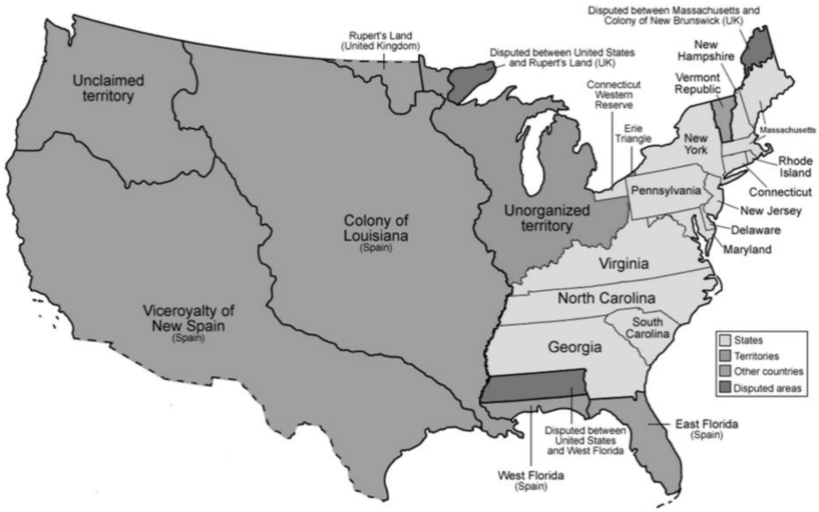


Figure 28: States and territories of the United States of America (1789).

Source: Wikimedia Commons (adapted)

(Figure 27). George Washington was elected as the first president on April 30, 1789, starting the period of the Washington Administration (1789-1797), which only lasted, voluntarily, two terms (a custom later included in the 22nd Amendment of the Constitution). The US Constitution was later amended with the *Bill of Rights* (1791).

And on March 4, 1789, the acting general government under the Articles, was replaced with the federal government under the *United States Constitution*. Now the United States of America (Figure 28) had effectively come into existence. Later in 1803 the former Spanish colony of Louisiana would be bought from the French—the *Louisiana Purchase*—for fifty million francs ($11,250,000) and a cancellation of debts worth eighteen million francs ($3,750,000) for a total of sixty-eight million francs ($15,000,000)[80]. In 1800 the capital moved from Philadelphia to Washington.

The problems with Britain were far from over, however. As the British blockade of France meant that they did not allow neutral countries (like America) to trade with France, British warships had been boarding and searching American ships and seizing American as well as British seamen, claiming that they were British deserters.

[80] Equivalent to $289 million in 2014; calculation based on historic opportunity costs. Source: http://www.measuringworth.com/

In 1794 they seized the ships—mostly American—in the harbour of St. Pierre on Martinique in the West Indies, treating the crews as criminals. In total, 250 merchant ships were confiscated, an issue ultimately resolved in *Jay's Treaty* in 1794. As compensation for the seizure, the British paid $10,345,200[81] by 1802. It seemed that this treaty would finally end the tumultuous period of the American Revolution. However, in 1812 the Anglo-American war (the *War of 1812*) broke out. The Americans, hampered by the trade restrictions the British imposed upon the US and the impressment of American sailors in the British Navy, declared war on Britain.

This 'Second War of Independence' between the US and Britain was fought out in three principal theatres: at sea, with the British blockade of the Atlantic coast of the US; in large naval battles on the American-Canadian frontier; and in the land battles in the South, where the Brits invaded New Orleans. In April 1814, with the defeat of Napoleon, the British adopted a more aggressive strategy, sending larger invasion armies and tightening their naval blockade. The Brits raided the shores of Chesapeake Bay, including an attack on Washington (1814). However, with the end of the Napoleonic Wars in Europe, both governments were eager for a return to normality, and peace negotiations began in Ghent in August 1814. On December 24, 1814, the diplomats finished and signed the *Treaty of Ghent*. It had been a costly war; over 8,000 Brits died in battle or from disease, and there were some 205,000 American casualties. Both sides spent over $100,000 fighting the war. The treaty secured official British acknowledgment of American maritime rights and allowed America to focus its efforts on defeating the Indian threat. Now the United States had gained their full independence of Britain.

In the meantime, the British were engaged in Europe in the last of the Napoleonic Wars; Napoleon had invaded Russia, and the *War of the Sixth Coalition* (1812-1814) raged in Europe. After Napoleon was defeated in the Battle of Leipzig (1813), the British ended the trade restrictions, and the Anglo-American war ended with the *Treaty of Ghent* on December 24, 1814. And the last boundary problems were dealt with in the *Convention of 1818*.

Overview of the American Revolution

Over a relatively short period of time, the British colonies in North America had undergone a dramatic range of changes. Not only had they severed the political ties with the country that had been the land of origin for most of its inhabitants, they had also changed dramatically in size. From

[81] Equivalent to $ 212 million in 2014; calculation based on historic opportunity costs. Source: http://www.measuringworth.com/

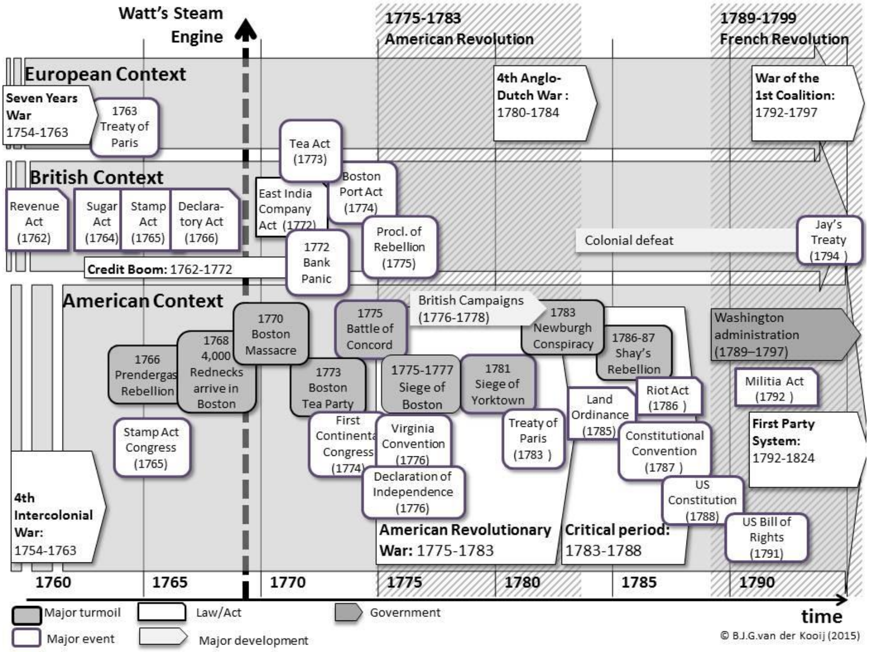


Figure 29: Overview of the American, British and European contexts for the American Revolution.

Figure created by author

the thirteen colonies that had emerged in the eighteenth century on the East coast of America, the United States had by 1803—with the Louisiana Purchase—increased in surface to cover the mid and eastern part of the American northern continent. Land originally occupied by the native American Indians, who were already decimated by the colonial germs[82] and the colonial guns of the Spanish, French, English and Dutch.

At the end of the eighteenth century, the former British colonies were in the process of severing ties with Britain forever, a revolution that took place within the following context (Figure 29).

The European context: As the British colonies were the result of the imperial and colonial policies of Britain in the eighteenth century, this conflict between the colonists and the British rulers must been seen in the much larger European context. There, the British, the French and the Dutch

[82] Epidemic diseases were the primary cause of death among the native peoples. They had no immunity to new illnesses, including smallpox, cholera and measles, which the Europeans brought to the Americas. Many tribes suffered huge losses—often, up to ninety percent of the population was wiped out.

were in nearly constant state of conflict. The expansionist policies of the marine nations Britain and Holland—not because they were so fond of sailing, but because they were eager to capture the riches of the colonies—created conflicting interests. The British, quite busy transferring the colonial wealth to London, were often confronted with the Dutch. They were used to Dutch privateers undermining their mercantile policies. In the same way, the merchant ships from the Dutch United Provinces, from the time of the first Dutch-Anglo War (1652-1654), were used to attacks from British privateers. So it was no surprise that—after all those earlier skirmishes at sea on both sides of the Atlantic—the Fourth Dutch-Anglo War erupted in the same time period as the American colonies revolted.

The British context: The Brits, as a maritime nation, were quite busy expanding beyond the British Island. The American colonies had been—along with the Indian Empire—the result of the commercial operations of the West Indian Company and the East Indian Company. Their mercantile politics had just one objective, and that was transferring colonial wealth to London while keeping other interested parties (Spanish, Portuguese, French and Dutch) out of the game. So British operational policies were primarily oriented toward the objective of British self-interest. This was not unusual, as every imperialist nation of that time did the same. And in that contexts, the East India Company's desire to solve its financial problems by directly exporting teas to the colonies ignited an already explosive atmosphere, leading to the Boston Tea Party.

The American context: A large part of the colonial discontent that arose in the eighteenth century was based on a simple political concept: 'no taxation without representation'. This was a slogan already familiar to the English from their own Civil War (1642-1651) more than a century before. While early mercantile policies (form early Navigation Acts to the *Sugar Act* in 1763) were opposed by the colonials, they did not create a revolutionary atmosphere because the 'salutary neglect' of the British authorities made evasive practices (the 'colonial evasion', with activities such as smuggling on a large scale) quite possible. But with the introduction of the *Stamp Act* in 1765 (and the earlier *Sugar Act* of 1764) a line seemed to have been crossed. Now the British had decided that the colonies had to pay for the British forces that occupied them. The *Declaratory Act of 1766* was the proverbial spark in the tinderbox, as the British showed utter disrespect of colonial feelings and acted—in the opinion of the colonists—contrary to colonial interests. The colonists did not have the ability to say a word about it, as they were not represented in the British Parliament.

The result of this contextual mix was the *Declaration of Independence* (1776), followed by a period of constitutional turmoil, war between the colonist militia and the British trained army, and the removal of the royal governors in the colonies. Then the different states, each with its own characteristics and interests, struggled to find a common governmental structure. After a decade their efforts resulted in the *US Constitution* (1778). A new nation was born.

The Shaping of the New Nation

The preceding analysis shows the development of American society up to the end of the eighteenth century. It paints—in our, by now, well-known rough brush strokes—an overview of the development of individual British colonies into a Confederation of independent states, the new nation of the United States of America. This was a new nation faced with a multitude of legislative, economic and social problems, some of which were created by the British, who found it difficult to part from their profitable colony. In addition, there were the French-Anglo conflicts during and after the French Revolution, conflicts where the instrument of naval blockade was used in the French Revolutionary Wars and Napoleonic Wars. These blockades hampered the American and Dutch traders and ultimately resulted in the second war of independence.

Figure 30: The Era of Good Feelings illustrated by "Independence Day Celebration in Centre Square".

Source: Wikimedia commons. Artist: John Lewis Krimmel (1819)

That War of 1812 gave a dramatic boost to the manufacturing capabilities of the United States. The British blockade of the American coast created a shortage of cotton cloth in the United States, leading to the creation of a cotton-manufacturing industry. The war also spurred on construction of the Erie Canal, which was built to promote commercial links, yet was also perceived as having military uses should the need ever arise. On the political side, the victorious Democratic-Republican Party defeated its long-time foes, the Federalists, who vanished from national politics. The result was an *Era of Good Feelings* (1816-1825), with the lowest level of partisanship ever seen in American history (Figure 30). This era would not last long, though, as in the 1820s the tide changed again.

Basically, the economy of the colonies differed from other economies due to the abundance of land and natural resources and the lack of labour. The economy was predominantly based on agricultural production (from cotton and rice, to wheat and sugar) and fishing produce, resulting in commercial trade overseas. And that commercial trade fluctuated tremendously, as it faced colonial restrictions and blockades. Trade lanes opened and closed frequently, resulting in economic commercial activates that fell and rose regularly. Overall, the revolutionary war and its aftermath imposed economic hardship on the new nation.

> *Several decades following the independence were exceptionally unstable, not merely two decades of bust and then one and a half of boom. There were ups and downs within these longer bust-and-boom periods. Because of the importance of foreign trade at the time, export instability had strong leverage effects throughout the economy.* (Walton & Rockoff, 2013, p. 125)

The New Western Frontier

The Treaty of Paris in 1783 had awarded the United States a new territory west of the Atlantic coast colonies (Figure 26). In addition, ten years later the *Louisiana Purchase* in 1803 would nearly double the surface of the new nation (Figure 28). The new land facilitated a westward expansion and opened up a massive migration to the west and south. Following a range of 'trails'—such as the Great Wagon Road from Pennsylvania to North Carolina—pioneers travelled to the new land in wagons trains. The dangers of the overland route were numerous: snakebites, wagon accidents, violence from other travellers, malnutrition, stampedes, Native American attacks, a variety of diseases, exposure, avalanches, etc.

The law that made this migration possible was the *Land Ordinance* of 1785. Intended to raise money through the sale of undeveloped lands, the law created a mechanism for selling and settling the lands. As settlers poured in, the frontier districts first became territories, with an elected

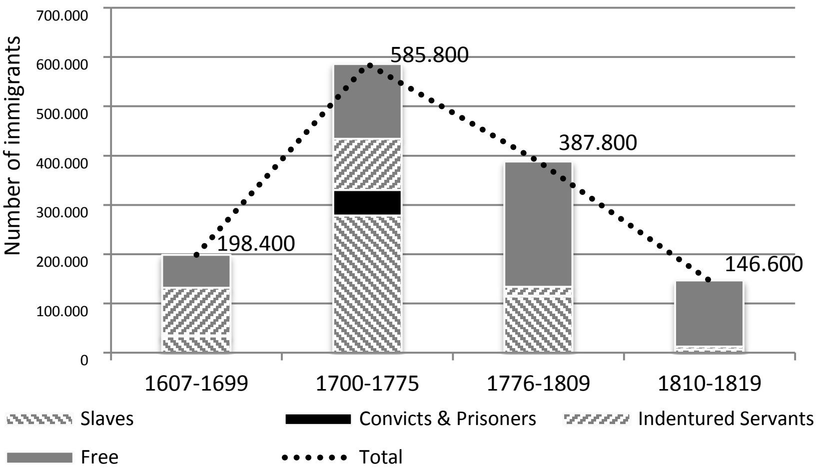


Figure 31: Number of immigrants related to their state of freedom.

Source: (Fogleman, 1998, p. 44) Table 1

legislature and a governor appointed by the president. When a territory's population reached 100,000, the territory applied for statehood. Soon the *Northwest Territory* would create the states of Ohio, Michigan, Indiana, Illinois, Wisconsin and Minnesota.

Though many immigrants were still arriving from Europe, something had changed: their natural status (Figure 31).

> *But in the late eighteenth and early nineteenth centuries, something fundamentally and permanently altered the nature of North American immigration. When war and independence came after 1775, disruptions in the British Empire forced many involved in the immigrant trade on both sides of the Atlantic Ocean to reconsider how they would do business. Further, many Americans concluded that a large immigration of slaves, convicts, and servants was incompatible with the egalitarian ideas of the Revolution and with the cultural changes occurring in the United States. These developments transformed an immigration primarily of slaves, convicts, and indentured servants into one of free subjects.* (Fogleman, 1998, p. 45)

> *For nearly two centuries most immigrants arrived in British North America in some condition of unfreedom, and the colonists considered this normal. Yet in the late eighteenth and early nineteenth centuries, the trend suddenly reversed. After 1808 few immigrants were servants or slaves, and by 1820 immigrants in servitude were numerically insignificant. The character of American immigration had permanently changed. …*

> *Free immigrants, not slaves, convicts, and servants, dominated the ranks of strangers entering the new republic. Whereas in the decades before the Revolution free immigrants made up only about one-fourth of all immigrants, during the thirty-five years after independence, free passengers made up nearly two-thirds of the total. And from 1810 to 1819, after the importation of African slaves was banned, free immigrants made up more than 90 percent of the total.* (Fogleman, 1998, p. 60)

After the American Revolution, that not only changed the ideological and political relations, but also the economic and commercial relations, between Britain and America, Americans no longer wanted overseas immigrants unless they were free. Immigrants still came in large volumes, and some of those immigrants were political refugees:

French Émigrés: As a result of the French Revolution in the 1790s, many 'émigrés' left France for America. They were monarchists, constitutionalists and republicans—each fled different phases of the Revolution, especially the Reign of Terror. A number of émigrés arrived in the Unites States with some sources of income and never apparently sought employment as they travelled the United States. Others travelled to Pennsylvania where, in 1973, they created a settlement they named *Azilum*. There, more than 100 upper-class noble settlers set up businesses and produced goods such as pots, furs and baskets. They also set up trading posts, schools and churches. But when Napoleon gave amnesty to the nobles, most went back to France. Others who had to work and settled in east coast cities like Boston, New York and Charleston. The priestly exiles travelled to places like Baltimore and regions like the Appalachian West and became religiously active there (Sosnowski, 2005).

Political Exiles: Then there were those emigrants who left their homeland due to political reasons. One of those immigrants, who came from England, was the dissenter Joseph Priestly, a scientist, philosopher and overt admirer of the French Revolution and American Revolution, who fled England's Birmingham in 1792 after the 'Church and King' riots[83]. Fleeing from England, he stayed for a while in France but soon decided to follow his sons, who had immigrated to America. After arriving in 1794 in New York City, he settled in Pennsylvania.

> *On his arrival in America, expecting still a safe haven and kindred spirits in the projected settlement on the Susquehanna, Priestley was to allow himself a full expression of his republicanism, of his continuing hostility to the government of England, and of his loyalty to the cause of France. He did, however, consistently*

[83] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015). Pp. 26-31.

avow his aversion to any involvement in the politics of America. That this was to be almost from the outset effectively impossible-that by his very presence, his reputation (and that of those with whom he was so closely associated), and by his actions, he was to remain a political figure who could not long remain unnoticed. (Graham, 1995, p. 39)

He became active as a minister, continued to publish his views and became close to President Thomas Jefferson. But he was now isolated from the scientific world and was unaware of the latest scientific developments. He also became entangled in the new nation's politics, which became more and more anti-French. He died in 1804.

Clearly, America was a nation of many nationalities from as far back as the colonial times due to the previously mentioned immigration (Figure 31). Large scale immigration resumed in the 1830s when some 600,000 people immigrated (1830-1840), and in the 1840s when more than 1.7 million people immigrated (1840-1850). People came from Britain, Ireland, Germany and other parts of Central Europe, as well as from Scandinavia. Most were attracted by the cheap farm land. Some were artisans and skilled factory workers attracted by the first stage of industrialization. The Irish Catholics were unskilled workers, who built most of the canals and railroads, and settled in urban areas. Many Irish went to the emerging textile mill towns of the Northeast, while others became longshoremen in the growing Atlantic and Gulf port cities. Half the Germans headed to farms, especially in the Midwest (with some to Texas), while the other half became craftsmen in urban areas.

Living in the New Nation: from Farms to Urbanization

By 1815 the overwhelming majority of the population was engaged in agriculture as family farmers, living lives of hardship and toil. They grew food and held cattle for their own consumption; surplus food was bartered in the local stores participating in the rural economy. The original native population was ravaged by the European and African diseases—including smallpox, measles, influenza, yellow fever and malaria. Also, among settlers, even with a high birth rate and high rate of early child death, diseases took many lives (eg the *Yellow Fever Epidemic* of 1793, which killed about 10 percent of the population). And nature was not forgiving. The eruption of the Tambora volcano in 1815 resulted in widespread crop failures, which led to food shortages in the 'year without summer': 1816.

Life in America in 1815 was dirty, smelly, laborious, and uncomfortable. People spent most of their waking hours working, with scant opportunity for the development of individual talent and interests unrelated to farming. … Most white Americans lived on family farms and worked land they owned of squatted

> *on. A farm of one's own had been the dream of old World peasantry: it seemed the key to dignity and economic security. … By1815, [the population] had reached almost 8.5 million.* (Howe, 2007, pp. 31-32)
>
> *This was not a relaxed, hedonistic, refined, or indulgent society. Formal education and family connections counted for comparatively little. The man who got ahead in often primitive conditions did so by means of innate ability, hard work, luck, and sheer willpower. Disciplined himself, he knew how to impose discipline on his family, employees and slaves. Impatient of direction, he took pride in his personal accomplishments. An important component of his drive to succeed was a willingness—surprising among agrarian people—to innovate and take risks, to try new methods and locations. With an outlook more entrepreneurial than peasant, the American farmer sought to engross more land that he could cultivate in hopes that its value would rise as other settlers arrived.* (Ibidem, p.38)
>
> *For all the political liberty that the American institutions and ideology promised to adult white men, in practical terms most lives were disciplined and limited by the economic necessities of a harsh environment and the cultural constraints of a small community.* (Ibidem, p.40)

The local family farms were connected to nearby towns by unpaved roads. When it rained, these pathways were muddy, when it was hot, they were dusty; maintenance was at its barest minimum. Long-distance transportation was only available by water (by sea or river). Most Americans lived close to the coast; more inland communities were confronted with isolation. And those that lived in the towns and small cities were confronted with the early urban miseries of crime, poverty and disease. Compared to Europe, with the big cities of London (1800: 800,000 inhabitants) and Paris (1800: 500,000 inhabitants), America had only small cities in 1800, although there were a few larger places, such as New York (1800: 60,000 inhabitants) and Philadelphia (1800: 70,000 inhabitants). These 'Atlantic Coast cities' had grown as a result of early colonial trade. Urban development took off slowly, but picked up in the 1820s when rural society, with farm families, became complemented by urban society, with the urban families.

Politics in the New Nation: Federalists and Democratic-Republicans

The majority of Americans were of British ancestry, be it English, Scottish or Irish. These Americans brought with them the culture of their origin; often, they were even more English than the English: 'They were provincials living on the edges of a pan-British world, and all the more British for that. … they were freeborn Englishmen.' And the English valued their 'liberty':

> *Liberty: Englishmen of everywhere of every social rank and of every political persuasion could not celebrate it enough. Every cause, even repression itself, was wrapped in the language of English liberty. No people in history of the world have ever made so much of it. Unlike the poor enslaved French, the English had no standing army, no letters de cachet; they had their habeas corpus, their trials by jury, their freedom of speech and conscience, and their right to trade and travel; they were free from arbitrary arrest and punishment; their homes were their castles. Although few Englishmen and no Englishwomen could vote for representatives, there was always the sense of participating in political affairs, even if this meant only parading and huzzahing during the periodic elections of the House of Commons.* (Wood, 2011, pp. 12-13)

That 'liberty' was not the same as 'freedom' was illustrated by all those whites, usually young men and women, who were indentured as servants or apprentices and bound to masters for periods from a few years to decades.

This background illustrates the culture[84] of the new nation, a culture that defined its politics[85]. In the period of time in which America was created, the political culture was—not too surprisingly—hotly divided, as the particular interests of different groups were often opposite from each other. There were the 'Federalists', who supported the proposed Constitution, and the 'Antifederalists', who opposed it, and their disagreement was all about 'individual liberties versus constitutional powers.

> *For Federalists, the Constitution was required in order to safeguard the liberty and independence that the American Revolution had created. While the Federalists definitely had developed a new political philosophy, they saw their most import role as defending the social gains of the Revolution. On the other hand there were those that opposed the ratification of the Constitution: the "Antifederalists". They believed that the greatest threat to the future of the United States lay in the government's potential to become corrupt and seize more and more power until its tyrannical rule completely dominated the people. Having just succeeded in rejecting what they saw as the tyranny of British power, such threats were seen as a very real part of political life. The most powerful objection raised by the Antifederalists, however, hinged on the lack of protection for individual liberties in the Constitution. Most of the state constitutions of the era had built on the Virginia model that included an explicit protection of individual rights that could not be intruded upon by the state. This was seen as a*

[84] Here culture is used in the sense of the ideas, customs, and social behaviour of a particular people or society (Oxford Dictionaries).

[85] Politics can have different meanings: *National politics* (the working out of forms of conflict between different groups of people and their interests); *Parliamentary politics* (the interaction in Parliament); *Party Politics* (the collective views, wheeling's and dealings of political parties to exercise political power); and *People's politics* (the representation of specific interests, such as religious interests).

central safeguard of people's rights and was considered a major Revolutionary improvement over the unwritten protections of the British constitution.[86]

As the United States after the American Revolution was still a fragile experiment in republican government, its political attitudes would be greatly shaped by events in Europe. It was the French Revolution that stimulated a profound new development in American politics.

Domestic attitudes toward the proper future of the American republic grew even more intense as a result of the example of revolutionary France. Conservatives like Hamilton, Washington, and others who would soon organize as the Federalist political party saw the French Revolution as an example of homicidal anarchy. When Great Britain joined European allies in the war against France in 1793, Federalists supported this action as an attempt to enforce proper order.

The opposing American view, held by men like Jefferson and others who came to organize as the Democratic-Republican political party, supported French actions as an extension of a world-wide republican struggle against corrupt monarchy and aristocratic privilege. For example, some groups among the Whiskey Rebels in western Pennsylvania demonstrated their international vision when they rallied beneath a banner that copied the radical French slogan of "Liberty, Equality, and Fraternity." [(ibidem)]

Clearly, internally the political scene of the young State was divided between those who heralded the French Revolution and those who shared the British fear of the revolutionary ideas. The Federalists, appealing to the business community, were dominant until 1800 while the Republicans, appealing more to the planters and farmers, were dominant after 1800. This division would lead to the two-party system of the Federalists (The Federalist Party) and the Democratic-Republicans (the Democratic-Republican Party), known as the *First Party System* (1792-1824). When Napoleon was defeated in 1815, and within the 'Era of Good Feelings' (1816-1825), this period of high tension politics faded out.

America would be caught up between the two dominant powers of that time, who were fighting in Europe. As a consequence of *Jay's Treaty* (1794-1795)—which resolved issues between Britain and the US that had remained since the Treaty of Paris in the midst of the French Revolutionary Wars—France suspended diplomatic relations with the US and seized more than 300 American ships over the next two years.

While royal France had supported colonial America in its revolutionary fight against the British, republican America now joined with Britain, its former Revolutionary enemy, to challenge the French. [(ibidem)]

[86] Text from: Ratifying the Constitution. http://www.ushistory.org/

Clearly, the shaping of the new nation, in the midst of the turmoil of changing international alliances, was a complicated affair. And although theoretical politics might have been sharing the simple ideas of 'liberty', practical politics were more complicated than that. The new nation was experiencing the political growing pains of a society in the making. But that was not the only pain the US was experiencing….

Working in the New Nation: from Farm to Factory

The economy of the new America was in bad shape when wealthy British merchants left cities like Boston and New York. The merchant activities were also decimated by the blockades during the Napoleonic Wars in Europe (1803-1815). By spring 1808 New England ports were nearly shut down, and the regional economy headed into a depression, with growing unemployment. The *American Embargo Acts* (1807), intended to stop trade with France and Britain, effectively throttled all American overseas trade. Even the renewed smuggling activities into Canada did not do much for the economy. Also, in 1812 the United States came in conflict with Britain again.

The bad mercantile trade situation also had another effect. It stimulated early industrialization, as the absence of guilds in colonial America meant that anyone could get started in a craft, become a journeyman and hire an apprentice. Based on the knowhow of Brits, the early manufacturing industry (ie the textile industry) developed through the efforts of entrepreneurial individualists.

> Take, for example, the work of the Brit *Samuel Slater* (1768-1835). Born in the village of Belper, England on June 9, 1768, the young apprentice Samuel Slater had gained a thorough knowledge of the organizations and practice of cotton spinning. Britain, eager to protect its industry, forbade exportation of anything related to machinery, including engineers. America, eager to obtain knowhow, offered bounties for textile information. Slater travelled in 1789 to New York, and soon came in contact with the Quaker entrepreneurs William Almy and Moses Brown. They created a co-partnership, and Slater constructed the first successful water-powered cotton spinning mill in 1790. In 1798 he organized a new firm, Samuel Slater & Company, that built the first mill using the Arkwright system in 1801. Soon he became partners in other cotton-processing projects. Next to his technical expertise, he added managerial and organization skills and created the 'Rhode Island System' of manufacturing. As a result of the Embargo of 1807, and the isolation during the *War of 1812*, the process of industrialization in New England gained momentum. By war's end in 1815, within 30 miles of Providence, there were 140 cotton manufacturers employing 26,000

hands and operating 130,000 spindles. The American textile industry was launched, and America entered the (first) era of Industrial Revolution.

Cut off from imports, other creative engineers further developed mechanical technologies and experimented with applying the new technology of steam power. Early steamboats and steam carriages were developed by John Fitch (1743-1798), James Rumsey (1743-1792) and John Stevens (1749-1838) and were put to work transporting people and goods.

One of those creative engineering types was *Robert Fulton* (1765-1815), born in an Irish farming family that had lost its farm in the 1771 mortgage foreclosure. His talent for drawing gained attention and brought him to England, where he met people like James Watt and the Duke of Bridgewater and wrote the *Treatise on the Improvement of Canal Navigation* in 1796. During a seven-year stay in France, he experimented with submarine boats and torpedoes. In 1801 he met, in Paris, the American *Robert R. Livingstone*[87], and together they undertook the financing and construction of an experimental steamboat. It failed, and the same fate was suffered by his boat designs offered to the British Navy in 1804. However, these attempts earned him a lot of industrious experience.

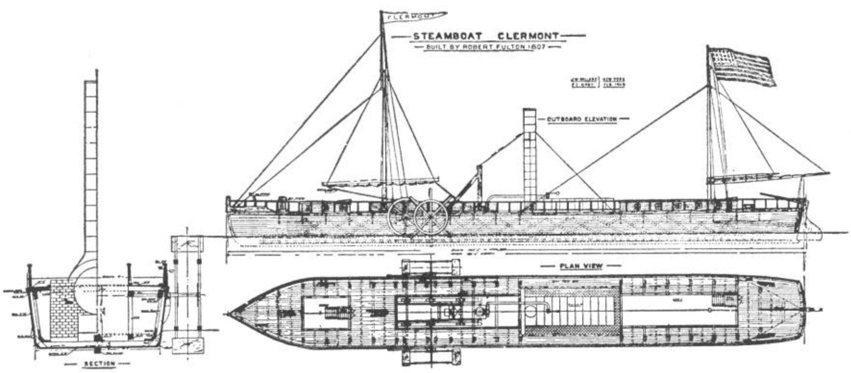


Figure 32: Plan of the steamboat "Clermont" built by Robert Fulton (1807).
Source: http://explorepahistory.com/kora/files/1/2/1-2-1588-25-ExplorePAHistory-a0l4q7-a_349.jpg

[87] Robert R. Livingstone (1755-1813), coming from the wealthy and powerful Livingstone family. A family that had originated with his grandfather Robert Livingstone (1654-1728), who had come in 1673 to the British colony of Massachusetts and had been the US Minister to France and had negotiated the Louisiana Purchase in 1803.

With all this experience, he returned to America in 1806. There, he partnered again with the political and financially powerful Robert R. Livingston, who earlier had obtained the monopoly on steamboat navigation on the Hudson from the State of New York—and whose daughter he married. Together they undertook the financing and construction of the North River steamboat (aka 'Clermont') and initiated a steamboat line from New York to Albany in 1807 (Figure 32). The boat used Watt's steam engine—built by Watt & Boulton in England—as a power source.

> *Very soon after his arrival in New York, he commenced building his first American boat, and finding that her cost would greatly exceed his estimate, he offered for sale a third interest in the monopoly of the navigation of the waters of New York, held by Livingston and himself, in order to raise money to build the boat, and thus lighten the burdens of himself and his partner, but he could find no one willing to risk money in such a scheme. Indeed, steam navigation was universally regarded in America as a mere chimera, and Fulton and Livingston were ridiculed for their faith in it. The bill granting the monopoly held by Livingston was regarded as so utterly absurd by the Legislature of New York, that that wise body could with difficulty be induced to consider it seriously.* (McCabe Jr, 1872, pp. 262-263)

Sceptics ridiculed 'Fulton's Folly', but their venture proved otherwise. The first trip on September 10, 1807, traveling 240 km from New York to Albany in 32 hours, proved to be quite successful. However, not everybody was happy with his new steamboat travelling regularly on the Hudson River.

> *…the "Clermont" was to run regularly between New York and Albany, as a packet-boat, she became the object of the most intense hatred on the part of the boatmen on the river, who feared that she would entirely destroy their business. In many quarters Fulton and his invention were denounced as baneful to society, and frequent attempts were made by captains of sailing vessels to sink the "Clermont" by running into her. She was several times damaged in this way, and the hostility of the boatmen became so great that it was necessary for the Legislature of New York to pass a law declaring combinations to destroy her, or willful attempts to injure her, public offenses punishable by fine and imprisonment.* (McCabe Jr, 1872, p. 269)

As he was granted a five-year monopoly to build steamboats, he soon built, in 1809, the 'Car of Neptune', followed by the 'Aragon' in 1811. After these first experimental steamboats came a number of commercially successful steamboats, until his steamboats coursed the rivers. When he died in 1815, he had built a total of seventeen steamboats (Hartenberg, 2015).

Not too amazingly, soon the competition appeared, among them the 'The People's Line' initiated by Cornelius Vanderbilt[88]. When the monopoly ended, others joined, and by 1840 over a hundred steamboats were in operation on the Hudson River. The same had happened elsewhere. By 1830 there were more than 1,200 steamers on the Mississippi. It was on the steamboat Natchez that the famous man from the French Revolution, the Marquis de Lafayette—invited by President James Monroe as the Nation's guest—travelled on the Mississippi in 1824.

The Age of Transportation and Industrialization[89]

A large contribution to the development from farm to factory was the improvement in transportation infrastructure. It started with some privately owned toll bridges, and the experience of the 'Turnpike Mania' (1751-1772)[90] in England led to the stock-financed turnpike organizations. The first privately financed turnpikes, such as the *Philadelphia-Lancaster Turnpik*e in 1794—a broad, 62-mile (100 km) paved toll way between Philadelphia and Lancaster, where turnpikes created the toll barriers— were soon followed by the 620 mile (1,000 km) long Cumberland Road (aka National

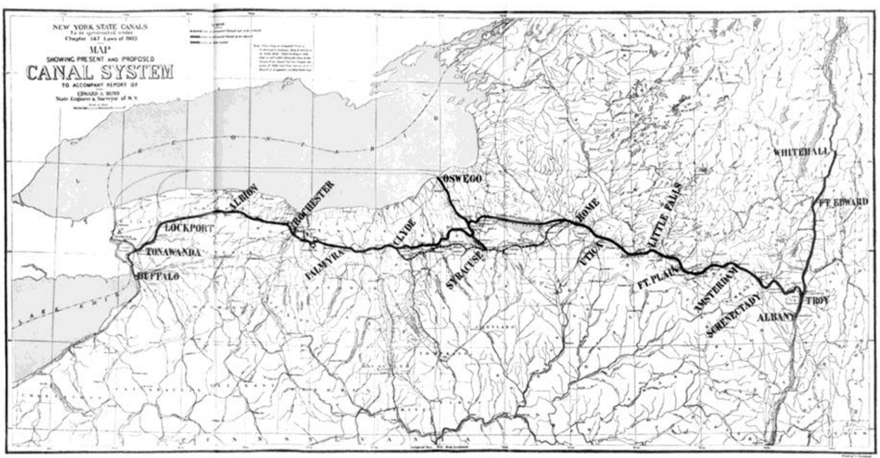


Figure 33: Erie Canal between Albany and Buffalo (1825).

Source: http://www.eriecanal.org/maps/canal_system-1903.jpg

---

[88] Cornelius Vanderbilt would later become a tycoon in the steamboat and railroad business. His great-great-grandfather, Jan Aertson or Aertszoon, was a Dutch farmer from the village of De Bilt in the province of Utrecht, Netherlands, who immigrated to New York as an indentured servant in 1650. At present your humble author is living in De Bilt.

[89] Based on a range of sources, such as: www.apstudynotes.org/us-history/topics/the-transportation-revolution/

[90] In England during the 1750s, there was turnpike mania when a thousand turnpikes covered 15,000 miles. The period was characterized by the rapid extension of turnpikes on roads created by turnpike trusts (some 389) that required an Act of Parliament.

Pike). By 1821 nearly 4,000 miles of 'turnpikes' had been completed, connecting the eastern cities (Klein & Majewski, 2008).

The experience with toll roads stimulated transportation over water in the United States. Many small scale canals for the transportation of goods were undertaken. While steamboats were conquering western rivers, canals were under construction in the northeast to further improve the transportation network, such as the *Erie Canal* from Albany, New York, to Buffalo, New York (Figure 33), that opened in 1825. The completion of the canal reduced travel time from New York City to Buffalo from 20 days to six, and reduced the cost of moving a ton of freight from $100 to $5. Its financial success inspired the construction of other canals, such as the *Delaware and Raritan Canal* (D&R Canal) in New Jersey, built in 1830. By 1840 some 3,000 miles of waterways had been constructed.

Between 1820 and 1830, many inventors and entrepreneurs began to apply emerging steamboat technology to engines that could travel on land. Steam locomotives were built, following British developments. One such example was the *DeWitt Clinton* steam locomotive (Figure 34). By the mid-1830s several companies were using steam-powered locomotives to move train cars on rail tracks. It started with the transportation of goods, such as the *Granite Railway* in 1826, a railway used to transport granite. This line was soon followed by the *Mohawk & Hudson Railroad* (1826) and the *Camden and Amboy Rail Road and Transportation Company* (C&A) that was chartered on February 4, 1830.

Figure 34: DeWitt Clinton steam locomotive (1830).

It is interesting to observe that the wagons were converted carriages traditionally pulled by horses.

Source: m.iphotoscrap.com

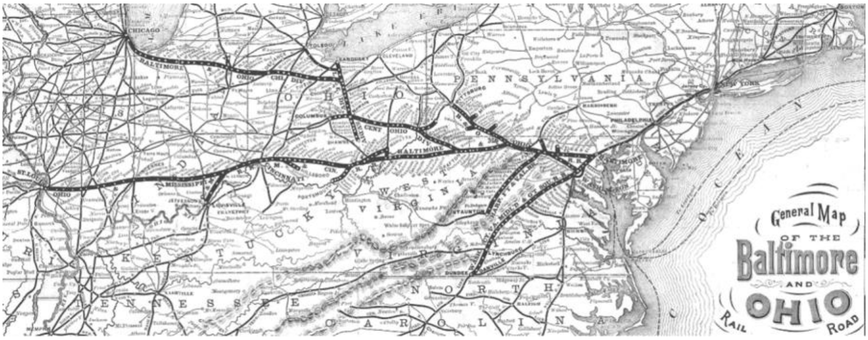


Figure 35: The Baltimore & Ohio Railroad network (1876).

Source: http://www.loc.gov/item/gm70002856/ (adapted)

The *Baltimore and Ohio Railroad Company* (Figure 35) was the first common carrier that offered scheduled freight and passenger service. The line, which ran over 14 miles, opened on May 24, 1830. It soon used the *Tom Thumb* locomotive impromptu assembled by Peter Cooper, who later became a successful industrialist manufacturing iron rails[91]. Allowing travel at the speed of 18 miles an hour, the 'Iron Horse' had arrived in America. It would result in the 'Railroad Boom' of the 1830s, with a large industrial spin-off manufacturing boilers, rails, and cars.

Transportation infrastructure facilitated the movement of goods over long distances to the various regions. In addition, it required a supporting infrastructure, which stimulated the growth of market towns where merchants, bankers, warehousemen, retailers and other middlemen provided the services needed to move the goods from producers to consumers. And goods could be produced without transportation restraints. Boston, whose merchant trade (eg sugar, molasses) was badly affected by the British naval blockade in the 1770s, and that had lost much of its merchant activity to New York, saw a rise in the manufacturing industry replacing commerce. Philadelphia, the former federal capital, with its abundant coal resources, high worker immigration rate, and ideal transportation location, became an important industrial centre (paper industry, grain milling industry and textile industry). All of these changes were due to the Transportation Revolution that took place in the first half of the nineteenth century.

[91] Peter Cooper would be one of the early investors in the *Newfoundland and London Telegraph Company* (1854) and the *American Telegraph Company* (1855), and he would also be involved in the Transatlantic telegraph cable (1858)

Science and Engineering in the New Nation

In the American colonies, the scientific infrastructure was poorly developed compared to the long-established societies, institutes and universities in Europe. This is not too surprising, though, when one considers the mercantilist nature of the colonies. The American colonies were primarily created as a source of economic profit for the British Empire. People who went to the colonies were not people who were emigrating because they were so well-off (ie economic emigration), because their religious beliefs were acceptable to the prevailing religion (ie religious emigration), or because their ideas and views were welcomed by the societies they lived in (ie political emigration). They immigrated because they were looking for spiritual and physical freedom and new opportunities to create a living. Some—like those 50,000 British convicts—were even forced to emigrate (ie penal emigration). And those well-off who went to the colonies of their own desire were often rent-seeking entrepreneurial individuals with pure economic motives (Finck, 2007).

That does not mean that there were no curious, inventive and creative people in the colonies. One need only look at the economic and technical spin-off of the Huguenot's emigration in the seventeenth century to see that. Those who fled to London[92], Amsterdam and Berlin contributed, due to their religious cohesion, technical skills and knowledge, to the development of the hosting countries. A similar phenomenon occurred with all the immigration into America—including Huguenots—and it contributed to the 'Yankee ingenuity' of the post-colonial days.

In the American colonial period, innovation was led by experimental scientists like *Benjamin Franklin* (1705-1790), who explored the 'nature of lightning' with his famous kite experiments in 1750[93]. Having been the British Postmaster for the colonies (1753-1774), he also set up the postal system in the colonies and became the US Postmaster General in 1775. So, both 'electricity' as well as 'communication' were among his many scientific interests. These can be added to his other intellectual and political achievements, as he would become one of the influential

---

[92] Such a flood of these new immigrants was washed onto British shores in the 1680s that a new word came into the English language at the time to describe them: 'rés' or refugees. Forty or fifty thousand crossed the Channel while Louis XIV sat on the French throne (1660-1714). Others had come in the time of the Tudors, especially during the reigns of Edward VI and Elizabeth. More continued to arrive during periods of persecution in the eighteenth century, for conditions in France could lead Protestants there to martyrdom for the sake of their beliefs as late as the 1760s. Source: Robin Gwynn examines the arrival of Huguenot French to England in the 17th Century. History Today, Volume 35, Issue 5, May 1985. http://www.historytoday.com/robin-gwynn/englands-first-refugees.

[93] Described in B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015) pp. 32-34.

Founding Fathers of the United States and serve as its first ambassador to France (1776-1785).

Another polymath in the arts, sciences and politics was *Thomas Jefferson* (1743-1826), who was also one of the Founding Fathers. Jefferson was a lawyer who acted as a delegate to the Second Continental Congress and who wrote the first draft of the Declaration of Independence. He was in Paris as a Minster to France on the brink of the French Revolution, meeting there with prominent people like the Marquis de Lafayette, and he witnessed the storming of the Bastille in 1789. Jefferson was a student of agriculture, who introduced various types of rice, olive trees and grasses into the New World. He also stressed the scientific aspect of the Lewis and Clark expedition (1804–06)[94], which explored the Pacific Northwest, and detailed, systematic information on the region's plants and animals was one of that expedition's legacies.

It was in this period before the American Revolution that life in the colonies was characterized by an exploding fascination with science, religious revivalism and experimental forms of government. It was a period in which many American scientists of the late eighteenth century were involved in the struggle to win American independence and forge a new nation.

Applied Science in the New Nation

During the nineteenth century, Britain, France and Germany were at the forefront of new ideas, views and theories in science and mathematics. These nations had the old established scientific institutions like the *Royal Society of London* (established 1660, London), the *Académie des Sciences* (Academy of Sciences: established 1666, Paris) and the *Königlich-Preußische Akademie der Wissenschaften* (Royal Prussian Academy of Sciences: established 1700, Berlin). Nothing like this was to be found in the colonies. That is not to say there were no institutions of higher education and no scientists. On the contrary, there were the nine colonial colleges that would evolve into renowned universities, including the *New College* (founded in 1636 in Massachusetts colony, later Harvard University), the *Collegiate School* (founded in 1701 in Connecticut colony, later Yale University), and the *College of New Jersey* (founded in 1746 in the Province of New Jersey, later Princeton University). However, the purpose and character of the educational institutions were quite different from the scientific institutions.

America's scientific infrastructure may have been quite primitive compared to the long-established societies, institutes and universities in

[94] This expedition was the first American expedition in 1804 to cross the western part of America after the Louisianan purchase of 1803.

Europe, and as a result, the United States may have lagged behind in the formulation of theory. However, it excelled in using theory to solve problems: applied science. This focus on realizing the artefacts based on new scientific discoveries—often described as engineering science—was born out of necessity, as the US was so far from the European sources of science. This created the context for all those early American engineering scientists that contributed to the early development of electric telegraphy in America: Joseph Henry (the son of Scottish emigrants), Samuel Morse, Alfred Vail and many others in the fields of electricity.

These American engineering scientists were joined by many European immigrants, attracted to the dogma-free, creative environment to develop their ideas and views. Many came from Scotland and England, others from the rest of Europe. They brought with them a lot of knowhow and experience in the technologies of their time. A notable early immigrant was the British chemist Joseph Priestley, who was driven from his homeland because of his dissenting politics in 1794[95]. Others would later follow him to the United States to take part in the nation's rapid growth. One example was Alexander Graham Bell—a man who will play a dominant role in the development of the telephone, as we will see later on—who arrived from Scotland by way of Canada in 1872. Another was the Serb Nicolas Tesla, who arrived in 1884 from Paris —where had worked for the Continental Edison Company— and had a great influence on the development of electric motors.

The totality of these developments created in America a 'Zeitgeist of Industrial Enlightenment' that represented the concept of freedom of spirit and body in a time where science and engineering created miracles. The 1850 song 'Uncle Sam's Farm,' written by Jesse Hutchinson Jr, of the Hutchinson Family Singers, captured this sense that a unique historical rupture had occurred as a result of scientific and social progress:

… Our fathers gave us liberty, but little did they dream.
The grand results that pour along this mighty age of steam;
For our mountains, lakes and rivers are all a blaze of fire,
And we send our news by lightning on the telegraphic wire …

[95] Described in B.J.G. van der Kooij: *The Invention of the Electro-motive Engine*. pp. 26-31 (2015).

Summary of the American Revolution

Over a period of two centuries the early colonies of North-America transformed into the society that created the *United States of Ame*rica. The society started with the first British settlers in the 1600s on the Atlantic coast, settlers who hardly survived in the harsh conditions. It grew into the American colonies of the British Empire in the 1700s, colonies populated with people who fled from the Old World, evidently not because their lives had been so wonderful and prosperous back there. At the beginning of the 1800s it became a new Nation, a Nation that consisted of people who predominantly lived in a rural economy, people who were busy with establishing families, setting up communities and churches, and competing in dividing the land. The majority of its people arrived unfree, as coloured slaves, as convicts or as indentured servants (ie white slaves). After their contracts ended they became colonists who found over the decennia their place in a self-governing society, a society that was not dominated by the monarchical and clerical powers of the King, the Aristocracy and the Church of the Old World they had come from.

> *In 1760 America was only a collection of disparate colonies huddled along a narrow strip of the Atlantic coast—economically underdeveloped outpost existing on the very edges of the civilized world. … Yet scarcely fifty years later these insignificant borderland provinces had become a giant, almost continent-wide republic of nearly ten million egalitarian minded bustling citizens who not only had thrust themselves into the vanguard of history but had fundamentally altered their society and their social relationships.* (Wood, 2011, p. 6)

It had been the Thirteen Colonies that created a new independent nation in the 1770s. The population at that time had increased to over two and a half million people. Then, after a period of revolt against British taxation, the social turmoil resulted in the American Revolution. The governmental ties with the British 'motherland' were severed, and 'British Colonial Rule' ended. The period in which the colonies and Britain had been tied together in the grip of mercantilism—purely a domination of British economic interests—now had ended, and the United States was on the brink of adopting the Industrial Revolution (Figure 36).

Spirit of Freedom

Generally speaking, living in America in the early colonial days was quite a challenge, and not an easy challenge, considering the often severe living conditions. But it gave people an opportunity for change. For the underprivileged it was a chance to escape from suppression and utmost poverty. It was a challenge to escape from the oppressive societal structures of the Old World, where the feudal times still echoed. On the other side,

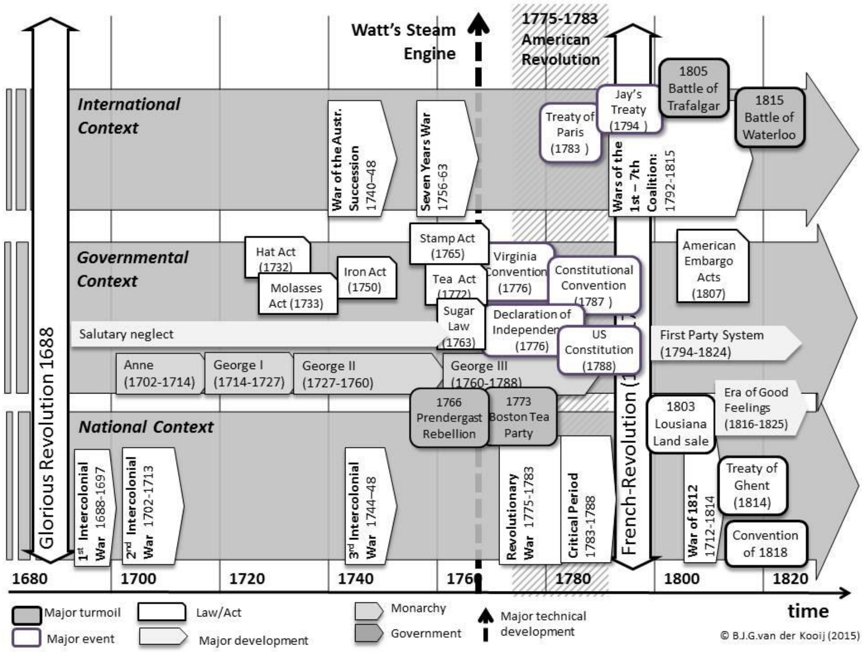


Figure 36: Overview of the context of the American Revolution in relation to Britain.

Source: Figure created by author

for the establishment of the Old World—from wool merchant to fur trader—America offered a challenging business venture, a place where profits were to be made, especially when those entrepreneurial activities were protected by governmental policies (the 'mercantilism'). And for the royalty? Simple—as landownership was predominant in those days, it gave the monarchy a new reservoir of untapped territory that could be distributed to those who were entitled to a 'feudal favour' from the king (such as the previously mentioned *William Penn*, who received the tract of land that became *Pennsylvania*)

What all those people had in common was that they all saw America as the country of freedom, an idea that attracted many European immigrants. To leave their country of origin, where they had lived over generations in a bonded situation, and facing an uncertain future in a totally unknown world, must have been a major decision in their lives. The majority of people looked for an environment where they could be industrious, acting in their own interests and for their own betterment. An environment where their labour worked to their own advantage, not that of the landowning lord, and where they could create industrious activities without the burden of King, the Aristocracy or the Clergy. It was this idea of a multi-dimensional freedom that attracted the immigrants. Among those freedoms, the most catching were the following:

Freedom from taxes to support the establishment: It was the desire to be free of the feudal structure of the past that still dominated the social structure of the Old World: the system of 'Manorism', where the Landowner—the lord of the Manor—exercised his rights over the people who lived on and who worked his lands.

Freedom from civil discrimination: It was the desire of freedom from a social structure where a few dominated so many, taxing them to their own advantage, denying them a place in the power structure. They looked for a place where they could decide on their own rights and obligations.

Freedom of oppressing religion: It was also the desire to be able to express one's religious beliefs, live according to one's own religious principles and—for example, like the Quakers did—build a society upon one's religious belief.

These were some of the dominant aspirations the immigrant's possessed. On the background, there were those fundamental freedoms the Enlightenment philosophers had proclaimed: the freedom of thought, freedom of speech, freedom of press, freedom to associate and organize, and the freedom from fear of reprisal. These aspirations were met in a basically different social environment. Again, speaking in general terms, in the Old World—ie England— the distribution of power in society was based on 'landownership'. In the New World—with its abundance of land—the distribution of power was based on 'labour-ship', or labour that was free to move. This 'labour-ship' resulted from the vast movement of people that had immigrated to, and within, America.

> *In America, prior to the emergence of African slavery, every man controlled his own labor, if not immediately, then after the expiration of his indenture. He might not control real estate, but he did possess his own labor, and it was labor which was the scarce commodity. … No man or youth needed to fear unemployment any longer. If he did not own land, then someone nearby was eager to hire his labor, and willing to forget even a criminal record. As a result, the coercive abilities of superiors were drastically reduced by the new environment. Though there was nowhere any rationalization for a popular distribution of power, economic or political, the facts of abundant land and labor scarcity yielded a distribution of actual wealth which would lay the foundation for widespread participation in political life.* (Brown, 1972, pp. 207-208)

It was this concept of individual freedom that was at the foundation of the new Nation. After the American Revolution, the new nation of the United States of America was seen even more as the land of freedom.

> *In the eyes of its citizens, America became an asylum for liberty in the world, and all mankind became America's constituency. Unlike traditional nationalisms based upon inherited language, culture, and birth, American nationality was defined by abstract universals-life, liberty, and the pursuit of happiness. … America was perceived in a dynamic way as a society which was physically expanding at the same time that it was developing its economy and perfecting its social order.* (Brown, 1972, p. 215)

America was the land of the 'modern man': people open to new challenges, people with faith that they could survive and prosper; people who had abandoned the fatalism of feudal life and replaced it with the ambition to shape their own lives; people who wanted to participate in their own society.

Dutch Tolerance as Legacy? [96]

One might remember the good old times when New York—then known as New Amsterdam—was still a Dutch settlement, before governor Peter Stuyvesant was defeated in 1664 and the settlement became British. Not only New York, but also the New England area had the remnants of the early Dutch influence in the manors. Although the British—as was obvious with all the wars they fought with them—were not too keen about the Dutch[97], there seems to be an observable Dutch legacy in the American culture.

PLACCAERT
Vande Statē generael
vande ghevnieerde Nederlanden:
BYDEN WELCKEN, MIDTS
DEN REDENEN INT LANGE IN'T SELFDE
begrepen, men verclaert den Coninck van Spaegnien vervallen vande Ouerheyt ende Heerſchappije van deſe voorſ. Nederlanden, ende verbiet ſijnen naem ende zeghel inde ſelue Landen meer te ghebruycken, &c.
SCRVTA- MINI.
TOT LEYDEN,
By Charles Silvius / ghesworen Drucker des Staten ſlandts van Hollandt.
M. D. LXXXI.
Met privilegie voor twee iaren.

Figure 37: Dutch Act of Abjuration (1581).

Source: www.rythovianan.wordpress. com

[96] The author is clearly of Dutch origin, and his historical nationalism maybe plays tricks on him in highlighting this point.

[97] That the English themselves were not too fond of the Dutch, can be observed as the English language still has quite a lot of negative expressions related to the Dutch: Dutch Treat, Dutch Date, Going Dutch (splitting the bill), Dutch Courage (booze-induced bravery), double Dutch (incomprehensible language), Dutch wife (prostitute), Dutch bargain, Dutch comfort (saying 'that could be worse'), Dutch uncle (sternness), Dutch nightingale (frog). All of these expressions originated from the seventeenth century (Bolt, Rodney. The Xenophobe's Guide to the Dutch).

We have to go back to the time when the Republic of the Netherlands, in 1581, declared their independence from Spanish rule under King Philip II. In the 'Plakkaat van Verlatinghe' (similar to the 'Declaration of Independence'), the Dutch declared that the people had the right to abolish the ruling king when he does not respect the laws and rights of his nationals.

> *Alsoo een yegelick kennelick is, dat een Prince van den lande van Godt gestelt is hooft over zijne ondersaten, om deselve te bewaren ende beschermen van alle ongelijk, overlast ende ghewelt gelijck een herder tot bewaernisse van zijne schapen: En dat d'ondersaten niet en sijn van Godt geschapen tot behoef van den Prince om hem in alles wat hy beveelt, weder het goddelick of ongoddelick, recht of onrecht is, onderdanig te wesen en als slaven te dienen: maer den Prince om d'ondersaten wille, sonder dewelcke hy egeen Prince en is, om deselve met recht ende redene te regeeren ende voor te staen ende lief te hebben als een vader zijne kinderen ende een herder zijne schapen, die zijn lijf ende leven set om deslve te bewaren. En so wanneer hy sulx niet en doet, maer in stede van zijne ondersaten te beschermen, deselve soeckt te verdrucken, t'overlasten, heure oude vryheyt, privilegien ende oude herkomen te benemen, ende heur te gebieden ende gebruycken als slaven, moet ghehouden worden niet als Prince, maer als een tyran ende voor sulx nae recht ende redene magh ten minsten van zijne ondersaten, besondere by deliberatie van de Staten van den lande, voor egheen Prince meer bekent, maer verlaeten ende een ander in zijn stede tot beschermenisse van henlieden voor overhooft sonder misbruycken ghecosen werden.* (Dutch text of Plakkaat van Verlatinghe)[98]

[98] English translation: *As it is apparent to all that a prince is constituted by God to be ruler of a people, to defend them from oppression and violence as the shepherd his sheep; and whereas God did not create the people slaves to their prince, to obey his commands, whether right or wrong, but rather the prince for the sake of the subjects (without which he could be no prince), to govern them according to equity, to love and support them as a father his children or a shepherd his flock, and even at the hazard of life to defend and preserve them. And when he does not behave thus, but, on the contrary, oppresses them, seeking opportunities to infringe their ancient customs and privileges, exacting from them slavish compliance, then he is no longer a prince, but a tyrant, and the subjects are to consider him in no other view. And particularly when this is done deliberately, unauthorized by the states, they may not only disallow his authority, but legally proceed to the choice of another prince for their defense. This is the only method left for subjects whose humble petitions and remonstrances could never soften their prince or dissuade him from his tyrannical proceedings; and this is what the law of nature dictates for the defense of liberty, which we ought to transmit to posterity, even at the hazard of our lives. And this we have seen done frequently in several countries upon the like occasion, whereof there are notorious instances, and more justifiable in our land, which has been always governed according to their ancient privileges, which are expressed in the oath taken by the prince at his admission to the government; for most of the Provinces receive their prince upon certain conditions, which he swears to maintain, which, if the prince violates, he is no longer sovereign.*
Source: http://www.let.rug.nl/usa/documents/before-1600/plakkaat-van-verlatinghe-1581-july-26.php

Different scholars have investigated the relationship between the Dutch 'Plakkaat van Verlatinghe' ('Act of Abjuration' Figure 37) and the American 'Declaration of Independence', and found quite a few similarities[99]. Not only do they claim similar causes (as in the grievances which led to the drafting of both), their descriptions of constitutions and representative systems are also quite similar.

> *Of all the models available to Jefferson and the Continental Congress, none provided as precise a template for the Declaration as did the Plakkaat…When you look at the two documents side by side, you cannot avoid noticing that the American Declaration more closely resembles its Dutch predecessor than any other possible model.'*[100]

But that similarity could also be the case because the Spirit of Time was ready for democratization, as already expressed by the French (eg Montesquieu) and English (eg Locke) philosophers of the Enlightenment period[101] (Coopmans, 1983; Lucas, 1998).

[99] Looking at the Dutch origins of New York, the historian Rusell Shorto in his book 'The Island at the Center of the World' related the Dutch culture of (religious, political and economic) tolerance with the spirit of freedom that characterizes the American culture. Could there be some Dutch contribution to the DNA of the United States?
[100] Source: Wolff, B.: *Was the Declaration of Independence inspired by Dutch?* University of Wisconsin-Madison News, June 29, 1998. http://www.news.wisc.edu/3049 (Accessed June 2015)
[101] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'*. (2015)

The Context for Technological Innovation

We started this chapter by realizing that *Technical Change* causes *Social Change*. We added to this the supposition that Social Change also sets the stage for Technical Change. In the preceding observations, we described the context for innovation in the early nineteenth century as set by social-political revolutions in the late eighteenth century: the English Revolution, the American Revolution and the French Revolution[102]. These revolutions created the context for the Industrial Revolution(s) to come. They have much in common—one aspect being that they all resulted in 'changing the scene'—but they differ considerably in what that 'change', and what that 'scene' was.

As described, the Enlightenment period, which brought a different perspective on the individual person in relation to the society he lived in, created a different social climate. The new perspective emphasized the 'natural rights' and 'legal rights' of the individual person, and the 'social contract' with those who govern. The concept of the natural rights of 'Life', 'Liberty' and 'Property' challenged the 'Divine Rights' of kings. These natural rights had already been implemented in 1581 when the Dutch created their Republic and, in the 'Plakkaat van Verlatinghe' (Act of Abjuration), abolished the rule of the Spanish ruler over their country because he had violated the fundamental rights of his subjects. They created their own freedom (ie independence). Evidently, freedom of body and spirit was an important aspect to creating the context for innovation.

Freedom of Body and Spirit

America had become the 'Land of Freedom' in the first half of the nineteenth century, a freedom related to the implementation of the basic *Rights of Englishmen.* Americans saw themselves as Englishmen and claimed the same rights. Or, as formulated by George Mason, one of the Founding Fathers of the United States:

> *'We claim nothing but the liberty and privileges of Englishmen in the same degree, as if we had continued among our brethren in Great Britain'* (Miller, 1959, p. 168).

Sure, there was something known as 'freedom for the English'. However, those liberties need to be seen in the context of their day, as today's observer would find them quite limited liberties. It was the beginning of a fundamental social change, as Thomas Jefferson stated in the preamble of the Declaration of Independence:

---

102 See: B.J.G. van der Kooij: *The invention of the Communication Engine 'Telegraph'.* (2015)

> *When in the Course of human events, it becomes necessary for one people to dissolve the political bands which have connected them with another, and to assume among the powers of the earth, the separate and equal station to which the Laws of Nature and of Nature's God entitle them, a decent respect to the opinions of mankind requires that they should declare the causes which impel them to the separation. …*
>
> *We hold these truths to be self-evident, that all men are created equal, that they are endowed by their Creator with certain inalienable rights, that among these are Life, Liberty, and the pursuit of Happiness.—That to secure these rights, Governments are instituted among Men, deriving their just powers from the consent of the governed.—That whenever any Form of Government becomes destructive of these ends, it is the right of the People to alter or to abolish it, and to institute new Government, laying its foundation on such principles, and organizing its powers in such form, as to them shall seem most likely to effect their Safety and Happiness… it is their right, it is their duty, to throw off such Government, and to provide new Guards for their future security.* (text of Declaration)[103]

Both the French and American Revolution—being so close in time—have that aspect of freedom in common, but basically they had a different drive.

> *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 contrast with this political drive, in France it was about the overturning of the established order; it was about 'Liberté, Égalité, Fraternité'. A slogan[104] that includes the Freedom ('Liberté'), but adds two other elements: the equality ('Égalité') and brotherhood ('Fraternité'). Both

[103] Source: Thomas Jefferson, The Works of Thomas Jefferson, Federal Edition (New York and London, G.P. Putnam's Sons, 1904-5). Vol. 3. Retrieved 2-6-2015 from the World Wide Web: http://oll.libertyfund.org/titles/801

[104] This slogan was used in different forms and with different additions during the revolution. Fraternité (Brotherhood) 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.

elements indicate that the drive was about more than only freedom of the individual; it also related to the role of community. For the French Revolution to realize freedom, the existing societal structure had to change. This meant a societal change of 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 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, pioneering 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 not without considerable resistance.

The differences between the revolutions were eloquently described by Nicolas de Caritat, Marquis de Condorcet[105], while he was hiding from prosecution for his ideas 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.* (Condorcet Caritat, 1795, p. 212)

---

[105] 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 Académie in 1793. In 1782 he was secretary of the Académie Française. In 1791 he was elected as a Paris representative in the Assemblée, 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 Sp*irit (1795) was perhaps the most influential formulation of the idea of progress ever written.

He describes a 'changing of the scene' that is both about a more complex 'scene', as well as a more profound 'change'. This idea is also recognized by the present day historian Gordon Wood when he describes the difference between the two revolutions.

> *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.* (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 change in societal institutions, but there was more because, in changing the societal structure, the social relations between people also changed.

The Context for Imitation, Invention and Innovation

All of the social changes described[106] created a different context for the individual person and his/her creative behaviour, a context that changed over time and that defined the different forms of 'change and novelty' in the different periods in time.

In *feudal times* the guild system limited the individual industrious creativity that tried to create change outside the boundaries set by the guilds. These boundaries could not be crossed without facing penalty and exclusion. This system held people in check, conserving the existing balance of power. The guild system was just one of the social constructs —such as the church and the lords of the manors—that held the people in check. Not only the poor plebs and peasantry, but also the awakening 'bourgeoisie', were encapsulated within the structures and institutions carefully maintained by the conserving powers of clergy and nobility. It was the time of 'imitation': for example, the 'Imitatio Christi' where painters used themes from the Bible to please their principals, the clerical aristocracy. Or the concept of 'Imitatio and Emulatio' that set the boundaries of the framework in which technical changes could be realized.

In the times of *religious dominance* where the conservative powers of the Roman-Catholic Church ruled, change was limited to within the

[106] We include here the description of the social consequences of the French Revolution as described in the case study 'The Invention of the Communication Engine Telegraph'.

doctrines set by that church. These doctrines created canon laws that were implemented and upheld by the church. It was power by indoctrination and even by physical force if necessary (ie the Inquisition). The clerical laws and rules governed whole societies by creating behavioural boundaries, and these boundaries could not be crossed without facing penalty and exclusion.

When that clerical power became challenged and even defeated, as it was in England in the 1580s by the English king Henry VIII, the resulting *scientific awakening* created, ultimately, an abundance of technical changes. It was necessary that the 'divine power of the clergy' be challenged before the 'divine power of the monarchy' could be replaced by the 'natural rights of the people'. And when that happened it opened the way to explore Nature. It created the stimulus for the creative individuals to be curious about 'the nature of matter' (and for matter one can place the natural phenomena like 'lighting', 'sound' and 'fire'). It was the time of 'invention'; the concept of fundamental discovery created insight and basic, conceptual artefacts, such as the invention of the electro-motive engines: the electric motor and the electric dynamo[107].

Then came the time of *industrial awakening*, which saw the development from small scale rural industrial activity to organized, large scale manufacturing, supported by technologies that freed men from being the physical supply of energy (eg steam technology realizing steam engines). Now those mighty kings (ie all those monarchs with 'Great' in their name) and famous generals were no longer the only 'heroes of society'[108] as the industrial class of entrepreneurial citizens became heroes. The admiration was now for the inventor-entrepreneur, like those who gave Britain the strength (as in the steam machine) and the power (as in guns) to fight their wars. Their technologies enabled massive changes in society as technical innovation transformed conceptual artefacts and scientific instruments into practical products. This created the stimulus for creative individuals to be entrepreneurial. It was the time of 'innovation': the concept of transforming insight into reality using previously developed skills[109]. The individual contribution to innovation was enabled by the free society that did not restrict, by religion, morally or ethically, the individual's creativity.

---

[107] See our other case studies in the Invention Series.

[108] Also known as Thomas Carlyle's 'Great Man Theory'.

[109] As conceptualized by Schumpeter's description of innovation and the role of the entrepreneur creating 'Business Cycles'.

Collective Behaviour: Spirit of times/Madness of times

What can be observed in the preceding text is that societal structures and institutions underwent massive change in the revolutionary times. Whether it was the creation of a new Nation by removing the shackles of governmental unfreedom, like in America, or the overhaul of the total societal structure, as in France, it all affected individual human behaviour. In a time when 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. The landless British peasant faced with the Enclosures of the former common lands, losing his means of existence and having to move to the cities, was not all that better off either. Continuously, individual behaviour was geared to survival, that is, finding food, shelter and safety.

When food was scarce and people went hungry, they had to act. When people were deprived of shelter—due to natural disruptions such as water floods, earthquakes and slides—people moved. Whatever the case, when people were threatened in their mere existence, they had to act. Sometimes this resulted in revolt, like all those food revolts. Sometimes the action was in the form of migration, finding better circumstances to live in. The consequence was often war and turmoil, as those who were invaded by the new immigrants 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. Obviously, the social classes that were already in place resisted the invasion of the 'revolutionists' —also called the 'innovators'—that threatened the core of their existence, an existence they were prepared to defend at all costs.

The Spirit of Times

That totality of individual behaviour among a collective created a societal behaviour described as the *Zeitgeist* ('Spirit of Time'). Take, as an example, the collective behaviour at different moments in time when America became the 'Promised land' with unheard of riches[110] and opportunities. Periods in time in which many decided to leave the world they knew for the unknown new world in the colonies, dreaming of

[110] From the presumed riches of the Incas for the early settlers, through the time when, in 1849, gold was discovered in California—the California Dream—this prospect seems to have been quite important for the decision to leave, the other factor being that what they were leaving behind was not that pleasant nor comfortable at all.

freedom. Not only the British immigrated 'en masse' in the eighteenth century; many French émigres escaped from their revolution to go to America, and in the nineteenth century many well-educated Germans fled the failed 1848 revolution. They welcomed the political freedoms in the New World, and the lack of a hierarchical or aristocratic society that determined the ceiling for individual aspirations. So, at different moments in time the different Zeitgeists were in existence.

One such Zeitgeist originated from the prospects of the *Empire of Liberty*.[111] This occurred at a time in America when everybody wanted to 'go west': the period of westward expansion of the American colonies also described as *Manifest Destiny*. It resulted in the 'Zeitgeist of the Expansion to the 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). Or take the example of the Zeitgeist in the *Era of Good Feelings*, the mood of victory that reflected a sense of national purpose and a desire for unity among Americans in the aftermath of the Napoleonic Wars. It created a period of political change, replacing the bitter political divisions in the young nation of the United States. In the late nineteenth century we see that 'spirit of time' as a reaction to preceding times of economic and/or hardship. Such as the *Gilded Age* (1870-1900) after the American Civil War (1861-1864), and *La Belle Époque* (1871-1914) in France after the Franco-Prussian War of 1871. These are just some examples of the many 'Zeitgeists' that can be found in history[112].

The Madness of Times

One has to realize that, along with the positive, joyful and stimulating Zeitgeists, there also were the periods with a 'negative Zeitgeist', violent times that were crowded with wars, turmoil and other destructive behaviour. In the eighteenth century, with all those absolute monarchies in Europe, many wars had to do with the interests of the monarchies themselves. Such as the Spanish War of Succession (1701-1714), the Austrian War of Succession (1740-1748), the War of the Polish Succession (1733–1738), and the War of the Bavarian Succession (1778–1779).

Others wars were related to political/economic dominance; such as the Seven Years War (1754-1763) between the great powers of Europe; the coalitions around France and those around England. This war was about

---

[111] A concept introduced by Thomas Jefferson in 1780. Jefferson envisaged this 'Empire' extending Westwards over the American continent, expansion into which he saw as crucial to the American future.
[112] See: B.J.G. van der Kooij: *The invention of Electric Light.* (2015) pp. 16-37.

colonial domains (especially of the riches of the Americas and India), the ruling of the oceans (and thus facilitating the trading companies) and the political dominance within Europe. Take the Fourth Anglo-Dutch War (1780–1784) that was about those irritating Dutch trading with Brittani's enemies during war. The enemies being the American colonists who had the temerity to start a revolution against British colonial rule. The daring Dutch, always keen on doing business, supplied the revolutionists with arms and munitions and exported their cotton, tobacco and indigo to Europe. At a profit, of course.

It was not only about wars between nations, as there were also civil wars, often part of the revolutionary periods in which societies changed fundamentally: such as the American Revolution (1765-1783) and the French Revolution (1789-1799).

Each conflict, in its own way, resulted in turmoil with 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 the times. Not only wartime violence, but also publicly sanctioned violence, as illustrated by the Hanoverian *Bloody Code* that resulted in public hangings up until 1830. These public affairs of collectively sanctioned violence attracted large crowds. Violence was the response to perceivied threats, be it from invading armies (as the French invading England), from civil conflicts where local conflicting interests clashed, or from the disturbances of social harmony (as in 'Law and Order'). The result was a form of societal brutal violence that was part of the social behavior of those times. In addition to that 'normal' type of brutality, there were other causes that contributed to the madness of the times. Such as those major societal changes that threatened the 'establishment': the existing societal powers of the royalty, aristocracy and clergy. They were the ones who had something to lose—their feudal prerogative rights and privileges—and who saw the Enlightenment and the related revolutions—quite justly—as threatening their existence, the way they were used to living, and the exercise of their powers. In such times, corporal and capital punishment were tools used to maintain the well-established 'order' of those classes that wanted to maintain. They were prepared 'to do what had to be done', from political machinations to physical violence.

As a consequence of this climate of violence and the maintenance of the vested interests of the establishment at that period in time, sometimes there were periods of a more intense and frantic collective behaviour of a specific social power. Take the example of the *Spanish Inquisition* (1478), in which the Roman-Catholic Church in Spain executed their ecclesiastical power by convicting and executing those they considered deviant. More recently we see the short-lived periods in time with specific collective behaviour, such as the period that was initiated by a negative collective behaviour called the *Great Fear* ('La Grande Peur') that flooded France in 1789, a period when dramatic climatic conditions created food shortages and grain speculation. Everywhere in France, peasantry undertook collective actions against those they considered to be the cause—the ruling class of the seigneurs and the 'Manorism'. Or take the period in the French Revolution called the *Reign of Terror* (1793-1794). This period began with the introduction in 1793 of the 'Law of Suspects', a law that made nearly everybody a suspect of anti-revolutionary behaviour, from the former nobleman stocking the harvest, to someone protesting about the rising prices of bread. The law created an *economic terror* that was soon followed by a *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.

Individual Behaviour: Thinking and Tinkering

Within the contexts of their time— including the before described 'Spirit/Madness of Times'— the individual inventors who shaped our technical foundations, lived, loved and struggled. A live with the personal circumstances that were shaped by the social group they belonged to, as they were raised in the traditions of their position in society. Many were educated in the spirit of the Guild-structure; the apprentice imitating the master. The prevailing method of guild-based education was "Emulation and Imitation" and that reflected in the technical progress. Others were not formally educated but, if being in the circumstances to do so, they educated themselves. Formal schooling, if available, was for the few and often limited in time. Only the rich could afford private tutorship.

The early years of formation of some of the famous 'electriciens' being relevant to our study, do illustrate this. In the nineteenth century Britain *Humphry Davy* (1778-1829) had little formal education until the age of sixteen, then became—after his father's death—apprentice to a surgeon at the age of seventeen in 1795, and became an early 'chemist' as so many apothecaries of those days[113]. His later assistant *Michael Faraday*, started as a fourteen year old apprentice to a local bookbinder. There he educated himself from the books that he worked on[114]. In France *Andre-Marie Ampere* (1775-1836) was allowed to self-education by reading from his rich father's

[113] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015). Pp. 47-53.
[114] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015). Pp. 53-58.

well-stocked library. He became a self-educated mathematician at the age of eighteen (in 1793) and mathematics teacher in 1799[115]. The American boy descending from poor Scottish immigrants, *Joseph Henry* (1797-1878), at the age of thirteen became an apprentice watchmaker and silversmith. It was a stroke of luck as he in 1819 entered The Albany Academy, where he was given free tuition[116]. And, to conclude this short overview, later in time *Thomas Edison* (1847-1931) was educated by his mother at home and started as boy selling candy and newspaper on trains. He got his early formation when he took a job of telegrapher. In the same period of time *Alexander Graham Bell* (1847-1922), from Scottish origin, was home-educated by his father—a well know teacher of deaf— and got formal schooling till the age of fourteen. At the age of sixteen, Bell secured a position as a "pupil-teacher" of elocution and music. These are just a few examples of the formation of those early thinkers and tinkerers that shaped the new technology of electricity. Their personal context and personal situation may have been completely different, what they had in common was their hunger for knowledge, their curiosity, the urge to investigate and experiment, the drive to create novelty and discover new things.

These aspects have to do with their personalities as they were shaped by the personal circumstances. Next to that, there are the social circumstances that influence individual behaviour, as the inventors we are considering were mostly living in different social circumstances. One can easily image—apart from other factors—the difference of the context for invention in different places and different times.

Image the time when England and Scotland became more and more entangled; the period of the Reign of the House of Hanover in the eighteenth and nineteenth century. In the Kingdom of Great Britain (1707-1800), with the Union of Scotland and England, the Scots traded independence for access to the bounties of the British maritime trade and trade routes. It became the period of the Scottish Enlightenment—with the Scottish thinkers as Adam Smith, David Hume— in which one of Europe's poorest countries changed into the birthplace of many inventors (from James Watt to Alexander Bell). Especially in the Low Lands with cities like Aberdeen, Glasgow and Edinburgh where the colonial wealth collected by the mercantilist traders (such as the Glasgow Tobacco Lords), and the easy access to Universities, created the context of the intellectual climate of the Industrial Enlightenment.

[115] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015). Pp. 40-44.
[116] See: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015). Pp. 65-66.

> *But also and more importantly, the Scottish people always maintained a strong sense of fairness, justice, democracy, rooting for the common man and the underdog, and always coated this with intellectualism for intellectualisms sake and an unadulterated dose of piousness, all of which served its designs well in its long-term struggles with England. As the New World opened up, no people were more ideally suited and prepared to take advantage of it than the Scottish. The U.S. became one of the primary beneficiaries of this preparation.* [117]

Imagine when living in the late eighteenth-century's English society—still with many remnants of its feudal history—where only the gentlemen of science could permit the luxury of 'thinking and tinkering'. Compare that to living in the early nineteenth-century New Nation of America where the 'tinkering and thinking' was needed to compensate for the loss of British technology and artefacts after the American Revolution severed the political ties between both countries. A development that continued in the late nineteenth century as the American Genesis:

> *No other nation has displayed such inventive power and produced such brilliantly original inventors as the United States during the half-century beginning around 1870. … Not only were tens of thousands of Americans inventing at the grass-roots level, but a singular band of independent inventors was also flourishing during the decades extending from about 1870 to 1920. … The era of independent inventors began about the time Alexander Graham Bell invented his telephone and Edison opened his Menlo Park laboratory in 1876.* (Hughes, 2004, pp. 13, 14. 15)

The Act of Invention; Conceptual Skills without Constraints

Those who contributed to the development of the emerging technology of electricity and its applications were not only curious. They also had the urge to create and the drive to discover something that had never existed before. They possessed individual skills—although some lacked additional and complementary knowledge they needed badly— but they all experimented.

In the process of experimenting, they were performing the 'Act of Invention' in which they combined insight in their specific fields of interest, and the instrumental skills—learned abilities—build up in their formative years. Skills that could be of a different nature; from the mechanical skills of the instrument maker to the more explosive skills of the early chemist. In addition to those instrumental, they seem to have possessed additional conceptual skills. Their dominant skill being the way they conceptualized and the methods by which they identified and solved problems. As the process of invention can be considering a winding trajectory of solving

[117] Review of Herman, A: How the Scots Invented the Modern World. (Herman, 2001)

small and big problems, it is a process where problems needed solutions. Thus, here we see another component of their behaviour. The 'ingenuity' to create solutions, to generate ideas, to evaluate and implement them. A process of combining abstract ideas (aka 'mental models') with physical objects (aka 'mechanical representations') called 'heuristics' or 'problem solving strategies' (Gorman & Carlson, 1990).

For the act of invention to be successful, the context has to be restriction free. That is to say, when the context forbids specific technical developments, the act of invention is restricted. Many of these restrictions are dominated by their time. Take the former times of the seventeenth-nineteenth centuries. The restrictions then were of a religious nature or, seen in the broader context, of a socio-economic nature. Such as the conservative powers of the Guild system[118].

Take the historic example of button-making in the seventeenth century. Button-making in France had been controlled by various guilds, depending on the material used, the most important part belonging to the Cord and Button makers' guild, who made cord buttons by hand. As buttons were popular, it was a profitable business. By the 1690s, tailors and dealers launched the innovation of weaving buttons from the material used in the garment; the thread buttons as opposed to the former solid button made from bone, wood, metal, ivory and cord. The question was if members of other guilds should be allowed to make buttons also. It became the *Guerre des Boutons* ('War of the Buttons'). It started simple:

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 proposed …

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 making. But the wardens of the button guild are not yet satisfied. They demand the right to search

[118] The institution of the Guild system—in France Corps de Métiers— has to be seen in the context of its time. In their origin, they were fraternities organized as associations: the craft guilds and merchant guilds. Over time, as they became monopolists being granted Letters of Patents by the monarchs in need of money, they became protective and conservative. And by the time the early proto-industrial society developed, the had outlived their existence.

> *people's homes and wardrobes and fine and even arrest them on the streets if they are seen wearing this subversive goods.* (Heilbroner, 2011, p. 30)

As we will see later on, the invention of the telephone took place in a context that was—at least technically— constrained. As the telegraph dominated much of the activities of the American inventors in those days, they were focusing on solving the problems of telegraphy (that is, the efficient use of the costly long copper transmission lines). An outsider was needed, the teacher of deaf Alexander Graham Bell, to create a breakthrough that resulted in 'electric speech'.

Technical Change

In the preceding sections we explored—from different levels, as we switched from a satellite's perspective to the helicopter view and the bird's eye perspective—the social, political and economic context for technological innovation in the 'real world', especially the world of American society up to the period we call the Industrial Revolution.

In total, we described the context as created by the English Revolution, the American Revolution and the French Revolution[119]. We observed the phenomena in the societies that contributed to those revolutions and discovered that these phenomena all had one main aspect in common: the transition from the feudal agrarian society into the democratized industrial society. In this transition, the old societal powers that had created privileges for some and unfreedom for many, had to make space for societies based on the human rights of freedom (liberty for all) and equality of mankind (as far as that was possible). These transitions prepared the societies for the era of industrialization to come. One could say that the social revolutions prepared the way for the industrial revolutions to come.

Changing Sources of Power

We observed previously the changes in societies that were related to emerging technologies like the General Purpose Technology (GPT) of 'steam technology', technologies in which discoveries, inventions and innovations resulting in steam technology took place and fulfilled a need[120]. Not that everybody was waiting to replace his horse immediately by a steam powered vehicle. However, that water problem of the English mines certainly needed to be solved urgently. We noted that, when the steam

---

[119] In the case study about telegraphy (Part I) the French Revolution is described extensively. Here in this case study (Part II) the American Revolution is described. In the next case study about the wireless communication engine (Part III), the English Revolution will be described.

[120] As described in detail in: B.J.G. van der Kooij: *The Invention of the Steam Engine.* (2015)

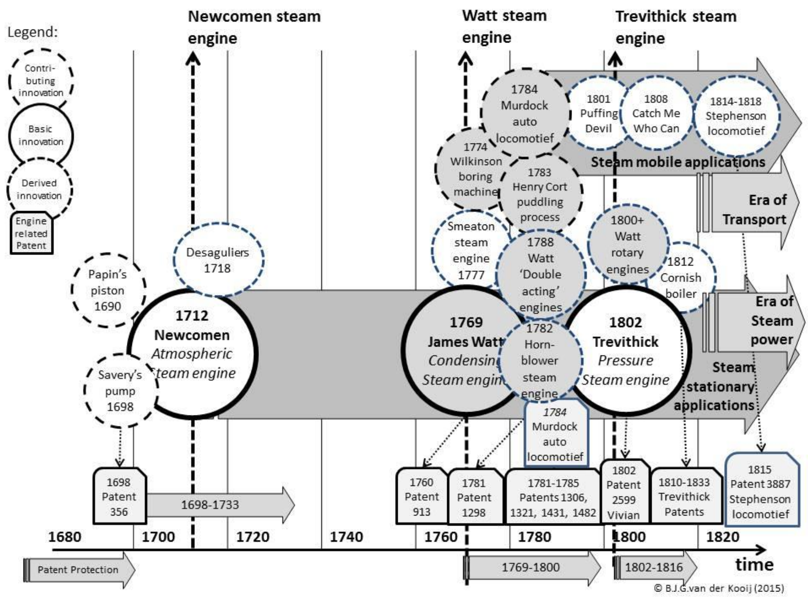


Figure 38: Overview of the clusters of innovations that created the steam-motive engines.

Source: B.J.G. van der Kooij: *The Invention of the Steam Engine* (2015) p.110

technology matured and diffused in society, it certainly fulfilled the manifest need for rotative power replacing the human, animal and natural power sources, a process of technologically induced change that took its time.

First, it took more than a century to come from Savery's 'Miners best friend'—his steam driven water pump (1698)—to Trevithick's mobile steam engine (1802). Second, before the transportation systems of the steam powered carriages, the steam boats and the steam locomotives became widely implemented, a few more decades had passed, decades in which the infrastructure of (rail)roads developed. During that process, together with other 'mechanical' technologies, steam technology changed society. The Invention of the Steam Engine (Figure 38) was part of a process that would later be called the First Industrial Revolution. It changed the way people and goods were transported, opening the world to travel and trade. It also changed the way people worked, supplying the rotative power that industrialization needed. Some social changes would emerge quickly, other social changes would only surface after a longer period of time. Sometimes, in a more remote and unconnected way, it was relatively simple developments that proved to have big impact. Take, for example, the aspect of 'timekeeping':

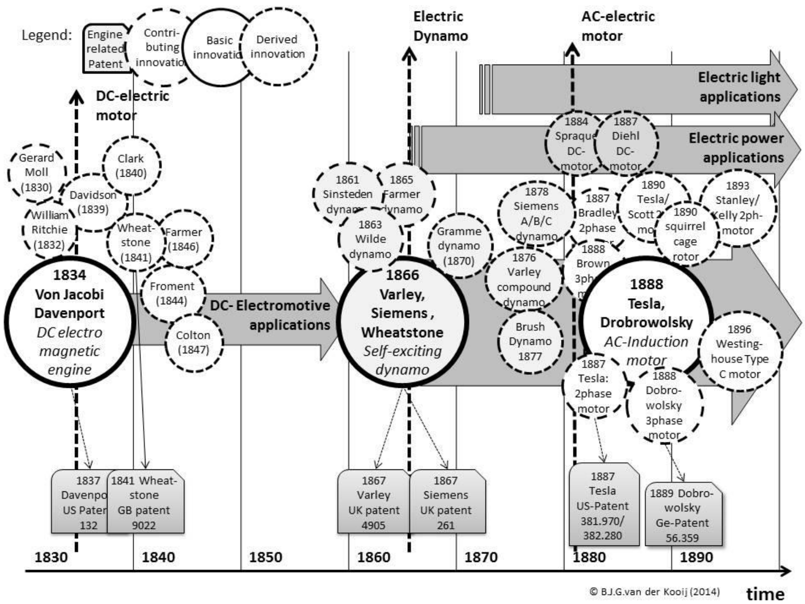


Figure 39: Overview of the clusters of innovations that created the electro-motive engines.

Source: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine* (2015) p.229

> *The first Industrial Revolution turned the timetable and the assembly line into a template for almost all human activities. Shortly after factories imposed their time frames on human behavior, schools too adopted precise timetables, followed by hospitals, government offices and grocery stores. Even in placed devoid of assembly lines and machines, the timetable became king.* (Harari, 2014, p. 352)

Next we observed the changes in society related to the General Purpose Technology of 'Electricity' that appeared in the early nineteenth century (Figure 39). It resulted, again over a long period of time, in electro-motive engines that created rotative power [121]. Those early efforts, although interesting to many, did not directly have a massive societal impact.

That impact came in the mid-1800s when a specific engine—the electric dynamo— was created. It was this engine that, replacing the awkward voltaic battery, could create electricity in abundance in different flavors (ie DC, AC). In addition, when the infrastructure for the distribution of AC-electricity was developed, it really took off. This breakthrough in the middle-nineteenth century initiated development in a range of applications

[121] As described in detail in: B.J.G. van der Kooij: *The Invention of the Electro-motive Engine.* (2015)

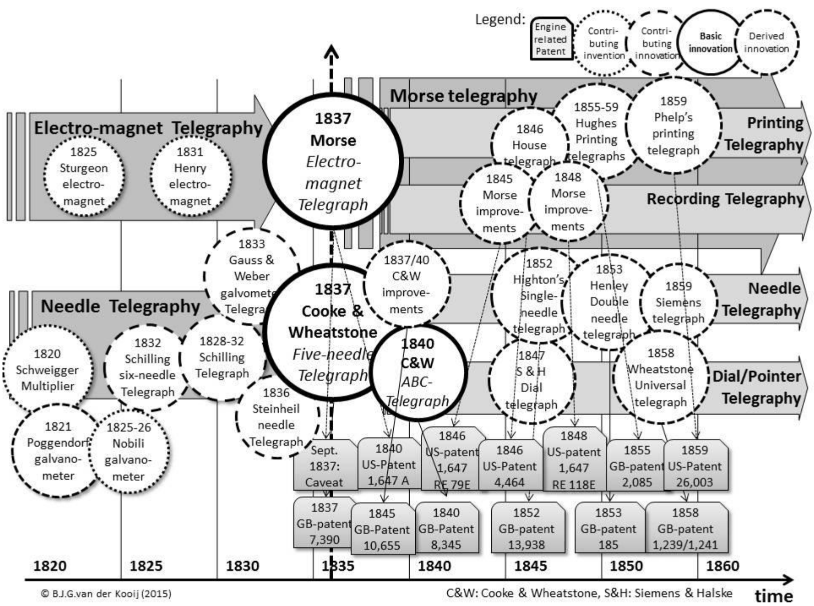


Figure 40: Overview of the clusters of innovations that created the communication engines of the telegraph.

Source: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015) p.449

based on electricity, such as electric light applications and power applications. Moreover, it was those applications that were to have a profound impact on society, changing the living conditions at home and working conditions at work. Thus, the General Purpose Technology of Electricity contributed to the Second Industrial Revolution.

The Change in Distant Writing

With the early development of the General Purpose Technology of Electricity during the First Industrial Revolution, the foundations for the second Industrial Revolution were laid. Although limited by the voltaic battery, there soon was a specific range of applications where electric technology created a breakthrough. And that was the field of long-distance communication: 'writing at a distance' with lightning speed using electricity (ie electric telegraphy).

Nearly at the same moment in time in the 1830s, two parallel developments took place that resulted in telegraphic engines (Figure 40). In America, it was Samuel Morse who created his magnet-based telegraph system, and in Great Britain it was William Cooke and Charles Wheatstone who created a needle-based telegraph system[122]. Both systems had their own development trajectory, but eventually the simplicity of Morse's concept prevailed in many applications. This resulted in a range of technical developments accompanied by massive entrepreneurial activity.

By the way, it was the telegraphic infrastructure that facilitated the dominance of 'time'. Telegraphy was first applied within the context of the emerging railway system; it was used to synchronize the—often different—local times between train stations.

> *The Royal Observatory, Greenwich, provided the standard for 'London time', counting noon from the sun's zenith over the 0° meridian. In 1852 the timekeepers at Greenwich introduced equipment that transmitted accurate time signals throughout the country over the electric telegraph network. By 1855 nearly all public authorities, such as churches and town halls, set their clocks to 'railway time', displayed on station clocks by station masters who adjusted them according to the signals from Greenwich. … Now people are no longer tuned to the rhythms of the sun and the seasons, but forced to keep pace with the hands of a clock.*[123]

What is Going to Happen in Distant Speaking?

In conclusion, we observed that these technical developments were the corner stones for the Second Industrial Revolution. Technologies—specifically, the electro-mechanical technologies—were the major driving force. These technologies, started in the nineteenth century, underwent massive changes themselves, in their development trajectories and spin-offs into other fields of application: electric light, electric power, and... electric communication.

Given the preceding observations in the first half of the nineteenth century, what can one hypothesize as being relevant in the next development of the speaking telegraph? A development that appears in the second half of the nineteenth century.

For one, based on the case studies mentioned, we can hypothesize that technology will again be initiating and fueling change in the coming period of the Second Industrial Revolutions. This influential role of technology is represented by the concept of *Technical Change*. In short it results in the hypothesis: *Technical Change was the motor of (economic/social) change.*

[122] As described in detail in: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'*. (2015)

[123] Source: http://www.sciencemuseum.org.uk/online_science/explore_our_collections/stories/the_world_runs_on_time#sthash.t30Le1rq.dpuf

Second, based on our earlier observations, we can hypothesize that technology-driven development took place in a society that itself had undergone massive changes in the First Industrial Revolution, preparing it for other changes to come. It was change in society resulting from Enlightenment, Liberalization and Democratization, but also from early Urbanization and pre-Industrialization. Hence, the role of independent societal development is represented by the concept of *Social Change.* In short it results in the hypothesis: *It was Social Change that facilitated Technical Change.*

Third, we observed in the earlier cases that the consequences of the technical developments, from electric light to electric motor and electric telecommunication, were enormous and affected society in many ways. One example of this is the factory system, in which people worked in a very different system of production than they were used to in their former agrarian times, when the cottage-industry was dominated by the rhythm of the days and the seasons. Now time was of essence, and the whistle of the factory controlled the pace of life. In short it results in the hypothesis: *It was Technical Change that resulted in Social Change.*

That being said, it is time we start looking at, and zooming in on, the next development in the Era of Communication that came after those early developments in telegraphy...

The Communication Era Expands

In our extensive analysis of the developments in the nineteenth century in the field of long-distance communication[124], we observed how discoveries, inventions and innovations resulted in the ''communication technology of telegraphy' that started the *Era of Communication*. The identification of 'Era' seems to hint at a quite relevant development. However, in what way was it relevant? Obviously, it was relevant for communication over distance, but were those technical changes also relevant in other ways? Let's have a look again at our earlier example of the importance of time keeping.

> The upcoming transportation facilities (train, coach) needed reliable timetables. In those days every city more or less had its own time, which could differ considerably. The unreliable clock in the old bell tower might have been replaced by the individual mechanical pendulum clocks, and times differed from city to city as there was not a general reference. It didn't matter too much as towns were operating rather independently from each other. For the naval operations, however, that was quite different, as the chronometer was used to establish the longitude of a position. Evidently, some form of synchronization and standardization was needed.
>
> That synchronization became possible when the telegraphic infrastructure in the 1850s started to develop. As electric communication travelled so quickly, it offered the chance to create the Greenwich Standard Time. When the telegraphic infrastructure developed, a time-synchronizing signal could easily be sent over the wires. Even more, when wireless telegraphy was developed, synchronizing of the ships clocks became possible. So, time became standardized.
>
> It seems just a minor thing, that synchronizing of time, but today's reality is that we have come to live in a time-dominated society. The feudal farm lacked any timepiece, and the sun was its only reference to time; the industrialized society, however, needed timekeeping to become organized. And today's society has a time-keeping device in nearly every tool or apparatus. From the smartphone to the microwave oven and the dashboard clock in cars; clocks are everywhere.

Alternatively, to take another example, one that relates to the 'transparency in pricing and markets'.

---

[124] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015)

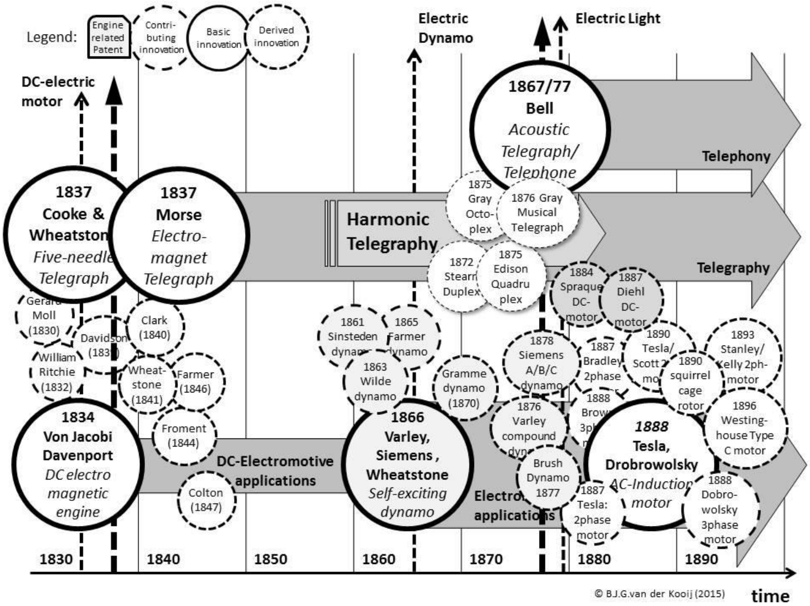


Figure 41: The telegraphic engines of Cooke & Wheatstone and Morse related to the clusters in the GPT of Electricity.

Figure created by author

Quite a mouthful, but just imagine those local communities where the products of early industrialization (commodities[125] like wheat and rice) and the cottage industry were offered for sale. Being sold on a local market, from local producers to local customers, the pricing was local. This could result in regional price differences. Having the possibility to exchange price-information for those commodities—in combination with the improved physical transportation of goods—with other, distant markets, sellers could look for other buyers, thus creating regional, and even international, markets. Telegraphy would facilitate the communication of market sensitive information. It is not surprising that the stock-market embraced early telegraphy rapidly.

These seemingly irrelevant examples of how 'timekeeping' and 'transparency' influenced our society and the individual behavior of its members were the consequence of the social changes that originated in the Industrial Revolutions. And those Industrial Revolutions were the result of

[125] Commodity: An economic good or service when the demand for it has no qualitative differentiation across a market. 'From the taste of wheat, it is not possible to tell who produced it, a Russian serf, a French peasant or an English capitalist.'

Technical Change as it occurred over time. One of those technologies was the General Purpose Technology of Electricity. And one of the early application areas was 'communication over distance'. There, the new phenomenon of electricity was applied to create the telegraphic engines, the inventions of the Englishmen Cooke & Wheatstone, and the American Morse in the late 1830s (Figure 41).

In the first half of the nineteenth century, electricity was in its infancy. It was battery powered, and that caused limitations on its use when power applications were explored (eg electric train/boat, electric DC-motors). However, that did not seem to be a problem with the communication technologies like the 'telegraph technology'. To explore what originated that technology, we have to go back to the discoveries that took place in the eighteenth century.

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[126]. Not much later this was followed by the understanding of the 'Nature of lightning' and the invention of the related 'Electro-motive power'[127]. 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 linked to electricity.

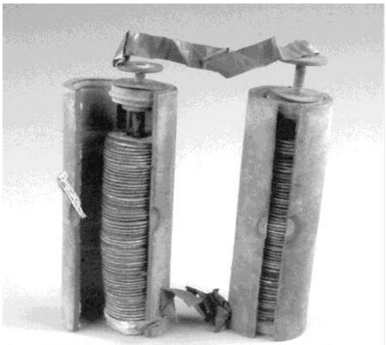


Figure 42: Alessandro Volta's chemical battery.

Source: http://alessandrovolta.it/wp-content/uploads/2011/07/144C.png

It was at the end of the eighteen century and the beginning of the nineteen century that the foundations for the understanding of the nature of electricity were created. It started with *frictional electricity*, created by rubbing different materials to generate 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 with his Philadelphia experiments. In these experiments in 1750, he proved the existence of electricity by flying a kite in

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

a thunderstorm. The kite twine conducted the 'electric fire' along the wire to a key that 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 were taken on by others who were able to create electricity differently with simple frictional machines (Hauksbee, Faraday, Nolet and others). The electricity-generating apparatus was born.

Other scientist looked for different forms of electricity, scientists like *Luigi Galvani* who, while dissecting frogs, discovered *animal electricity*. This was the new phenomenon by which 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 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 at 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; the *voltaic electricity*. The 'wet' battery was born (Figure 42).

Over time, these early scientists grasped more or less the nature of electricity. 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* who in 1820 observed during a lecture that a compass needle would move when an electric current passed through a nearby electric cable (Figure 43). This was the discovery of electromagnetism. Its publication created an uproar in the savant community of those days.

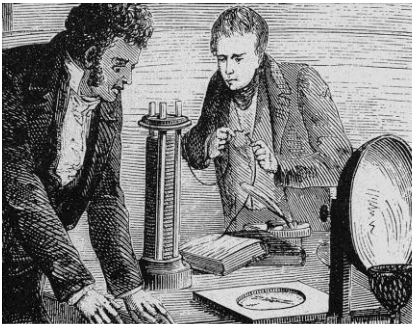


Figure 43: Hans Christian Oersted's needle experiment.

The voltaic battery is visible between the scientists, and the compass lies on the table.

Source: http://alessandrovolta.it/wp-content/uploads/2011/07/149A.png

Hearing of these experiments, the Frenchman *Andre-Marie Ampere* became excited by the discovery. After repeating Oersted's experiment, he started experimenting himself. He explained the mechanism behind Oersted's discovery, that an electric current influenced the movement of the magnetic needle. But he did not explain the reverse action: magnetism influencing an electric current. That was done by Michael Faraday, who was also intrigued with Oersted's 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 transformer). Connecting a battery to the first coil resulted in current in the second coil. He had found the induction effect and thus expanded the relationship between magnetism and electricity: the electromagnetic induction. It was then *William Sturgeon* (1783-1850) who in 1825 conceptualized that electricity and the properties of metal could create a magnetic force; the electromagnet was born (Silvanus P. Thompson, 1890, p. 199). Its enormous power was demonstrated by the powerful magnets created by Joseph Henry.

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 44). 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 Oersted's discovery a century before. He concluded, after describing in short the developments leading to the telegraph that changed the world of communication:

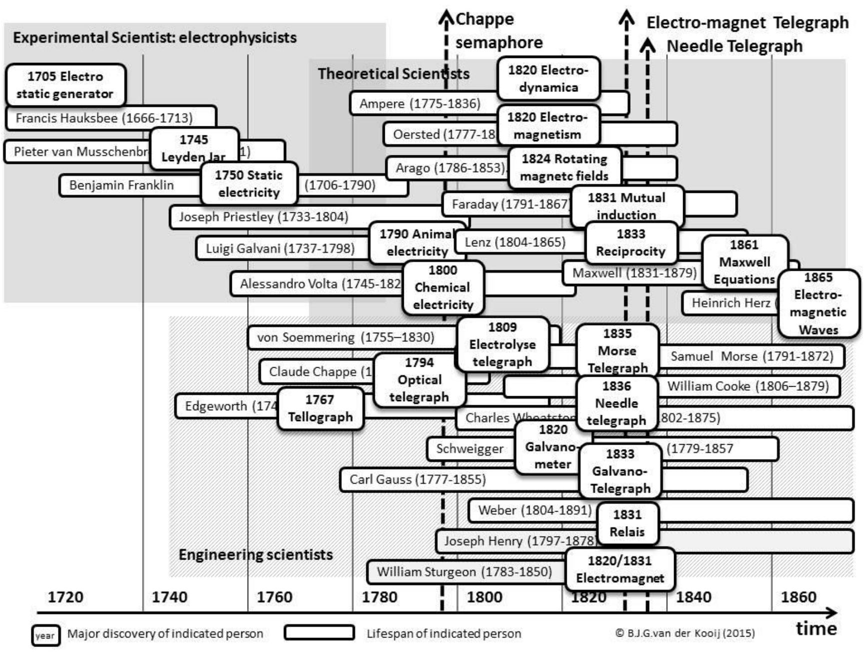


Figure 44: Experimental, engineering and theoretical scientists discover telegraphy.

Source: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'*. (2015) p. 447.

> *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. They managed to use their knowledge to apply electricity in real life. Basically, 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. However, there proved to be another use for electricity. Electricity would also become the medium for the *transportation of information* by means of telecommunication. In those early days two artefacts proved to be fundamental to its development: the galvanometer and the electromechanical relay. But there was something else, a development in a totally different field of scientific curiosity.

Discovering Acoustics

Hearing, next to seeing, is obviously one of the most important of the human senses as we heavily depend on it. What we are hearing are sounds, created by vibrations of the air. These vibrations are caused by our environment, from the wind blowing through the trees and thunder splitting the skies, to the sounds created by fellow men. Human speech consists of vibrations that are created as the air in the lungs passes the vocal cords. What we are hearing are those sound waves that touch the hearing membranes in our ears.

It is not too surprising that sound piqued scientific interest very early in history, and curious minds wanted to find out about the 'Nature of Sound'. Already in the sixteenth century Galileo (1564-1642) experimented with vibrating string. This interest in experimenting with sounds, shared by others like Isaac Newton (1642-1727), over time developed into the field of *acoustic research*. Basically, acoustic research experiments were related to three distinct segments: (1) the production of sound, (2) the propagation of sound and (3) the reception of sound.

The Theory of Sound

The origins of scientific interest in creating sounds were already manifest in the late eighteenth century. Many of the 'acoustic scientists' in those times had a relationship with music. Some played an instrument, others tried to create musical instruments. Whatever the case, they had in common that the phenomenon of vibrations creating sound fascinated them. In Germany for example, it was the physicist *Ernest F F Chladni* (1756-1827) who published in 1787 a book *Entdeckungen über die Theorie des Klanges* ('Discoveries in the theory of Sound'), the result of his work with vibrating plates. This book was followed in 1802 with his publication *Die Akustik* about his experiments with making sound visible[128]. He realized one could do this by applying flour onto a metal plate, vibrating the plate, and seeing the patterns in the flour develop.

> *Chladni's patterns drew the attention of leading French scientists and, on 7 February 1808, Chladni demonstrated his experiment in a two-hour audience with Napoleon. Napoleon, who considered himself something of a mathematician, was sufficiently impressed at, not only did he fund a French edition of Die Akustik, he also instituted a prize for the mathematical explanation of the patterns. The value of the prize was one kilogram of gold.*[129]

Chladni, like many others, tried to get a grip on the properties of sound. One of those properties was the velocity of sound, a field already explored by Isaac Newton. Chladni experimented with measuring sound velocity in different gases. Other scientists occupied themselves with the reflection and diffraction of sound. They experimented with using cylindrical pipes and

---

[128] It is not surprising that Michael Faraday, who knew of Chladni's experiments and reproduced them, tried to make the magnetic forces visible with iron powder. It proved to be a good method to visualize the magnetic field.

[129] Morris, S., Sharman, L.: Images of Sound Symmetry hidden and manifest in physics and art. Source: http://www.physics.utoronto.ca/nonlinear/preprints/idea_s02_02-morris-sharman.pdf

long tubes to transmit sound, anticipating the development of artefacts like the stethoscope and the megaphone. Take, for example, the Frenchman *Jaen-Baptiste Biot* (1774-1862), a physicist and astronomer, who experimented with iron water pipes of some 1,000 meters in length in Paris. Generally speaking, acoustic research in those days was about sounds created by the human voice or by musical instruments, bells, tuning forks, strings and vibrating plates.

In the nineteen century, the acoustic research became more mathematically oriented (eg calculating the velocity of sound, as mentioned) and it tried to explain the fundamentals of acoustics. It was the French Mademoiselle *Sophie Germain* (1776-1831) who developed a theory for Chladni's vibrating plates and produced in 1821 a mathematical, four-order equation in a paper called *Recherches sur la théorie des surfaces élastiques* ('Investigations in the theory of elastic surfaces'). Her mathematical work was part of a broad interest in a mathematical theory of sound that was explored by other French mathematicians like Euler, Dennis Poisson and Legendre. The latter, Adrien-Marie Legendre, contributed significantly during the rebellious days of the French Revolution. He was a member of the French Academy des Sciences as well as the British Royal Society.

In England, work was done on understanding the production of vowel sounds, for example, by *Robert Willis* (1800-1875). His theory of vowel production assumed a close correspondence between the vowel sound production and the production of musical notes using an organ: the lung acted as a bellows, the vocal folds acted as the reed, and the mouth cavity acted as the organ pipe. His 'inharmonic theory' or 'transient theory' was different from the later 'harmonic theory' of vowel production.

It was *Charles Wheatstone* (1802-1875), the child of a musician, and a musical instrument maker himself, who became well known for his 'Enchanted Lyre' (1821). This apparatus to transmit sound over a (short) distance through a tight wire, was demonstrated in salons and made him well known to the public[130]. He contributed to the *harmonic theory*, based on his view that the vowels arose from the vibrations of the vocal cords through the strengthening of certain overtones by the resonances of the mouth. Wheatstone's view was later expanded as a general hypothesis by the German physicist and mathematician *Hermann Grassmann* (1809-1877) and developed into a theory by Hermann Helmholtz.

---

130 See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'.* (2015), p.233

Next to these theoretical contributions, there was also the practical experimenting related to the production of speech. In Germany, *Wolfgang von Kempelen* (1734-1804) developed a 'speaking machine' (1791). This model of the human vocal tract (Figure 45) consisted of a bellows, a reed and a simulated mouth. Von Kempelen was, as so many, interested in the phenomenon of 'Automata', artificial machines that had human characteristics or robot-like behaviour.

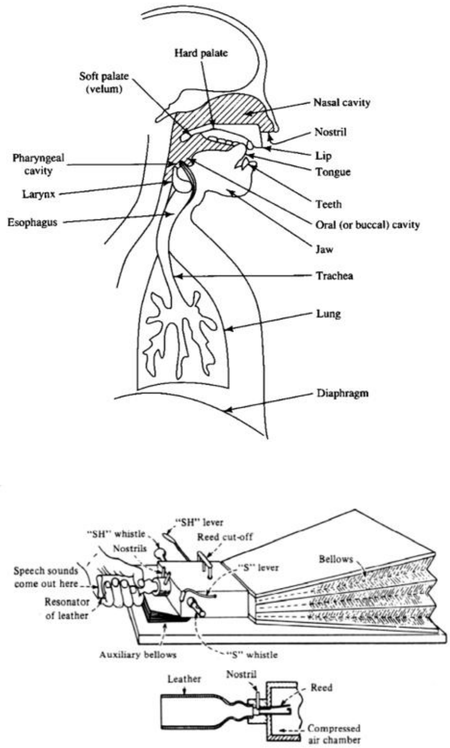


Figure 45: The human system of voice production (top) and diagram of von Kempeler's Speaking Machine (bottom).

Source: http://www.cs.princeton.edu/

Based on his experimenting, he created a chess-playing machine called 'The Turk'. It was shown to the court, at public exhibitions and was presented to the elite of that time (such as Napoleon). However, it was a hoax, as a diminutive human chessmaster concealed inside the cabinet puppeteered the Turk from below by means of a series of levers. Von Kempelen also created a manually operated speaking machine. In 1789, he published a book containing his nearly twenty years of speech research, 'Mechanismus Der Menschlichen Sprache Nebst Beschreibung Seiner Sprechenden Maschine' ('The mechanism of human speech and description of his Speaking Machine').

Another example of an 'automata' of that time was the speaking machine developed by the German engineer *Joseph Faber* (1850). This machine, that he built after reading Von Kempeler's book about his speaking machine, was shown on several occasions to the Bavarian court in 1840-1841. After moving to America he showed his invention in early 1844 in New York. It was Joseph Henry who visited Faber's workshop in 1845. Henry observed that sixteen levers or keys 'like those of a piano' projected sixteen elementary sounds by which 'every word in all European languages

Figure 46: Faber's Euphonia (1846).

Source: http://history-computer.com/Dreamers/Faber.html

can be distinctly produced.' A seventeenth key opened and closed the equivalent of the glottis, an aperture between the vocal cords. 'The plan of the machine is the same as that of the human organs of speech, the several parts being worked by strings and levers instead of tendons and muscles.' In 1846 Phineas Taylor Barnum (an American showman, businessman, scam artist and entertainer, remembered for promoting celebrated hoaxes), looking for a fresh novelty, contacted Faber, named the speaking automaton 'Euphonia' and took the inventor to London, where the machine was exhibited at the Egyptian Hall (Figure 46). The machine was on the show for decades, where it was admired by a well-known speech elocutionist Melville Bell—the father of Alexander Graham Bell.[131]

Later, it was the German *Karl Rudolph Koenig* (1832-1901), maker of musical instruments, whose Sound Analyser (1860) based on the Helmholtz resonator principle, revolutionized musical and scientific worlds by demonstrating visually that musical notes and voices were in fact made up of simple sounds.

All these experimental contributions created the foundations for the scientists who explored more fundamentally the 'theory of acoustics'. In Germany, *Hermann Ludwig Ferdinand von Helmholtz* (1821-1894), a physicist who unravelled the mystery around the qualities of sound, was one of the many physicists who studied sound. He discovered that a musical sound is very rarely a simple tone, but is made up of several tones, sometimes as many as ten or fifteen, having different degrees of intensity and pitch (the 'harmonics'[132]). Helmholtz did not stop after analysing sounds of so many kinds: he invented a method of synthesis by which the sounds of any kind of an instrument could be imitated. (Dolbear, 1877, p. 22). In 1862 Helmholtz published a book, *On the sensations of Tone*, that described how he

[131] Source: Joseph Faber's Euphonia. http://history-computer.com/Dreamers/Faber.html
[132] A tuning fork, when made to vibrate by an electric current, gives out a tone without harmonics or overtones.

had produced vowel sounds with electrically-driven tuning forks. He created the 'Helmholtz Resonator', a device that could generate complex sounds of many frequencies[133] (Figure 47). Helmholtz's work would later be a great inspiration for Alexander Graham Bell's early experimenting.

In England, *John William Strutt* (1842-1919), also known as Lord Rayleigh as he inherited the Barony of Rayleigh[134], was greatly interested in acoustics. He became Professor of Physics[135] at the University of Cambridge, his alma mater as he had studied there at the Trinity College. Rayleigh published the two-volume *Theory of Sound* in 1877. In these publications, he covered subjects such as the *Vibrations of systems* (Vol. I) and *Aerial vibrations* (Vol. II). By 'systems', he meant vibrations in physical

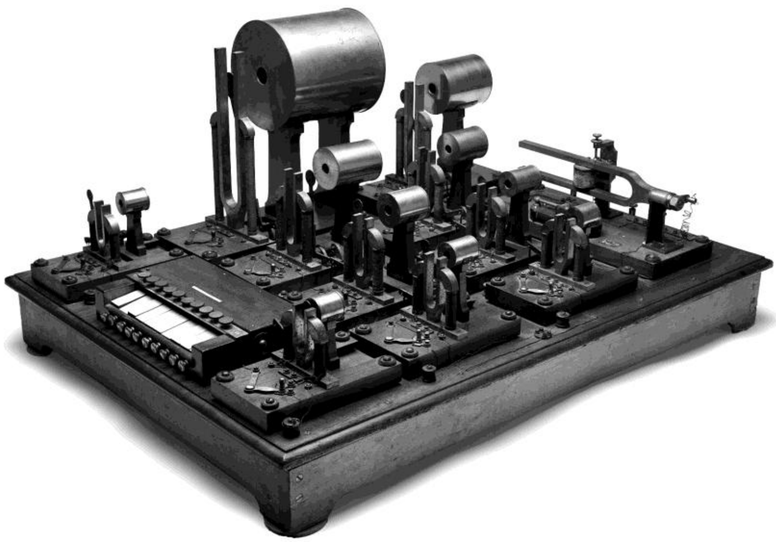


Figure 47: Sound synthesizer by Koenig after the Helmholtz Resonator (1865).

Source: www.synthtopia.com

[133] Helmholtz's apparatus uses tuning forks, renowned for their very pure tone, to generate a fundamental frequency and the first six overtones which may then be combined in varying proportions. The tuning forks are made to vibrate using electromagnets, and the sound of each fork may be amplified by means of a Helmholtz resonator with adjustable shutter operated mechanically by a keyboard.

[134] The title Rayleigh has no particular significance, except that it is the name of a small market town in the county of Essex and is euphonious. The first 'baron' had been his grandmother Charlotte Mary Gertrude, who accepted the title King George IV wished to honor her husband with. For details: Wells, P.N.T.; *Lord Rayleigh*. http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=1602845

[135] Strutt was the second person to occupy the Cavendish professorship. He predecessor was James Clerk Maxwell, who was among the founding fathers of the theories of electricity.

objects like strings, bars, membranes and plates. The aerial vibrations were the phenomena he observed in gasses and elastic solids. For his contributions to science—especially the discovery of the argon gas—he was awarded the Noble Price in Physics in 1904. In the field of acoustics, the contributions which bear Rayleigh's name are those of Rayleigh scattering, the Rayleigh criterion and Rayleigh waves. It was the Englishmen Sir *George Stokes* (1819-1903), known for his work on the fundamental aspects of spectroscopy that created insight into the physical properties of light, such as the phenomenon of fluorescence, who also contributed to the theory of sound. Like the effect of wind on the intensity of sound and an explanation of how the intensity is influenced by the nature of the gas in which the sound is produced.

What these rough brush strokes of the development of acoustic science illustrate is the fact that the work of the inventors of communication engines like the telephone fits in a pattern of curiosity into the 'Nature of Light' that occupied many inventive people. People who each made their own contributions, from the simple hands-on experiments to the complex mathematical theory. One of these inventors was Alexander Graham Bell, whom we will meet later on.

The Recording of Sound

All of the preceding contributions concerned the more theoretical world of sound and acoustics. Along with the scientists already mentioned, many engineering scientists in the mid- and late-nineteen century that were studying this field were trying to find applications, like the Frenchmen *Edouard-Leon Scott de Martinville* (1817-1879), who was focusing on the principles of *Phonautography*. He asked himself if human speech could be converted to written text. He devised an apparatus, the 'Phonautograph', and got it patented—French patent № 31.470 (May 18, 1857). The apparatus looked and worked like a human ear; it had a diagram with a writing stylus connected to the membrane (Figure 48). And that stylus wrote on a

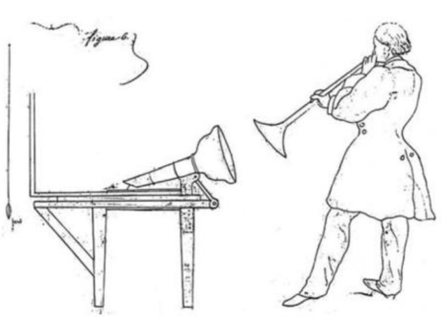


Figure 48: The Scott Phonautograph (1857).

Shown is Figure 6 from French Patent No. 31.470 (1880).

Source: Pantalony, D. Altered sensations: Rudolph Koenings Accoustical workshop ... https://kylejanzen.files.wordpress.com/2011/09/pho rotating piece of blackened recording paper. These were the first engineering efforts to record sound.

In the engineering efforts to reproduce recorded sound, the next step was taken by the *Frenchman Charles Cros* (1842-1888). He invented the 'Paleophone', an apparatus capable of registering and reproducing sounds which had been engraved with a diaphragm. He gave a copy of his paper to the French Academy of Sciences in April 1877, three months before Thomas Edison's invention of the phonograph, but did not patent the process until May 1878 and never made a working model.

That was different in the case of *Thomas Edison* (1847-1931), who, with his invention of the 'Phonograph' in 1877, created the first device with which sound could be recorded, stored and reproduced (Figure 49). Originally, due to his background in telegraphy, he was trying to develop the automatic telegraph. This was a machine that would transcribe signals as they were received. In this instance, the signals were in the form of the human voice, so that they could then be delivered as telegraph messages. For a recording medium, he used tin foil. For his work, Edison was granted US Patent №. 200,521 on February 19, 1878. This patent was soon followed by other patents, such as US patent № 203,014, granted in April 30, 1878, for a speaking telegraph. Edison raised money and started, in 1877, the *Edison Speaking Phonograph Company* that was short-lived after a short profitable period. Then it faded away as the quality of the reproduced voice was simply too poor. It would take another decade before a better functioning apparatus was developed by Charles Sumner Tainter and Alexander Graham Bell, who used a wax cylinder to store the recorded sounds.

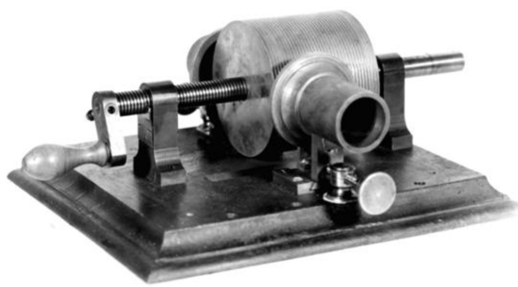


Figure 49: The Edison Phonograph (1877).

Source: http://www.timesunion.com/local/article/e-sounds-of-science-3981255.php

Another example of applied engineering in this specific field of acoustics was the work of *Emile Berliner* (1851-1929). In the 1870s he had already worked on the development of the loose contact microphone that was acquired by Bell. In the 1890s he developed the transition from the phonographic cylinders to the flat disc. After studying both the

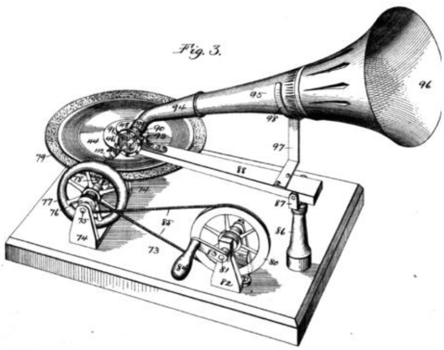


Figure 50: The Berliner Gramophone (1895).

Shown is Figure 3 from US Patent No. 534,543 of Feb. 19, 1895

Source: USPTO

'Phonograph' (Thomas Edison) and the 'Graphophone' (Alexander Graham Bell), he concluded he needed a medium that was harder than the wax-cylinder and that could be reproduced. It became—after a lot of technical problems had been solved—the gramophone disc, that would replace the wax cylinder and become the major medium of distributing music in the time to come.

> *After trying many different substances, Berliner finally turned to zinc. Following many failed trials, he arrived that a process whereby he would coat a zinc disc, made from regular stovemaker's zinc, with a beeswax and cold gasoline mixture. Then he cleared away the coating with fine lines made by a stylus attached to a mica diaphragm so that it would vibrate from side to side. Then, after coating the blank reverse side of the disc with varnish, he would immerse the disc in an acid bath. After a certain time, the acid etched the fine lines into grooves in the zinc, leaving the remaining parts of the disc untouched. With the vibrations fixed into the zinc, the disc could be placed on a turntable and the sound reproduced with a steel stylus. This is how the earliest disc records were eventually made. Unlike the cylinder machines which could be used for both recording and playback, Berliner's method required two machines, one for each process.*[136]

He called the machine that played the music the 'Gramophone' and the recording process 'Voice Etching.' For the inventions, he received US patents № 372,786 and № 382,790 on November 8, 1887, and on May 15, 1888, respectively. To commercialize his invention, he created the *United States Gramophone Company* with an office in Harper's Ferry, West Virginia. But the sales of the original hand-powered Gramophone were not financially successful. The instruments, which were made by outside vendors, were used in exhibitions and demonstrations as a scientific novelty. Berliner, as the principal owner of the company, lost a considerable amount of money. That changed when he found new partners and adapted the 'gramophone'. Instead of the original hand power, he applied a spring motor. It was patented as US Patent 534,543 on February 19, 1895 (Figure

[136] Source: http://memory.loc.gov/ammem/berlhtml/berlgramo.html

50). To exploit this patent, he created, with partners, the *Berliner Gramophone Company* in the US in 1985, the *Gramophone Company* in London in 1897, the *Deutsche Grammophon* in Hanover in 1898 and the *Berliner Gram-o-phone Company of Canada* in Montreal in 1899.

Speech Disorders and Elocution[137]

Along with the previously mentioned contributions towards understanding the 'Nature of sound', both its theory and application, there was another area of scientific interest that would prove to be important for the development of the 'speaking telegraph': the scientific activities related to *dumbness and deafness*. The condition of dumbness arises when a person is unable to communicate vocally, has a speech disorder like stuttering or cannot speak that all. While the mouth is used as the organ to produce speech, the ear is the organ used to detect sound, and when that organ does not work properly, we speak about deafness. It is quite understandable that as soon as deafness/dumbness was more fundamentally observed, there were people wondering what caused it, what could be done to solve it and which remedies could be developed to treat it. Much of their efforts focused on teaching the deaf and dumb to communicate.

There is a long history of teaching the deaf sign language and lip-reading. In France, it was a priest, *Abbé Charles Michel de 'Epée* (1712-1789), who created the first public school in 1755 in Paris. In 1788 *Samuel Heinicke* (1727-1790) opened a school for the deaf in Leipzig, Germany. In America, it was *Thomas Hopkins Gallaudet* (1787-1851) who was involved with teaching the deaf and who founded the National Deaf-Mute College in Washington. In England, *Thomas Braidwood* (1715-1806) established a school in Edinburgh and in 1760 initially accepted only one deaf pupil. Braidwood's success in teaching speech to this one boy led to a swift increase in the number of students, to twenty pupils by 1780.

This detour in the field of speech disorders and the development of deaf-institutes has to be brief. But it shows that the scientific efforts into acoustic were not only related to the 'Nature of sound', but also related to its implication for people with hearing problems. It brings us to England, although quite some time later, where it was *Alexander Melville Bell* (1819-1905)—the father of the Alexander Graham Bell we will meet later on—who was involved in 'elocution'. As an elocutionist from Scotland, AM Bell analysed speech sounds and offered practical guidance and exercises for conducting speech therapy (ie the use of visible speech charts indicating location of articulators for different sounds).

[137] Elocution is the study of formal speaking in pronunciation, grammar, style and tone.

He was engaged in teaching the deaf by signing and lip-reading, and he developed the system of 'Visible Speech'. In the 1850s-1860s he lectured at the University of Edinburgh and the University of London on speech elocution and speech disorders. He wrote numerous publications, such as the 'Faults of Speech' (1880), and 'Observations on Defects of Speech' (1883). After two of his children, Edward and Melville, died of tuberculosis in 1870, he immigrated to Canada with his wife Eliza Symonds, his parents, sister-in-law and his son Alexander Graham Bell.

The Nature of Sound

The preceding rough brush strokes paint a picture of some of the early contributions to 'acoustics' made by theoretical and engineering scientists in the nineteenth century. On the one hand, there were the contributions of a highly abstract nature, like those of the mathematical thinkers. And on the other hand, there were the contributions of a more practical nature, like those of the mechanical tinkerers. Sometimes, however, the distinction between the theoretical and engineering scientist was not too distinct, as with people like von Helmholtz, who, in experimenting with his Resonator, created his device at the same time that he helped develop the more theoretical aspects of sound.

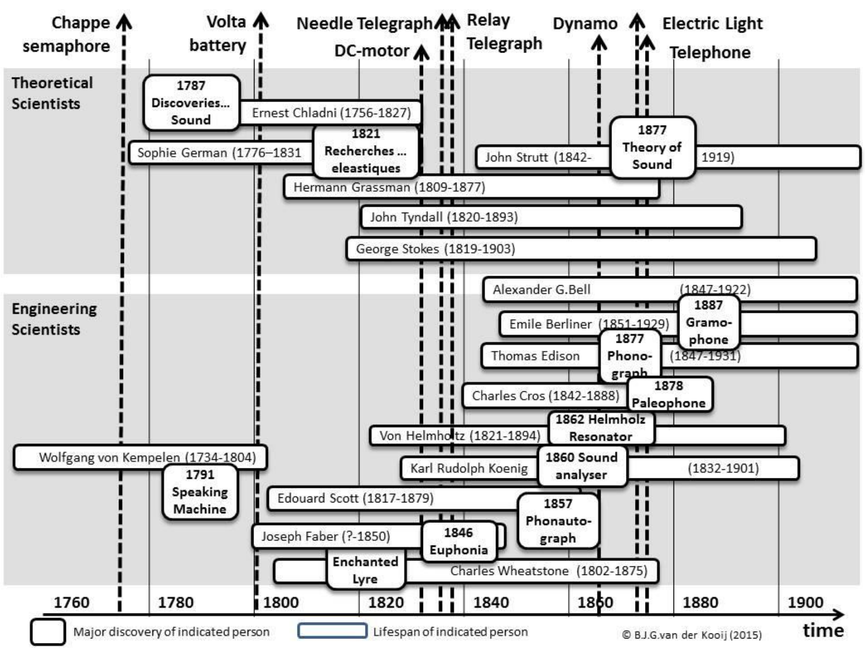


Figure 51: Scientists discovering Nature of Sound.

Source: Figure created by author.

Figure 51 shows an overview of the contributions of these scientists related to the actual developments in the communication technologies (such as the Chappe Semaphore of 1793, Morse's relay telegraph of 1837 and Cooke and Wheatstone's needle telegraph in 1837). Clearly, the second half of the nineteenth century was a period in which the science of acoustics began to develop a body of scientific substance. It was also the time when developments in the electro-motive engines resulted in the early electric dynamos, a new source of electric energy that would replace the awkward voltaic battery.

Discovering Harmonic Telegraphy

So, science had not only discovered the 'Nature of Lightning', resulting in the development of all those electric apparatus—from the electro-motor to the telegraph—they had also gotten insight into the 'Nature of Sound', leading to the creation of a range of sound-related apparatus like the gramophone. Then, the combination of both insights would result in a totally new development that would ultimately result in an apparatus called the 'telephone'. In modern terms, this was a transition from 'digital' to 'analogue', from the ON/OFF system of early telegraphy to the analogue speech of the telephone. To understand that fundamental change, we have to go—shortly—to the basics[138].

As analysed elsewhere[139], electric telegraphy is about 'distant writing'. Using an ON/OFF code system, the mechanical devices and the electrical infrastructure made it possible to transmit information over large distances. There was a slight problem, though. For classical written communication — transported by horsepower— we developed over time an alphabet

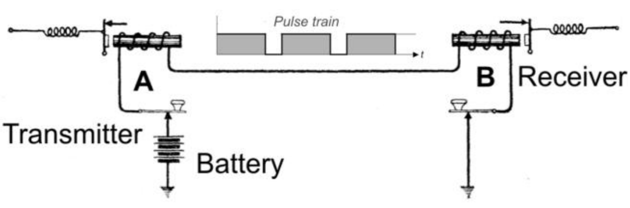


Figure 52: Principle of distant writing between Point A and Point B.

Pressing the switch in the transmitter (left) results in movement of the electromagnet in the receiver (right). Tapping creates a train of pulses traveling the wire with lightning speed.

Source: Adapted from Cyclopedia of Telephony & Telegraphy Vol. 1. http://www.gutenberg.org/files/15617/15617-h/15617-h.htm

---

138 The following analysis of the technical aspects is simplified for better understanding by the non-technical reader. For the specialized reader, it might contain disputable shortcuts.

139 See: B.J.G. van der Kooij: *The invention of the Communication Engine 'Telegraph'. (2015)*

consisting of a standard set of letters (ie the written elements A, B, C, etc). These letters were used to write down words in sentences that created a message (as in a 'letter of correspondence'). The message—written on paper—was then transported by physical means, such as by mail coach, over some distance from point A (the sender) to point B (the receiver). In telegraphy, the message had to be coded during its transport because the communication medium of electricity required it. And at the receiving end, the message had to be decoded and written down as a readable text.

Basically, the development of telegraphy was about the development of an electrical—digital—engine to transport the message between those points A and B[140], an engine that consisted of two parts: the transmitter at point A and the Receiver at point B (Figure 52). By pressing a switch connected to a battery (the transmitter in point A), a current through a wire would activate the electric device like a relay (the receiver at point B). That movement could be used—with an additional pen and a strip of paper—to 'write' the information. Voila, 'distant writing' was realized. But the writing was not in readable text; it was the coded information in the form of 'dots

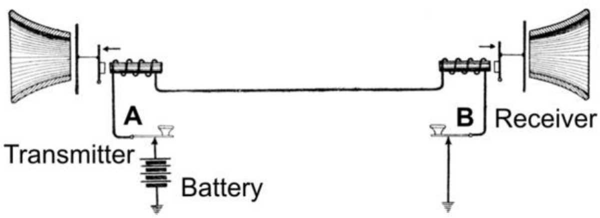


Figure 53: Principle of the acoustic telegraph with a sounder.

The closing of the switch in the transmitter (left) results in a movement of the magnet in the receiver (right). The magnet moves the diagram that creates a sound. The receiver becomes a Sounder.

Source: Adapted from Cyclopedia of Telephony & Telegraphy Vol. 1 http://www.gutenberg.org/ files/15617/15617-h/15617-h.htm

---

140 It might help the non-technical reader to explain some fundamentals of communication here. Telegraphy was about the presence of an electric current (DC: Direct Current) in a wire between point A and point B. The switching of a key at point A created the binary information at point B in the electromechanical relay when this went from OFF to ON. This basic unit of information is called a 'bit'. Morse used this binary capability to create the 'dots and dashes', where different combinations—as originally realized by his rails—each had a specific alphabetic meaning (ie the letter 'A': ● —, 'B': — ●●●, 'C': — ● — ●, etc.). Cooke and Wheatstone used the binary capability of the galvanometer, but transmitted—in the five needle telegraph—at a given moment a *byte* existing of 5 bits (ie '/ / \ \ /'. Now each byte had its specific alphabetic meaning. And, again, it was the presence of a current that would move the needle from OFF (right) to ON (left). The conversion from the binary ON/OFF information into the alphabet was originally done by the human mind (ie the operator of the telegraph).

and dashes' that travelled the wire like a speeding train. That is the basic concept of telegraphy, a concept that saw later many mechanical improvements and enhancements over time, such as the keyboard with a key for each letter/character (at the sending end), and the printing telegraph that printed the letters/characters (at the receiving end).

One of those improvements was the concept of the Sounder (Figure 53). Closing the switch in the transmitter resulted in an audible sound at the receiving end. In a primitive way, sound was introduced in telegraphic systems. Now it was time for the next—quite fundamental—step.

As the popularity —that is the use—of telegraphs increased, the technical infrastructure ran into problems of capacity. This resulted in efforts to transmit more messages at the same time over the same wire: the multiplexing telegraphs. Different technologies, all using the ON/OFF concept of switching a Direct Current (DC) were explored. However, to make more efficient 'multiplexing' possible, a fundamental change had to be made in the type of current that was applied. Instead of Direct Current (DC), now *Alternating Current* (AC) was used (Figure 54). In relation to acoustics, that type of current was called in that time 'undulating current' in analogy with the words 'undulating sound' that indicate the rise and fall in pitch of a sound. It was a type of electricity that was generated by the new device of the electric dynamo, which was developed in that same period of time[141]

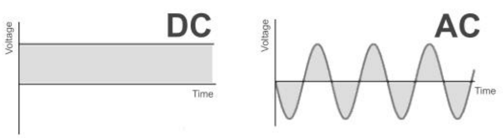


Figure 54: Principle of Direct Current and Alternating Current.

Basically, sound is a range of frequencies of mechanical vibrations — called tones— in the air. AC electricity can have different and distinct frequencies, the best known are the 50Hz/60Hz frequencies. Now, with electricity, AC-signals with different and combined frequencies[142] were used to distinguish between the different sounds. This was a complicated affair where different frequencies created an individual multi-frequency—aka a 'harmonic'—signal (Figure 55). So, to cut the analysis of this development short, the DC-signal was replaced with different AC-signals that each were identifiable and unique. The originally binary system of the telegraph (ON/OFF) now possessed analogue properties, as the resulting undulating current contained the different frequencies that (individually) were to be

[141] See: B.J.G. van der Kooij, *The Invention of the Electro-motive Engine* (2015, pp.87-125).
[142] The frequency indicates the number of undulation per minute. The more undulations, the higher the frequency.

switched on and off. It was the birth of the 'harmonic' telegraph, where each telegraph transmission had its own frequency (eg 200Hz, 400 Hz, etc.).

The next step was to transmit multi-frequency signals like the human voice over the telegraph line, thus giving birth to the 'acoustic telegraph'[143]. Now 'undulating currents' would be used for the transmission of the analogue signal created by the telephone transmitter (soon to be called the Microphone). Undulating currents transmitted the signal over the cable to the receiver (soon to be called Earphone), where they were converted into sound. 'Distant writing' of the telegraph would thus be replaced by the 'distant speaking' of the telephone in which a spoken word at point A—converted into an undulating current by the transmitter—would be transmitted to point B where it would be converted—by a receiver—into a spoken word. However, before that was to happen, the telegraph had to be converted from the writing apparatus into the sounding apparatus (Figure 56).

Figure 55: Undulating currents of the acoustic telegraph creating a letter.

The spoken letters (right side) are transmitted as a variating current (left side) over the line.

Source: Adapted from Cyclopedia of Telephony & Telegraphy Vol. 1 http://www.gutenberg.org/files/15617/15617-h/15617-h.htm

Two artefacts contributed enormously to the development of this trajectory: the *microphone* (called 'Transmitter') and the *earphone* (called 'Receiver'). Both are used as a conversion mechanism; the microphone converts sound into an analogue electrical signal, and the earphone converts the analogue electrical signal into sound. A cable connects the two devices, and the battery supplies the electrical current (Figure 56).

143 The human voice is an example of an analogue signal where different frequencies of sound are created by vibrating vocal cords. A specific sound is thus made up by a multitude of frequencies. As multiplexing introduced different frequencies in telegraph systems, the step to voice-transmission over the telegraph line is quite a logic one. One needs only additional devices to convert the human voice into an analogue electric signal (as done by the microphone), and to convert the analogue signal into sound (as done by the loudspeaker or earphone). The signal itself is transmitted by an alternating current (AC). One transmits now an AC-current instead of a DC-current.

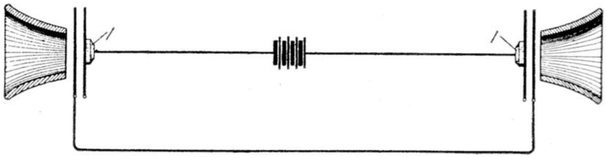


Figure 56: Principle of the electrostatic telephone.

The sound vibrations in the transmitter (left) are transported by undulating currents to the receiver (right), where the movement of the diaphragm creates the sound. And vice versa.

Source: Adapted from Cyclopedia of Telephony & Telegraphy Vol. 1 http://www.gutenberg.org/ files/15617/15617-h/15617-h.htm

As we will go and see further on, the development of the *transmitters* stated with the work of the Englishman *David Edward Hughes* (1831-1900). In 1878 he created a carbon microphone where the sound waves created undulations in the current in the electrical circuit. As we will see in more detail later on, it was people like the American *Francis Blake Jr* (1850-1913) and *Emile Berline*r (1851-1929) who perfected the microphone and created the device that was for a long time used in telephony-systems.

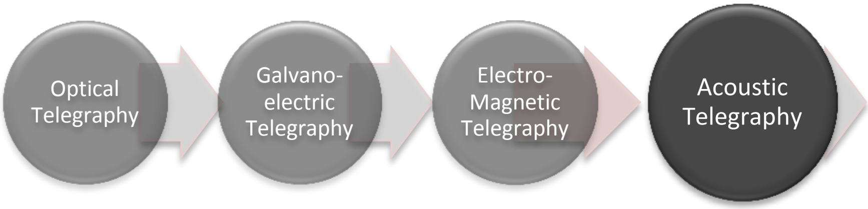
Basically, the acoustic telegraph system is as simple as the 'normal' telegraph. The telegraph being the transmission system of the telegraph key, the electric cable and the recording electro-magnet. Now, there is a sound-electricity converter at one end called 'transmitter', then there is a stretch of cable that ends in an electricity-sound convertor called receiver. In reality is becomes more complex as distance increases, the number of subscribers explodes and the telephone-exchanges come into play.

In the preceding section, we have seen how the introduction of 'sound' into 'telegraphy' opened the doors to a completely new development called 'telephony'. As it used cables to transmit the electric information, it would lead to 'cabled telephony', a communication system that over time resulted in a massive communication infrastructure spanning the globe.

From those early optic communication systems — such as Chappe's semaphore system widely used in Europe up to the mid-nineteenth century— developed the electric telegraphic communications systems. Then it were the parallel developments in Europe —where Cooke & Wheatstone developed the needle telegraph— and America where Morse developed the electromagnet telegraph in the 1830s. It soon created an industrial bonanza, and by the 1850s telegraph networks could be found dotting the landscape[144]. Telegraphy started the Era of Communication (let us call it Part I we covered before). Next, it was telephony that extended the Era of Communication (let us call that Part II to be covered in this study). However, there was more to come, and that was the 'wireless' (to be called Part III). That will be the next study, first let us go and look how the invention of 'Acoustic Telegraphy' (aka the telephone) came to be.

[144] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015).

The Invention of Acoustic Telegraphy



In the mid-nineteenth century, it was clear that the *telegraph-concept* of telecommunication could be profitable as it was an answer to a large governmental and public need. People, business, lotteries, stock exchanges and news agencies already covered long distances by classical methods, but the need was for faster, and even instant, telecommunication. The electric telegraph offered that facility—for example, with Morse's code system—in the form of 'writing over distance'.

As vocal speech is the dominant form of human communication, one would expect that 'speaking over distance' developed from the domain of vocal speech. However, most creative people with an 'electrical' education and background were attracted to further improving the telegraph, and most did not have a vocal speech background. The 'electriciens' were active in improving the existing telegraphic systems. In telegraphy, the hunt was for the multiple use of telegraph lines; everybody looked for—what was then called—the 'harmonic' telegraph. Trying to improve on the *single-message* ON/OFF-system they put their efforts into *multi-message* ON/OFF-systems.

Surprisingly enough, it was people from a different background who created the 'acoustic telegraphy' that enabled 'speaking over distance'. People such as *Alexander Graham Bell*, a man who had a background in vocal speech, and *Antonio Meucci*, who had worked in many occupations before turning to the application of electricity. We will explore that extensively further on. In the end, it was these 'outsider' people who developed apparatus for converting the vocal frequencies of the human voice into electrical variations, instead of switching the electricity 'ON' or 'OFF' with a 'telegraph key' in a increasingly smarter way. These outsiders created a single-message system that was 'analogue', as it used the frequency spectrum of the human voice (20-20,000Hz). They created the 'acoustic' telegraph that would become the telephone by following the analogue approach (Figure 57).

There is a striking similarity of these efforts with the early experiments that resulted in electric light[145]. Remember *Humphry Davy*, and others, who tried to 'bridge the voltaic gap' and created sparks that gave a strong illumination, or *Robert Groove*, and others, who bridged the same voltaic gap with a thin wire and thus created a more comfortable glowing light. After the light experimenters came all those thinkers and tinkerers who experimented with electromagnets (Sturgeon, Henry, and others)[146]. As a side effect, these explorations resulted in a wave of experimentation on the acoustical effects of magnetization. *Charles Page* had already described the sounds that were made by coils in his 'The Production of Galvanic Music':

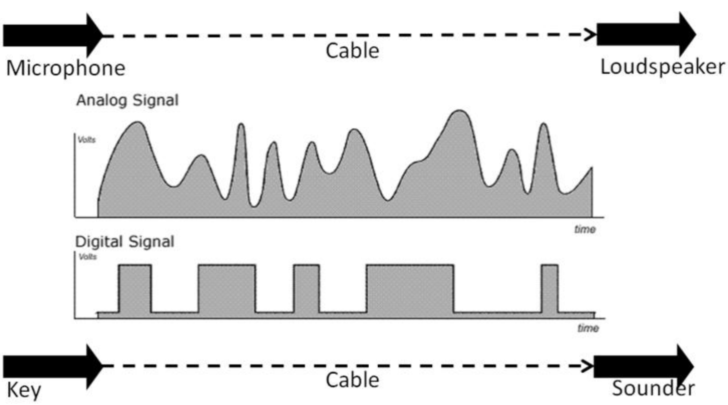


Figure 57: Difference between an analogue and digital signal.

Shown are the analogue electric signal as related to the telephone (top) and the digital signal as related to the telegraph (bottom).

---

[145] See: B.J.G. van der Kooij: *The Invention of the Electric Light.* (2015).
[146] See: B.J.G. van der Kooij, *The Invention of the Electro-motive Engine* (2015).

> *When one of the connecting wires [of the coil] was lifted from its cup a bright spark and a loud snap were produced. When one or both poles of a large horse shoe magnet, are brought by the side or put astride of the spiral, but not touching it, a distinct ringing is heard in the magnet, as often as the battery connexion with the spiral is made or broken by one of the wires… The ringing is heard both when the contact is made and broken.* (Page, 1837)

This observation of a curious man was a first, small step that would lead to a major invention later on. One by one, the new phenomenon of electricity was related to other physical phenomena; after movement, light and communication, it was now sound.

Early Days of Harmonic Telephony

If there is one name associated with the telephone, it is that of *Alexander Graham Bell* (1847-1922), who is regarded by many as the father of the telephone. Certainly, as we will see later on, he played a dominant role in the enterprising and innovative culture of the East Coast of America in the late 1800s. It was a time of technological developments based on the new phenomenon of electricity: the electric light, electric tramways, and electric telegraphy. Alexander Graham Bell was not the only one working in this area, as other inventors were also fascinated by this new phenomenon of 'speaking at a distance'. People like Edward Farrar, Amos Dolbear, Sylavanus Cushman, Daniel Drawbaugh, Antonio Meucci and James McDonough (America); in Europe, it was people like Charles Bourseul (France), Johann Philipp Reis (Germany) and many others, many of those disappeared in the fogs of history.[147] Let's have a look at some of their early experimenting efforts.

Engineering Scientists and their Acoustic Experimenting

Many engineering scientists contributed to the device that would become the early version of the telephone, partly because they developed artefacts that would later become components of the telephone. To give an impression, we will only mention a few that are, one way or the other, related to the development of the *speaking* telegraph. This is not the place to explore the world of acoustic experimenting, but we can conclude that all their efforts resulted in a basic knowledge of how to make electro-mechanical acoustic devices: the *audio technology*. They resulted, for example, in a device later called the 'microphone' that could convert sound vibrations

[147] See for more details: Lewis Coe: The Telephone and Its Several Inventors. McFarland & Co., 1995; Dominic Gabriel Cianciusi: Tuscan Telephone Triumph. Panick Enterprises Inc. (2010)

into electrical variations.

As early as 1850 the mayor of Keen, N.H., the American *Edwar Farrar* (unknown) was one of those experimenters who was trying to send tones over telegraph lines. In 1851 he developed a reed melodeon and experimented with it for sending tones over telegraph lines. However, he abandoned his project. Around 1860 the German teacher Philip Reiss (1834-1874) experimented with a quasi-telephonic transmitter and receiver. 'Like Farrar, Reiss was principally absorbed with musical tones as an assist to researching speech transmission. … Neither their transmitter nor any other had speech capability' (Weidenaar, 1995, p. 1). We will return to Reiss later, but first we will go and explore those other early contributors with a non-electrical, and often more musical background, experimenting with the new phenomenon of 'Telegraphy'. Their explorations were the early contributions into what later became known as 'telephony'.

Take *James McDonough* (unknow), a well-to-do furniture manufacturer whose hobby, since 1867, had been experimenting with electrically produced sound. His 'sound reproducer' was nothing more than an electromagnet positioned close to an iron disc attached to a flexible membrane. It differed little from the electromagnetic receivers used by many of the early experimenters. Not content with just producing sound electrically, for years he had pondered the possibility of sending the human voice over a telegraph wire. By 1875 he had created a device that he claimed would do just that. He called it the *Teleloge*, and on April 10, 1876, applied for a patent (Figure 58). But unlike Alexander Bell, who could get patents issued in just two or three weeks, McDonough's application would be mired down in Patent Office hearings, interference actions and general red tape for over eight years.[148]

Figure 58: The McDonough Transmitter: The Teleloge (1876).

Source: http://www. antiquetelephonehistory. com/ McDonough.html

In France it was the civil engineer *Charles Bourseul* (1829-1912) who, on August 28, 1854, published an article in the weekly French newspaper *L'Illustration*: 'La merveilleuse découverte de la transmission électrique de la parole'. As an engineer and mechanic (instrument maker) working in a

[148] Source: http://www.antiquetelephonehistory.com/McDonough.html

telegraph company, he had gained experience in telegraphy. Working to try and improve Breguet's and Morse's telegraphs, he experimented with a device we would today call a microphone. About his idea, he wrote:

> *Imaginez que l'on parle près d'une plaque mobile, assez flexible pour ne perdre aucune des vibrations produites par la voix, que cette plaque établisse et interrompe successivement sa communication avec une pile : vous pourrez avoir à distance une autre plaque qui exécutera then même temps les mêmes vibrations … Quoi qu'il arrive, il est certain que, dans un avenir plus ou moins éloigné, la parole sera transmise à distance par l'électricité. J'ai commencé des expériences à cet égard : elles sont délicates et exigent du temps et de la patience, mais les approximations obtenues font entrevoir un résultat favorable.* [149]

Interestingly, his idea of a device that 'alternately makes and breaks the current' was an imitation of the telegraph key that could 'make or break' a contact; it was the *make-and-break* principle that many explored. His idea was considered to be 'une conception phantastique' (a wild idea) by his superiors. He envisioned the telephone concept but did not succeed in realizing a working prototype. He failed to develop the device needed on the receiving end, what we would call today a loudspeaker.

On the sideline, we also find the Italian *Innocenzo Manzetti* (1826 – 1877) from Aosta. He, needing little sleep, was a night worker who seemed to have been involved in an 'Automaton' (say, a mechanical robot), for which he wanted to develop an artificial voice. He designed a device that he eventually presented to the press in 1865. But that was all; there were no patents requested and nothing more than a newspaper article report on his activities.

In contrast with these early contributors from a non-electrical background, there were others, more familiar with electricity:

The American *David Edwin Hughes* (1831-1900) was born in London, immigrated to America and became professor of music in Bardstown, Kentucky. He developed a printing telegraph that was used by many early telegraph companies. For this, he was granted US patents № 14,917, № 22,532 and № 22,770 in the years 1856-1859. In 1879 he discovered that

---

[149] Source: l'Illustration du 26 août 1854. www. http://telephoniste.free.fr/historique/. (Accessed February 2015).
Translation: "Suppose that a man speaks near a movable disc sufficiently flexible to lose none of the vibrations of the voice; that this disc alternately makes and breaks the currents from a battery: you may have at a distance another disc which will simultaneously execute the same vibrations.... It is certain that, in a more or less distant future, speech will be transmitted by electricity. I have made experiments in this direction; they are delicate and demand time and patience, but the approximations obtained promise a favorable result." (Evenson, 2000, pp. 242-243)

electric sparks would generate a radio signal. These could be detected by a telephone receiver he developed. With regard to the telephone, he demonstrated a 'loose contact' carbon microphone before Alexander Bell patented his in 1877. Hughes' device used loosely packed carbon granules—the varying pressure exerted on the granules by the diaphragm from the acoustic waves caused the resistance of the carbon to vary proportionally, allowing a relatively accurate electrical reproduction of the sound signal. He did not take a patent but reported his invention to the Royal Society in London on May 8, and made it and its details available to the general public on June 9, 1876, and thus 'gave his invention to the world'.[150]

The German *Emile Berliner* (1851-1929) was born into a Jewish merchant family from Hanover. He completed an apprenticeship to become a merchant, as was family tradition.

> *The Berliners lived at first in dire poverty, for until the French occupation of the area in the Napoleonic period, Jews were prohibited from belonging to a craft or business guild. Under the new, liberalized laws the family's fortunes changed. Moses was able to establish a successful "cut and yard goods business." … Four years after the further liberalization of oppressive laws against Jews in 1842, the family was able to acquire citizenship. The third generation Samuel Berliner was a manufacturer of linen goods, while his brother Meyer, was in the business of dyeing and washing of silk and wool fabrics. … A friend of his father, Nathan Gotthelf, visited the family from America in 1866. Herr Gotthelf had emigrated to the United States, and eventually became the proprietor of a dry-goods store in Washington. Hanover was taken over by the militaristic Prussians, and the Jews were again subjected to severe repression. Emile would soon become eligible for military conscription. In 1869, Gotthelf returned to Hanover and offered Emile a post in his store.* (Kurinsky, n.d.)

To avoid being drafted for the Franco-Prussian War (1870-1871), Berliner migrated to the United States in 1870.

> *The family scraped together the money for his voyage to the U.S.A., and in 1870 nineteen-year-old Emile left Germany for New York on the Hammonia. Times were hard in the U.S.A. Unemployment was rampant after the panic of 1873, and Emile left Washington and returned to New York to find work. "He sold glue. He painted the backgrounds of enlarged tin-type portraits - his talent for drawing stood him in good stead for artistry. He gave German lessons." During this period he added the "e" to his name, "deprussianizing" the German "Emil" to the "Anglo-Saxon" "Emile." Emile worked for a time in Milwaukee and*

[150] Source: Robjohns, H.; A brief history of microphones. http://microphone-data.com//media/filestore/articles/History-10.pdf (Accessed February 2015). Worrall, D.M.; David Edward Hughes: Concertinist and inventor. http://www.angloconcertina.org/files/HughesforWebsite.pdf

> *then returned to Washington. Emile found time to take up the study of music. He took lessons in piano and violin. His musical studies may have been the root of his fascination with acoustics, a field that was then in its infancy. Avidly seeking knowledge, Emile went to the Cooper Institute in Washington, studying electricity and physics part time.* (Kurinsky, n.d.)

In Washington, sometime later around 1876, he invented a device that would become a subject of much legal manoeuvring later on: the microphone.

> *In 1876 he was fascinated by the telephone, and set out to construct one on a different plan. Several months later he had succeeded and was overjoyed to receive his first patent for a telephone transmitter. He had by this time climbed up from his bottle-washing to be a clerk in a drygoods store in Washington; but he was still poor and as unpractical as most inventors. Joseph Henry, the Sage of the American scientific world, was his friend, though too old to give him any help. Consequently, when Edison, two weeks later, also invented a transmitter, the prior claim of Berliner was for a time wholly ignored. Later the Bell Company bought Berliner's patent and took up his side of the case. There was a seemingly endless succession of delays—fourteen years of the most vexatious delays—until finally the Supreme Court of the United States ruled that Berliner, and not Edison, was the original inventor of the transmitter.* (H. N. Casson, 1910, p. 119)

In 1878 the Bell company bought the rights to use Berliner's microphone patent for $50,000[151] and gave him a well-salaried position as chief-engineer in the company.

The preceding analysis shows some of the participants in the development of the 'acoustic technology'. Their work would be a source of inspiration for the later development of the telephone. One has to realize though, that many of the previously mentioned developments were based on the 'make and break' principle. For some, the development of the speaking telegraph was only a scientific issue; others had more commercial plans. Fact is, many of the previous experimenters did not succeed in transferring their idea into a technically and commercially viable product. That is to say, they may have had the idea of something that would later in time be called a telephone, they may have made experiments to prove its feasibility, some may even have built a prototype or even creating a working component like the microphone, but they did not succeed in creating a working *system* that reached the market. That was done by others with another concept; they used the 'variable resistance' principle.

[151] Equivalent to $1,220,000 in 2014 when calculated as wealth based on of the historic standard of living. Source: www.measuringworth.com.

Early Contributors to the Speaking Telegraph

The development of telegraphy and telephony is in fact the development of a system. The telegraph is a system, with the telegraph transmitter, the telegraph line and the telegraph receiver. It is the same for the telephone: transmitter, transmission line and receiver. Before Alexander Bell was granted his patent for the telephone in 1876, many inventive engineers and scientists were already working on systems that formed the field of the *speaking telegraph*. Let us look at some of these early contributors in detail.

Phillipp Reis

The German Johann *Phillipp Reis* (1834-1874) got his education from the Hassel Institute in Frankfurt am Rhein (Germany) and the Polytechnic School at Karlsruhe. In 1855, after his military service in Cassel, he went back to Frankfurt. In 1858 he was offered a post at the Institute of his formal master, Hofra Garnier. Reis had studied the organs of the ear and the idea of an apparatus for transmitting sound by means of electricity had floated in his mind for years. In his home ' laboratory', he had been working for nine years on a specific device (Figure 59). He wrote:

Incited thereto by my lessons in Physics in the year 1860, I attacked a work begun much earlier concerning the organs of hearing, and soon had the joy to see my pains rewarded with success, since I succeeded in inventing an apparatus, by which it is possible to make clear and evident the functions of the organs of hearing, but with which also one can reproduce tones of all kinds at any desired distance by means of the galvanic current. I named the instrument ' Telephon'. (Sylvanus P Thompson & Reis, 1883, p. 5)

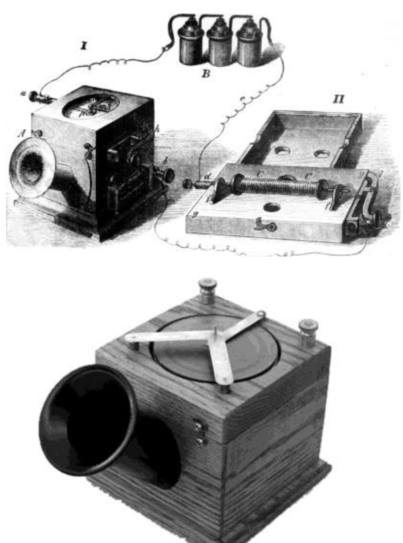


Figure 59: Drawing of the system (top) and Model (bottom) of the Reis Telephone.

Source: (top) Wikimedia Commons; Sylvanus P.Thompson: Phillipp Reis, Inventor of the Telephone, (bottom) http://www.antiquetelephonehistory.com/images/reistrans.JPG

He made several models (1858, 1861 and 1863). Speaking into the mouthpiece did vibrate a parchment membrane, producing 'loose-contact' between two platinum contacts. This was same approach that Bourseul had mentioned. Drawing on his experience in telegraphy, Reis apparently thought that the actual making and breaking of the contact could transmit the complex series of tones necessary for articulate speech. At the receiving end, the speech-modulated current altered the magnetic state of a steel knitting needle inside a wound solenoid mounted on a resonating box, creating the spoken text. On October 26, 1861, he presented in Frankfurt for 'Der Verein' a reflection on *'Das Physikalische Telefonieren durch galvanischen Strom'*, but there wasn't too much interest. Two years later there were 50 copies of the 'Telephon' made by a German company. But it was not practical enough to be a commercial success. The sickly Reiss died of tuberculosis in 1874, two years before Bell filed his patent application.

Reis never did apply for a patent, but he 'gave his invention to the world'. He disclosed all details of construction and operation of his 'Telephon' both orally and in writing to anyone wishing to know them.[152]

Daniel Drawbaugh

There were serious scientists trying to discover the fundamentals of their field of interest. And there were those who 'jumped on the bandwagon' when Bell's invention became widely known. Urged on by the lawyers who opposed Bell's patent, was the blacksmith and 'designer' *Daniel Drawbaugh* (1827-1911). He claimed to have developed a telephone system before 1876, but was in such 'utter and abject poverty' that he could not get himself a patent. This remark was in contrast to the fact that he already had some patents in his name, mostly for mechanical devices such as pneumatic tools, hydraulic rams, folding lunch boxes and coin separators. 'Between 1851 and 1867 he received eight patents, and by the early seventies has sold rights to some for amounts ranging up to $6,000.'[153] (Bruce, 1990, p. 173)

> *The fact about Drawbaugh is that he was a mechanic in a country village near Harrisburg, Pennsylvania. He was ingenious but not inventive; and loved to display his mechanical skill before the farmers and villagers. He was a subscriber to the Scientific American; and it had become the fixed habit of his life to copy other people's inventions and exhibit them as his own. He was a trailer of inventors. More than forty instances of is imitative habit were shown at the trial, and he was severely scored by the judge, who accused him of "deliberately falsifying the facts." His ruling passion of imitation, apparently, was not diminished by the loss of his telephone claims, as he came to public view again in 1903 as a trailer of Marconi.* (H. N. Casson, 1910, p. 98)

[152] Source: http://www.chezbasilio.org/reis.htm. Accessed February 2015.
[153] Equivalent to $110.000 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

When a group of investors some time later in 1880 formed the *People's Telephone Company*, they bought his claims for $20,000[154]. They started manufacturing telephones and applied for a patent on Drawbaugh's behalf (filed July 21, 1880). The patent claimed that Drawbaugh was the inventor of the telephone. On October 31, 1882, he was granted US Patent № 266.615 for a Telephone transmitter that described his invention as follows:

> *The invention consists in a telephone having two diaphragms, inclined to one another, so that the line of junction of their edges shall bisect the mouth-piece orifice. Sound chambers are formed between these diaphragms and the exterior case of the instrument, and between the two inclined diaphragms are arranged series of low conductors, which are put under compression simultaneously on opposite sides by the vibration of both diaphragms.* (Patent text)

That was the first patent. In the following years, 1883-1884, he—in fact the assignee of the People's Company—was granted many patents for telephone transmitters, patents where the People's Telephone Company was the patent holder (eg US Patents № 276,136; № 276,137; № 287,111; № 291,311; № 295,741; № 295,742; № 297,578; № 297,579; № 298,676; № 303,627; № 303,628; № 303,629; and № 307,026). After eight years of litigation, his priority claims were rejected, and Drawbaugh was reprimanded by the Court for his falsifications.

Antonio Meucci

Antonio Meucci (1808-1889) was born in Florence in a large family with eight brothers. In spite of the quite poor circumstances the family lived in, his father managed to have him admitted to the *Accademia di Bell Arti* (Academy of Fine Arts) on November 27, 1821. He was, at that time, thirteen years old. Meucci attended the schools of Chemistry and Mechanics. It was the time after Napoleon's occupation of Northern Italy and Tuscany (1799-1814), and the time of Galvani's work (in Bologna) and Volta's work (in Pavia) on electricity.

At the end of his education, he was employed as customs officer at the gates of Florence. In October 1833, he got a job as an assistant to the engineer of Florence's theatre of the Court, the *Teatro della Pergola*. It was a time of political turmoil, and after being involved in conspiracies for the liberation of Italy, he spent some time in jail. Later he would find himself under constant surveillance from the police of the Grand Duchy. Quite understandably, he began to look for a change of venue.

---

154 Equivalent to $470.000 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

> *In the fall of 1835, another renowned theater impresario, Don Francisco Martí y Torrens, came to Florence in search of talented artists, with the aim of introducing the Italian Opera, then at the apex of its success throughout the world, in Havana (Cuba). He offered Antonio Meucci the job of chief engineer, and his wife Esterre the job of chief costumer, in the magnificent Gran Teatro de Tacón, which was to shortly replace the Havana's smaller Teatro Principal. The Meuccis readily accepted, also to escape the surveillance from Florence's police.* (Catania, 2001, pp. 56-57)

Arriving in Havana, the Italian Opera Company debuted on January 12, 1836. In 1844 Meucci used the laboratory next to the theatre to set up a small factory for electroplating swords, helmets and other military supplies. He used a set of Bunsen batteries that were bought in New York. As the busy theatrical season lasted during autumn-spring, he had many summer months at leisure. That time he spent on studying the new phenomena around electricity: *electrochemistry* and *electrotherapy*. In 1848 he started experimenting with electrotherapy, in cooperation with some local physicians, and this brought him to the speaking telegraph. In Meucci's own words, this is what happened:

> *A man in my employment that one time, somewhere about 1849, complained of being sick, and I thought to try electricity on him. ...I called to him to put the copper part of his instrument in his mouth.. . . the man, while he had the copper in his mouth, cried out from the effects of the shock. I thought I heard is sound more distinctly than natural. I then put is copper of my instrument to my ear, and heard the sound of his voice through the wire. This was my first impression, and the origin of my idea of the transmission of the human voice by electricity. (Antonio Meucci, 1885-1885). And I gave it immediately the name of "Speaking Telegraph." (Deposition of Antonio Meucci, 1885/1886, Ans.) ...*
>
> *[during that time in] Havana . . . by means of some little experiments, I came to discover that with an instrument placed at the ear and with the aid of electricity and a metallic wire, the exact word could be transmitted, holding the conductor in the mouth.* (Catania, 2001, pp. 57-58)

Meucci stayed for fifteen years in Havana, the best time of his life, earning good wages. But, as his contract at the theatre was coming to an end, Meucci started looking to apply his inventive capabilities in a more dynamic place, such as New York. He therefore left Havana with his wife Esterre Mochi, on April 23, 1850, for New York, where they arrived on May 1, 1850. When they left they had accumulated a capital of $20,000[155]. Being quite wealthy, he arrived in the Italian colony of New York amidst

[155] Equivalent to $625,000 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

political exiles who were generally of the high classes but often completely destitute of means. He bought a cottage and the adjacent land in Clifton (Staten Island). To create employment for his countrymen, he started a candle factory adjacent to his house. The American business environment was quite tougher than expected, and he was strangled by suppliers of raw material on one side and distributors of the finished product on the other side. The venture failed after a year.

Over the years his wife Estelle was more and more bound to bed by rheumatoid arthritis and could seldom leave her bedroom. So he wanted to create a communication facility between her bedroom (upstairs on the third floor) and his laboratory (downstairs in the basement). He originally used a traditional (mechanical) 'call bell'. This being a rather rude solution, he experimented and constructed an electromagnetic instrument between 1858-1860 that gave better results (Figure 60, top). This brought him to the idea of a communication system to bridge larger distances. (Figure 60, bottom).

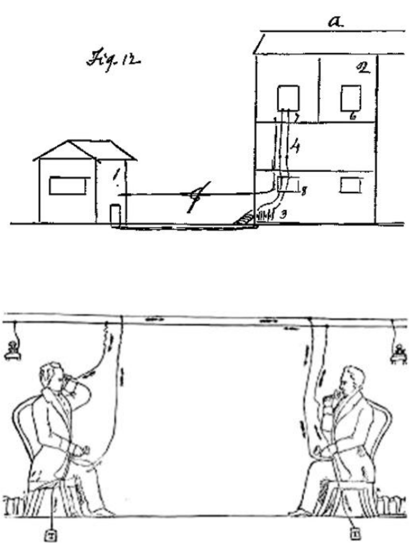


Figure 60: Top: First telephone link created in Meucci's house in Clifton (1854-1855). Bottom: Scheme of a telephone conversation, devised by Antonio Meucci in 1857-1858.

Source: Top: Basilio Catania. http://www.chezbasilio.org/havana1.htm. Bottom : Source: (Catania, 2001)

Meucci also thought of finding capitalists to invest in his invention and to pay for patenting the same. He entrusted a friend, Enrico Bendelari, a wealthy commission merchant (later to become the Italian Consul General of Canada), to seek them in Italy, as Bendelari was to sail there for business. Bendelari left New York on September 22, 1860. In his affidavit (Bendelari, 1880), he stated that as soon as he arrived in Naples, he proposed Meucci's invention to various capitalists, as well as to Naples' Deputy Postmaster, Settimio Volpicelli, but without success. … Given the lack of interest encountered, in or about 1861, Meucci resolved to publish his invention in L'Eco d'Italia, an Italian newspaper of New York. (Catania, 2001, p. 60)

This act of publication would cause him later problems in patenting his invention, as the US Patent Act prescribed that no invention could be patented if it had been previously 'described in any printed publication in this or any foreign country'. Therefore, by disclosing an invention in a printed publication, it would be 'given to the world', but it would also attach forever the name of the inventor to the invention. That meant for Meucci 'no money, but maybe glory'.

In the meantime, Meucci had, after closing the ailing candle factory, started a lager beer brewery, called the Clifton Brewery, in the former candle factory. He made some bad managerial decisions, trusted the wrong people, and creditors (among whom was his lawyer) were after him for their money; it all brought him into problems. As he had mortgaged his property as security for loans, his house and brewery were auctioned in November 1861. This left him penniless and homeless. He was desperate and had to find a job.

> *From 1859 to 1867, Meucci worked for a William E. Rider, whose father owned half of the Goodyear patents for rubber production. Rider made an agreement with Meucci that entitled him to select any inventions made by the latter, get a patent at his own expense, and pay Meucci a salary of between $15 and $20 a week (a salary normally paid to a handyman), plus 5% of any net profits arising from any applied invention. Obviously, Rider chose those inventions that he deemed to be readily profitable. Therefore, although it was widely known that Meucci had invented a means for transmitting speech electrically, Rider joined the score of businessmen distrusting its potentiality to yield profits.* (Catania, 2001, pp. 61-62)

Now Antonio Meucci had a job and he had a source of financing his patents, he could continue his inventive work (Figure 61) working for Rider. Soon he started to patent his inventions: paraffin candles (US Patent № 22,739), siccative oils, lamp burners, and chemical paper pulp. In his spare time, Meucci worked on his speaking telegraph, further improving the already good results obtained from 1858 through 1860. He had to surmount many technical problems, such as maintaining good line quality over a long distance, not using iron wire but copper wire and insulating the copper wire. Between 1864 and 1865 Meucci greatly improved his electromagnetic instrument and constructed a model (Figure 62) that he described as:

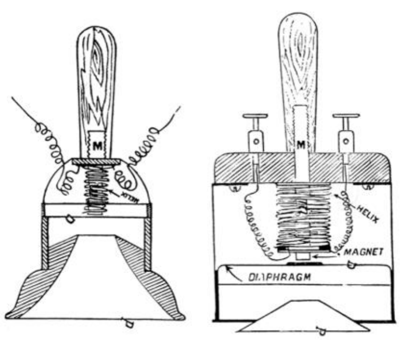


Figure 61: Meucci's prototypes: 1857 (left) and 1867 (right)

Source: Atlanta, August 1932, Vol.XII, No.5, p.201

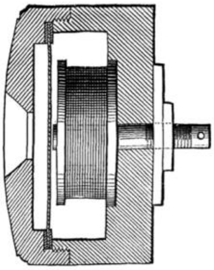


Figure 62: Muecci's telephone (1864-1865).

A similar model was given to Grant for testing purposes.

Source: Scientific American Supplement, No 520. December 19, 1885. http://www.gutenberg.org/files/13401/13401-h/13401-h.htm#13

This instrument was made from a soap box of boxwood; the cover was screwed on the top of the box; it had an iron diaphragm; the bobbin was large, and the magnet extending rough, the coil had a read upon it by which I could adjust it to the diaphragm. This was the best instrument that I had ever made for transmitting and receiving the words. (Catania, 2001, p. 64)

Then, in July 30, 1871 disaster struck. On a voyage to New York the ferryboat to Staten Island had its boilers exploded, killing sixty passengers and wounding more than two-hundred passengers (Figure 63).

Among them was Meucci, who was severely wounded. In order to pay for his medical treatment and the daily household expenditures, his wife sold all his electrical and telephone apparatus. The job was gone, there were no savings, and Meucci was a poor man depending on the aid of his friends. As one of them, John Fleming, declared later:

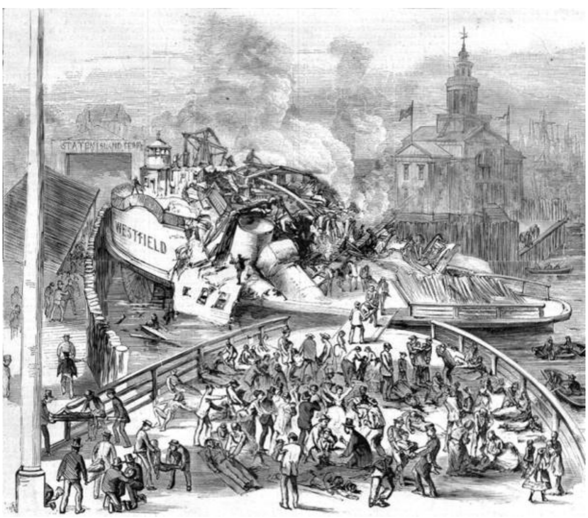


Figure 63: The Staten Island Ferry Boat Disaster immediately after the explosion (1871).

Source: New York Times, Harper's illustration

I knew Mr. Meucci from 1871 to 1877. He was very poor indeed. During these years the overseer of the poor helped him, and the neighbors helped him sometimes, and I among the rest. We always gave to her. . . . another reason why we gave to Mrs. Meucci was, we all thought he was experimenting with his talking telegraph, and might spend our donations on his experiments. (Fleming, a junk dealer) (John Fleming, 1885) (Catania, 2001, p. 65)

This support made it possible to stay alive, but it did not pay for his ambition of inventing. However, he managed to find some support, and on December 12, 1871, he and his new partners Tremeschin, Zilio Grandi and Breguglia established a partnership '*Telettrofono Company*' that would embark on creating the speaking telegraph as invented by Meucci. The agreement stated:

> *The said parties above named, have agreed and by these presents do agree to become copartners together under the firm of Telettrofono Company (Speaking Telegraph), in the business of making and trying all the necessary experiments for the accomplishment of the Telettrofono, i.e. of the transmission of the word (human voice), through electric wires, invented by the aforesaid Antonio Meucci. … And to that end and purpose the said parties hereby covenant and agree that the said copartners, A. A. Tremeschin, A. Zilio Grandi and S. G. P. Breguglia, shall be fully impowered, and they promise and bind themselves to do their best endeavors to secure patent for the same invention in any State of Europe, or other part of the world, to form copartnerships, to raise companies, to sell or assign, in part, the rights of such invention, and to do all what can result to the benefit and good success of is enterprise; and it is agreed, also, that the said parties, Tremeschin, Zilio Grandi and Breguglia, shall bear, at their own charge that equal share, at the rate of one third each, all the expenses of any kind and nature, for whatever experiment which shall be deemed useful and necessary to the aforesaid purpose. And it is agreed, also, that the said Antonio Meucci shall be exempt of any charge for such expenditures in consideration of his invention.*[156]

The agreement was clear: Meucii would contribute his patent rights, the investment needed would come from the partners, and the profits would be shared. To safeguard his invention, he prepared a description of his invention, had it translated into English (Meucci did not master English that well) and asked a patent lawyer—JD Stetson—to prepare for an application. However, the cost of the patent was$250[157] which Meucci could not pay by himself. And by that time most of his backers had chickened out of their earlier commitment. For $10, though, the lawyer was willing, with a minimal effort, to create the specification for the caveat[158] titled 'Sound telegraphy' (plus the deposition cost of $10).

---

156 Source: http://www.chezbasilio.org/telettrofono_co.htm

157 In 2014 this would be nearly $5,000; calculation based on real price. Source: http://www.measuringworth.com/uscompare/relativevalue.php

158 A caveat was a form of a pre-patent in which the inventor stated the general outline of his invention. The caveator had the right to be advised by the patent office in case any other inventor filed an application on the same subject. This advice or 'notice to complete' would allow the inventor to file, within the term of 3 months, his own application, which if passed by the examiner of interference, would ensure his priority. The fee for maintaining a caveat was $10 per year.

> *After spending ½ hour to hear the oral explanation from Bertolino (Meucci not speaking English), he spent another hour for both studying the papers and drawings left with him and dictating the specification of the caveat. He then sent the caveat to the patent office without attaching any drawings, presumably because he expected to include them in a regular patent application, as was Meucci's wish. The caveat, titled "Sound Telegraph," was filed in the patent office on December 28, 1871.* (Catania, 2001, p. 66)

With the caveat submitted to the US Patent Office on December 28, 1871 (number 3,335[159]), Meucci had established protection for his invention. Next he went and prepared to start the newly formed company. But again, he did not have luck on his side. One partner died, another returned to Italy, and a third withdrew from the partnership that was practically dissolved. To get permission to use telegraph lines for field experiments, he had been introduced to Edward B. Grant, vice president of the *American District Telegraph Company*—a company of the *Western Union Group*—of New York. So Meucci prepared a description of his system, had it translated in English, added a copy of his caveat and his drawings, and delivered everything along with a test telephone to Grant in the summer of 1872. Notwithstanding Meucci's frequent and urgent calls, it took Bell four years to conclude that he was not interested. 'Sorry, but all the material was lost' was his lame excuse. In the meantime, the caveat needed yearly renewal (at the cost of $10). Meucci failed to raise the amount in the third renewal, so shortly before 1875 his caveat expired. This was a dramatic fact as he had lost his legal position, as stated by Zenas Fisk Wilber, the principal patent examiner in charge of telegraph related inventions: 'Had Mr. Meucci's caveat been renewed in 1875, no patent could have been issued to Bell.'[160]

In 1876, when Alexander Graham Bell got his US patent № 174,465, Meusii contacted his lawyer Stetson, who did not have a clue about the technicalities of the matter at hand and was not much of a help. Meussi got in touch with another lawyer, as he wanted to get recognition for his claim of being the inventor of the telephone. He wrote letters to newspapers, claiming his priority, he was interviewed by reporters, and he was contacted by companies interested in buying his rights. But that effort took a while.

> *On April 25, 1883, he entrusted the New York law firm Lemmi & Bertolino to legally protect his claims (Michael Lemmi, 1883). Shortly after, the law firm received a proposal for purchasing Meucci's rights from a subsidiary of the American Bell, the Mexican Bell Telephone Company, with headquarters in*

159 Meucci, Antonio, Sound Telegraph, US Patent Office Caveat No. 3335, filed Dec. 28, 1871; renewed Dec. 9, 1872; Dec. 15, 1873.

160 Source: Zenas Fisk Wilber, 1886, Affadit (n.a., 1886)

Boston, Massachusetts, in the same building as the American Bell (Schiavo, 1958). Other calls were made directly by the American Bell, who hinted at a value of 1 million dollars for Meucci's invention. (Catania, 2001, p. 69)

The first offers were refused as they were considered a ploy to get rid of Meucci's claims. But he did accept a fourth offer on September 22, 1883, and Meucci transferred all the rights for his patent to a syndicate composed by William W Goodwin, James Work, and Robert R. Dearden of Philadelphia (all of them shareholders of the *Globe Telephone Company* of New York) and Alfred P Willoughby of Chicago. Meussi became electrician of the Globe Telephone Company.

In 1885 the *Globe Telephone Company* addressed a petition to the America Government to annul Bell's patent. This resulted in a lawsuit against Bell, one of the many Alexander Bell was facing. As the US Government considered in 1987 to annul Bell's patent (because of fraud and misrepresentation of reality), fate hit for the last time. Meucci died in October 1889, and the case was discontinued. The only thing Meucci left to history were his patents (Table 1), the legacy of an inventive man.

Table 1: Some of the patents granted to Meucci (1860-1876).

Patent №	Granted	Description
US 22,739	1860	Paraffin Candle Mould
US 36,192	1862	Smokeless Kerosene Lamp
US 36,419	1863	Process for treating and bleaching oil or kerosene
US 44,735	1865	Processes to obtain paper pulp from wood
US 46,607	1865	Process for making wicks out of vegetable fiber
US 53,165	1866	improved process for making paper-pulp from wood
US 122,478	1872	Improved method of manufacturing effervescent drinks from fruits
US 142,071	1873	Improvement of sauces for food
US 168,273	1875	Method for testing milk
US 183,062	1876	Hygrometer

Source: USPTO

Amos Dolbaer

After graduating from Ohio Wesleyan with a Bachelor of Arts degree in 1866, *Amos Emerson Dolbear* (1837-1910) obtained the degree of Master of Arts and Master of Engineering from Michigan University in 1867 and secured a position as an assistant professor of Natural History at Kentucky University. In 1868 he travelled to Beany College where he was a full Professor of Natural Science until 1874. In the middle-1870s he became professor at Tufts College (a university in Medford, Massachusetts) where he chaired the Department of Astronomy and Physics. He was a 'theoretical scientist' who did pioneering research concerning the conversion of sound into electric variations. His research resulted in the static telephone. He explains in his book 'The Speaking Telephone', published in 1877, about creating the telephone:

> *I was able, with a few preliminary experiments, to determine the proper conditions for the transmission of speech in an electric circuit; and, without the slightest knowledge of the mechanism which Prof. Bell had used, I devised the following arrangement for a speaking-telephone. …* (Dolbear, 1877, p. 27)

He observed that, as all the basic principles of the telephone system had been known from the telegraph technology developed since the 1840s, it took too long to create the speaking telephone.

> *To some it may seem strange that a simple thing as the telephone is, involving nothing but principles familiar enough to every one interested in physical science, should have waited nearly forty years to be invented. The reason is probably this: Men of science, as a rule, do not feel called upon to apply the principles which they may discover. They are content to be discovering, not inventing. Now, the schools of the country ought to make the youth quite familiar with the general principles of physical science, that the inventive ones—and there are many such—may apply them intelligently.* (Dolbear, 1877, p. 29) [161]

Dolbear had already worked in the mid-1870s on the telephone concept, before Bell, but he never patented it as he had not seen the need for it. When he heard about the specifics of Bell's work—the Massachusetts community of inventors was not that big—he did not hurry the completion of his telephone and finished it in early 1877. He then learned that Bell had applied for a patent covering the permanent-magnet telephone on January 15, 1877. It was in that period that he started cooperating with Western Union's subsidiary, the *Gold and Stock Company*. In September 1877, in exchange for a share in the financial profits from his inventions and a research stipend of twenty-five dollar a week, he assigned his patents to that company (Bruce, 1990, pp. 266-267).

His telephone experiments resulted in an invention for which he was granted US Patent № 199,041 on January 8, 1878, after filing it in December 6, 1877. However, he was just too late with his invention to be a competitor in the priority debate that arose later on.

---

[161] This distinction between the discovery of the phenomenon, and the application of that discovered fact into something workable, is quite fundamental. Discovery relates to the principles behind a phenomenon (such as sound) and creating the first artifacts related to it. Invention, being the transformation of a principle into usable artifacts working on those principles, complements that action. In today's understanding, the latter would be called 'innovation'.

My improvements consist, first in combining, with the permanently-magnetic cores and elastic diaphragm of a telephonic instrument, an electro-magnet, attached to and supported by said diaphragm, and so arranged as to act an armature to the first-mentioned cores… (text of patent)

He improved upon the principle, and in his next patent, US Patent № 220,205 on September 30, 1879, it said quite something similar:

My improvement consists in mounting the elastic diaphragm of a telephonic instrument, which forms the armature of the electro-magnet, upon a rigid frame, to which the edges of the said diaphragm are secured in the usual manner. ... An instrument thus constructed and arranged may be conveniently made to serve the double purpose of a telephonic transmitter or receiver, and of a Morse sounder or receiving instrument. (text of patent)

This device he invented was in its essence a convertor; it converted the sound waves into electric variations and vice versa.

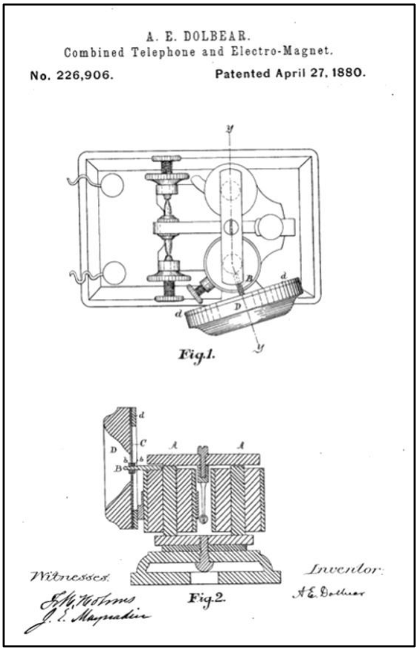


Figure 64: Drawing from US Patent № 226,906 for Dolbear receiver (1880).

Source: USPTO

His next work resulted in a telegraph receiver that he patented on April 27, 1880, as US patent № 226,906 (Figure 64). The patent description describes the invention:

I have discovered that if a small rod of iron steel (preferably soft iron) be connected to a diaphragm and the whole be mounted, as shown in the drawings, in relation to an electro-magnet the rod will move toward and from the magnet so as to vibrate the diaphragm when varying currents of electricity are sent through the coil of the magnet, or, in other words, that such a contrivance will make an excellent telephony receiver well adapted for use with any of the ordinary transmitters. (text of patent)

In April 5, 1881, he was granted a patent for his further work: US patent № 239,742 for an 'Apparatus for transmitting sound by electricity'.

From these examples, it is clear that Dolbear was very much into inventing devices we would call a microphone or loudspeaker in our times. The question arises as to why he did not file his inventions earlier for a patent, as that would have been before Bell filed his first telephone patent.

> *In the fall of 1876, Dolbear met Percival D. Richards, who offered to market his inventions. Dolbear already had a telephone prepared, which used a permanent magnet and required only a few slight improvements before marketing. He was ignorant to the formalities of patent law, however, and had no idea that he was facing intense competition. Dolbear wanted to perfect his telephone so that it was of the utmost ability by the time he applied for a patent. Thus, instead of rushing to the patent office, he brought his telephone to a machine shop in order to have the rods re-magnetized. Unfortunately, Dolbear was unaware that this was the same shop in which Bell, his main competitor, performed all of his experiments [that is, Charles Williams's workshop].*
>
> *Hubbard contacted Richards to tell him that this permanent magnet telephone had already been patented by Bell. Having been friends with Bell, Richards believed that Hubbard was telling the truth and did not verify the claim. When Richards proposed a joint patent between the two inventors, Hubbard refused. At this point, Dolbear and Richards discontinued (some say foolishly) their attempt to obtain a patent. Parallel to his patent battle the year before with Gray, Bell had never mentioned using a permanent magnet in his telephone before obtaining a patent for it on January 30, 1877. This was only four days after he had filed, and conveniently right after Dolbear had sent his invention to the machine shop.* (Wineke, Caudill, & Mixon Jr, 2014, pp. 3-4)

Whatever the exact case, it is clear that Bell and Dolbear were working on similar inventions in the same period of time. But each went his separate way. And Dolbear's way went in the direction of Western Union, the giant telegraph company that became embroiled with the small start-up operation of the Bell associates.

> *Though he was facing what he believed to be unfair circumstances, Dolbear remained confident that he had an invention that was more useful than Bell's and that would provide greater benefit to the public. To gain funds for his experiments, Dolbear made an agreement with the Western Union Telegraph Company on December 6, 1877, for the provision of funding. Soon after, Western Union was investigated by the Bell Telephone Company for infringement, and the former wanted to cancel their contract with Dolbear and buy his inventions. Dolbear asked for $10,000, and Western Union agreed. Later, Dolbear discovered that Western Union was willing to pay him up to $100,000 for his inventions* (Wineke et al., 2014, p. 4)

It was thus that, after the agreement between Western Union and the Bell National Telephone Company, in early 1880 Dolbear's patents would be owned by Bell. The same was the case with Gray's patents, as we will see later on.

At the end of 1879 and the beginning of 1880 the *Dolbear Electric Company* was incorporated to exploit Dolbear's patents (Table 2) and enter the fast-growing telephone market, a fact that did not escape the attentions of Bell's attorneys. They sued Dolbear, and he lost and went out of business. But he would never give up his claim to be the inventor of the telephone. Next, other experiments with electric sparks that created the 'Herzian Waves'[162] made him an early pioneer in wireless communication. He was granted US Patent № 350,299 on October 5, 1886, for his invention labelled as 'Mode of Electric Communication': 'My invention relates to establishing electric communication between two or more places without the use of a wire or other like conductor.' (text of patent)

He had a system that included 'induction coils, carbon and condenser telephone transmitters and batteries in a wireless set-up with grounded

Table 2: Some of the patents granted to Amos Dolbear (1879-1886).

Patent №	Granted	Description
US 199,041	January 8, 1878	Improvement in telephones: Combining cores and elastic diaphragm of a telephonic instrument with an electro-magnet. (filed December 6, 1877)
US 220,205	September 30, 1879	Combined Speaking-Telephone and Morse-Sounder
US 226,906	April 27, 1880	Combined telephone and electro-magnet.
US 239,742	April 5, 1881	Apparatus for transmitting sound by electricity (transmitter). (filed Jan 24, 1880)
US 240,578	April 26, 1881	Apparatus for transmitting sound by electricity (receiver).
US 288,215	November 13, 1883	Telephone; *My invention consists in the combination, with two coils on the same core, of two transmitters and two batteries or equivalent generators, one in circuit with each coil.*
US 325,659	September 8, 1885	Telephone system: combined transmitter, receiver and call bell.
US 350,299	October 5, 1886	Mode of electric communication.
US 355,149	December 28, 1886	Telephone Receiver: using, in place of an uncovered metal diaphragm, a diaphragm coated on one or both sides with a dielectric substance which is electrified.

Source: USPTO

[162] The name for electromagnetic waves that result from an electric source. This effect was discovered by Heinrich Rudolf Herz in the 1880s.

wires that both ends of a communications link.' It would bring him in conflict with another inventor: Guglielmo Marconi. (Cummings, 2012, p. 22)

Elisha Gray

Elisha Gray (1835-1901) was born in Ohio into a Quaker farming family. After his elementary education he had tried the apprenticeship for blacksmith and ship joiner.

> *While serving his apprenticeship as a ship joiner he became friends with a student form Oberlin College, H.S.Bennett (later a professor that Fisk University), who told him of the exceptional educational opportunities available that at institution. ... As soon as he had finished his apprenticeship, Elisa began, that the age of 22, a five-year program of preparatory school and college, concentrating on the physical sciences, especially electricity.* (Evenson, 2000, p. 13)

When he finished school in 1862, he married and found his way into inventing machines, such as a self-adjusting relay and an annunciator for hotels.

> *At age of thirty-two, Gray launched his new career. He had assessed some of the problems of telegraphy, and one that particularly struck his fancy was the problem of relay circuits sticking either open or shut. Gray solved this problem with what he called an automatic, or self-adjusting, relay. In April 1867 he filed a patent application and submitted a patent model. His patent was granted six months later. Receiving his first patent was exciting for Gray, but things were even more exciting when he demonstrated (with the hope of selling) his relay to Western Union officials in Cleveland. … Two weeks after his first letter he again wrote his wife: "My machine is a perfect success so far.... All agree in pronouncing it one of the most beautiful working instruments they ever saw. Mr. Willey [my lawyer] says I ought to be a happy man in as much as I am bound to be rich and celebrated" ...* . (Hounshell, 1975, p. 136)

Apparently, Gray was, in the early stage of his career, already toying with the idea of commercializing his inventions. He had some ideas about a machine—what we would today call a 'teletype machine'—that could be operated without specific knowledge of Morse's code and used, for example, to transmit information about stock quotes.

> *He persuaded General Anson Stager, the Western Union superintendent who had praised his first invention, to purchase an interest in such a printer—even though at this time it existed only in Gray's mind. … with the money from Stager, Gray purchased a half interest in the telegraph-instrument manufacturing shop in Cleveland which had made his first patent models.* (Hounshell, 1975, p. 137)

In 1869, in association with his friend Enos Barton, a former telegraph operator, Gray established the company Gray & Barton. Their main product line was telegraphic equipment that they supplied to the telegraph company *Western Union Telegraph Company*, a company that became also their investor. So, Western Union joined, and they renamed the company in 1872 into the *Western Electric Manufacturing Company.*

> *Gray & Barton's performance impressed Western Union leaders. In 1872, three years after Gray and Barton became partners, Western Union (with William Orton as president) purchased a one-third interest in their company, incorporated under a new name, Western Electric Manufacturing Company. … Gray retained the position of superintendent and sat on the board of the new company; Enos Barton became secretary; and General Stager, who remained as vice-president of Western Union, was president.* (Hounshell, 1975, p. 139)

In 1874 Gray left his position as chief engineer and devoted his time to independent research and development, backed by his patron Dr Samuel S White of Philadelphia, who financed his work for part of the profits. Gray began to work on a 'harmonic telegraph', which he hoped would transmit several messages simultaneously at a different pitch (ie frequency). In 1875 he managed to create a transmitter and receiver. The transmitter was first a single tone transmitter, soon to be followed by a dual tone transmitter. The receiver was an electromagnet and had a diaphragm. He applied for a patent, and on July 27, 1875, he was granted US patent № 166,095 and US patent № 166,096 for his invention 'Electric Telegraph for Transmitting Musical Tones' (Figure 65). So, using multiple frequencies produced by single-tone transmitters, could maybe offer possibilities for 'multiplexing'.

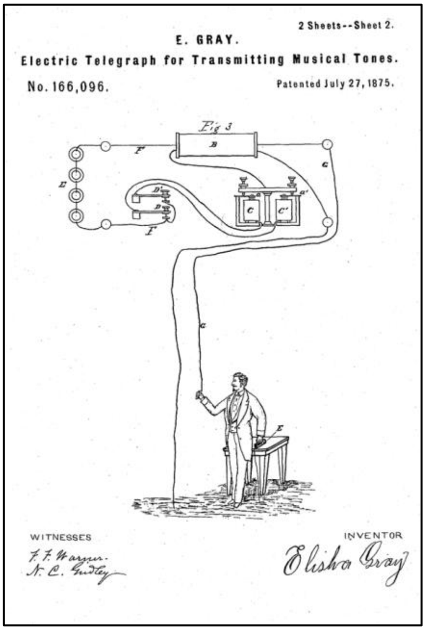


Figure 65: US Patent 166,096 drawing for Gray's Electric Telegraph for Transmitting Musical Tones (1875).

Source: USPTO

> *Multiple telegraphy would be technically more difficult. But it would also be immeasurably more important for an inventor interested in making money. As*

> *noted earlier, the telegraph at this time was primarily a dot-dash code system which used intermittent, direct current. Because of this, only one message could be transmitted over a single wire at one time. With continued expansion of the telegraph industry this became quite cumbersome, as well as expensive. At length, jungles of wires threatened to choke the air above city streets. Western Union was willing to pay up to $1 million to the inventor who could make their wires carry a number of messages simultaneously. To be sure, other inventors had been trying to devise multiple message schemes, but none had yet succeeded. As Gray perceived it, Western Union was ready to make him a rich man.* (Hounshell, 1975, p. 144)

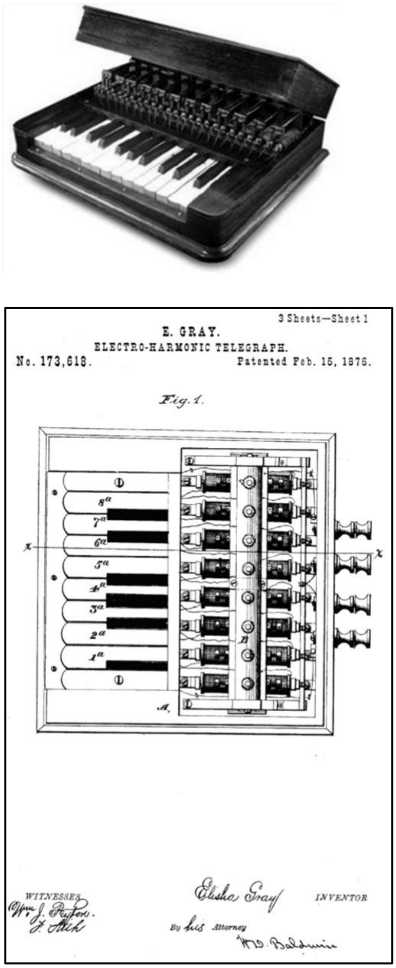


Figure 66: Model (top) and patent drawing for Grey's Electric Harmonic Telegraph (1876).

Source: USPTO, ccrma.stanford.edu

To demonstrate his invention, Gray built an organ-like transmitter with eight keys, devised another diagram receiver and applied for multiple patent applications for his multiple telegraph system. On February 15, 1876, he was granted US patent № 173,619 for this invention (Figure 66).

Elisha Gray gave the first public demonstration of his invention for transmitting musical tones at the Presbyterian Church in Highland Park, Illinois on December 29, 1874, and transmitted 'familiar melodies through telegraph wire' according to a newspaper announcement, possibly using a piano as a resonating amplifier. He continued these demonstrations for several years. On April 2, 1877 he gave widely publicised 'Telephone Concert' where a well-known pianist performed on Gray's 16-key telegraphic transmitter. (Weidenaar, 1995, p. 2)

Gray was aware that Alexander Graham Bell was also working on the multiplex telegraph and on the transmission of speech electrically. Bell however, as we will see, was devoted to developing his speaking telegraph.

> *Bell seems to be spending all his energies in [the] talking telegraph. While this is very interesting scientifically it has no commercial value at present, for they can do more business over a line by methods already in use than by that system. I don't want at present to spend my time and money for that which will bring no return." The "they" Gray mentioned were the Western Union men, the officials who controlled telegraphy in the United States and the men who were bidding for Elisha Gray's multiple telegraph system. He knew that "they" were not bidding for a telephone because he knew they thought the telephone was a toy.* (Pizer, 2009, p. 152)

Figure 67: String Telephone or Lover's Telephone.

Source: Du Moncel; the Telephone, the Microphone and the Phonograph. (Hounshell, 1975, p. 153)

Gray had his reservations about Bell's work. He would be greatly surprised in the near future: 'As to Bell's talking telegraph, it only creates interest in scientific circles, and, as a toy it is beautiful; but ... its commercial value will be limited.'[163] The toy he was referring to was a lover's telephone, or string telephone, which consisted of two metal cans connected by a string. It was a primitive mechanical device (Figure 67).

Whatever the case, it was clear that Gray had to speed up his work. On February 14, 1876, Gray, like Meucci in the same year, filed with the US Patent Office a caveat (an announcement of an invention he expected soon to patent) describing an apparatus 'for transmitting vocal sounds telegraphically' (Figure 68). It described the inventions as:

> *To all whom it may concern: Be it known that I, Elisha Gray, of Chicago, in the County of Cook, and State of Illinois, have invented a new art of transmitting vocal sounds telegraphically, of which the following is a specification:*

[163] Letter to William D. Baldwin, his attorney (1 Nov 1876). Telephone Investigating Committee, House of Representatives, United States 49 Congress, 1st Session, Miscellaneous Documents (1886), No. 355, 1186.

It is the object of my invention to transmit the tones of the human voice through a telegraphic circuit, and reproduce them at the receiving end of the line, so that actual conversations can be carried on by persons at long distances apart.

I have invented and patented methods of transmitting musical impressions or sounds telegraphically, and my present invention is based upon a modification of the principle of said invention, which is set forth and described in letters patent of the United States, granted to me July 27th, 1875, respectively numbered 166,095, and 166,096, and also in an application for letters patent of the United States, filed by me, February 23d, 1875. (Pizer, 2009, p. 189)

The Caveat described a system of communication based on the 'variable resistance method'. Gray claimed to have created a system where the voice could be transmitted electrically. His claim was simple: 'I claim as my invention the art of transmitting vocal sounds telegraphically through an electric circuit' (text of caveat). The caveat application was, as was normal procedure, put in the in-basket for later processing. After filing the caveat, his lawyer William Baldwin was notified that Gray's caveat was in conflict with another application.

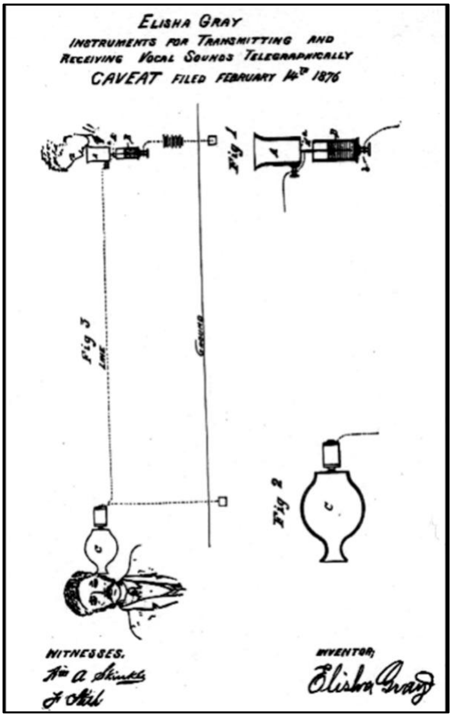


Figure 68: The diagram as part of the 1876 caveat for Gray's telephone.

Source: http://repo-nt.tcc.virginia. edu /classes/tcc315/Resources/ ALM/Telephone/Images/graycav.gif

This required Gray to convert his caveat to a patent application for his device within three months. However, less than a week after is notification, Baldwin received another notice that the interference had been withdrawn. He soon found out that the patent application which conflicted with Gray's caveat was Alexander Graham Bell's and that Bell would be issued a patent within a few days. (Hounshell, 1975, p. 154)

Gray continued, as his financial backer SS White wished, to work on multiplex telegraphy in anticipation of the Centennial Exhibition that was to be held in Philadelphia. Multiplexing telegraphy, that was where the money was, White assumed, and he made this quite clear to Gray. So

Gray worked on his 'Octoplex' and did not continue experimenting with his telephone. As we will see, Bell took another tack and continued on his speaking telegraph with the 'variable resistance' principle. But the experts in the telegraph business did not see much future in it. Gray agreed with that:

> *... talking telegraph is a beautiful thing in a scientific point of view ... But if you look at it in a business light it is of no importance. We can do more ... with a wire now than with that method. And speed is the only thing we are after. Of course it may, if perfected, have a certain value as a speaking tube. This is the verdict of practical telegraph men. The verdict of "practical telegraph men" was delivered late in 1876 by their chief spokesman, William Orton, president of Western Union. It came when Bell and his associates offered to sell the Bell patents to Western Union for $100,000. Orton gave an outright refusal. He wanted a multiple telegraph, not a "scientific curiosity."* (Hounshell, 1975, p. 157)

But they soon changed their mind, and that would be the beginning of a massive 'patent war' around the most valuable patent that ever was granted: Bell's patent № 174,465.

> *Western Union, after its executives realized the value of the telephone, now wanted to enter the telephone business—but they would have to do so without Bell's patents. Late in 1877 they decided to contest Bell's priority in the invention of the telephone. So they made an agreement with Gray and chose to base their claim to priority on Gray's caveat.* (Hounshell, 1975, p. 158)

Table 3: Some of the patents granted to Elisha Gray.

Patent №	Granted	Description
US 69,424	Oct 1, 1867	Self-adjusting Telegraph relay
US 132,907	Nov 12, 1872	Improvement in printing-telegraph instruments
US 162,057	April 13, 1875	Improvement in electric annunciators
US 166,094	July 25, 1875	Improvement in receivers for electro-harmonic telegraphs
US 166,095	July 27, 1875	Improvement in Electrical Telegraph for Transmitting Musical Tones (Octoplex telegraph)
US 166,096	July 27, 1875	Improvement in Electric Telegraph for Transmitting Musical Tones
USRE 6670 /71/ 72 E	July 25, 1876	Improvement in printing-telegraph instruments (original US patent 132,907, filed November 12, 1872)
US 172,993	Feb 3, 1876	Improvement in electric annunciators for elevators
US 173,618	Feb 15, 1876	Improvement in Electro-Harmonic Telegraphs
US 175,971	April 11, 1876	Improvement in telephonic telegraph apparatus
US 186,340	Jan 16, 1887	Improvement in electro-harmonic telegraphs
US 223,345	Oct 19, 1880	Telephonic Telegraph

Source: USPTO

Later in life, after this episode with the telephone, Elisha Gray would continue with his inventive work. In 1887 he developed the *Telautograph*, a device that could remotely transmit handwriting through telegraph systems. He organized the *Gray National Telautograph Company* in 1888, later renamed the *Telautograph Corporation* when he withdrew his involvement from business by selling his shares. This company was, after a series of mergers, finally absorbed by the Xerox Corporation, the manufacturer of copy machines.

From a blacksmith's apprentice to professor at Obelin University, having more than 100 patents to his name, Elisha Grey can be called a successful inventor (Table 3). He made, during his lifetime, over five million dollars from his patents. (H. N. Casson, 1910). Nevertheless, he always stayed bitter over that one patent he failed to obtain: the patent for the speaking telegraph.

Thomas Edison: Multiplexing Telegraphy

Thomas Edison (1847-1931), quite active in the application of electricity—for example the electric light bulb[164]—was also busy with the the telegraph. He had obtained a range of patents for telegraph equipment, such as printing telegraphs. In the mid-1870s he also was busy by finding a solution for the multiplexing problem and was experimenting with vibrating reeds. His work on duplex telegraphy resulted a first patent granted on February 24, 1874 for a duplex telegraph: US Patent № 147,917. He later was granted US patent № 480,567, which although granted in 1892, was already applied for in 1874. Simultaneously, he had covered his rights in other countries: Great Britain, dated February 5, 1875, №. 384; France, dated April 28, 1875, № 107,859; Italy, dated April 30,1875, № 2,940 and № 7,803; Austria-Hungary, dated June 28, 1875, № 2,936 and № 14,584; and Russia, dated May 24, 1878, №. 3,163.

Based on this principle—where each vibrating reed created a different undulating current (ie frequency)—he was able to transmit different telegraph signals simultaneously. In 1874 Thomas Edison invented the first quadruplex telegraph—his most important telegraph invention—which was capable of sending two messages simultaneously in each direction. 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 had 13,000 miles of quadruplex lines by 1878. He sold the rights to Western Union for $10,000 in 1874. In addition, his later patents were assigned to Western Union (Table 4).

[164] See: B.J.G. van der Kooij: *The Invention of the Electric Light.* (2015) pp. 124-134

This concludes our analyses of all those activities of curious and ingenious men, often with completely different background, who were fascinated by the possibilities created by the new phenomenon of electricity. Just as had had happened with telegraphy—and with electric light—telephony now stood on the brink of its creation. But it needed someone from outside the field of electrics to create the breakthrough, just as the painter Samuel Morse had been an outsider in the early development of telegraphy.

Table 4: Some of the acoustic telegraph patents granted to Thomas Edison.

Patent №	Granted	Description
US 480,567	Aug 9, 1892	Duplex Telegraph. (filed September 1, 1874)
US 182,996	Oct 10, 1876	Improvement in acoustic telegraphs: sending pulsations over the line as result from tremolo circuit closers. (filed May 16, 1876)
US 185,507	Dec 11, 1877	Improvement in electro-harmonic multiplex telegraphs: use of tuning forks or reeds as vibrating device. (filed August 3, 1876)
US 186,330	Jan 16, 1877	Improvement in acoustic electric telegraphs: vibrating reeds that the vibrations shall open and close the short-circuiting wire. (filed May 16, 1876)
US 198,089	Dec 11, 1877	Improvement in telephonic or electro-harmonic telegraphs: use of reeds vibrating in different periods of time. (filed April 6, 1876)
US 200,993	Mar 8, 1878	Improvement in acoustic telegraphs: to transmit eight different messages at the same time over a single circuit without interference with one another. (filed September 18, 1876)
US203,019	April 30, 1878	Improvement in circuits for acoustic or telephonic telegraphs: solving interference between wires fused for speaking telegraph. (filed February 21, 1878)
US 235,142	Dec 7, 1880	Acoustic Telegraph: use of tuning fork as vibrating device. (filed on September 30, 1876)

The word 'acoustic 'was in that time often used to describe the harmonic telegraphy.
Source: USPTO

Alexander Graham Bell's Acoustic Telegraph

Alexander Graham Bell (1847 – 1922) was born in Edinburgh, Scotland. He was the son of the illustrious Professor Alexander Melville Bell and his wife Eliza Grace Symonds, who became deaf later in life. Alexander was deeply touched by that deafness and was taught a sign language so he could talk with her anyway. His grandfather, father, uncle and brother kept themselves busy and earning a living with speaking, elocution and the education of deaf people.

> *His grandfather, also named Alexander Bell, had forged for himself a reputation as an impressive, if under employed, actor and orator. Endowed with a commanding speaking voice and considerable physical bearing, Alexander Bell sought to unleash in others the full potential of the spoken word. His attention was especially drawn to those for whom the act of speaking presented daunting challenges. His work with such individuals led him to publish writings that included, The Practical Elocutionist and Stammering and Other Impediments of Speech. By 1838, he was regularly being referred to in the London press as "the celebrated Professor of Elocution."* [165]

His father Melville Bell, having a feeble health, went as a young man in 1838 to America to restore his health. Till 1842 he had several jobs, but returned back to London with a growing commitment to the field of speech. By that summer he was teaching speech in London. Over the years Melville designed a speech system called 'Visible Speech'; a method of teaching the deaf to speak, and wrote about his methods. Among those a famous paper on elocution: *The Standard Elocutionist* (1860).

His son Alexander Bell—or Aleck as he was called—received his formal training at the University of Edinburgh and later the University of London, but he was self-learning. He grew up in an environment that would be decisive for his later life: intellectual and occupied with the subject of speech/deafness. Already at an early age he came in contact with mechanical devices that were related to sound, the speaking automata, as his father took him and his brother to exhibitions[166] where a 'talking figure' was shown.

---

[165] Source: http://www.pbs.org/wgbh/amex/telephone/peopleevents/mabell.html (Accessed October 2015).

[166] In England and Scotland of those days, the new inventions of scientific discoveries were publically shown and attracted the public's attention. Charles Wheatstone, for example, presented his 'Enchanted Lyre' to audiences. The Hungarian Thomas von Kempelen presented, next to his chess-playing automaton that was demonstrated across Europe, a speaking machine.

> *The elder Bell was a student of acoustics with a special interest in speech production. Still intrigued by the memory of Faber's device [the talking figure] in 1863, he took his son Alexander, then about sixteen years old, to see the "speaking machine" of British scientist Charles Wheatstone, the one [Joseph] Henry had found inferior to Faber's. After the visit, Melville challenged Alexander and his brother to build such a machine of their own. That year they began work on the project and soon succeeded in having their speaking machine cry, "Mama."* (Millikan, p. 3)

It was therefore quite logical that Aleck Bell experimented with the phenomenon of speech. Soon he became so proficient that he became a part of his father's public demonstrations and astounded audiences with his abilities. He indeed made, together with his brother Edward, an 'automaton' —in this case a mechanical talking head that could produce sounds. It was in 1866 that he became acquainted with Helmholtz's book 'The Sensations of Tone as a Physiological Basis for the Theory of Music'. He read how Helmholtz used electromagnets in combination with tuning forks (the 'Helmholtz Resonator'). It was Aleck Bell's first acquaintance with the new phenomenon of 'electricity', and a new exciting world opened up for him. (Bruce, 1990, pp. 49-51)

Immigration and Early Experimenting

In 1867 Alexander's brother Edward died of tuberculosis (the 'white plague'), soon to be followed by his second brother Melville. As Alexander also had a feeble health, and given Melville's earlier experiences in America, the family decided to leave in 1870 to Newfoundland, Canada. There, they bought a farm in the neighbourhood of Brantford, Ontario. Shortly after Alexander joined his father in instructing deaf people. In addition, he created a workshop on the farm for experimenting with relays and tuning forks (like he had read about in the 'Helmholtz Resonator'). And he came in touch with telegraphy, which was quite a phenomenon in the New England of those days.

His father's fame brought them to visit Boston where they gave lectures and demonstrations on the 'Visible Speech' system.

> *It appears that his father, while lecturing in Boston, had mentioned Graham's exploits with a class of deaf-mutes; and soon afterward the Boston Board of Education wrote to Graham, offering him five hundred dollars if he would come to Boston and introduce his system of teaching in a school for deaf-mutes that had been opened recently. The young man joyfully agreed, and on the first of April, 1871, crossed the line and became for the remainder of his life an American.* (H. N. Casson, 1910, p. 21)

Soon he took up a permanent residency in Boston. His father helped him set up his private practice by contacting Gardiner Greene Hubbard, the president of the Clarke School for the Deaf, for a recommendation. In October 1872 he opened his 'School of Vocal Physiology and Mechanics of Speech' with his first class of thirty students. A year later he became professor of Vocal Physiology at Boston University. In 1861 Boston had also seen the start of the Massachusetts Institute of Technology (MIT). As the main city of New England, which was the cradle of American industry, Boston had plenty of skilled artisans, inventors, electricians, machinists and engineers: the technological elite of the nation (Bruce, 1990).

Experimenting with Piano Wires and Electromagnets

This environment of Boston stimulated him to pick up his experiments again. He lived in the house of the family of one his students, the Sanders family, whose son Georgie he tutored privately for $350 a year. There he had a workshop in the cellar to conduct his tinkering experiments with electromagnets and piano wires.

> *"Often in the middle of the night Bell would wake me up," said Thomas Sanders, the father of Georgie. "His black eyes would be blazing with excitement. Leaving me to go down to the cellar, he would rush wildly to the barn and begin to send me signals along his experimental wires. If I noticed any improvement in his machine, he would be delighted. He would leap and whirl around in one of his `war-dances' and then go contentedly to bed. But if the experiment was a failure, he would go back to his workbench and try some different plan.*" (H. N. Casson, 1910, p. 23)

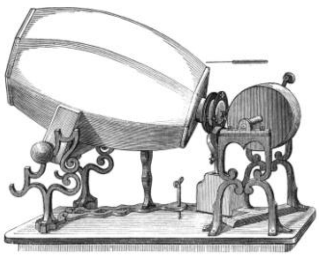
Working during daytime, teaching in the evenings, the nightly hours were devoted to his experiments. This lifestyle soon took its toll, and he decided to quit his deaf institute. He only kept two private students: Georgie Sanders, deaf from birth, and the fifteen-year-old Mabel Hubbard who had lost her hearing at the age of five and was a devoted pupil. Her father, the previously mentioned Gardiner Greene Hubbard, a wealthy lawyer from upper-class Boston ancestry, also decided that he wanted Alexander to continue working with his daughter. Both Sanders and Hubbard would later play an important role in Alexander's life. But Mabel took the main position, as she married him in 1877.

Alexander experimented during the summer of 1874 with 'sounds made by galvanism', tinkering with electromagnets, coils, tuning forks and vibrating reeds. His initial work was influenced by Scot's 'phonautograph', a mechanical recording device that transformed sound into a phonautogram (Figure 69). These first efforts were along the mechanical trajectory.

One of his early ideas was to install a harp at one end of the wire and a speaking-trumpet at the other. His plan was to transmit the vibrations over the wire and have the voice reproduced by the vibrations of the strings of the harp. By attaching a light pencil or marker to a cord or membrane and causing the latter to vibrate by talking against it, he could secure tracings of the sound-vibrations. Different tracings were secured from different sounds. He thus sought to teach the deaf to speak by sight. (Towers, 1917 Chapter XII)

Soon he expanded his work with electromechanical devices like the electromagnet he had seen used in Helmholtz's electromagnetic tuning fork, a sound generating device (Figure 69). Ultimately, Bell thought it might be possible to generate 'undulating electrical currents' that corresponded to sound waves. And he hit on the same phenomenon Charles Page had described in his 'The Production of Galvanic Music': sounds that were made by the coils of an electro-magnet (Page, 1837).

In the autumn of 1874, I discovered that the sounds emitted by an electro-magnet under the influence of a discontinuous current of electricity are not due wholly to sudden changes in the magnetic condition of the iron core (as heretofore supposed), but, that a portion of the effect results from vibrations in the insulated copper-wires composing the coils. An electro-magnet was arranged upon circuit with an instrument for interrupting the current,—the rheotome[167] *being placed in a distant room, so as to avoid interference with the experiment. Upon applying the ear to the magnet, a musical note was clearly perceived, and the sound persisted after the iron core had been removed. It was then much feebler in intensity, but was otherwise unchanged,—the curious crackling noise accompanying the sound being well marked.* (Bell, 1876, p. 2)



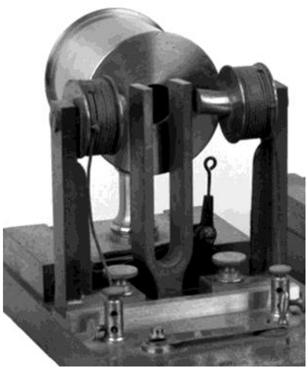


Figure 69: The Phonautograph invented by Scott (1859), and the Helmholtz resonator with the electromagnetic tuning fork.

Source: (top) Wikimedia Commons, (bellow) © Whipple Museum of History of Science, University of Cambridge,. Fair use is claimed.

[167] An instrument that periodically or otherwise interrupts an electric current. For example: with a frequency of 100 times per minute.

It was Hubbard to whom Bell showed his early acoustic experiments in October 1874. He was first met by quite a bit of scepticism, especially when he presented the concept of using multi frequencies to transmit information. He conceptualized the ‘musical telegraph’ that should create the frequency on one side of a line with a tuning fork, receiving it with an electromagnet on the other side. The idea was born, in today’s language, to transmit signals by using AC-currents of different frequencies.

> *Bell was illustrating some of the mysteries of acoustics by the aid of a piano. "Do you know," he said to Hubbard, "that if I sing the note G close to the strings of the piano, that the G-string will answer me?" "Well, what then?" asked Hubbard. "It is a fact of tremendous importance," replied Bell. "It is an evidence that we may someday have a musical telegraph, which will send as many messages simultaneously over one wire as there are notes on that piano." Later, Bell ventured to confide to Hubbard his wild dream of sending speech over an electric wire, but Hubbard laughed him to scorn. "Now you are talking nonsense," he said. "Such a thing never could be more than a scientific toy. You had better throw that idea out of your mind and go ahead with your musical telegraph, which if it is successful will make you a millionaire."* (H. N. Casson, 1910, p. 25)

One has to realize this was in the time when telegraph engineers were eagerly looking for ways to improve upon the efficiency of telegraphy: the hunt was for multiplex-telegraphy in which several messages could be transmitted at the same time. This multiplexing was of economic importance as it could reduce the costly investments in new telegraph lines now that telegraph traffic was booming. Bell very well understood that.

> *The fact that sounds of different pitch can be simultaneously produced upon any part of a telegraphic circuit is of great practical importance; for the duration of a musical note can be made to signify the dot or dash of the Morse alphabet, and thus a number of telegraphic messages may be sent simultaneously over the same wire without confusion by making signals of a definite pitch for each message.* (Bell, 1876, p. 4)

With his experimenting Alexander Bell was touching on the development of the trajectory of the telegraph. A trajectory that occupied many inventors of that time, who sought to transmit more telegraph signals simultaneously over the wired. One of them being Joseph Stearns who developed a duplex (two-message) system.

> *In 1872, Western Union adopted Joseph Stearns's duplex (two-message) system and it was soon clear that fortune and fame awaited the inventor of a four- or eight-message system. After reading a newspaper story about the Steams duplex, Bell became convinced that he could devise a multiple message telegraph using his knowledge of acoustics. In pursuing this invention, Bell was actively encouraged by*

> *his future father-in-law, Gardiner Hubbard.* (Gorman & Carlson, 1990, p. 137)

Bell had the concept for a 'harmonic telegraph' in his mind and he decided to apply tuned reed relays—essentially an electromagnet with a spring-like armature or reed—as they could vibrate at different frequencies to distinguish the separate transmission:

> *By sending each message at a different tone, one could theoretically transmit and receive several simultaneous messages on a single wire. While the principle of sending and receiving one message using an acoustic signal had been demonstrated, no one had succeeded in sending and receiving several simultaneous signals. It was this problem that Bell set out to solve.* (Gorman & Carlson, 1990, p. 138)

The Patent Association Agreement (1875)

Obviously, Hubbard was impressed, as he saw in Alexander's experiments the first glimpses of realizing his ambition of popularizing telegraphy (as we will see further on). Bell, Sanders and Hubbard then created an association based on a *Patent Agreement* on February 27, 1875, in which Sanders and Hubbard would finance Bell's experiments and each of the partners would have one-third of the rights, including future patents.

> *Memorandum of Agreement made and concluded this twenty-seven day of February A.D. 1875 by and between A. Graham Bell of Salem, Massachusetts; Thomas Sanders of Haverill, Massachusetts; Gardiner G. Hubbard of Cambridge, Massachusetts.*
>
> *Whereas the said Bell has invented certain new and useful methods of and apparatus for Telegraphing, for which he has applied for Letters Patent of the U.S. and is about to apply for other patents in the U.S., and has assigned all his rights, title and interest in and to said inventions or improvements to the said Bell, Sanders and Hubbard, parties to this Agreement, and has agreed to assign to said parties all his right, title, and interest in and to any further improvements he may make in perfecting said inventions or improvements. Now therefore the said Sanders and Hubbard do hereby severally agree that they will each contribute one half part of all expenses incurred in taking out the Patents for said inventions or improvements and of any interference or interferences that may be had as well as the necessary expenses that may be incurred in perfecting said inventions. And it is further agreed between the parties hereto, that if said inventions should prove to be of value, that the said parties shall transfer all their rights to a company to be organized for the purpose of more easily managing and controlling said patents.*

The stock that shall be issued for said patents to belong to said several parties, according to their respective interest therein, namely one third each.[168]

The agreement was clear. Bell was to put up ideas and experiments, Sanders and Hubbard would put up the cash. The three men were equal partners to share whatever profits developed from the enterprise, and to provide the necessary capital, manpower and information necessary to sustain the effort. But… their vison of what to focus on was quite different.

At this point in time, the partner's vision of the end product differed. Both Sanders and Hubbard saw the device as a supplement to the existing telegraph system, and urged Bell to concentrate on developing a system of multiple messaging over a single electrical wire. … Bell, on the other hand, was convinced that the device's greatest utility was to be found in being directed toward the spoken rather than the written word. (Ward, 1997, p. 122)

This simple agreement began what eventually became the largest single business enterprise in the history of mankind. It was clear, should the inventions prove valuable, a company was to be organized to control the patents, with each of the partners to get one-third of the stock. (Bruce, 1990, p. 139). Bell's early work reflected the objectives as set by the partners. It resulted in his first patent. On April 6, 1875, he was granted US Patent № 161,739 for 'improvements in transmitters and receivers for electric telegraphs'. The patent was for an invention capable of sending more telegraphic messages simultaneously (Figure 70). Thomas Sanders and Gardiner Hubbard were the assignees[169].

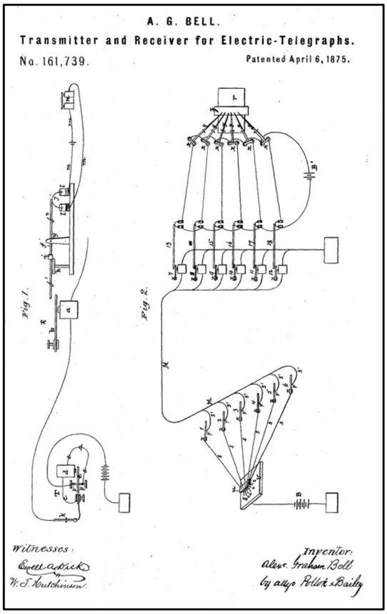


Figure 70: Bell's patent № 161,793 (1877).

Source: USPTO

That financial support changed much for Alexander, who lacked the mechanical and instrumental skills to realize many of his ideas. Now he could afford to hire—for $13.25/week—the experienced electrical and

[168] Source: Library of Congress, A. G. Bell Family Papers. http://memory.loc.gov/ammem/bellhtml/bellhome.html

[169] The assignee is the entity that is the recipient of a transfer of a patent application, patent, trademark application or trademark registration from its owner on record (assignor).

mechanical designer Thomas A. Watson (then eighteen years old), already working at the workshop of Charles Williams Jr[170]. In that workshop, men were working the metal lathes, producing parts for telegraphic products or creating prototypes that inventors —like the electrician Moses Farmer— asked them to make on specification. And Watson was the one who would make those prototypes.

Soon they simulated in their own laboratory—now in the attic of the Boston shop of Charles Williams Jr (Figure 71), as Bell had moved there from his cellar at the Sanders residence—a telegraph line and started working on Bell's ideas for an acoustic telegraph. As the telegraph is a binary system and the acoustic telegraph an analogue system, they needed a converter that could modify the (mechanical) sound vibrations into an electric signal and vice versa (today called the microphone and loudspeaker). The problem was clear, but the solution to that problem was not that clear at all.

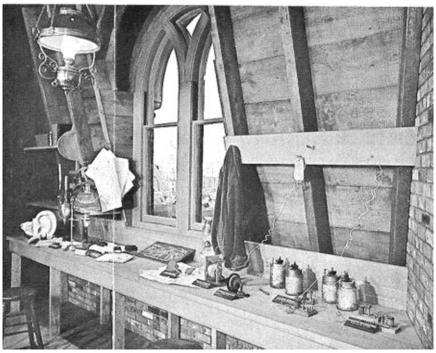


Figure 71: Bell's workshop in the Attic of Charles Williams' workshop in Boston.

Source: Reconstruction on the Exhibition at the headquarters of the New England Telephone.

From Conception to Demonstration

From 1872 on, Bell conducted his experiments, applying his knowledge of 'Visible Speech' and two specific machines, the previously mentioned *phonautograph*[171] and the *manometric* capsule[172], by means of which the vibrations of sound were made plainly visible. Then, in the summer of 1874, an idea from a totally unrelated field of knowledge popped up.

[170] Thomas Edison also set up shop in the same building as the Williams shop to best avail him of its services. (Shulman, 2008, p. 58)

[171] This device could record sound. It was designed by the Frenchman Édouard-Léon Scott de Martinville, and patented on March 25, 1857. His phonautograph was constructed as an analog of the ear canal, eardrum and ossicles.

[172] A device for studying air vibrations in a pipe or resonator, consisting of a rubber membrane which is stretched over a hole in the pipe, or over the end of a flange attached to such a hole, and apparatus for measuring vibrations of the membrane. The German physicist Rudolf Koenig (1832-1901) and the Hungarian physiologist Adam Politzer (1835-1920) experimented with this kind of apparatus while studying the workings of the human inner ear. They presented their findings in 1861 at the Académie des Sciences in Paris.

> *He mentioned these experiments to a Boston friend, Dr. Clarence J. Blake, and he, being a surgeon and an aurist, naturally said, "Why don't you use a REAL EAR?" Such an idea never had, and probably never could have, occurred to Bell; but he accepted it with eagerness. Dr. Blake cut an ear from a dead man's head, together with the ear-drum and the associated bones. Bell took this fragment of a skull and arranged it so that a straw touched the ear-drum at one end and a piece of moving smoked glass at the other. Thus, when Bell spoke loudly into the ear, the vibrations of the drum made tiny markings upon the glass.* (H. N. Casson, 1910, p. 26)

The Conception of the Membrane Telephone

Soon Bell studied and experimented with the human ear (Figure 72). From this experience, he concluded that a membrane (like the ear-drum) could be used to convert vibrations mechanically. It would be a decisive moment in the development of his telephone, as Bell reflected later: 'The conception of the telephone took place during that summer visit to my father's residence at Brantford, in the summer of 1874 and the apparatus was just it was subsequently made, a one-membrane telephone on either end' (Joel & Schindler, 1975, p. 5).

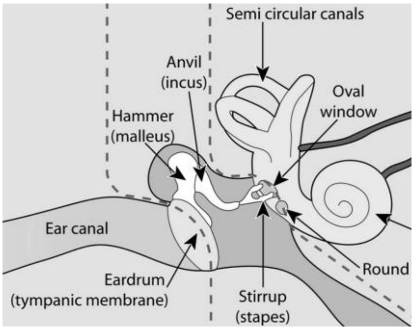


Figure 72: Diagram of part of human ear.

In the middle is shown the diaphragm of the eardrum and the 'bones' (hammer and anvil).

Source: Wikimedia Commons

> *Bell noticed how small and thin was the ear-drum, and yet how effectively it could send rills and vibrations through heavy bones. "If this tiny disc can vibrate a bone," he ought, "then an iron disc might vibrate an iron rod, or at least, an iron wire." In a flash the conception of a membrane telephone was pictured in his mind. He saw in imagination two iron discs, or ear-drums, far apart and connected by an electrified wire, catching the vibrations of sound at one end, and reproducing them that the other. At last he was on the right path, and had a theoretical knowledge of what a speaking telephone ought to be. What remained to be done was to construct such a machine and find out how the electric current could best be brought into harness.* (H. N. Casson, 1910, p. 27)

Thus, Bell started, in July 1874, to use a membrane to convert acoustic, mechanic vibrations into 'undulating' electrical signals[173].

[173] Bell distinguished different electrical currents: *'Intermittent currents are characterized by the alternate presence and absence of electricity upon the circuit; Pulsatory currents result from sudden or*

> *Bell now arrived at the basic mental model of how sound could be converted into a fluctuating current, combining a diaphragm like the one on the phonautograph with a reed relay like the one on the harp apparatus. But he thought that the reeds would not induce sufficient current to transmit tones loud enough to be detected. Consequently, Bell and his assistant, Thomas Watson, tried through the winter and spring of 1875 to construct a multiple telegraph using separate reed relays.* (Gorman & Carlson, 1990, p. 140)

The 'idea' was conceived, but it would take quite some time before he managed to create a functional apparatus. Thus, this summer was the moment in time that saw the conception of the membrane telephone. By November 1874, Bell had completely conceptualized the diaphragm transmitter and receiver, and the concept of 'electric speech' was born. (Bruce, 1990, pp. 122-124)

> *Combining the mechanical representations of the reed relay and the diaphragm, Bell's induction telephone of June 1875 confirmed his mental model of the possibility of transmitting sound waves using a fluctuating Current.* (Gorman & Carlson, 1990, p. 140)

In the meantime, Sanders and Hubbard had put pressure on Bell. They wanted him to forget about his experiments with ears and focus on harmonic telegraphy to create a multiplex system. There was a reason for their insistence, as getting more capacity on telegraph lines was the hot topic in telegraphy business at that time.

> *Sanders and Hubbard, who had been paying the cost of his experiments, abruptly announced that they would pay no more unless he confined his attention to the musical telegraph, and stopped wasting his time on ear-toys that never could be of any financial value. What these two men asked could scarcely be denied, as one of them was his best-paying patron and the other was the father of the girl whom he hoped to marry. "If you wish my daughter," said Hubbard, "you must abandon your foolish telephone." Bell's "School of Vocal Physiology," too, from which he had hoped so much, had come to an inglorious end. He had been too much absorbed in his experiments to sustain it. His professorship had been given up, and he had no pupils except Georgie Sanders and Mabel Hubbard. He was poor, much poorer than his associates knew.* (H. N. Casson, 1910, p. 28)

In March 1875, on a visit to his patent lawyer in Washington, the quite poor Bell turned for advice to Professor Joseph Henry, who at that time was secretary of the Smithsonian Institute and was known as the expert in the field of electricity. Henry was the man who had been one of the

---

instantaneous changes in the intensity of a continuous current; and undulatory currents are produced by gradual changes in the intensity of a current analogous to the changes in the density of air occasioned by simple pendulous vibrations.' (Bell, 1876, p. 9) founding fathers of the electromechanical relay, the device that fuelled the development of Morse's electromechanical telegraphy[174]. When the young man and the old man met, there was half a century between them[175].

> *For an entire afternoon the men worked together over the apparatus that Bell had brought from Boston, just as Henry had worked over the telegraph before Bell was born. … "You are in possession of the germ of a great invention," said Henry, "and I advise you to work at 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.* (H. N. Casson, 1910, pp. 29-30)

These words were the encouragement Bell needed, as he wrote to his parents: 'I cannot tell you how much these two words have encouraged me,' he told his parents. 'I live too much in an atmosphere of discouragement for scientific pursuits. …Such a chimerical idea as telegraphing vocal sounds would indeed to most minds seem scarcely feasible enough to spend time in working over. I believe, however, that it is feasible, and that I have got the cue [sic] to the solution of the problem' (Millikan, p. 4). To Henry, he wrote: 'You were kind enough to express an interest in the experiments to which I directed your attention in Washington, and I trust that I do not take too great a liberty in addressing you again upon the same subject. I have recently been led to the belief that an intermittent current of electricity creates a molecular vibration in the conductor through which it is passed; - and that this is the cause of the noise we heard proceeding from the empty helix of wire…'[176]

This encouragement was what Bell needed. He started to acquire the knowledge—and the other help he need—to work out his idea, an idea that would be patented, less than a year later, as an addition (Figure 7) to US Patent № 174,465 on March 7, 1876. This patent looked as if it was about harmonic telegraphy (Figures 1 through 6) using electromagnetic effects: 'When, therefore a permanent magnet is caused to vibrate in front of the pole of an electromagnet, an undulatory current of electricity is induced in the coil of the electromagnet…' However, it would take a year until he could speak those famous words: 'Watson come here.' But before that was to happen, he needed more help from others.

---

[174] See for details: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015) pp. 338-374.
[175] Bell was born in 1847, and Henry was born in 1797.
[176] Source: The Alexander Graham Bell Family Papers. Library of Congress. http://memory.loc.gov/cgi-bin/ampage?collId=magbell&fileName=005/00500110/bellpage.db&recNum=0. (Assessed October 2015)

Hubbard's Fight against the Telegraph Monopoly

It was clear that Alexander was a driven researcher, working in the stimulating environment of New Jersey. Telegraphy on the East Coast of America was at that time a booming business, and telegraph lines and telegraph offices had been popping up everywhere. Many people were involved, from inventors to entrepreneurs. Not only were entrepreneurs setting up companies to provide telegraphic services, but many technical workshops were starting to manufacture the telegraphic equipment that was needed. Telegraphy was hot, and among the many inventors improving the telegraph, quite a few tried to create a system with more efficiency, better quality and faster transmission[177].

From this Telegraph Bonanza of the service providers, through a range of mergers and acquisitions, a giant company had emerged that was known as *Western Union Telegraph Company* (Figure 73). The lawyer and politician Gardiner Green Hubbard was a declared opponent of the mighty Western Union Telegraph Company that had created, in cooperation with the *Associated Press* news agency, quite a monopolistic position that served mainly the interests of both companies. Evidently, they opposedany change that could threaten that monopoly.

> *[Hubbard] had made extensive and parallel studies of the government-controlled mail system and the commercially owned telegraph industry. As a result of these investigations, he came to a basic conclusion: telegraph were not always readily accessible to the general public and, even more significantly, their rates were much too high for the average citizen. In addition, those rates displayed geographic discrepancies that defied logic... Based on his analysis of that study he proposed what he considered a most logical consolidation.* (Evenson, 2000, p. 20)

His proposal, *The proposed Changes in the Telegraph System* (Hubbard, 1873), made on request of the Postmaster General, did not meet with much newspaper coverage, as it was obviously against the interest of Western Union and the Associated Press. However, his work became well known after he found others ways to publish about it.

> *In a widely read article in the Atlantic Monthly on the subject, Hubbard wrote that the population of Britain spent some $5 million to send roughly 18 million telegrams. In the United States customers spend close to twice as much to send just 13 million telegrams. The size of the country, Hubbard believed, could not fully account for the difference.* (Shulman, 2008, p. 86)

[177] See for details: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015) pp. 395-397.

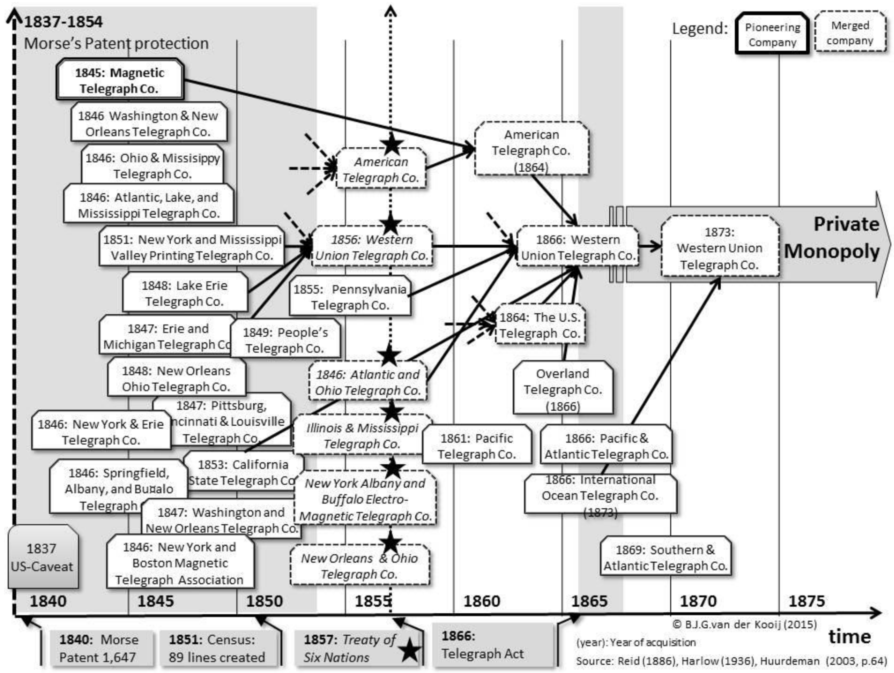


Figure 73: The mergers and acquisitions in the US telegraph industry that resulted in the Western Union Monopoly.

Source: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015) p.434

Hubbard did not call for the US Post Office to actually take actually over the telegraph industry, as was under consideration in Britain. He proposed that the government should finance the creation of a new, privately owned (for example by Hubbard and consorts), United States Postal Telegraph Company. That company would build a network in service of the government.

The politically experienced and well connected William Orton, president of Western Union, opposed this proposal by all means. Western Union was even bribing members of Congress by supplying them with a card entitling them to free use of telegraph services, in addition to free railway passes[178]. He also started a lobbying campaign. However, Hubbard's view was quite well accepted in political circles, as the political climate certainly was against the Western Union monopoly.

178 Nowadays giving presents to members of Parliament is considered a 'deadly' offence in politics. At least in the Netherlands, where even the gift of a bottle of wine has to be reported publically.

> *In 1866 two different proposals for regulating the telegraph industry were presented to Congress. Senator B. Gartz Brown, a Republican from Missouri, felt that the solution for Western Union's hegemony was direct intervention, by the Federal government, in the telegraph industry. Brown proposed that the government should build, and operate, a telegraph system in direct competition with Western Union. At the same time that Brown introduced his bill, Senator John Sherman, a Republican from Ohio and later father of the Sherman Anti-trust Law, filed a bill that sought to use Federal funds to underwrite the construction and operation of a private telegraph company that would compete against Western Union. Both Brown and Sherman recognized that the telegraph had become a national institution, and that the use of existing regulations by State courts and State laws was no longer effective. …The passage of the Sherman bill put Western Union on notice that the Federal government was going to become a major influence over their industry.* (Ward, 1997, pp. 116, 119)

Orton's tactics worked; none of the many initiatives put up for vote in the Congress succeeded in getting a majority. The effort to create an alternative telegraph system had failed. Western Union had won the war to keep communications in the private sector, and—at least for the time being—unchallenged by the Federal government. (Ward, 1997, p. 121)

It was quite an exciting situation. On one hand, there was the monopoly. On the other hand, there was Hubbard, and many others among those in political power, wanting to reform the telegraph industry. That is, they wanted to curb the power of the monopoly. Along with other bills introduced in Congress around this time—such as the Brown Bill and the Sherman Bill[179]—Hubbard's proposal resulted in the Farnsworth Bill, nicknamed the 'Hubbard Bill'.

> *The instigator of the Farnsworth bill, and the chief corporate sponsor of the United States Postal Telegraph Company, was Gardiner G. Hubbard of Boston, …sought to create a national telegraph system by taking the remaining small regional telegraph companies still in existence, and linking them into a national system. Under Hubbard's plan, the United States government, in essence, would capitalize the existing systems at a higher value than their current assets, and then guarantee them a ten percent annual return, on the higher value, for a period of ten years. Hubbard's plan was, in fact, the same type of stock*

[179] Senator B Gartz Brown, a Republican from Missouri, felt that the solution for Western Union's hegemony was direct intervention, by the Federal government, in the telegraph industry. Brown proposed that the government should build, and operate, a telegraph system in direct competition with Western Union. Senator John Sherman, a Republican from Ohio and later father of the Sherman Antitrust Act, filed a bill that sought to use Federal funds to underwrite the construction and operation of a private telegraph company that would compete against Western Union.

"watering" scheme that Western Union had been accused of by Sherman and Brown, but this time done with the use of Federal funds rather than the private investment market. (Ward, 1997, pp. 120-121)

As a result of lobbying and political and procedural parliamentary manoeuvring, the bill disappeared from the agenda in 1869. By in 1873 Hubbard's last efforts had failed.

Hubbard, on the other hand, was not as willing to give up the fight. Recognizing that the House Committee was against him, he sought to have the bill introduced by the Senate Postal Committee. For the next three years, Hubbard haunted the halls of the Senate, and the Senate Postal Committee, seeking a favorable recommendation. But his efforts were to no avail Finally, in 1873, two years after the expiration of the Sherman bill, Hubbard returned to Boston to seek new endeavors in investment . …

In addition to stopping the nationalization challenge, Western Union emerged from the struggle as the undisputed champion of the free market in the United States. Its financial power reached not only into the banking and capital markets of the country, but also into the highest levels of political authority in the nation. For all practical purposes, Western Union had become a law unto itself, and a formidable foe to anyone seeking to challenge it in either the private or public arena. (Ward, 1997)

That was all the activity going on in the political arena. In the meantime, Western Union had also something else on their mind. Being a—public owned—company, profit was important. That meant reducing costs and limiting investments was always a management issue. Therefore, they focused on technically improving telegraph systems so that they would function more economically. And they were willing to pay good money for those inventors who could help them out. That being the case, the search for improving *harmonic telegraphy* was high on the agenda of many researchers, such as Elisha Gray, Thomas Edison, van Rysselberghe, Mercadier and La Cour.

However, in the mid-1870s, the unfulfilled hope of harmonic telegraphy was too alluring to dampen enthusiasm. Nobody knew then that this was a theory ahead of its time. They were all searching for the telegraphic equivalent of the philosopher's stone, that elusive element that would transform Morse's single message instrument into a true multi-message machine. (Evenson, 2000, p. 38)

In the middle of this, Alexander Bell was more than eager to enter the stage. He had his ideas about how to create a 'harmonic telegraph system that could send up to ten times as many messages over the same wire as any commercial telegraph system then limited to four messages at a time'

(Evenson, 2000, p. 24). This was a way to improve upon the capacity of the telegraph system, making lower pricing possible and benefiting the general public. That was Hubbard's objective during all his political involvements. Therefore, it is obvious that Hubbard had reason to urge Bell to put his inventive efforts into the harmonic telegraph.

The Dawn of Bell's Telephone (1874-1877)

One has to realize that Alexander Graham Bell was a professor of speech: he understood the basics of vocal sounds, and he had experience in speech therapy. Speech and sound had become the focus of his life. He was not a professional inventor with a mechanical or electric education, nor did he have a mechanical background. His forte was not his understanding of electricity or mechanics. His strength was to apply his limited technical understanding to work on vocal applications that he very well understood. And he was obviously a dedicated man.

The Transmission of Sound

After Bell had returned from his discussion with Joseph Henry in March 1874, he tried to follow both his own ideas about electric speech and Hubbard's wish to work on harmonic telegraphy. That approach changed on June 2, 1875, when, together with Watson Bell, he worked on his concept of the membrane device and its vibrating properties. They experimented with the thin metal reeds close to the electromagnet in a testing situation with different devices in different rooms, connected by a cable.

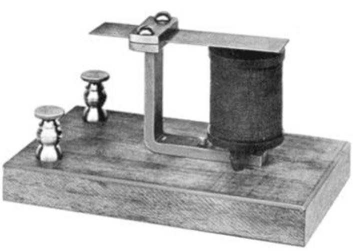


Figure 74: Replica of Bell's Harmonic Telegraph receiver (1875).

Source: http://www.sciencemuseum.org.uk/

The essence of his harmonic telegraph was that several messages could be sent using different frequencies created by the reeds on the transmitter[180]. At the other end of the transmission line, the receiver would have to distinguish these frequencies and separate the messages from each other using reeds again (Figure 74). Therefore, the transmitting reed and the receiving reed needed to be 'in tune'. Tuning the receiver to the same frequency as the reed from the transmitter was a delicate job.

[180] In the mechanical world, the tuning fork is a device that vibrates and creates a sound of a specific frequency. In the electrical world, the equivalent is an electric oscillator set on a specific frequency.

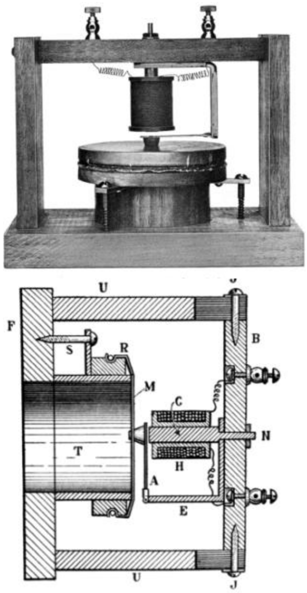


Figure 75: Gallows model (top) and principle (bottom) of Bell's telephone (1875).

Key: T--speaking tube; M--parchment C--core diaphragm relay; A--reed armature of magnet; H--magnet coil. Note how this device consisted of two basic Bell mechanical representations: the diaphragm and the reed relay.

Source: http://www.antiquetelephonehistory.com/ (top); Gorman, M.E., Carlson, W.B.; *Interpretating Invention as a cognitive process*... p.142

Bell had set up three transmitters, each set to a different frequency, and six reed receivers, all connected to the same line. Three of the receivers were in Watson's room, and the other three were near Bell. He had been going on this routine when, for some reason, he failed to get the expected response on one of Watson's receivers. Suspecting a stuck reed on the corresponding receiver, a fairly common problem, he asked Watson to check and if necessary, to free the reed. … To mitigate this possibility [the reed getting latched to the core by residual magnetism], Bell turned off the electricity while Watson investigated. Suddenly, Bell noticed the reed of another receiver to vibrate for no apparent reason. He dashed into the room where Watson was checking the faulty receiver and asked him what he had done – and whatever it was, to do it again. Watson replied he had simply done what he always did: plucked the reed of the stuck receiver to free it up and set it into vibrating again. …

For the next hour or so, Bell and Watson plucked the reeds of the various electromagnets and listened to the induced sounds in the other reed recovers. Bell contemplated what he was witnessing. There was, he correctly theorized, enough residual magnetism in the iron cores of the receivers/transmitter that a vibrating reed in one could generate an alternating current sufficiently strong to vibrate the reed in another receiver/transmitter. To Bell, this was a most significant and surprising discovery - it completely dispelled a previous assumption he had made. (Evenson, 2000, p. 52)

Then Bell continued his experiments and pressed one of the reeds to his ear just enough to dampen the reed's natural frequency.

> *To his amazement, he could hear, ever so faintly, the different pitches of the other receivers as Watson plucked each one in turn. The reed receiver, as he held it against his ear, acted as a crude earphone. When he made the magnetic field stronger by passing a battery current through the receiving electromagnet, the sound became noticeably louder.* (Evenson, 2000, p. 57)

Bell and Watson discovered on June 2, 1875, that movements of the reed alone in a magnetic field could reproduce the frequencies and timbre of spoken sound waves. Then Bell reasoned by analogy to the mechanical *Phonautograph* that a skin diaphragm would reproduce sounds like the human ear when connected to an iron reed or hinged armature. Therefore, he asked Watson to prepare a new device from a crude drawing he made: the *gallows model telephone* as it was later called (Figure 75). With that device, they started a more sophisticated experiment. Bell connected the gallows model to several cells of a battery and to the previous reed relay. While Watson listened on the reed receiver, Bell shouted into the diaphragm of the instrument. Watson claimed that he could hear 'vocal sounds' coming from the reed receiver, but he could not make out what Bell was saying. They switched places, and Watson shouted while Bell listened. Again, no speech was heard. Disappointed, Bell called the experiment a failure.

With newly built devices, they experimented again, but they failed to hear transmitting speech, although Watson maintained he could detect, ever so faintly, some kind of transmitted sound made by the human voice. It was clear there was some more experimenting to do. And so they did.

> *This first telephone was essentially a reed relay connected to a parchment diaphragm. As one shouted into the diaphragm, it vibrated the relay's reed armature. As this reed moved through the magnetic field of the relay's coil, it induced a fluctuating electric current in the coil. This current could then be transmitted by wire to a receiving relay, which vibrated and reproduced the original sounds. Because this and other telephones were based on the phenomenon of electromagnetic induction, they were called induction telephones.* (Gorman & Carlson, 1990, p. 141)

In January of 1876 the patent application was written, claiming that he had invented a means for electrically transmitting speech, although no working model could be presented[181]. In the meantime Bell and Watson started to follow another development trajectory using the principle of the variable resistance.

At the Centennial Exhibition in May-November 1876, a first prototype of the new designs for the transmitter was shown. It applied a piece of iron connected to the membrane. That piece of iron moved within a coil, creating a small, undulating current. It was in fact based on the principle of the dynamo, where a coil moving in a magnetic field creates an alternating current. This model became known as the Centennial Model (Figure 76)

---

[181] Bell, as a British subject, could not use the caveat procedure. He had to apply for a patent. The Patent Law did not require a working model, but the Patent Office was permitted them by regulation, which the Office did.

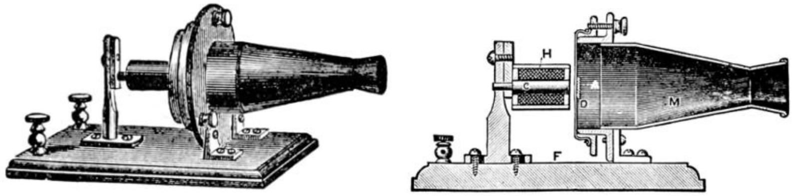


Figure 76: Model and cross section (right) of the Centennial membrane transmitter (1875).

Source: Wikimedia Commons

that created, as we will see later on, the unexpected excitement and the early recognition for telephony at the Exhibition.

Bell's First Telephone Patent

Due to Hubbard's pressure for the harmonic telegraph, and Hubbard's experience as a lawyer in patent cases, it was decided to apply for a patent. Not much later, on his twenty-ninth birthday, March 3, 1876, Alexander Bell received US patent № 174,465, dated March 7, 1876[182], the *First Telephone Patent* as it was going to be called later on.

It was a patent that had a special paragraph added to it:

> *After drawing up the specifications for his latest application, almost as an afterthought, Bell added an illustration roughly depicting his earlier device, the gallows telephone from the previous summer … He also added a brief paragraph describing the instrument in the illustration. Just what connection [that specific text] had to the rest of the patent application, which was for the harmonic telegraph, has forever remained a mystery.* (Evenson, 2000, p. 59)

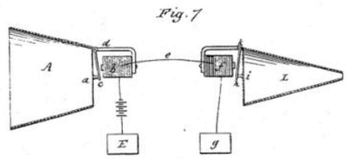
This addition was the description of Figure 7 of the US patent № 174,465 (top, Figure 77). He described it (in the language used in patents) as:

> *One of the ways in which the armature c, Fig. 5, may be set in vibration has been stated above to be by wind; another mode is shown in Fig. 7, whereby motion can be imparted to the armature by the human voice or by means of a musical instrument. The armature c, Fig. 7, is fastened loosely by one extremity to the uncovered leg d of the electro magnet b, and its other extremity is attached to the center of a stretched membrane, a. A cone, A, is used to converge Sound-vibrations upon the membrane. When a sound is uttered in the cone the membrane 4 is set in vibration, the armature c is forced to partake of the motion,*

[182] The official publication date for the patent was March 7, 1876, conforming to standard practice that dates the patents on the Thursday following the week they are granted.

and thus electrical undulations are created upon the circuit the b the f g. These undulations are similar in form to the air vibrations caused by the sound—that is, they are represented graphically by similar curves. The undulatory current passing through the electro-magnet f influences its armature h to copy the motion of the armature c. A similar sound to that uttered into A is then heard to proceed from L.[183] (text of patent, p.3)

This would be the basis for the last of his five claims made in the patent. The first four claims were related to harmonious telegraphy. In the fifth, he claimed the invention of the telephone: '[I claim] the method of; and apparatus for, transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sound, substantially as set for' (text of patent, p.4). When the patent was granted, his method and/or apparatus had become protected under the patent laws of that time. That protection was for a period of 17 years. The patent gave him a right he would have to defend, though, as it was quite a broad patent by its description.



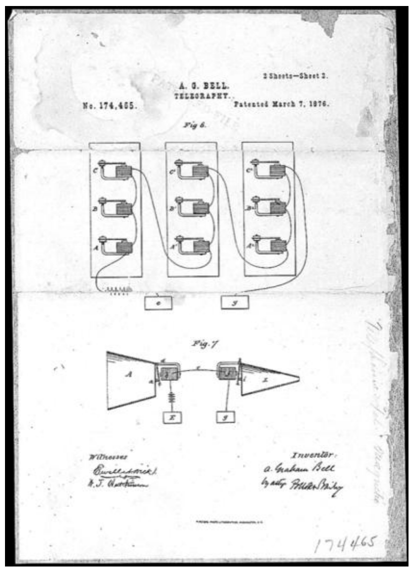


Figure 77: The famous Figure 7 of Bell's First Telephone Patent № 174.465 (1876).

Shown is Figure 7 (top) and the whole page of the patent (bottom).

Source: USPTO

On his twenty-ninth birthday, Bell received his patent, No. 174,465—"the most valuable single patent ever issued" in any country. He had created something so entirely new that there was no name for it in any of the world's languages. In describing it to the officials of the Patent Office, he was obliged to call it "an improvement in

[183] Source: Improvement in Telegraphy. US patent 174,465 filed February 14, 1876, issued March 7, 1876. United States Patent and Trademark Office (USPTO).

telegraphy," when, in truth, it was nothing of the kind. It was as different from the telegraph as the eloquence of a great orator is from the sign-language of a deaf-mute. (H. N. Casson, 1910, p. 34)

This patent would later prove to be fundamental, but at time it was just the result of a lot of effort. After his unsuccessful attempts in 1875, Bell went back again to work on the harmonic telegraph. Hubbard was consistently putting pressure on him to do serious work on the harmonic telegraph. They did not see any economic gain in sending vocal sounds over a wire, as they needed a harmonic telegraph system that would send simultaneous multiple telegraph messages over a line.

In January 1876, after additional testing and experimenting, Bell was ready again to file a patent application for it. Due to a specific reason we will discuss later, he told his lawyer to wait before deposing his application. But he had included that specific paragraph, and Figure 7, without much proof that it actually worked. It was clear that additional work was needed.

But in the days around 7 or 8 March [1876] Bell started to investigate the concept of a wire vibrating in water. … To verify the concept, Bell hastily connected a tuning fork, a battery and one of the reed receivers he had been using in his experiments with the harmonic telegraph. These elements were connected in serial fashion to a bowl of slightly acid water. Bell held the reed receiver, which acted as a crude earphone, against his ear and then stuck the tuning fork.

… to his surprise and delight he could hear clearly but faintly the sound of the tuning fork coming from the reed receiver. He had converted the audible sound of the tuning fork into an electrical current – an undulating current – and then converted it back into an audible sound at the reed relay. (Evenson, 2000, pp. 97-98)

After some more experimenting, Watson constructed a diagram type of device with which the sounds could be used to vibrate a platinum wire in a conductive acid liquid; this became known as the liquid transmitter (Figure 78, Figure 80). He had created a microphone based on the principle of variable resistance. In hindsight, knowing what we know today of electricity, this was a remarkably simple principle that needs some explaining.

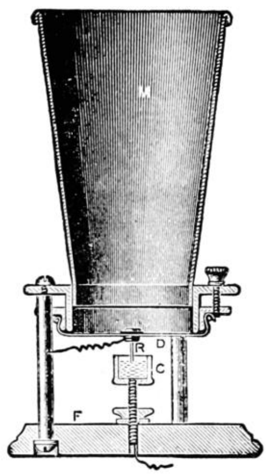


Figure 78: Principle of the liquid transmitter (1876).

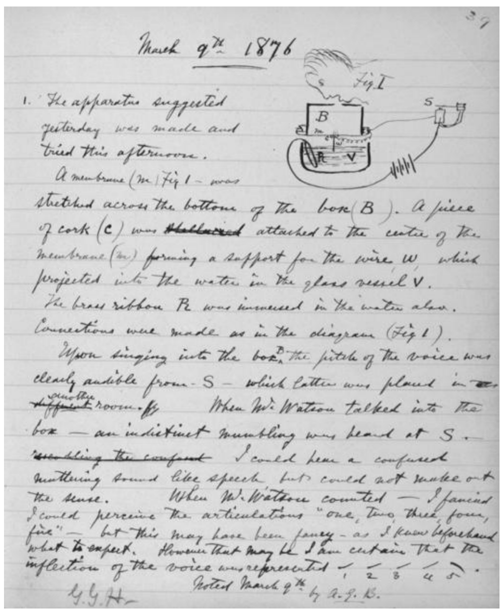
Source: (Land, 1907)

Figure 80: Model of the liquid transmitter (1876).

Source: www.sparkmuseum.com

The technical principle of variable resistance: As shown in Figure 78 sound waves/vibrations move the diaphragm (D) and the needle (R) connected to it. By emerging the needle deeper into the acid liquid in the cup (C), the resistance of the construct changes. This changing of the resistance creates the undulatory current in the electric circuit, causing a receiving electromagnet to move a vibrating reed. That reed movement should then be the replica of the sound vibrations that move the diaphragm.

In his notebook, Bell described the principle on March 9, 1876 (Figure 79). Then they did the initial tests on March 10, 1876, that resulted in the transmission of speech clearly. He wrote his parents: 'I was in one room at the Transmitting Instrument and Mr. Watson at the Receiving Instrument in another room, out of ear-shot. I called out into the Transmitting Instrument, "Mr. Watson—come here—I want to see you." And he came! He said he had heard every word perfectly distinctly come from the electro-magnet at the other end. … is was a great day for me' (Evenson, 2000, pp. 98-99).



39

March 9th 1876

1. The apparatus suggested yesterday was made and tried this afternoon.
A membrane (m) Fig 1 – was stretched across the bottom of the box (B). A piece of cork (C) was ~~[illegible]~~ attached to the center of the membrane (m) forming a support for the wire W, which projected into the water in the glass vessel V.
The brass ribbon R was immersed in the water also.
Connections were made as in the diagram (Fig 1).
Upon singing into the box B the pitch of the voice was clearly audible from – S – which latter was placed in ~~a~~ ~~different~~ another room. When Mr Watson talked into the box – an indistinct mumbling was heard at S. ~~mumbling the confused~~ I could hear a confused muttering sound like speech but could not make out the sense. When Mr Watson counted – I fancied I could perceive the articulations "one, two, three, four, five" – but this may have been fancy – as I knew beforehand what to expect. However that may be I am certain that the inflection of the voice was represented 1 2 3 4 5.

Noted March 9th by A. G. B.

G. G. H.

Figure 79: Sketch from Bell's notebook describing the principle of the liquid transmitter (1876).

Source: https://www.loc.gov/collection/alexander-graham-bell-papers

> *It was a great day for Bell. For the first time he had actually heard speech transmitted electrically over a wire. His use of the expression 'articulate speech' [in the patent application] is significant since it clearly demonstrates he makes a distinction between that and the vocal sound mentioned in his patent [of March 7, 1876].* (Evenson, 2000, p. 99)

Surprisingly enough, the actual fact that he had now a device that could transmit articulate speech over an electric line was not published widely. Later it would be called the Eureka-moment of Bell and Watson (Shulman, 2008, p. 13). Bell certainly realized the potential his invention could have:

> *I feel I have at last found the solution of a great problem and the day is coming soon when telegraph wires will be laid on to houses just like water and gas is, and friends will converse with each other without leaving homes.* (Shulman, 2008, p. 15)

He now had the transmitter that he claimed in his patent, but as the liquid transmitter was not practical, he soon went back to using electromagnetic induction. (Gorman & Carlson, 1990, p. 144)

The Telephone Patent Conspiracy

In the late 1860s and early 1870s, the telegraph industry was booming. Telegraphy had become an essential facility for private, governmental and business communication and meant serious business. Many people were involved, among those the thinking and tinkering inventors of that time. Like Alexander Graham Bell pursuing both the *harmonic telegraph* and his pet the *acoustic telegraph*. Bell was not the only inventor, as others—such as the independent inventors like Thomas Edison—were also working on the same line of ideas. Quite well realizing 'where the money was', they were following the trajectory of incremental innovations as they solved the major technical problems of the telegraph technology at that time. One of those problems was the bridging of long transmission distances (ie the *induction problem*). Another problem was the *coding/decoding problem* at the receiving end of the telegraph line where skilled operators were needed to decode the 'dots and dashes'. The biggest problem of all was the *capacity problem* of the *single-line single-message system*.

Over time, as popularity grew, telegraph cables choked the cities. Logically, inventors focused on the development of the *single-line multi-message system*. First came a system enabling two messages at the same time, the *Duplex-system*. This was soon followed by a system capable of handling four messages at the same time (ie the *Quadruple-system*). And finally came the *Octoplex-system* that could handle eight messages at the same time.

And then, in February 1876, the paths of these two inventors, Alexander Graham Bell and Elisha Gray, crossed each other. Two different men with different backgrounds were brought together on the same battlefield of harmonic telegraphy. Gray could be called a 'telegraph man', as he well knew and understood the electro-mechanical technology. He had solved the 'decoding problem' with his inventions related to the printing telegraph. This had created a close relationship between Western Union and Gray. He was a professional inventor who more or less accidentally had touched on the *speaking telegraph*. Bell was a 'speech man'. From his ancestral background in elocution, and his early professional life at his deaf institute, he had been occupied with 'speech'. The knowhow of electrical concepts and the related fine mechanic skills were alien to him. He was more of an amateur inventor, although obsessed and driven by his desire to create something related to speech: the *speaking telegraph*.

Monday, February 14, 1876[184]

It was on February 14, 1876, that two people visited the offices of the US Patent Office in New York. One of them was the lawyer of Alexander Graham Bell, the other the lawyer of Elisha Gray.

Gray had been in Washington since January 1876. He was working on his telegraphic devices to be shown at the *Centennial Exhibition*[185] that was to be held from May to November in Philadelphia. He had met with his lawyer William Baldwin and was planning to meet his financial backer Samuel S White in Philadelphia. Before that he wanted to file a patent caveat on the 'speaking telegraph'. So in the next couple of days the text and drawings for the caveat were prepared by Elisha Gray himself, his assistant William Goodbridge and the draftsman William Skinkle employed by Baldwin's law office. The work was completed on Saturday, February 12, 1876. However, it was too late to be sent to the Patent Office.

Bell had been working for months to perfect his design for the harmonic telegraph. He had worked on the speaking telegraph only on the side, due to Hubbard's pressure for serious work. He was preparing several other patent applications, among those the one that would become the 'Second Telephone Patent'. When he had prepared for the first patent application, he had included a drawing related to the transmission of vocal sounds (the famous Figure 7). He then had asked his patent lawyers Pollok & Baley to finalize it. After signing it on January 20, 1877, he asked the

[184] This section is largely based on the detailed analysis made by Edward Evenson in his book the *Telephone Patent Conspiracy of 1876* (Evenson, 2000). Due to its detailed nature we have condensed his observations and conclusions.

[185] This was one hundred years after the signing of the Declaration of Independence that marked the demarcation of the thirteen American States from the British Empire.

lawyer to wait in filing it at the Patent Office. This was due to the fact that he was also applying for a patent in Britain[186].

Somehow, the information that Gray was preparing for filing a caveat had reached the office of Bell's lawyer Anthony Pollok. Also, Hubbard, when hearing that Gray, a man he admired, was going to file a caveat for the transmission of vocal sounds was surprised. He realized that Bell's work on telephony was maybe not so frivolous after all. Together, Hubbard and Pollok evaluated the possible consequences. As they considered possible ways of action, it was clear to them that filing the patent application was crucial. Due to the nature of the British Patent Act of 1836, and as both Bell and Gray were going to claim the transmission of 'vocal sounds', it was imperative that Bell file his application *before* Gray filed his caveat. Even if it physically did not arrive before Gray's application, it had to appear to have arrived first. And the way to realize that was the registration in the log book called the 'cash blotter' (Evenson, 2000, p. 68).

On Monday Bell's application was delivered to the Patent Office. It arrived there *after* Gray's application for the caveat had been brought in.

> *Ordinarily, Bell's hand-delivered application would simply have been tossed into the in-basket, as Grey's had been, where it would remain until later in the day. At that time, the contents of the basket would be removed and sent to the chief clerk's office, where they would be recorded as the final entries in the cash blotter. After this they would be combined with the mailed-in applications and readied for distribution next to the appropriate patent examiners. But that did not happen. The person who brought in Bell's application demanded that it be taken immediately to Room 118. Because of this unusual request it was not thrown into the in-basket. Therefore, before heading for Room 118, the clerk had no choice but to stop at the chief clerk's office, and request that Bell's application be entered immediately into the daily blotter, thus interrupting the process of entering the morning's mailed-in applications. The chief clerk's assistant had just finished the first four documents from the morning's mail bag when Bell's application arrived. Bell's application, therefore, became the fifth entry on that day's cash blotter.* (Evenson, 2000, p. 69)

So, in bypassing the standard procedure, Bell's application, although physically arriving later at the Patent Office than Gray's application, was entered in the cash blotter *before* Gray's application could be entered:

---

[186] British law at the time granted patents only to inventions not patented elsewhere first, so Bell drew up several copies of his harmonic telegraph patents and sent some to be filed in Britain first. Bell had made an agreement with the Brown brothers: Gordon Brown and his brother George Brown, a former premier of Canada and a well-connected politician. It was agreed that George Brown would sail to England and file the patent on Bell's behalf (for a 50% share in the future profits).

'Because Gray's caveat was still in the in basket, it wouldn't be recorded until later that day, when all the other hand-delivered document would be taken to the chief clerk's office. It would become the 39th entry on that blotter' (Evenson, 2000, p. 69)

Inside Knowledge?

Bell's patent application was given some days later to the patent examiner Zenas Fisk Wilber, one of the occupants of Room 118, for further examination.

> *Sometime during the week of February 14, the patent officer in room 118, Zenas Wilber, had time to read and compare Gray's caveat of February 14 with Bell's patent application of the same date. In his opinion, claims 1, 4 and 5 might possibly interfere with the subject of Gray's caveat. Because of past problems, Wilber was not going to overlook possible interference – especially one involving Gray. Therefore, on February 19, following standard Patent Office procedure, Wilber notified Pollok and Bailey, as well as Gray's attorney, William Baldwin, of this and stated that Bell's patent would be suspended for 90 days*[187]
> (Evenson, 2000, p. 73)

Pollok and Bailey responded by sending a letter to the Commissioner of Patents Ellis Spear in the Patent Office requesting to establish 'whether or not our application was not filed prior to the caveat in question ... If our application was filed earlier in the day than was the caveat, then there is no warrant for the action taken by the Office' (Evenson, 2000, pp. 76-77). This was important as, when Bell's application was filed before the caveat, there was no cause to declare an interference. Wilbert, contacted by the commissioner Spear—his superior in the patent Office—responded that, according to the Patent Law, only the *date* of filing and not the *difference in time* was relevant. Spear disagreed and instructed the time factor to be considered. The result was that Wilber informed, on February 25, Pollok and Bailey that the suspension had been lifted.

It would take some additional legal manoeuvring as there was also another, earlier, application by Gray that could have caused the suspension, but Bell was allowed to make an amendment to his current application. Although this was an illegal act, as it was intended to avoid a possible interference, the patent was amended on several points. The result was that the patent was issued to Bell, and, although it was for the simultaneous sending of telegrams, it became Bell's famous first telephone patent. But it was so only in legal terms, as the device of the telephone was still to be developed.

---

[187] This was standard practice, as in the 90 days the caveat holder was given the opportunity to complete his invention and file a regular patent application.

From its original filing on February 14 to the issue of the patent on March 7, 1876, it had only taken 17 days, despite the challenge of two interference actions. It was Spear's unorthodox decision to apply the time noted in the cash blotter that made the difference as to who got the priority rights.

> *Although there was no justification for Spear's action, this much we do know: he had absolutely no idea what impact his decision would have. Yet if historians had to pick the one pivotal point in telephone history, it would have been the instructions Acting Commissioner Spear gave to Examiner Wilbur on February 25, 1876.* (Evenson, 2000, p. 89)

Later in time, when the Patent War was in full swing, the question would be raised if Zenas Fisk Wilber—one way or the other—had informed Bell about the caveat (for example, about who the cavatear was and what its contents were). As a caveat, both its origin as well as the content, was a strictly confidential document, that would have been a breach of conduct. Remarkably enough, the drawing of the 'speaking telephone' in Gray's caveat application was found also in Bell's notebook and dated March 8, 1876. (Figure 81)

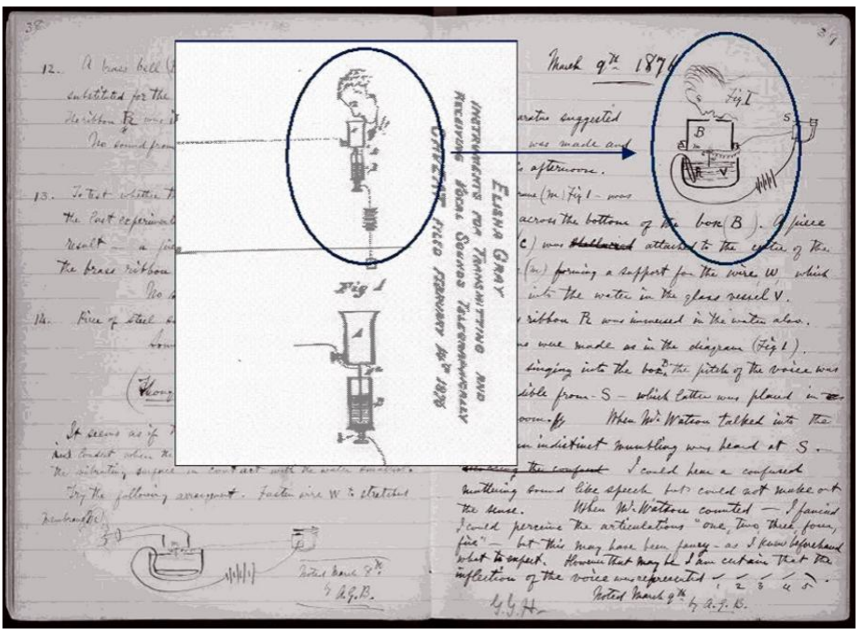


Figure 81: Comparison of the illustration of the telephone in Alexander Graham Bell's diaries (March 8, 1876) and Elisha Gray's patent application (February 14, 1876).

Source: Wikimedia Commons, based on Schulman, S.; the Telephone Gambit: Chasing Alexander Graham Bell's Secret.

Wilber, at that period in time, was having problems; he was alcoholic and he owed money to Bell's attorney Marcellus Bailey, his former colleague in the army.

> *Wilber's history does not confer a high degree of credibility on him. He was a known alcoholic, a bribe taker, a petty embezzler, and a man of many faults. In short he was a rather disputable character. However, in fairness to Wilber, we must state that these were not separate faults; most of them were the direct result of his alcoholism, now generally considered a form of illness.* (Evenson, 2000, p. 166)

Though Wilber might have been suspected of cooperation in Bell's interest, it was never legally proven. But he fact is clear that Wilber showed Bell the contents of Gray's caveat. For his trouble, he received a $100 bill, as he acknowledged later in an affidavit when he decided to come clean: 'I am convinced by my action while Examiner of Patents that Elisha Gray was deprived of proper opportunity to establish his right to the invention of the telephone, and I now propose to tell how it was done' (Evenson, 2000, p. 168). He declared also about Bell's involvement:

> *After the suspension of Bell's application had been revoked, Professor Bell called upon me in person at the office, and I showed him the original drawing of Gray's caveat, and I fully explained Gray's method of transmitting and receiving. Professor Bell was with me quite a time on this occasion, probably upwards of an hour, when I showed him the drawing and explained Gray's method to him. The visit was either the next day or the second day after the revocation of the suspension.* (Evenson, 2000, pp. 169-170).

This 'action' had resulted in crucial changes in the patent when Bell was given the chance to make amendments.

Underground Railroad to Patent Examiner

As mentioned, some days after February 14, 1876, Wilber had told Bell that his patent application had been suspended due to a caveat by another inventor. He also had given Bell the opportunity to make some amendments. It was quite a while later, in January 1887, that this would become a legal issue. Then the attorney Lysander Hill, representing the People's Telephone Company, charged the American Bell Telephone Company with fraud. It was about US patent № 174,465 issued in 1876.

> *The brief stated that the crucial description of the variable resistance method and the present fourth claim were not in Bell's patent application when it was filed on February 14, 1876. This information, Hill charged, was appropriated from Gray's caveat filed that same day and illegally inserted into Bell's application a few days later. Hill alleged that Bell's attorneys, Pollok and Bailey, had an*

> *"underground railroad" to the patent examiner, from whom they received illicit knowledge of the variable resistance method described in Gray's caveat.* (Evenson, 2000, p. 176)

What he had observed was that the text of the original application, called the Brown's copy[188] of January 26, 1876, was based on the patent application notarized and filed five days earlier (January 20, 1876). This text was different from the text of the patent application of February 14, 1876. It was different at a crucial subject: the fourth claim that related to the variable resistance. This was the first time that Bell's patent was challenged on the basis that it had been obtained fraudulently. Normally, during the different telephone lawsuits, it had been challenged to be invalid because it had been anticipated by an earlier inventor.

The lawsuit was brought to justice but rejected by the Court. Justice Waite argued: 'At any rate, the bare fact that the difference exists, under such circumstances, is not sufficient to brand Bell and his attorney, and the officer of the patent-office, with the infamy which the charges made against them imply' (Evenson, 2000, p. 184). Bell retained his patent rights after verdict.

Demonstration of Bell's Invention

On March 10, 1876 Bell demonstrated his invention to five professors of science in the Boston Athenaeum of the Massachusetts Institute of Technology. The demonstration was successful, and Bell was invited to repeat it on May 25 for the MIT's Society of Arts.

The first opportunity to demonstrate his invention to the general public was not much later at the large scale Centennial Exhibition that was held in Philadelphia from March till November 1876. Through Hubbard, who was a Centennial Commissioner, Bell managed to get a booth. It was a timely act with a surprising event: the visit of an Emperor (Figure 82).

> *On the following Sunday after-noon, the judges were to make a special tour of inspection, and Mr. Hubbard, after much trouble, had obtained a promise that they would spend a few minutes examining Bell's telephone. By this time it had been on exhibition for more than six weeks, without attracting the serious attention of anybody. When Sunday afternoon arrived, Bell was at his little table, nervous, yet confident. But hour after hour went by, and the judges did not arrive. The day was intensely hot, and they had many wonders to examine. There was the first electric light, and the first grain-binder, and the musical telegraph of Elisha Gray, and the marvelous exhibit of printing telegraphs shown by the*

[188] This text was given to Brown when he sailed to England in January 26, 1876. The copy had been in files of the Dowd case since 1878 but went unnoticed for eight years.

Figure 82: The Emperor Pedro II and Empress of Brazil visit Bell's booth at the Centennial Exhibition (1876).

Source: http://www.mainlesson.com/

Western Union Company. By the time they came to Bell's table, through a litter of school-desks and blackboards, the hour was seven o'clock, and every man in the party was hot, tired, and hungry. Several announced their intention of returning to their hotels. One took up a telephone receiver, looked at it blankly, and put it down again. He did not even place it to his ear. Another judge made a slighting remark which raised a laugh at Bell's expense. Then a most marvelous thing happened—such an incident as would make a chapter in "the Arabian Nights Entertainments."

Accompanied by his wife, the Empress Theresa, and by a bevy of courtiers, the Emperor of Brazil, Dom Pedro de Alcantara, walked into the room, advanced with both hands outstretched to the bewildered Bell, and exclaimed: "Professor Bell, I am delighted to see you again." The judges at once forgot the heat and the fatigue and the hunger. Who was this young inventor, with the pale complexion and black eyes, that he should be the friend of Emperors? They did not know, and for the moment even Bell himself had forgotten, that Dom Pedro had once visited Bell's class of deaf-mutes at Boston University. He was especially interested in such humanitarian work, and had recently helped to organize the first Brazilian school for deaf-mutes at Rio de Janeiro. And so, with the tall, *blond-bearded Dom Pedro in the center, the assembled judges, and scientists—there were fully fifty in all—entered with unusual zest into the proceedings of this first telephone exhibition.*

A wire had been strung from one end of the room to the other, and while Bell went to the transmitter, Dom Pedro took up the receiver and placed it to his ear. It was a moment of tense expectancy. No one knew clearly what was about to happen, when the Emperor, with a dramatic gesture, raised his head from the receiver and exclaimed with a look of utter amazement: "MY GOD—IT TALKS!" (H. N. Casson, 1910, pp. 37-39).

Soon the other scientists, such as Joseph Henry, William Thomson and others in the notable company, followed, listened and talked and were astonished by the fact that a voice could be carried over an electric wire. After much deliberation, they awarded Bell a *Certificate of Award* (Figure 83). From then on, his little apparatus became the star of the Centennial.

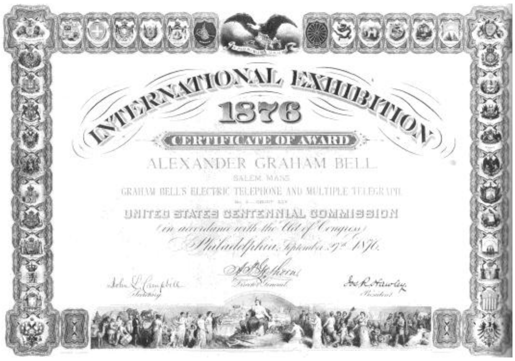


Figure 83: The Award given to Bell at the Centennial Exhibition (1876).

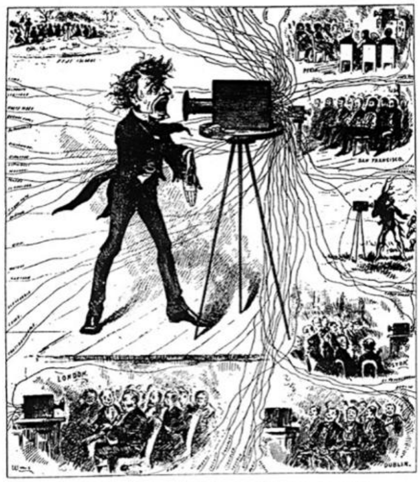
Source: http://www.mainlesson.com/

Public Awe: From Negativism to Enthusiasm

That attention was limited. Back in Boston Bell's invention was not greeted with that much enthusiasm any more. Businessmen were sceptical; they saw it as a scientific toy. In a way, he experienced the same thing that Samuel Morse had felt when Congress regarded him as a nuisance with his telegraph proposals, and that Westinghouse had felt when he was called a fool for proposing 'to stop railroad trains by wind' (because of his invention of the air-brake system for trains).

The London Times alluded pompously to the telephone as the latest American humbug, and gave many profound reasons why speech could not be sent over a wire, because of the intermittent nature of the electric current. Almost all electricians—the men who were supposed to know—pronounced the telephone an impossible thing; and those who did not openly declare it to be a hoax, believed that Bell had stumbled upon some freakish use of electricity, which could never be of any practical value. (H. N. Casson, 1910, p. 43)

The English were not the only ones who ridiculed Bell. In addition, in America, the local press took up ridiculing his work, like the Daily Graphic in New York, who published the cartoon 'Terrors of the Telephone-The Orator of the Future' (Figure 84).



Terrors of the telephone (From *Daily Graphic*, New York, March 15, 1877).

Figure 84: Terrors of the Telephone: cartoon as published in the Daily Graphic, New York (March 15, 1877).
Source: Wikimedia Commons

As one realizes that the telegraph was not a facility the general public used because it was so expensive, it is not too surprising that his 'speaking telegraph' was also not directly embraced by the public. But it was not only the general public; the business community also responded faintly. And the press ridiculed his work.

> *…The Boston Times said, in an editorial of bantering ridicule: "A fellow can now court his girl in China as well as in East Boston; but the most serious aspect of this invention is the awful and irresponsible power it will give to the average mother-in-law, who will be able to send her voice around the habitable globe."*
>
> *… there were hundreds of shrewd capitalists in American cities in 1876, looking with sharp eyes in all directions for business chances; but not one of them came to Bell with an offer to buy his patent. Not one came running for a State contract. And neither did any legislature, or city council, come forward to the task of giving the people a cheap and efficient telephone service. As for Bell himself, he was not a man of affairs. In all practical business matters, he was as incompetent as a Byron or a Shelley. He had done his part, and it now remained for men of different abilities to take up his telephone and adapt it to the uses and conditions of the business world.* (H. N. Casson, 1910, p. 45)

Luckily, such a man was not far away. Bell's father-in-law, Gardiner Hubbard, though a lawyer and not directly a businessmen by nature, took up the challenge to introduce the telephone to a hostile public. With his extensive experience in local and state government (remember his efforts concerning the Hubbard Bill), he was the right man in the right place to promote the new 'speaking telegraph' all over America.

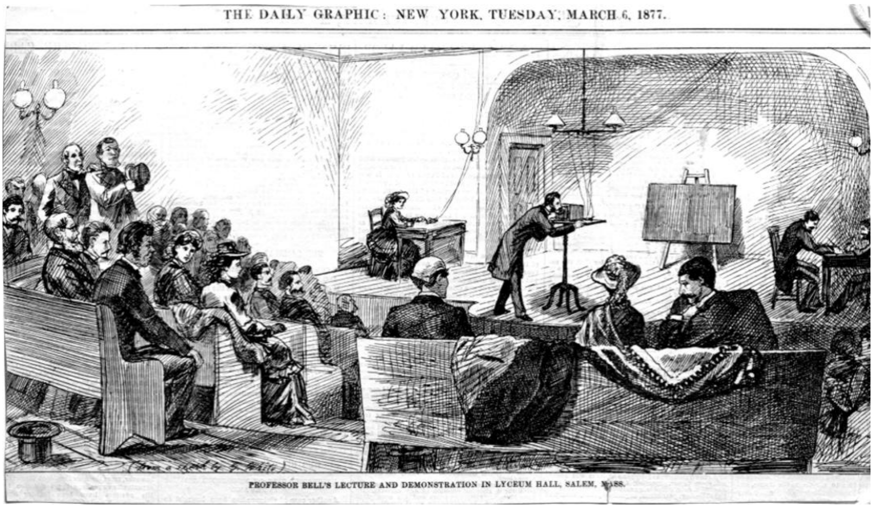


Figure 85: Alexander Graham Bell demonstrating the telephone in Salem, Massachusetts (1877).

Source: New York Daily Graphic (6 March 1877).

Soon Hubbard arranged demonstrations for an astonished public, and he urged Bell and Watson to perform a series of sensational feats with the telephone. Starting in late 1876, for a hundred dollars per lecture—the first payments he received for his invention—he continued in early 1877 with a series of ten lectures, borrowing telegraph lines to set up his demonstrations, like those given in the Lyceum in Salem on February 12, 1877 (Figure 85). Bell was in Salem in front of an audience of 500-600 people, and Watson was in Boston. Remarkably, the news item made by the Globe reporter in Salem was sent by the same connection. Bell reported on it the next day in a letter to his wife:

> … *the Globe reporter in Salem composed the despatch and dictated it to me sentence by sentence. I repeated each sentence to Mr. Watson through the Telephone—and Mr. Watson repeated it to me by Telephone that I might be sure he understood it. A Globe reporter in Boston took it down from Mr. Watson's voice. There was no hitch from first to last—even the proper names being understood. The despatch was transmitted (in spite of the repetition of each sentence) in a much shorter time than could possibly have been done with the Morse system.—a shorthand reporter being fully occupied.* [189]

[189] Source: Letter from Alexander Graham Bell to Gardiner Greene Hubbard, February 13, 1877, with transcript. http://lcweb2.loc.gov/mss/magbell/079/07900405/07900405.pdf (Accessed October 2015)

The Salem-demonstration was a success on its own. However, the dispatch of that news item and its publication (Figure 86) would have even greater consequences.

The Rutland Daily Globe

THURSDAY, FEBRUARY 15, 1877.

SENT BY TELEPHONE.

The First Newspaper Despatch Sent by a Humna Voice Over the Wires.

SALEM, February 12, 10.55 P. M.

Professor A. Graham Bell, the inventor of that wonderful instrument the telephone, which has caused so much interest in the scientific world and which is now becoming so popularity known, lectured on his invention at Lyceum hall this evening.

It was a very noteworthy occasion, certainly; and the complete success attained led to the discussion of many plans for the further practical utilization of the telephone which sends its first newspaper despatch to the *Globe* readers for their declaration and wonder, this morning.—*Boston Globe.*

Figure 86: Newspaper reporting Bell's demonstration in Salem (February 12, 1877).

Reprint in the Rutland Daily Globe of Boston Globe's Item.

Source: Sheddan, D.: Today in Media History. http://www.poynter.org/

> *But when a column of news was sent by telephone to the Boston Globe, the whole newspaper world was agog with excitement. A thousand pens wrote the name of Bell. Requests to repeat his lecture came to Bell from Cyrus W. Field, the veteran of the Atlantic Cable, from the poet Longfellow, and from many others. As he was by profession an elocutionist, Bell was able to make the most of these opportunities. His lectures became popular entertainments. They were given in the largest halls. At one lecture two Japanese gentlemen were induced to talk to one another in their own language, via the telephone. At a second lecture a band played "the Star-Spangled Banner," in Boston, and was heard by an audience of two thousand people in Providence. At a third, Signor Ferranti, who was in Providence, sang a selection from "the Marriage of Figaro" to an audience in Boston. At a fourth, an exhortation from Moody and a song from Sankey came over the vibrating wire. And at a fifth, in New Haven, Bell stood sixteen Yale professors in line, hand in hand, and talked through their bodies—a feat which was then, and is to-day, almost too wonderful to believe.* (H. N. Casson, 1910, p. 51)

One could conclude that Bell's demonstrations had put the new phenomenon of telephony on the public agenda, just as Morse had put telegraphy on the agenda some decades before[190].

Initially, the telephone faced with many of the same problems that the telegraph had faced. A curious public, and excited press, greeted its introduction, but there was no real understanding on the part of the collective mind of American society, at this time, of the potential value of the telephone to the country. While it was obvious that it could be used for

[190] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015) pp. 353-357.

personal communications within a city, it was not obvious that its use could be extended across long distances, and used for commercial or news purposes. As such, there was reluctance on the part of investors and customers to actually become involved in the company. (H. N. Casson, 1910, pp. 42-46)

Bell's Second Telephone Patent

Although his work was still closely linked to the harmonic telegraphy, Bell had, more and more, focused on the telephone. He had been testing at his father's house in Brantford the transmission of speech over some distance. It was a one-way transmission. Not much later he would start experimenting with two-way communication. On October 9, 1876, Watson and Bell recorded their conversation and published it in the *Boston Daily Advertiser* of October 19, 1876. The Cone-shaped devices were now replaced with the box-like transmitters (Figure 87). This was the beginning. More publicity would come after he applied for the Second Telephone Patent.

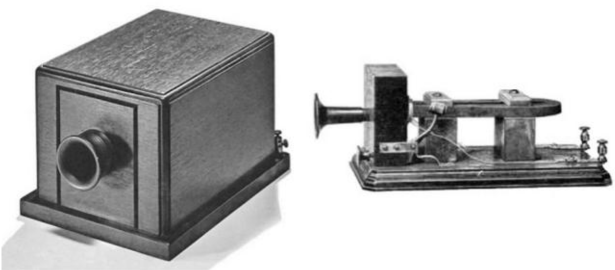


Figure 87: Model of box-type transmitter (1877).
This type of telephone was used by E T Holmes
Source: http://www.telephonymuseum.com/

On January 15, 1877, he applied for a new patent. He referred to the text of his first telephone patent (the previously mentioned US Patent № 174,465). In the patent he had 'described a method of an apparatus for producing musical tones by the action of undulatory currents of electricity, whereby a number of telegraphic signals can be sent simultaneously over the same circuit, in either or both directions, and a single battery be used for the whole circuit' (text of patent),

Now he applied for a new patent to protect his invention: 'My invention has for its object, first, the transmission simultaneously of two or more musical notes or telegraphic signals on a single wire in both directions, and with a single battery...; second, the electrical transmission by the same means of articulate speech and sounds of any kind without the necessity of using a voltaic battery.' (text of patent).

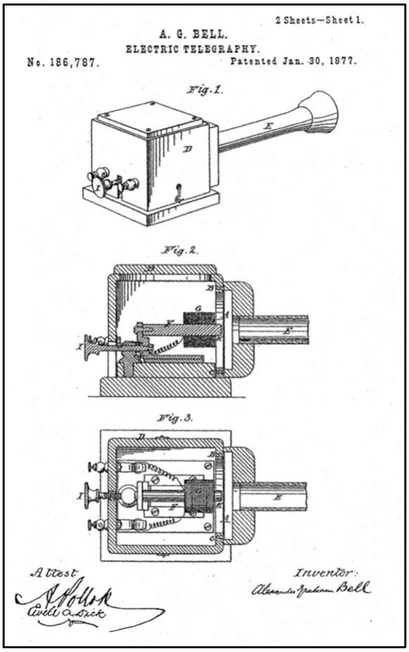


Figure 88: Bell's Second Telephone Patent № 186,787 (1877).

Source: USPTO

From this description, it was clear that he still coupled the *harmonic* telegraphy for multiple telegraph transmissions to the *acoustic* telegraphy for sound transmissions. Nothing was mentioned about the liquid transmitter. It was obvious that further experimenting had resulted in the replacing of the acidic water with the electromagnetic device.

On January 30, 1877, he was granted US Patent № 189,787 (Figure 88). It was this second telephone patent that would be the cornerstone for Bell's Telephone Company that started in mid-1877.

Other Patents Granted to Alexander Bell and Thomson Watson

As we will see later, quite a bit went on related to these patents that was of a business nature. The technical development of the phone continued as the result of Bell and Watson's experimenting. It was a continuous process of improvements, first by Bell and Watson, later by others.

Alexander Graham Bell's patents: The First and Second Telephone patent mentioned before, were not the only patents Alexander Bell was granted in relation to telephony. He worked on the problems related to the equipment of that time, such as the power supply where the wet cell was a problem (US Patent № 181,553 of August 29, 1876, that was filed shortly before, on August 12, 1876). Also the quality of the speech transmission was a constant point of attention. Quite a few improvements to parts of the telephone equipment (ie transmitter and receiver) were patented. And the problems of transmission quality over longer distance were also worked on (Table 5). But none of these subsequent patents would have the same impact as the First and Second Telephone patents.

Table 5: Some of the patents granted to Alexander Graham Bell

Patent №	Granted	Description
US 161,739	Apr 6, 1875	Improvement in Transmitters and Receivers for Electric Telegraphs (tuned steel reeds)
US 174,465	Mar 7, 1876	**First Telephone Patent:** Improvement in Telegraphy
US 178,399	June 6, 1876	Telephonic Telegraphic Receiver (vibrating reed)
US 181,553	Aug 29, 1876	Improvement in making electric currents to replace voltaic batteries
US 186,787	Jan 30, 1877	**Second Telephone Patent:** Electric Telegraphy (permanent magnet receiver)
US 201,488	Mar 19, 1878	Speaking Telephone (receiver design)
US 213,090	Mar 11, 1879	Electric Speaking Telephone (frictional transmitter)
US 220,791	Oct 21, 1879	Telephone Circuit; Return wires for quality improvement
US 228,507	June 8, 1880	Electric Telephone transmitter
US 230,168	July 20, 1880	Automatic short circuiter for Telephones
US 235,199	Dec 7, 1881	Apparatus for signaling and communicating, called Photophone
US 235,496	Dec 14, 1880	Photophone transmitter
US 238,833	Mar 15, 1881	Electric call bell
US 241,184	May 10, 1881	Telephone Receiver
US 244,426	July 19, 1881	Telephone Circuit
US 250,704	Dec 13, 1881	Speaking Telephone: ear piece and mouth piece

Source: USPTO

Thomas Watson's patents: One of the problems of early telephony was informing the 'caller' that someone would like to speak to him. As the calling party had to alert the called party that there was a call waiting, a device was needed to create an alert. Watson devised a so called 'ringer' that was patented as US Patent № 210,886 on December 17, 1878. It was a device that operated on a low frequency AC-current. The generator to create that AC current was already patented by Watson under US Patent № 202,495 on October 11, 1877.

Another point of interest was the connection of subscribers with each other and with the central office switchboard. He was in 1880 granted US Patent № 234,154 for it. In 1882 he was granted US Patent № 252,160 for a compound telephone that was used in combination with a telephone-exchange. These were just a few of the contributions Thomas Watson made to the improvement of the telephone (Table 6). In total, he had some 60 patents in his name.

Table 6: Some of the patents granted to Thomas Watson.

Patent №	Granted	Description
US 199,007	Jan 8, 1878	Buzzer for telephone apparatus
US 202,495	Apr 16, 1878	Improvement in telephone call-signal apparatus
US 209,592	Nov 5, 1878	Improvement in automatic switch or cut-out for telephones
US 210,866	Dec 17, 1878	Polarized Armature for Electric Bells
US 217,561	July 15, 1879	Speaking Telephones: improvement of Blake's telephone
US 231,739	Aug 31, 1880	Telephone: improving the transmitter
US 232,788	Sep 28, 1880	Telephone Circuit
US 232,862	Oct 5, 1880	Vibrating surface for Sound Transmission
US 234,154	Nov 9, 1880	Telephone Exchange System
US 245,105	Aug 2, 1881	Telephone: improvements in the conversion of sound waves in electric undulations
US 245,600	Aug 16, 1881	Telephone Signal
US 252,160	Jan 10,1882	Compound Telephone
US 256,258	Apr 11, 1882	Telephone Exchange System

Source: USPTO

Early Telephones and Telephone Lines

The product concept of the telephone reflected the conceptual model depicted by the US patent № 186,787 of 1877 which covered the box-like transmitter (Figure 87, Figure 88). Later, the design was influenced by the microphone that was developed by Francis Blake, and was to function as the carbon transmitter. His microphone fitted nicely in the 'butterstamp' model (Figure 89). It got this nickname because it resembled the stamp used to make small parts of butter.

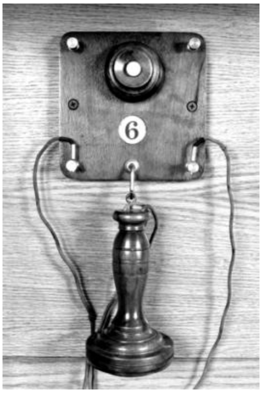


Figure 89: The Butterstamp telephone (1877).

The devices functioned both as receiver and transmitter.

Source: JKL Museum of Telephony. http://collectionsonline.nmsi.ac.uk/

These origins resulted in the first archetype models offered to the market. These were the 'butterstamp' telephone (Figure 89) where the butterstamp was both receiver and transmitter, and the 'coffin' telephone (Figure 90). The butterstamp receiver became the standard until the early 1900s. At the close of 1878, 246 Blake transmitters were in service, and by July 1, 1879, the number had increased to 7,000. (Land, 1907, p. 406)

Soon the butterstamp-type and box-type telephones were complemented by additional functionality. Instead of the traditional shouting in the horn, the function of the 'caller or buzzer' was added to the telephone. It was based on Watson's patent № 199,007 of 1878. It resulted in the wooden wall-mounted telephones, equipped with the bell that rang when a caller wanted to communicate, that came known as the Coffin (Figure 90).

Figure 90: Coffin model of the Bell Receiver/ Transmitter made by Charles Williams (1879).

A single magneto hand telephone could serve as both a receiver and transmitter. Some models came with two, one for each hand.

Source: http://www.telegraph-history.org/charles-williams-jr/part2.html; Tom Adams (left)

The Bell Telephone Company agreed to purchase all their telephones from Williams, paying him $1.60 for each hand telephone, and $2.45 for each box telephone. Each was subject to inspection by the company's superintendent, Watson. Williams numbered the instruments in series, the leases were closely monitored, and Watson personally shipped all the instruments. (ibidem) [191]

These archetype models soon developed —using different types of transmitters (Blake, Berliner and Edison models were applied)— into a range of different models. The volume of telephones increased considerably, with 340,000 units of the Blake-based systems in use by 1878.

The telephone apparatus was connected by wire, thus creating a direct line from point-to-point. These private lines became party lines went other telephones were hooked up on the same wire.

The first customer was a friend of Williams, Roswell C. Downer. On May 1, 1877, Downer rented two phones that were put on a private line between his State St. office and Downer's home in Somerville. The first paying customer was James Emery who on May 30, paid Williams 20 dollars for a year lease. Williams carried it around in his pocket for a while until he could ask Gardiner Hubbard what to do with it. (ibidem)

[191] Source: http://www.telegraph-history.org/charles-williams-jr/part2.html (Accessed October 2015).

However, the three components of the system—the magneto bell and receiver, the Blake transmitter, and the batteries—were problematic in their practical use. Soon a new model appeared: the three box wall mount telephone. This model was also produced by the licensee E T Gillilard of Cincinnati and Law (Figure 91).

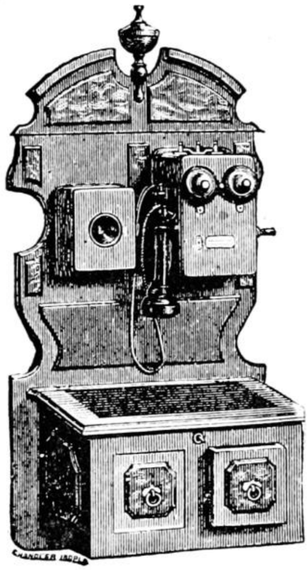


Figure 91: Gillilard wall mount models (1879-1880). The devices functioned both as receiver and transmitter.

Remarkably, Charles Williams and Thomas Lane obtained in 1881 US Patent № 12,179 for the design of a three box wall mount telephone (Figure 92):

> *Our design relates to the combination or grouping, on a single back board, of a disk shaped magneto box, a transmitter and battery-box accompanying the hand-telephone, the object of the design being to improve the form of the back board, and the relative arrangement thereon of the magneto box, the transmitter, and the battery-box, so that the back board, with the apparatus thereon, shall have a neat and symmetrical appearance* (text of patent).

Not much later he would pay attention to the development of telephone switchboards, obtaining US № Patent 248,821 on October 25, 1881, for it.

These early archetypes of telephones were not the result of a well-planned production system where telephones were manufactured in series. As Williams' shop was basically engineering oriented, their method of production was 'piece by piece':

> *From 1877 to the spring of 1879 the Bell Company relied exclusively on Williams' shop for telephones and associated apparatus. By early 1879, Williams could not keep up with the demand. Williams' machinists were not used to being strictly production workers, they were considered craftsman, used to making modifications on the fly for inventors. Additionally, Williams stated, ... 'Almost every batch we turned out was an improvement over the preceding*

ones'... By February 7, 1879 Williams' employees were working 11 hours a day but production was up to only 35 phones per day.[192]

Later, also other manufacturers, licensed to make the telephones, produced the wall mount Three Box model. Such as the Viaduct Manufacturing Company in Baltimore (Figure 93).

The design of the early phones was pure functional, and it was realized in wood. The power supply to function was still the electric battery. It was placed in the box at the bottom of the apparatus. In a sense, it became part of the furniture although it was wall mounted.

Figure 92: Charles Williams' Three Box wall mount telephone (1881).

The desk was used to take notes during the conversation. It contained the battery.

Source: http://telephones.newenglandhistorywalks.com/models

Figure 93: Three Box wall mount telephone made by Viaduct Manufacturing (1893).

The desk was used to take notes during the conversation. It contained the battery.

Source: http://telephones.newenglandhistorywalks.com/models

[192] Source: Charles Williams Jr. Part Two: Human voice send by telegraph. http://www.telegraph-history.org/charles-williams-jr/part2.html. (Accesses October 2015).

Early Years of Bell Telephone Company

Obviously, as (long) distance communication was by now well established by the telegraph, dominated by Morse based telegraphy and the Western Union monopoly, the interest for the new invention of the speaking telegraph at first was minimal:

> *The main problem of the telephone in its earliest stages was simply one of application: no one knew what to make of it or what to do with it. It was a mysterious, marvelous, almost magical instrument – but for what purpose? It was not something for which society had been longing. … So despite the telephone's amazing capabilities, there was a lot of social and cultural inertia to overcome.* (Evenson, 2000, p. 120)

The telephone apparatus was an immature product and still in its infancy with a lot of technical shortcomings. Its potential use was mainly seen as a—short distance—replacement for the telegraph. It was not too difficult to ridicule that replacement as indeed, for example, the quality of the transmission was quite poor: one had to shout into the box to be heard. Nevertheless, there were already the first innovative customers to be found who were willing to pioneer with the new phenomenon.

> *The only telephone line in the world at this time was between the Williams' workshop in Boston and the home of Mr. Williams in Somerville. But in May, 1877, a young man named E. T. Holmes, who was running a burglar-alarm business in Boston, proposed that a few telephones be linked to his wires. He was a friend and customer of Williams, and suggested this plan half in jest and half in earnest. Hubbard was quick to seize this opportunity, and at once lent Holmes a dozen telephones. Without asking permission, Holmes went into six banks and nailed up a telephone in each. Five bankers made no protest, but the six indignantly ordered "that play toy" to be taken out. The other five telephones could be connected by a switch in Holmes's office, and thus was born the first tiny and crude Telephone Exchange. Here it ran for several weeks as a telephone system by day and a burglar-alarm by night. No money was paid by the bankers. The service was given to them as an exhibition and an advertisement.* (H. N. Casson, 1910, p. 51)

The early adaptor Holmes might have been one of the first customers (who even supplied his own cables), but it took more than a year to build up the customer base using some 800 telephones. Most subscribers used the telephone as a (faster) addition to the services already supplied by telegraphy. That telephony would complement, and later replace, telegraphy as an instrument for social interaction, was hardly imaginable.

A Challenge in the Making

The early pioneers of the telephone business were confronted with a multitude of problems. On the one hand, they had an immature product that was in its technical infancy and which right for existence had to be proven as there was not a market. The value of—short—distant speech had yet to be proven to the general public. The same public that would, within a decade, start to embrace it. On the other hand, they were up against the mature telegraph industry with a monopoly in tele-communication.

This all made the early years already quite challenging for the partners in the Association. In addition, they were operating within the pessimistic investment climate, as in the mid-1870s, the country's economic situation was quite volatile. The Bank Panic of 1873—the Victorian equivalent of the Wall Street Crash of 1929—followed by an economic depression, had led to a limited capital market. The investment climate was negative as result of corrupted and failed railroad developments, such as the proposed Erie Railroad. There, the robber barons had created havoc.

> *That year, 1875, Jay Gould, Jim Fisk, and Daniel Drew challenged Cornelius Vanderbilt's control of the Erie Railroad. In the ensuing stock war, Vanderbilt used the power of the New York Courts to issue arrest warrants for Gould, Fisk, and Drew, while the three freebooters created an armed fortress in a New Jersey hotel - and printed watered railroad stock in the basement of the hotel. Eventually, the Erie Ring - as Gould, Fisk, and Drew were referred to in the press - drove Vanderbilt out of the Erie, and gained control of the railroad. The three then proceeded to bleed the company dry of both capital and profits. Within one year of its acquisition, Gould, Fisk, and Drew had driven the railroad into bankruptcy, while personally taking everything of value owned by the company. … The stock and capital manipulations of types like Gould, Fisk, Drew, and Vanderbilt, combined with the lingering depression, created a chronic shortage of capital in the investment markets of the 1870s. It was against this backdrop that Bell, Sanders, and Hubbard sought to establish, and capitalize a new, and unproved, product and service - the telephone.* (Ward, 1997, pp. 121-122)

Then, on the positive side, there was a promising invention with patent protection, and some people with enough vision and imagination to have an idea of a future to come. The infrastructure created by telegraphy, all those wires clogging the streets, had paved the way for the telephone infrastructure. In that context, the partners were having to make some tough decisions. For the three members of Bell's Patent Association, the coming period of some five years—in which the entrepreneurial efforts would start to exploit the patent rights of Bell's invention—would be hectic and change their lives completely.

Failing Negotiations with Western Union

In that economic and financial context for the new start-up company, the partners had to make a choice on what business strategy to follow. One of the options was selling the patent rights and enjoying the financial compensation. Indeed, Hubbard had started, in late 1876, negotiations with the big and mighty Western Union to sell the patent rights. However, Gardiner Hubbard was the last person that William Orton, President of Western Union, wanted to see. During the protracted fight over the Postal Telegraph Company bills, Orton had come to personally despise Hubbard. But they did meet, and they spoke; the negotiations dragged on for months. Western Union had an internal committee investigate the offer. It came with negative advice:

> *The Telephone purports to transmit the speaking voice over telegraph wires. We found that the voice is very weak and indistinct, and grows even weaker when long wires are used between the transmitter and receiver. Technically, we do not see that this device will be ever capable of sending recognizable speech over a distance of several miles. Messer Hubbard and Bell want to install one of their "telephone devices" in every city. The idea is idiotic on the face of it. Furthermore, why would any person want to use this ungainly and impractical device when he can send a messenger to the telegraph office and have a clear written message sent to any large city in the United States?*
>
> *The electricians of our company have developed all the significant improvements in the telegraph art to date, and we see no reason why a group of outsiders, with extravagant and impractical ideas, should be entertained, when they have not the slightest idea of the true problems involved. Mr. G.G. Hubbard's fanciful predictions, while they sound rosy, are based on wild-eyed imagination and lack of understanding of the technical and economic facts of the situation, and a posture of ignoring the obvious limitations of his device, which is hardly more than a toy... .*
>
> *In view of these facts, we feel that Mr. G.G. Hubbard's request for $100,000*[193] *of the sale of this patent is utterly unreasonable, since this device is inherently of no use to us. We do not recommend its purchase.* [194]

Not surprisingly, this advice was followed upon, and the negotiations were ended. Western Union had other things to worry about, as it was under attack by Jay Gould, the robber baron who had his eye on the telegraph business.

---

[193] Equivalent to $ 2,330,000 in 2014 calculated on the basis of historic standard of living: Source: www.measuringworth.com

[194] Based on a publication of Warren Bender (A.D. Little, Inc.) published in Transactions of the IEEE Systems, Man & Cybernetics Society. Source: http://www.cclab.com/billhist.htm (Accessed February 2015)

How about Starting a Business?

Hubbard had failed to sell Bell's invention to Western Union—even after renewed negotiations in September 1877 with related parties. They realized the situation they were facing; the public was still not too interested, and businessmen failed to grasp the important business opportunity that was in front of them. All that made the partners conclude that they did not have many options left. They would have to try to organize the implementation of the telephone system by themselves. This decision was supported by their experience with some early interoffice applications where a telephone point-to-point connection (the 'direct' or 'private' line) had been installed, and that looked promising enough.

> *Hubbard followed with great interest the efforts of Holmes and other local entrepreneurs as they struggled to install telephones on private lines and set up exchanges. These developments convinced Hubbard that there was indeed a market for telephones for use within cities. Rather than sell the telephone patent to other capitalists, Hubbard and his associates decided in July 1877 to form the Bell Telephone Company. This company was to hold the Bell patents and issue licenses to individuals who wanted to set up local telephone exchanges.* (Carlson, 1994, p. 177).

Hubbard's business instinct proved to be right. 'By the time the *Bell Telephone Company* opened its doors on July 9, 1877, there were almost 300 sets installed. From that point on, the number of installed sets would increase almost geometrically every few months' (Evenson, 2000, p. 124).

As the business prospects looked good, they had to get organized. And so they did, creating the 'Bell Telephone Company, Gardiner G. Hubbard Trustee', with $450,000 in capital and twelve thousand telephones that were leased to customers, creating a lovely cash flow. In fact, they had organized the *Bell Telephone Association*, a trust in which Gardiner Hubbard, the primary Trustee[195], acted as President, and Thomas Sanders was the Treasurer. As Alexander Bell was the inventor, organizing the business was left to Sanders and Hubbard[196]. That meant several major subjects: financing the operation, organizing the manufacturing facilities, and taking care of sales and marketing. Thus, the trustees operated a company under the name of the *Bell Telephone Company*, with the following ownerships:

---

195 In New England, at this time, this type of Trust organization was fairly common, and usually composed of individuals who were personally connected. In order to establish the Trust, one person had to be designated the primary Trustee, and the other partners had to assign their rights to the patents to the Trustee. The Trustee was responsible for developing the firm commercially, and was the final authority for all company decisions.

196 Each was partner for a 30%-share, Watson was added for 10%-share.

> *5,000 shares of stocks were issued in the company, and divided in the following manner: Gardiner G. Hubbard, 1,387: Gertrude McC. Hubbard, wife of Gardiner Hubbard, 100: Mabel G. Bell, daughter of Gardiner G. Hubbard and wife of Alexander Graham Bell, 1,497: Alexander Graham Bell, 1,497: Thomas Sanders, 1,497: Thomas A. Watson, 499: and 10 shares each to Charles E. Hubbard and Alexander Graham Bell. The final distribution of stock gave the Hubbard family control of the Bell Telephone Company.* (Ward, 1997, p. 123)

The burden of financing fell on Thomas Sanders, and he solved the financing problem by supplying the funds himself: 'Sanders eventually invested some $ 110,000[197] of his personal wealth, essentially all he could scrape together, before the company started to make money' (Evenson, 2000, p. 127).

> *He [Sanders] was not rich. His entire business, which was that of cutting out soles for shoe manufacturers, was not at any time worth more than thirty-five thousand dollars. Yet, from 1874 to 1878, he had advanced nine-tenths of the money that was spent on the telephone. He had paid Bell's room-rent, and Watson's wages, and Williams's expenses, and the cost of the exhibit at the Centennial. The first five thousand telephones, and more, were made with his money. And so many long, expensive months dragged by before any relief came to Sanders, that he was compelled, much against his will and his business judgment, to stretch his credit within an inch of the breaking-point to help Bell and the telephone. Desperately he signed note after note until he faced a total of one hundred and ten thousand dollars. If the new "scientific toy" succeeded, which he often doubted, he would be the richest citizen in Haverhill; and if it failed, which he sorely feared, he would be a bankrupt.* (H. N. Casson, 1910, p. 56)

Marketing and promotion was Hubbard's responsibility. This was not easy in an economic time where many railroad bubbles were bursting, and where the telegraph was dominated by Western Union. To sell the telephones, still seen by many as a toy, Hubbard copied a marketing model that had previously been used elsewhere. Drawing on his earlier experiences[198], it was decided that licensing the right to use their patented system, in combination with leasing the equipment, was going to be their business model:

---

[197] Equivalent to $2,240,000 in 2014 based on of historic standard of living. Source: www.measuringworth.com

[198] Hubbard had been chief legal advisor to the Gordon-McKay Shoe Machinery Company. At this time, shoe manufacturing equipment was not sold to shoe producers, but rather leased. Each pair of shoes produced resulted in a royalty being paid to the shoe machinery company. (Ward, 1997, p. 124)

> *Any person wishing to develop and operate telephone service in a local area, were given a charter from the Bell Telephone Company to provide services within the designated area. The investor was required to capitalize all the costs associated with the construction of the actual wire lines that serviced the designated area. Bell Telephone Company provided all the equipment necessary to operate the system, including the telephones - and, eventually, the switching systems. The new company leased equipment from Bell Telephone, and in turn leased telephones to customers. Licenses were granted for a five year period. At the end of five years, Bell would extend the agreement if the investor had fulfilled its obligations, or Bell could exercise a right to purchase clause, and acquire the company at the fair market value. … The arrangement allowed Bell to expand services quickly with a limited amount of out-of-pocket capital investment on the part of the company - by 1879 185 such agreements had been granted, covering the majority of the major cities in the United States.* (Ward, 1997, p. 124)

This was the marketing plan Hubbard insisted upon for the fledging Bell Telephone Company, and it was the best business decision the company ever made.

In the beginning, residential users of the so-called 'private lines' between two points could lease a pair of telephones for $20 a year; commercial users paid $40 a year[199]. When more subscribers were connected to that private line—that now became a 'party-line' where everyone could hear each other's conversation (Figure 3)— another $10 per subscriber was required. And quite a few subscribers were happy to pay for such a novelty.

Bell on a Busy Honeymoon: Demonstrations and Business

With the partners busy running the business, Alexander Bell had other things of a more private nature to take care of. He had fallen in love with his pupil—Hubbard's daughter— and married Mabel Hubbard on July 11, 1877, and the couple left on a year-and-a-half honey-moon to Europe[200]. Mabel and Alexander Bell's honeymoon would turn out to be a frenetic business trip for the celebrated inventor. Bell was there to do business.

In Britain, Bell had managed to obtain a patent. He sold five-eighths of the patent rights to a businessman, William Reynolds, who had great plans. However, Reynolds he failed miserably. And he was not the only one, as Enos Barton, the founder of Western Electric Co., who was competing Bell

[199] The amount of $20 then is equivalent to $490 in 2014 based on a historic standard of living. Source: www.measuringworth.com. In 2015 most people pay a similar amount for the lease and use of their smartphone.

[200] Around that time the *Association Agreement* had also been updated: now Mabel was a 30% partner, and Bell kept ten shares in his own name. Those shares would make Mabel a very wealthy woman.

at the time, also tried to establish an export trade in telephones and failed.

> *These able men found their plans thwarted by the indifference of the public, and often by open hostility. "The telephone is little better than a toy,' said the Saturday Review; "it amazes ignorant people for a moment, but it is inferior to the well-established system of airtubes." "What will become of the privacy of life?" asked another London editor. "What will become of the sanctity of the domestic hearth?" Writers vied with each other in inventing methods of pooh-poohing Bell and his invention. "It is ridiculously simple," said one. "It is only an electrical speaking-tube," said another. "It is a complicated form of speaking-trumpet," said a third.* (H. N. Casson, 1910, p. 247)

Notwithstanding the public reaction, Bell was giving demonstrations wherever possible, such as his demonstration to the more technical audience of the Society of Civil Engineers on October 31, 1877.

> *On the evening of 31 October 1877, Bell was invited to address this august institution at the Institute of Civil Engineers in Westminster. The honour thrilled him to such a degree that he stayed up late that night to tell his parents all about it – by letter, of course. He wrote: "The hall was crammed and numbers were turned away. I am told that all the principal scientific men of London were present." Bell, ever the technologist, used a limelight projector to show off 50 views of his machinery.* [201]

There also was the demonstration of the telephone on November 28, 1877, for the Society for the Encouragement of Arts. According to the newspaper Times:

> *'If any proof were wanting of the universal interest this remarkable instrument is exciting, it was shown by an assembly of the members which not only filled the hall and staircases of the building, but overflowed into the street outside.'* (ibidem)

Having convinced the more technical audiences, he went on to convince the British nobility. He also gave a personal demonstration to Queen Victoria of England on January 14, 1878. It was the peak of his high-level public relations work when he presented the Queen with two of his wonderful apparatus done in ivory, especially made for her (Bruce, 1990, p. 241).

> *This incident, as may be imagined, did much to establish the reputation of telephony in Great Britain. A wire was at once strung to Windsor Castle. Others were ordered by the Daily News, the Persian Ambassador, and five or six lords and baronets. Then came an order which raised the hopes of the telephone men to the highest heaven, from the banking house of J. S. Morgan & Co. It was the*

---

[201] Source: http://londonist.com/2014/08/londons-first-telephone-call-mayfair-to-ravenscourt-park.

> *first recognition from the "seats of the mighty" in the business and financial world. A tiny exchange, with ten wires, was promptly started in London; and on April 24, 1879, Theodore Vail, the young manager of the Bell Company, sent an order to the factory in Boston, "Please make one hundred hand telephones for export trade as early as possible." The foreign trade had begun.* (H. N. Casson, 1910, p. 252)

It was the result of Bell's public relation efforts that had in would not much later, June 14, 1878 to be precise, resulted into the creation of the *Telephone Co., Ltd (Bell's patents).* It was the first telephone company in Britain. It had a capacity for 150 lines and opened with 7 or 8 subscribers.

> *The Telephone Co. Ltd, in its first month was merely an agency for selling and fitting up instruments and private lines; and the equipment –sombre omen of thirty years of inactivity that were to follow – was all imported from the United States.* (Robertson, 1947, p. 12)

Bell was not the only inventor active in Britain. His company was to be followed by the creation of other companies, such as—on August 2, 1878— a company of Bell's rival Thomas Edison: the *Edison Telephone Company of London Ltd,* This company was to work with Edison's British microphone patents.

Soon the first exchanges were popping up in London. In early 1879, in Glasgow, an exchange was opened called the 'Glasgow Medical Telephone Exchange'. And in October 1879 the 'Lancashire Telephone Exchange Company' started. It would become a field of fiercely-competing start-ups, again with many mergers and acquisitions. That frenzy resulted three years later in the 'National Telephone Company', the merger of the different smaller companies. Also, equipment manufacturers building telephones were started, such as the 'Gower-Bell Telephone Company' that started in October 1881. Under the Bell license, it would—as we will see further on in more detail—become the Post Office's choice when it started to compete with the private companies. It was a disaster in the making.

> *So, from first to last, the story of the telephone in Great Britain has been a "comedy of errors." There are now, in the two islands, not six hundred thousand telephones in use. London, with its six hundred and forty square miles of houses, has one-quarter of these, and is gaining at the rate of ten thousand a year. No large improvements are under way, as the Post Office has given notice that it will take over and operate all private companies on New Year's Day, 1912. The bureaucratic muddle, so it seems, is to continue indefinitely.* (H. N. Casson, 1910, p. 255)

Doing Business in Europe?

The demonstrations Alexander Bell gave in England, and the resulting business developments, showed that the telephone, although still an immature product trying to find its application, had a lot of business potential. For Bell and his associates it was clear that, after having obtained the US patents, his invention had to be protected in Europe too.

The first country to file a patent application was Great Britain, an obvious choice for many American inventors of that time. For Bell, this was quite interesting as foreign rights were not included in the Association Agreement, and they could be a source of additional income to him. To obtain his British patent, which was a complicated affair and always carried the risk of prior publication, he made an agreement with the Canadian Brown brothers. However, this effort collapsed, and it was along a different route that Bell was granted British patent 4,765 in 1876. This patent controlled, however, only the telephone receiver, where Edison's British patent would control the transmitter.

Soon, Bell organized to obtain patent rights in other European countries. Again, there he experienced the same problems. Getting a patent in Europe was complicated because every country had its own specific patent law. In November 1877 he wrote to Hubbard: 'I have taken patents in Italy, Norway, Sweden and Denmark, but no patents are granted in Holland or Switzerland and if I do not sell quickly here – Europe will be flooded with cheap telephones from Holland and Switzerland.'[202]

The Scandinavian patents were obtained due to the fact that a Norwegian civil engineer named Jens Hopstock on his own initiative took out Scandinavian patents in Bell's name. The grateful Bell gave him a two-year license (Bruce, 1990, p. 246). However, the German patent had been lost because Bell was too late under the rules of the German Patent Law. And indeed, the German company Siemens & Halske, already a dominant electric manufacturer active in telegraphy—among other things like electric motors and dynamos—, soon produced cheap telephones. Getting a patent in the Netherlands was impossible because there the patent law was suspended in 1869. And in France, the patent application was in jeopardy because telephony threatened the governmental telegraph system.

Doing business in all these different countries proved even more difficult. The governments acted differently, the potential local business partners were not always chosen that wisely. And Edison was a strong adversary in Britain because of his patent position, not because of the

---

[202] Letter from Alexander Graham Bell to Gardiner Greene Hubbard, November 1, 1877. Source: http://www.loc.gov/resource/magbell.07900418/?sp=8

success of his company. Then, after quite a bit of struggling, Edison and Bell joined forces and created the 'United Telephone Company Ltd.' (Bell's and Edison's patent) on May 13, 1880.

Overall, the trip to Europe might have increased the public awareness of the new phenomenon of telephony, form a business point of view it was not too successful. For Alexander Bell personally, doing business was not one of his best capabilities, as he acknowledged some years later when he wrote: 'I am not a business man and must confess that financial dealings are distasteful to me and not at all in my line' (Bruce, 1990, pp. 147-148).

However, by now others saw the business potential of the 'speaking telegraph'. Not only in England, but all over Northern Europe.

Ericsson: The Birth of a Telecom Giant

The news of the invention of the 'speaking telegraph' spread around Europe like a wildfire. It created a lot of interest and consequent entrepreneurial activity. An example of this is the story of Lars Magnus Ericsson who created the foundations of a company that would grow into a giant of the telecommunication business.

Lars Magnus Ericsson (1846-1926) was born on May 5, 1846, as the sixth child of smallholders Eric Ersson and Maria Jonsdotter at a farm in a small village in Sweden. At a young age, he joined his father working in the local silver mine. After his father death he started working—already a strong boy at the age of sixteen—in the forgery of a silver mine. In 1867, he went to Stockholm, a city where the Industrial Revolution was in full swing. For agricultural Sweden this was the beginning of its industrialization. The great "Age of Invention" had introduced many novelties in the Swedish society: from railways to telegraphy. It resulted in a lot of industrial activity, such as the manufacturing of locomotives.

Like Lars Magnus, thousands made their way from the countryside each year to seek their fortunes in Stockholm. There Lars worked there for six years for an instrument maker named *Öllers & Co. Telegraph Factory* who mainly created telegraph equipment. It would be the start of the development of his electro-mechanical skills.

> *In Öller's workshop, Lars Magnus was able to work not only with telegraph equipment but also items such as sewing machines and electric bells, as well as devices for electro-medical treatment, teaching and experiments. Everything was produced by hand and therefore vulnerable to fierce competition from foreign companies with large-scale production. … During his five years with Öller, 1867–1872, Lars Magnus was able to gain everyday experience in design and also in supervising other workers. After work, he spent his time on more theoretical studies, including languages; he*

> *taught himself good German and English, for instance. But mostly he did what he enjoyed best: design and draftsmanship.* (Karlsson & Lugn, 2009) [203]

Because of his skills, he was given a travel grant to visit an exhibition in 1869 Moscow and St.Petersburg, followed by two state scholarships to study instrument making abroad between 1872 and 1875. One of the companies he worked at was Siemens & Halske[204] in Berlin where he stayed two years. After that, he worked in workshops in Bern and Neuchatel, Switzerland.

> *'I immediately found a position with Siemens & Halske, then the most eminent workshop in the world for telegraphy and electrical engineering, and I was immediately enraptured to see not merely superior engineering but also the excellent arrangements for the comfort of the workers, which have ever since lodged in my mind as the best of examples.' … 'My income in Switzerland was very sparse but by dint of living on bread and milk, and by traveling fourth-class, I was able to move on and ended up in Karslruhe where a certain Herr Schwerd had founded a factory for the manufacture of telegraph equipment for the Baden railways. As I had recently left Siemens, I was familiar with the area in which Herr Schwerd wished to work and may well have given him one or two useful hints, as when we had to part in the autumn, with tears in his eyes he proffered me a small gratuity.'* [ibidem]

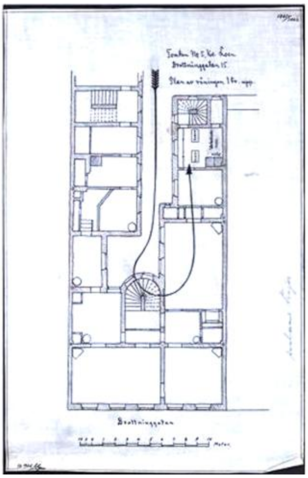


Figure 94: Lars Magnus Ericsson's workshop (1876).

Source: Archive Telefonaktiebolaget LM Ericsson http://www.ericssonhistory.com/company/from-birth-to-merger/lars-magnus-ericssons-mechanical-engineering-workshop/

By now he had become an expert instrument maker with considerable skills in telegraphy. After his return to Sweden he started a—quite small—workshop of his own together with his friend Carl Johan Andersson on April 1, 1876, trading under the name of Firma L.M. Ericsson & Co. (Figure 94). The small enterprise grew and prospered. Around that time, the news of the invention of the telephone came to Europe. Bell's visit to England and his

[203] Source: Cited text is from http://www.ericssonhistory.com/changing-the-world/phones-for-everyone (Accessed November 2015)

[204] The German company Siemens & Halske by that time had already become a major manufacturer of telegraph equipment. See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'.* (2015) pp.291-305

demonstrations reached the Swedish newspapers, and some of his telephones had been sold to pioneering Scandinavians. Such as the Norwegian engineer Jens Hopstock.

> *Just over a month later [than the Bell Company was started], on August 21–22, 1877, Bell telephones were demonstrated in Stockholm by Jens Hopstock, a Norwegian engineer who soon became Bell's exclusive agent in Norway, Sweden and Denmark. As part of his marketing, Hopstock connected two Bell telephones between the Grand Hotel and the telegraph office at Skeppsbron, and lectured to the Swedish Railways Association. His main targets were officials at the Swedish Telegraph Board and Swedish Railways. King Oscar II was offered a special demonstration at the palace at Drottningholm, west of Stockholm. Two cables were erected between two of the royal buildings – "and the American apparatus passed muster one more time", the press reported.* [ibidem]

Bell's telephone, still in its infancy, was soon copied by Siemens & Halske—as it was not patented in Germany, nor in the Nordic countries—and within weeks the telephones were offered for sale by an agent in Stockholm. Soon Bell's telephones were manufactured in Oller's workshop in December 1877, and others followed suite. Lars Magnus became interested, started repairing faulty telephones, and in December 1878 sold the first telephones of his own production.

> *One qualified player in this nascent industry, Siemens & Halske, also lost no time. On December 6, 1877, the company's agent in Copenhagen, the Ritzau Bureau, advertised in Stockholm offering telephones like those used by the Post & Telegraph Office in Berlin. Bell's telephones had not been presented in Berlin until October 24, but the head of the German post and telegraph system acted immediately and asked Siemens & Halske to make some copies of the telephone. Werner Siemens soon saw that they could be made more powerful if Bell's rod magnets were replaced by larger horseshoe magnets. This was the beginning of Siemens & Halske's telephone business and it took no more than six weeks until they had an agent offering telephones for sale in Stockholm.* [ibidem]

This introduction of the first telephone meant that the first fixed telephone lines in Sweden had to be erected. Soon the experimental lines were followed by the first entrepreneurs offering telephone services, and creating telephone exchanges, to the eager public. The Telephone was the talk of the town, everybody—who could afford one—wanted the modern communication tool.

In September 1880 the Bell Telephon AB started its network in Stockholm, offering its services to 121 customers. Other networks followed, using Bell's telephones but often the telephones were manufactured by Lars Magnus. By 1880 he designed a wall-mounted telephone that he sold in combination with his plug board exchange (Figure 95). Before the end of 1881, local networks had been built in Gothenburg, Malmö, Sundsvall, Norrköping, Linköping, Eskilstuna, Västerås and Örebro. The first three chose Bell as their supplier, the last five L.M. Ericsson & Co. It was the beginning of the telephony era in the Scandinavian countries. Lars Magnus expanded his company with a factory in Tulegatan, manufacturing telephones in large volumes, improving the technology and creating new designs that became known as the Swedish Design. By 1883, the second Industrial revolution was well underway. Electricity had penetrated society: electric light had arrived and telephony was on the brink of its breakthrough. Sweden became industrialized and many Swedish inventors and entrepreneurs contributed to this industrial development.

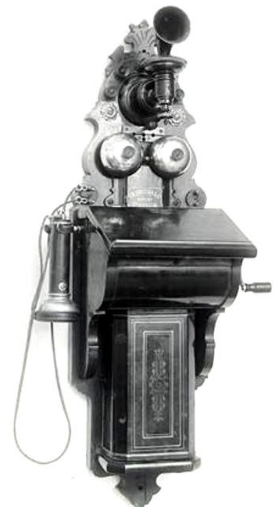


Figure 95: Lars Magnus Wall mount Telephone (1882).

Source: Archive Telefonaktiebolaget LM Ericsson http://www.ericssonhistory.com/products/the-telephones/Ericssons-wall-telephone-set-the-pulpit-telephone-from-1882/

In 1883, two new "genius industries" were founded: Elektriska Aktiebolaget in Stockholm, the forerunner of ASEA, based on the dynamo construction developed by Jonas Wenström (manufacture initially took place in Arboga); and AB Separator, based on the centrifugal separator invented by Gustaf de Laval a few years earlier. Its factory was built on Fleminggatan in Stockholm. …

In February 1883, Cedergren issued a prospectus for the establishment of a new, independent Swedish telephone company, Stockholms Allmänna Telefonaktiebolag (SAT), which would offer "public telephone connections at a lower price and the use of Swedish equipment". It aimed to provide "telephone lines in every building and for all the tenants in them". L.M. Ericsson & Co. had to undertake on its part not to supply telephones or any other equipment to any other telephone company in Stockholm. …

Stockholms Allmänna Telefonaktiebolag [Stockholm Public Telephone Company] was founded in April 1883 and began operations on May 15; by the end of June more than 600 shares had been taken up. On October 31, 1883, it opened its central telephone exchange. … A 1,200-line gantry was erected on the roof of the central exchange, which was built to cope with 3,000 subscribers. [ibidem]

This was Scandinavia in 1883. Six years after Bell's invention, the crude apparatus of the speaking telegraph that would become the telephone, had started to conquer the north of Europe. Even, in 1887, a telephone play called 'On the Phone' was in the theatres. In Sweden it was L.M.Ericsson who supplied the telephones—among those the famous Skeleton Telephone of 1892 (Figure 105)—and the exchanges.

By 1889, the Bell Company moved out of the Swedish telephone market, leaving it to the Swedish entrepreneurs. In 1900, Lars Magnus retired from his company, and over the coming years the company would grow with the telephone expansion and become a giant in the telecommunication business.

Western Union enters the Telephone Business

In the meantime, back in the US, the business interest had also changed completely. Although the telegraph firms—ie Western Union as it had quite a monopoly—had not been interested originally, when it became clear that Bell was selling many of his telephones, they changed tactics.

> *By the technical standards of the telegraph industry, Bell's first telephones were pathetically crude and Western Union managers were probably confident that their inventors could design a better telephone. With talented experts such as Edison, Elisha Gray, and George Phelps (who supervised the electrical shops of Western Union), all of them knowledgeable about the acoustic telegraph, it seemed far more sensible for Western Union to perfect its own telephone [Gorman/Carlson p.144] … By January 1877, as it became clear that Western Union would not buy Bell's telephone patent, Edison stepped up his telephone efforts. … By the spring of 1878, both Edison and Western Union were satisfied with the carbon telephone, and the company installed it in several cities. Edison assigned his telephone patents to Western Union for $100,000.* (Gorman & Carlson, 1990, pp. 149, 154)

Western Union not only stepped up the technical developments as executed by its independent inventors, it decided to go in the telephone business. Within six months after the *Bell Telephone Company* was founded, in December 1877 Western Union created the *American Speaking Telephone Company* with $300,000 capital[205]. One of the reasons was that they saw the telephone as a complimentary service to their telegraph business. Instead of physically going to the telegraph office, customers could phone the office and dictate the message to be transmitted.

[205] Its agent was Peter A. Dowd, who acted as an agent distributing the telephones manufactured by Western Union. He would be the one Bell attacked for infringement later on.

The creation of this company had two effects. First, the action of Western Union became a huge threat to Bell's enterprise. Western Union loudly declared that: '… it had "the only original telephone," and that it was ready to supply "superior telephones with all the latest improvements made by the original inventors—Dolbear, Gray, and Edison"' (H. N. Casson, 1910, p. 60). It was not just a business threat; that technical argument had become a concern to Bell and Watson also.

> *The rumors that Watson and the Bell people had been hearing were just more than rumors. Their customers were complaining that the Bell instruments were not nearly as powerful as those of the American Speaking Telephone Company, the Western Union subsidiary.* (Evenson, 2000, p. 129)

One has to realize that after the original discovery and the patent of 1876, no working model had been supplied to the Patent Office. Even worse, it took Alexander Bell three years to produce a good working telephone. Having an idea, creating the invention and patenting the concept, is something totally different than creating a practical, working device. Second, Western Union's entry in the telephone business changed the general view that the telephone was just a toy because such a large company was investing in it. And that changed, in turn, the investment climate. So, Bell and his companions—that is, Sanders and Hubbard—acted, and in February 1878 the *New England Telephone Company* was organized.

> *Sanders's relatives, who were many and rich, came to his rescue. Most of them were well-known business men—the Bradleys, the Saltonstalls, Fay, Silsbee, and Carlton. These men, together with Colonel William H. Forbes, who came in as a friend of the Bradleys, were the first capitalists who, for purely business reasons, invested money in the Bell patents. Two months after the Western Union had given its weighty endorsement to the telephone, these men organized a company to do business in New England only, and put fifty thousand dollars in its treasury.* (H. N. Casson, 1910, p. 61)

The discussion was how to stay in control with so many new investors. Instead of reorganizing the Bell Telephone Company, Hubbard agreed to allow the formation of a new company, the *New England Telephone Company*, that would have sole and exclusive coverage of the New England market. The new company issued 50,000 shares of new stock, which were immediately purchased by the Boston Financiers. (Ward, 1997, p. 125)

As the prospects for the new activities had changed considerably, they not only needed capital. The original Association was badly in need of professional management. None of the partners were, after the first venturing start, equipped to guide the company into the next phase of its formidable growth. Therefore, they needed somebody with a background in the amazing new technologies of telegraphy and someone experienced in running a large organization.

It so happened that Hubbard, on his many trips through America on his mail commission, regularly met with someone who was in authority over thirty-five hundred postal employees; his name was Theodore N Vail[206].

> *One morning the indefatigable Hubbard solved the problem. "Watson," he said, "there's a young man in Washington who can handle this situation, and I want you to run down and see what you think of him." Watson went, reported favorably, and in a day or so the young man received a letter from Hubbard, offering him the position of General Manager, at a salary of thirty-five hundred dollars a year. "We rely," Hubbard said, "upon your executive ability, your fidelity, and unremitting zeal." The young man replied, in one of those dignified letters more usual in the nineteenth than in the twentieth century. "My faith in the success of the enterprise is such that I am willing to trust to it," he wrote, "and I have confidence that we shall establish the harmony and cooperation that is essential to the success of an enterprise of this kind." One week later the young man, Theodore N. Vail, took his seat as General Manager in a tiny office in Reade Street, New York, and the building of the business began.* (H. N. Casson, 1910, p. 62)

This way, in 1878, they got the first professional manager on board. Soon, it was Theodore N Vail (1846-1920) who organized the business and brought in investors. And the chief leader of the financiers was William H. Forbes, one of the Boston Brahmins. He would be the other person that would guide the company through the next years of its turbulent growth.

David against Goliath: Bell Telephone Company Fights Western Union (1877-1879)

As part of its strategy to crush Bell, in March 1878 Western Union had filed a block of interferences against patents on behalf of Gray and several other inventors. But in September 1878 the management of the Bell Company had decided to fight back in court. One of the first things Vail did was to turn the table against Western Union and send a copy of Bell's patent to every agent: 'We have the only original telephone patents,' Vail wrote. 'We have organized and introduced the business, and we do not propose to have it taken from us by any corporation' (H. N. Casson, 1910, p. 63).

[206] Theodore Newton Vail (1845-1920) was member of the Vail family of Morristown, New Jersey. He was the nephew of Alfred Vail, friend and co-worker of Samuel Morse who also lived in Morristown for several years. In 1876 he was appointed General Superintendent of the US Postal Service's 'Railway Mail Service'.

Next, Vail restructured the contracts with the agents, made them all the same five-year lease, confined each agent to one physical place and reserved them all the rights to connect one city to another. In addition, he started standardizing the telephonic equipment by controlling the factories that made it. But it was still the little David against the giant Goliath: the Bell Company against Western Union. And that little Bell, both the 'New England Telephone Company' and the 'Bell Telephone Company', was struggling indeed:

> *Month after month, the little Bell Company lived from hand to mouth. No salaries were paid in full. Often, for weeks, they were not paid at all. In Watson's note-book there are such entries during this period as "Lent Bell fifty cents," "Lent Hubbard twenty cents," "Bought one bottle beer—too bad can't have beer every day." More than once Hubbard would have gone hungry had not Devonshire, the only clerk, shared with him the contents of a dinner-pail.*
>
> *Each one of the little group was beset by taunts and temptations. Watson was offered ten thousand dollars for his one-tenth interest, and hesitated three days before refusing it. Railroad companies offered Vail a salary that was higher and sure, if he would superintend their mail business. And as for Sanders, his folly was the talk of Haverhill. One Haverhill capitalist, E. J. M. Hale, stopped him on the street and asked, "Haven't you got a good leather business, Mr. Sanders?" "Yes," replied Sanders. "Well," said Hale, "you had better attend to it and quit playing on wind instruments." Sanders's banker, too, became uneasy on one occasion and requested him to call at the bank. "Mr. Sanders," he said, "I will be obliged if you will take that telephone stock out of the bank, and give me in its place your note for thirty thousand dollars. I am expecting the examiner here in a few days, and I don't want to get caught with that stuff in the bank."* (H. N. Casson, 1910, p. 74)

In the meantime, Alexander Bell had returned from his honeymoon of a year-and-a-half. He had failed to establish a solid telephone business in England, was severely discouraged and even became hospitalized. The company struggled again, and was on the brink of bankruptcy. The business was half-starved by cheap rates and clumsy apparatus.

> *Fortunately, there came, in almost the same mail with Bell's letter, another letter from a young Bostonian named Francis Blake, with the good news that he had invented a transmitter as satisfactory as Edison's, and that he would prefer to sell it for stock instead of cash. If ever a man came as an angel of light, that man was Francis Blake. The possession of his transmitter instantly put the Bell Company on an even footing with the Western Union, in the matter of apparatus. It encouraged the few capitalists who had invested money, and it stirred others to come forward. The general business situation had by this time become more settled, and in four months the company had twenty-two thousand telephones in*

use, and had reorganized into the National Bell Telephone Company, with $850, 000 capital and with Colonel Forbes as its first President. (H. N. Casson, 1910, p. 75)

The technical problem of voice quality now solved, this was the chance for the Bell Company to get engaged in the battle of David against Goliath. The management decided to defend their patent rights and attack the giant Western Union. This company was one of the largest in the world. A company backed by rich investors like the Vanderbilts, with $40 million in capital and owning the rights of way along roads, railroads and on housetops. In other words, a formidable adversary that was aggressive, buying out several of the Bell exchanges, starting a war with others, and preparing infringement cases on Gray's patents. For a small operation like Bell's, to engage in corporate war against such an adversary was close to corporate suicide.

The Bell - Western Union Agreement (1879)

At that time Western Union itself was under attack from a robber baron. His name was Jay Gould, and he was a railroad baron who had bought up a range of smaller telegraph companies and created the American Union, and who was after Western Union's telegraph monopoly. Gould's threat of a hostile takeover, that would ultimately succeed in 1881, worried Western Union's management. Gould also went into the telephone business, gaining control of telephone companies that owned the telephone exchanges and local networks. He started to connect them with each other—thus creating the early regional telephone networks—through the existing telegraph network of American Union. Obviously, the alliance of Gould's and Bell's interest could create a business threat for Western Union.

On the personal level, much had changed. The former president of Western Union, William Orton, had died; his successor was Norvin Green. On the Bell side, the Bostonian investors, who had financed the expansion of Bell Telephone and were led by William H. Forbes, were now effectively in power. With the old powers gone, Green and Forbes, without the personal history Orton and Hubbard had, began negotiating a settlement.

> *Forbes immediately began unofficial discussions with Western Union to find a settlement to the corporate war. Western Union was more inclined to talk to Forbes once they realized that Hubbard's position in the company was limited. Over the next several months, as the Gould challenge reduced Western Union's earnings, discussions were held over settlement. For a while both parties discussed the possibility of direct merger, but eventually, after Gifford's advice concerning the patents, it was decided, instead, to sign the settlement agreement under which Western Union would receive a portion of Bell's profits.* (Ward, 1997, p. 125)

Therefore, the hostilities between the two companies were ended with the agreement on November 10, 1879. Western Union Company gave up all its patents, claims, network and inventory of 56,000 phones (a Western Union phone at right). In return, they would receive 20% of the rentals over the next seventeen years—the life of the Bell patents. Bell also was to pay $325.000[207] and stay out of the telegraph business.

Bell's Manufacturing gets Organised

Again, a major problem for the pioneering company had been solved. But there were others that needed attention too. The business development may have been successfully focused on the organization of the *licensing-business*, but all those phones had to be made. Originally, the manufacturing of the telephones was organized by Watson. He used the Boston shop of Charles Williams Jr, who also had made Alexander's prototypes. And here they had earlier rented space for Bell's experimenting (Figure 96).

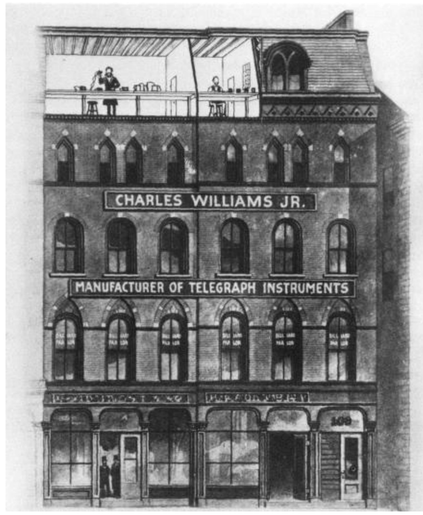


Figure 96: Charles Williams' electric workshop in Boston.

Bell had rented space in the attic.

Source: USPTO

Bell made a manufacturing arrangement with Charles Williams Jr. Under the patent protection, no one else was allowed to manufacture, install or use a telephone similar to Bell's telephone. Only when they obtained a manufacturing license would this be possible for some trusted manufacturers. Early in 1877 Watson gave Williams the first production order of 25 'box telephones' and 50 'hand telephones'. Soon he was manufacturing phones at the rate of 25 a day and could not keep up with the demand.

> *Until 1881, Bell obtained its telephones from the shops of Charles Williams, Jr. of Boston. Williams shop had employed Thomas A. Watson, and was used by Alexander Graham Bell to conduct many of his early experiments. The arrangement with Williams was based on a personal relationship with Bell and*

[207] Equivalent to £7,960,000; calculation based on historic standard of living. Source: http://www.measuringworth.com/ukcompare/relativevalue.php. (Accessed December 2015)

Watson, and also on the fact that Williams extend to the fledgling company a very generous line of credit. But Williams shop was hard pressed to meet the growing demand for telephone sets, and even as early as 1879 Theodore Vail was complaining about the backlog on telephone orders produced by the Williams Shop's methods of production. (Ward, 1997, p. 155)

In the spring of 1879, a newly formed "National" Bell Telephone Company made agreements with four other geographically located manufacturers for telephone equipment. The Electric Merchandising Co. of Chicago, Davis and Watts of Baltimore, Post and Company of Cincinnati, and the Indianapolis Telephone Company. (A recent Bell licensee run by E.T Gilliland.) Williams was still the sole producer of receivers and transmitters but now free to focus on them only, although he did make some apparatus for the New England and New York markets. By the end of the year, Williams invested $2000.00 on new machinery and increased his work force to 60. His production went to 670 phones a week and by 1880, a 1000 per week, but it was still not enough.[208]

As the Bell Company started leasing more equipment to the entrepreneurs who organized a telephone company, Bell had to better control the manufacturing of those telephones. They were lucky, as after the agreement with *Western Union* in November 1879, their manufacturer of telephones, *Western Electric Mfg. Co.*, came out the settlement without a telephone network to supply to. It was quite an interesting situation. On the one hand, there was a manufacturing organization without a client, and on the other hand, there was a telephone network that had a manufacturing problem.

By this time, 1881, Western Union was pressuring Western Electric to either sell the company outright to Western Union, or face the real prospect of having Western Union assign its work to another company. The pressure by Western Union toward Western Electric was the direct result of the take-over of Western Union, in 1881, by Jay Gould. Gould's take-over of Western Union was marked by a high level of public uneasiness, and ruthless business tactics. (Ward, 1997, p. 156)

Within this context, Bell made a strategic move, that suited the owners of Western Electric. Charles Williams became involved in the deal too.

A proposal was then made for the creation of a Consolidated Mfg. Co., formed by a merger of the Gilliland Co. and Charles Williams' factory into the Western Electric Mfg. Co. On July 5 1881, Western Union, who was under a hostile take-over that at time, sold its one third interest in the W.E. Mfg. Co. to the American Bell Telephone Co. … On July 23, 1881, Charles Williams offered

[208] Source: http://www.telegraph-history.org/charles-williams-jr/part2.html (Accessed June 2015).

> *to sell his firm to the American Bell Co. for $120,000 in return for cash or stock of the new Consolidated Mfg. Co. A contract was signed on February 6, 1882 along with a complex series of stock transfers. Out of this the Western Electric Company was formed receiving permanent and exclusive rights to manufacture telephones and apparatus for American Bell. By April of 1882, Bell owned 53 percent of Western Electric's stock. Williams' now expanded shop on 109 and 115 Court Street became a Western Electric factory, with Charles Williams staying on as its manager. Ibidem*

With the growth of telephone usage, the local networks of telephone exchanges expanded. By 1880 they were well established, and the need to be connected to each other over longer distances became apparent. As there was already a cable system in existence for telegraphy over long distances, agreements were made to lease these wires for the telephony usage. This resulted again in reorganization, and on February 28, 1885, the *American Telephone and Telegraph Company* was created. It would become the parent company (AT&T) for all the later developments of the Bell System[209].

Bell Gets Organised (1875-1885)

Returning to the subject of organizing the business, the following had happened. From that early *Patent Agreement* between Alexander Bell, Thomas Sanders and Gardiner Hubbard in 1875, after the two important patents had been granted in 1876 and 1877, it had come to the creation of the *Bell Telephone Company, Gardiner G. Hubbard Trustee* that was to exploit the patents. As Hubbard also controlled his daughter Mabel's shares by power of attorney along with his own, he had the majority.

The decision to start exploiting the patent rights by licensing it to others resulted in the creation of the *New England Telephone Company* in February 1878. In addition to the New England Telephone Co., the *Bell Telephone Company* was created on July 30, 1878 (Figure 97). Gardiner assigned all patents owned to him or held by him to the new company. This meant that soon Hubbard's dominant role in the further development of the company would end.

In a short period of a few years (1875-1877), the first organizational structures had been created (Figure 97, top). Soon, in 1879, they would be reorganized again, this time in the *National Bell Telephone Company* and the *International Bell Telephone Company* in 1879. The International Bell (IBTC) was organized in order to promote sales of its telephone equipment throughout Europe. It rapidly evolved into a holding company as an

[209] By 1900 there were nearly 600,000 phones in Bell's System; that number shot up to 2.2 million phones by 1905, and 5.8 million by 1910.

important European telephone service provider and manufacturer, with major operations in several countries. Examples of this include operations in the Netherlands where, in 1881, the *Nederlandsche Bell Telefoon Maatschappij* (Dutch Bell Telephone Company) was formed, and the operations in Belgium where, in 1882, the *Compagnie Belge du Téléphone Bell* (the Bell Telephone Company of Belgium) was formed.

That was only the beginning, as the rapid growth of the business—the result of Vail's management —required further expansion. And that expansion needed to be financed. As it was obvious now that there was a future in telephony, quite a few Bostonion investors could be found willing to invest. This had already, in 1879, resulted in the creation of the *National Bell Telephone Company* with a capital investment of $850,000[210].

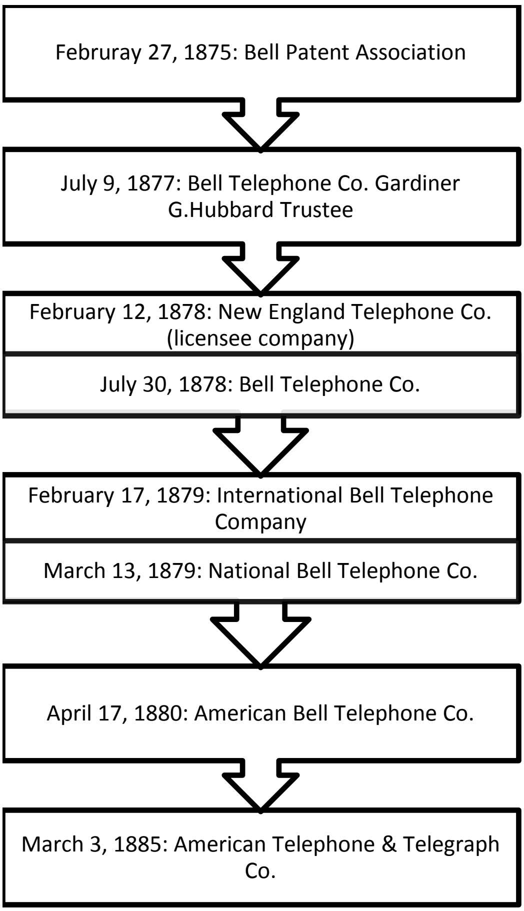


Figure 97: Successive organizations and companies of Bell (1875-1885).

Source: Based on (Joel & Schindler, 1975): Figure 2-1, p.27

During the early phase of corporate organization William H. Forbes, a prominent Boston financier and son-in-law of Waldo Emerson, joined the group of Boston investors who had combined to provide financial support for the Bell interest. … On January 29, 1879 Forbes took steps towards uniting all of the Bell interests in one company to be called the National Bell Telephone Company. …. Then, on March 20 of the same year, both the New England Telephone Company and the Bell Telephone Company assigned

[210] Equivalent to $20,800,000 in 2014 when calculated as wealth based on the historic standard of living. Source: www.measuringworth.com.

> *their rights under the two basic Bell patents to is new company, and these two earlier companies were consolidated.* (Joel & Schindler, 1975, p. 30)

> *As part of the process of incorporation, the new majority stockholders accused Hubbard of financial mismanagement, voted Forbes in as President, and reduced Hubbard to only a member of the Executive Board of the Company* (Ward, 1997, p. 126)

As the spread of telephony in the late 1870s and early 1880s was spectacular, competition was also becoming strong. Rival companies popped up, and the concept of leasing began to show its limitations. In order to gain more control of the licensing companies, it was necessary to participate in these companies buy acquiring stock. Also, the agreement that was reached with the *Western Union Telegraph Company* in 1879 meant a considerable increase in business as the *American Speaking Telephone Company* went to the Bell-side. That meant that considerably more capital was needed, and the *National Bell Telephone Company* had to be reorganized.

> *To permit this reorganization on an adequate scale and to permit the new corporation to hold stock in other corporations, the Massachusetts Legislature passed a special Act by Governor Long on March19, 1880. ... In accordance with this Act the American Bell Telephone Company was formed on March 20, 1880. … On December 8, 1880, the American Bell Telephone Company declared its first dividend (3%) and on March 29, 1881, issued its first annual report.* (Joel & Schindler, 1975, pp. 31-32)

Bell was now the *American Bell Telephone Company*. The power structure had changed, and Bell, Watson, Sanders and Hubbard's role in the company had ended.

> *The final cut to Hubbard, and the remaining original partners, came the next year. With the settlement of the corporate war with Western Union, a firm patent in hand, and control now vested in the Boston banks and financial houses, the Board of Directors once again reincorporated Bell under Massachusetts law. On April 17, 1880 the American Bell Telephone Company came into existence. In the process, both Hubbard and Sanders were excluded from the management structure of the company. In protest, Bell resigned from the company, while still being retained as a consulting engineer, and moved to Canada. Thomas Watson was given the position of general inspector of equipment, but removed from the actual construction of the equipment. Three years later, Watson resigned to pursue new interests. … What had originally been developed as a close family and socially connected network of collaborators and investors, fell to the financial might of the market and the need for capital. Bell Telephone was now controlled exclusively by the Boston financial market.* (Ward, 1997, p. 126)

By the end of 1879, two national monopolies had been created in the telecommunications industry: Western Union for telegraph, and Bell Telephone for telephones. In the process, the original telephone pioneers had been forced to leave their creation in the hands of others, many of them Bostonians.

From the early start some five years ago, through a range of corporate reorganizations, the 1875 patent association with Bell, Hubbard and Sanders in control, had grown into the American Bell Telephone Company, a company now controlled by others, such as the Bostonian financiers headed by William Forbes.

> *By the end of 1880 American Bell Telephone Company had been transformed from a personal, closely knit group of inventors and financial backers, into a formal corporation controlled by the majority owners of the company's stock. It would be wrong, though, to assume that there did not exist a personal relationship between the new owners. The new group that had assumed control of the corporation had both financial and social roots within the upper strata of Boston families, and between them, and their family relations, controlled fifty-six percent of the newly incorporated company's stock. The leader of the new group was William H. Forbes, who, in 1880, was elected President of American Bell Telephone.* (Ward, 1997, p. 156)

In half a decade, a revolutionary development had taken place, and the early pioneering partners had lost power. In the meantime, the telephone market continued to grow. What started with those first lines in 1877 had by 1880 grown into some 50.000 telephones in the US. That was only a prelude of what was to come in the near future.

The Founding Fathers Leave the Organization

By 1881 both Thomas Watson and Alexander Bell, being financially independent by that time, had left the company and gone their own ways. The Bell Company, in all its different organizational forms and associated companies, proceeded to grow. It would become one of the biggest telephone companies in the world. The share each of the associates held in the activity diminished over the years quickly (Figure 98), but as later the total value of the stock rose over the years, their share made them wealthy.

In early 1880 Alexander Bell had left the Bell Telephone Company and had sold quite a few of his and Mabel's shares by 1883. Originally, the partners Bell, Hubbard and Sanders each owned one third of the Association (1873). Over time that changed; their individual share in ownership dropped, but the value of the Bell Telephone enterprise rose. The value of their diminishing ownership would rise steadily. Take, for example, the Bell's shares (his wife Mabel had gotten most of Bell's shares

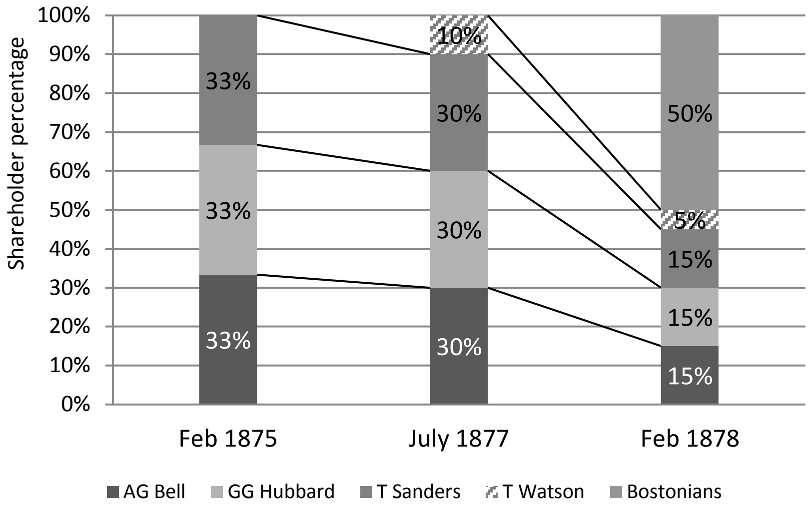


Figure 98: Development of early shareholding rights by the partners.
Source: (Bruce, 1973) p.291

as a wedding gift). In March 1879 their 1,106 shares had a value of $71,890. Then the value had risen from $65/share in March 1879, to $350/share in September, $500/share in October, and $775/share in November. After the Western Union agreement they were even valued at $1,000/share. Regularly, they sold some of the shares. When in 1880 the National Bell Telephone Company was created, and the shareholders got 6 shares in the new company for every share they owned, the Bell's (ie Mabel) owned 2,975 of new shares. In 1881 a third of these were sold. By 1883 all their American investments were valued at $900,000[211], yielding an annual income of $37,500[212]. At the beginning of 1885 they still had 2,038 shares that paid $32,380 in dividends. (Bruce, 1990, p. 292)

In his mid-thirties, Alexander Graham Bell was a rich man, who pursued his inventive interests in science and technology, from aircraft to the *photo-phone*. But his passion was with the hearing-impaired. He spent much of his royalties on the *Association to Promote the Teaching of Speech to the Deaf*. However, he could not disconnect himself from the disputes, lawsuits and controversies around his patents. They would haunt him the rest of his life.

211 Equivalent to $21.5 million in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

212 Equivalent to $896,000 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

Together with Charles Sumner Tainter, a scientific instrument maker, engineer and inventor, he created in 1880-1881 the Volta Laboratory (also known as the 'Alexander Graham Bell Laboratory'). This was funded by a trust fund, the Volta Fund, with money Bell had obtaining winning the French 'Volta Prize'. The prize was awarded to Bell in 1880 by the Académie Francaise for his work on the telephone. The laboratory focused on research for the analysis, recording and transmission of sound. It resulted in the inventions of a) the *photophone*, a wireless, optical telephone that transmitted speech with a beam of light, and b) the *phonograph*, a sound recording device using a wax cylinder. But his main interest remained helping and working with deaf people. Bell died of complications arising from diabetes on August 2, 1922. Upon the conclusion of Bell's funeral, 'every phone on the continent of North America was silenced in honour of the man who had given to mankind the means for direct communication at a distance. (Osborne, 1943, p. 18)

Thomas Watson was 27 years old when he resigned in 1881. After a yearlong trip through Europe, he married and started a farm. But farming did not agree with him, so he started his own machine shop and worked on a steam engine. In 1883 he founded, with other businessmen, the *Fore River Ship and Engine Building Company* that soon became one of the largest shipyards of the US, employing 4,000 people. Although the company went into a downturn later on, Watson pursued other interests like geology and elocution. He even spent, at the age of 56, a year in Great Britain as a Shakespearean actor. Watson died of heart disease on December 13, 1934, when he was 80 years old (Camenzind, 2007, p. 87).

Subsequent to Bell and Watson's departure, the other contributors to the early telephone also withdrew.

> *Thomas Sanders sold his stock for somewhat less than a million dollars, and presently lost most of it in a Colorado gold mine. His mother, who had been so good a friend to Bell, had her fortune doubled. Gardiner G. Hubbard withdrew from business life, and as it was impossible for a man of his ardent temperament to be idle, he plunged into the National Geographical Society. He was a Colonel Sellers whose dream of millions (for the telephone) had come true; and when he died, in 1897, he was rich both in money and in the affection of his friends. Charles Williams, in whose workshop the first telephones were made, sold his factory to the Bell Company in 1881 for more money than he had ever expected to possess.* (H. N. Casson, 1910, p. 85)

Overview of the Pioneering Years

In the preceding, we have observed quite in detail what happened around the invention of the telephone by Alexander Graham Bell. It is time to wrap up this analysis of the pioneering years of the man and his invention as it occurred over the time period of less than a decade.

The young Alexander Graham Bell—as one can observe from all the accounts from his early life after immigration—was a man with two specific fields of interest. Firstly, he was educated in the tradition of his father: elocution and the acoustics of speech. He had built up considerable experience working with the deaf, and had over time built up knowledge what others had discovered about the 'Nature of Sound' (eg Scot, Helmholz). By profession an acclaimed teacher of the deaf, with training and talent in music and elocution, not to mention a familial flair for the dramatic, one could say that the 'acoustics of speech' was his field of expertise. Secondly, he was like so many people in that period of time, fascinated by the new technology of electricity. The new possibilities that the telegraph brought in transmitting the written word over a distance with lightning speed, sparked also his imagination. Imagine that the spoken word could be transmitted in an equivalent way over distances. In short, Bell was enthusiastic about—maybe even obsessed with—'electric speech'. It was a man with a vison and a drive who hardly could have known what the future would bring.

Early Development Activity: from Idea to Concept

From his early experimenting in his workshop on the Brantford farm in Canada, Bell followed a development trajectory where he wanted to transmit sound—the collection of air vibrations with many frequencies—over distance, investigating the properties of other devices like the piano and the human ear. From his piano-experiments to his ear membrane-experiments, transmitting sound was his focus. He had the idea that "it would be possible to transmit sounds of any sort" by the continuous variation of the intensity of the electric current. This became his idea of the 'undulatory current'. But that current had to be created, it had to be converted from the mechanical air vibrations that constitute sound.

Bell held lengthy discussions with his father explaining what he thought he could achieve with a sound-driven transmitter. A device that was producing an electrical signal which would instantaneously travel an electrical circuit like the telegraph to a receiver at another location where it would be converted back to sound. He wrote 'If I could vary the intensity of the electric current in exact proportion to the variation of the air density in the production of words, I would be able to transmit speech by telegraph.' (Rens, 2001, p. 47). For that he needed to convert the air-vibrations into 'undulatory currents' (aka Alternating Current: AC). Therefore, Bell was having his vision on both the transformation and transmission of sound.

The question was how to realize that transformation and transmission. He went for advice to Joseph Henry, who inspired him to continue and acquire one way or the other the knowhow he needed. Although being capable in his profession, he was lacking knowledge and skills in the mechanical and electric arts. He was not an instrument maker (like Watson), neither was he a 'electricien' (like Henry and Farmer). Nevertheless, as we have seen, he managed to compensate those lacking capabilities. Moreover, he found himself in an adequate environment as Boston at that time was a stimulating business environment. A city where telegraphy is everywhere: the telegraph service providers, but also the manufacturers of telegraphic equipment. The city was a beehive of optimism that characterized the Gilded Age. In addition to that, since the mid-forties Boston had developed into the nation's leading scientific centre. Higher education in technical disciplines and scientific research work was executed at the Massachusetts Institute of Technology, opened in 1865. All in all, Boston was an important centre in the region of New England where the American Industrial Revolution at first developed.

Early Business Activity: from Association to Corporation

Having profiled in general terms the man, his aspirations, visons and capabilities, as well as his experimental activities, one can see that there are quite important moments early in his life related to the development of the telephone. Those were the activities of a more business-like nature. Initially it was about finding people who were willing to finance his experiments, willing to help fulfil his dreams. In today's terms we would call them angel-investors. People who would be involved, who had complementary capabilities and, above all, shared his vison. Not much time later, it was about expansion, about the growth of the activities (Figure 99).

Work of Helping Angels

Bell had his vision about realizing his dream of 'electric speech'. By 1874 he had proved it to be possible, but he lacked the means and capabilities to convert that dream into reality. He needed money to finance the further development. He needed people with complementarily knowledge and experience. Luckily he found them close by as both the fathers of his two students—who know him now quite well on a personal level—believed in his vision.

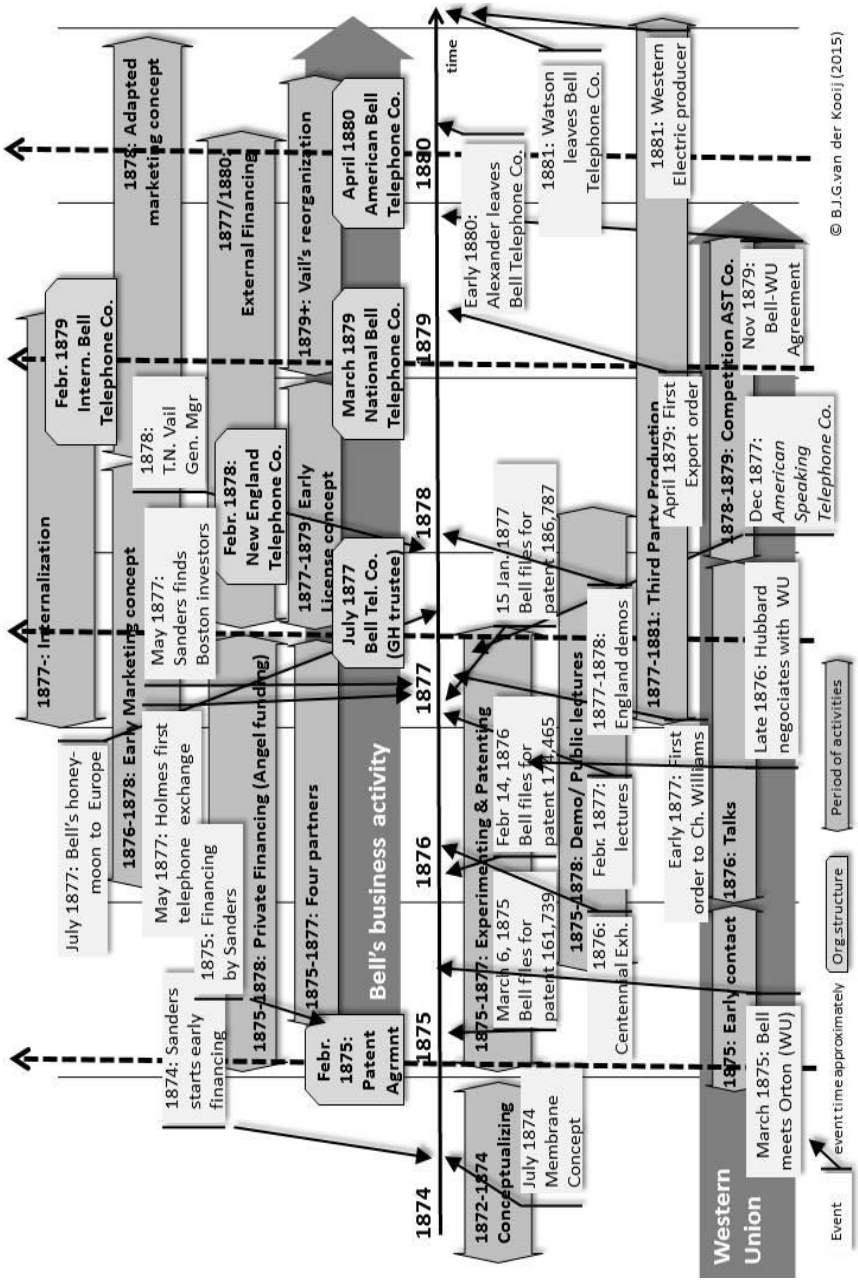


Figure 99: Timeline of the pioneering years of Bell's business development.
Figure created by author

Both had seen him working with dedication, both believed in his dream. Sure, each of them might have had a different personal objective, but they both recognized the value of Bell's experiments and the result he obtained.

The three of them created the *Patent Agreement* in February 1875, each having a third participation in the agreement. Not much later, the fourth partner was added to the association when the 'mechanicien' Watson—who as employee of Charles Williams had already earlier worked with Bell—joined the team and got a 10% share in the agreement. Without doubt, the partners had had lengthy discussions over what to do with Bell's idea and his vision. Hubbard bringing in his experience with the politics around telegraphy, his vison what should be done to serve the people with better communication services. Sanders, as experienced executive, contributing with his ideas how act. It is not too difficult to image Bell's mood at that moment in time:

> *From this moment, Bell was a man of one purpose. He won over Sanders and Hubbard. He converted Watson into an enthusiast. He forgot his musical telegraph, his "Visible Speech," his classes, his poverty. He threw aside a profession in which he was already locally famous. And he grappled with this new mystery of electricity, as Henry had advised him to do, encouraging himself with the fact that Morse, who was only a painter, had mastered his electrical difficulties, and there was no reason why a professor of acoustics should not do as much.* (H.N. Casson, 1910, p. 31)

The next question was how to organize all those activities that were needed. Activities—next to those of a technical nature Bell and Watson took care off—that were related to doing business[213].

> *It was impossible for Sanders, or Bell, or Hubbard, to prepare any definite plan. No matter what the plan might have been, they had no money to put it through. They believed that they had something new and marvellous, which someone, somewhere, would be willing to buy. Until this good genie should arrive, they could do no more than flounder ahead, and take whatever business was the nearest and the cheapest. So while Bell, in eloquent rhapsodies, painted word- pictures of a universal telephone service to applauding audiences, Sanders and Hubbard were leasing telephones two by two, to business men who previously had been using the private lines of the Western Union Telegraph Company.* (H.N. Casson, 1910, p. 57)

[213] On present terms this was the range of activities of creating and executing a business plan: defining product/-market combinations, finding financial means, using opportunities and compensating weaknesses, etc., etc..

Now the experimenting had proved the concept and the initial financing was more or less taken care of by the 'angels'[214], it continued their pioneering phase to convert the prototypes into working models, and protect it by patents. One option was obvious as many contemporary independent inventors—such as Edison and Gray—did the same: sell the idea and the patent and let someone else commercialize it. The most likely candidate was the giant monopolist in telegraphy: the Western Union Telegraph co. However, as they could not find Western Union interested in acquiring the patent rights, they had to look for another options. That option was to commercialize the patent by themselves. That meant that, next to the technical activities, that also the business-activity had to be developed. From developing a business model (licensing the rights and equipment to external parties: the service providers), to the marketing concept (leasing the equipment), and the first production runs (the apparatus made by external parties). As the market was not existing (except for a few early adaptors like Holmes), quite some promotion in the form of demonstrations (eg the Centennial Exhibition) and lectures (eg those in Salem) were needed also. In short, by entering the business they were faced with a completely different ball game.

Creating the Pioneering Business

After the telephone had been born in Boston, baptized in the Patent Office, and given a royal reception at the Philadelphia Centennial Exhibition, now came the next phase of creating an organization. Sure, on the technical front quite some development had to be done to create a working apparatus. The first equipment was to be manufactured and leased to the early service providers. Soon they ran into financial problems. That the expanding business needed additional financing was obvious to Sanders who would end up supplying ninety percent of the money needed. Thus to find more money, Sanders looked around for external funding and he found a solution:

> *Sanders's relatives, who were many and rich, came to his rescue. Most of them were well-known businessmen -- the Bradleys, the Saltonstalls, Fay, Silsbee, and Carlton. These men, together with Colonel William H. Forbes, who came in as a friend of the Bradleys, were the first capitalists who, for purely business reasons, invested money in the Bell patents. Two months after the Western Union had given its weighty endorsement to the telephone, these men organized a company to do business in New England only, and put fifty thousand dollars in its treasury.* (H.N. Casson, 1910, p. 60)

[214] In today's vocabulary the early financing of a venture by relatives and people who believe in the inventor and his vision, is called 'angle funding'.

Conducting a business is not easy, and soon they were confronted with the next problem. The contact with Western Union had not only failed to result in selling the patent rights. Even worse, Western Union had decided itself to go into the telephone business. It was a massive competitor for the pioneering partners. Although it was Goliath against David, Western Union actions also gave Bell's invention credit in the market. It also became clear to them—and others around them—that their decision to go into the telephone business was going to work. As they foresaw a much larger market than the regional market in New England, Bell went to England, combining his honeymoon with business. Now the trust Bell Telephone Company (GH Trustee) was created, a second milestone in the development of the business.

> *In a short time the delighted Hubbard found himself leasing telephones at the rate of a thousand a month. He was no longer a promoter, but a general manager. Men were standing in line to ask for agencies. Crude little telephone exchanges were being started in a dozen or more cities. There was a spirit of confidence and enterprise; and the next step, clearly, was to create a business organization. None of the partners were competent to undertake such a work. Hubbard had little aptitude as an organizer; Bell had none; and Sanders was held fast by his leather interests. Here, at last, after four years of the most heroic effort, were the raw materials out of which a telephone business could be constructed.* (H.N. Casson, 1910, p. 61)

Not much later it became obvious that a more professional management was needed to guide the exploding business. They found it in Theodore N.Vail who became the company's first general manager. Bell was now accompanied by able made who would bring the company is it next phase.

> *Vail proceeded to build up a definite business policy. He stiffened up the contracts and made them good for five years only. He confined each agent to one place, and reserved all rights to connect one city with another. He established a department to collect and protect any new inventions that concerned the telephone. He agreed to take part of the royalties in stock, when any local company preferred to pay its debts in this way. And he took steps toward standardizing all telephonic apparatus by controlling the factories that made it.* (H.N. Casson, 1910, p. 67)

So, the business activity was duly professionalized. It ended the pioneering days of the early business development of Bell's invention. Not that the next period would be easy, as the infant company was facing a multitude of problems in the years to come before the American Bell Company was created in 1880. That was not anymore a responsibility for the associates. By the early 1880s Bell—and soon Watson and Hubbard—had faded out their active involvement in the company. It had been a hectic

Table 7: The patents granted to early telephony (1870-1880).

Patent №	Inventor	Granted	Description
Caveat 3,335	A Meucci	Dec 12, 1871	The employment of a sound conductor
US 161,739	A G Bell	Apr 6, 1875	Multiplexing intermittent signals on a single wire using multiple vibrating steel reeds in make-break circuits.
US 166,096	E Gray	July 27, 1875	Harmonic telegraph consisting out of multi-tone transmitters
US 174,465	A G Bell	Feb 14, 1876	First telephone patent
Caveat	E Gray	Feb 14, 1876	The water transmitter
US 186,787	A G Bell	Jan 30, 1877	Second Telephone Patent: Electromagnetic (magneto) telephone using permanent magnets, iron diaphragms, and a call bell.
US 222,390	T Edison	Dec 16, 1879	Consisting of two metal plates separated by granules of carbon.
US 222,652	E Berliner	Dec 14, 1880	Carbon diaphragm microphone.

Source: USPTO

decade for the Bell associates. A decade where many contributed—from Meucci to Berliner with inventive activities they often patented—to the early development of the acoustic telegraph (Table 7).

The pioneering days being over, the former associates lost the grip on the developments to come.

> *Nevertheless the old guards power was clearly passing. Bell was left out of the new board at his own request. Gardiner Hubbard continued to play some part in the company's affairs. But Thomas Sanders had already resigned as treasurer, and soon withdrew to the sidelines. Thomas Watson found himself rich, overworked, yet still young enough to hanker after "a larger life and new experiences". The "lonely, fascinating, pioneer work" of the early days was now parcelled out among many workers.* (Bruce, 1990, p. 281)

Development of the Bell System

From that early agreement between Bell, Hubbard and Sanders in 1875, the *Bell Patent Association* had grown, by 1880, into the new company called *American Bell Telephone Company*. It had been a pioneering period in many ways. Then, with the creation in 1880 of 'American Bell', a new phase started. Their 'telephone' product had grown from an ugly prototype into a working device that enabled spoken communication. From early public unawareness, early adaptors had picked up the technology, and the market for telephony had started to emerge. The early growth of the local networks had started. The financial needs of the growing company had resulted in new powers controlling the company. So much had changed for the early pioneers, that their time to leave was approaching. By the early 1880s the pioneering days for the associates were over. Now American Bell faced a new period in its development, a period of growth. In the exploding market with emerging competition, the focus was on business development. Strategic choices had to be made, and competition had to be faced. For Bell, the Monopoly Era had started.

The Bell Monopoly Era (1880-1894)

Up to the late 1870s the growth of the pioneering business—as we have seen before—was moderate. But then the public became aware of the advantages being able to communicate at a distance by voice instead of the written word (the telegram). Although not know at the time, the telephone market was going to explode in the next decade (Figure 100). For people familiar with what had happened in the telegraph market, it was not that complicated to imagine what the enormous potential for telephone services would mean in terms of opportunities to do business. This explosive market development did not happen only in the US; it was also seen in Britain and the rest of Europe. However, outside of the US, Bell hardly had any patent protection.

Therefore, Bell's new management developed a new business strategy, one based on the experience with the telegraph, that was oriented toward profiting as much as possible from the strengths they had: the Bell patents. As the business model of the Bell Telephone Company facilitated local initiatives, many companies providing telephone services were created. The early choice was to focus on urban areas; rural areas were left unserved. Bell was the facilitator that responded to the public need for the speaking telegraph.

> *Initially, Bell's defeat of Western Union resulted in a positive public perception of the firm as the little corporate David which slew the corporate Goliath, Western Union. But Bell's expansion strategy undermined the initial positive image, and*

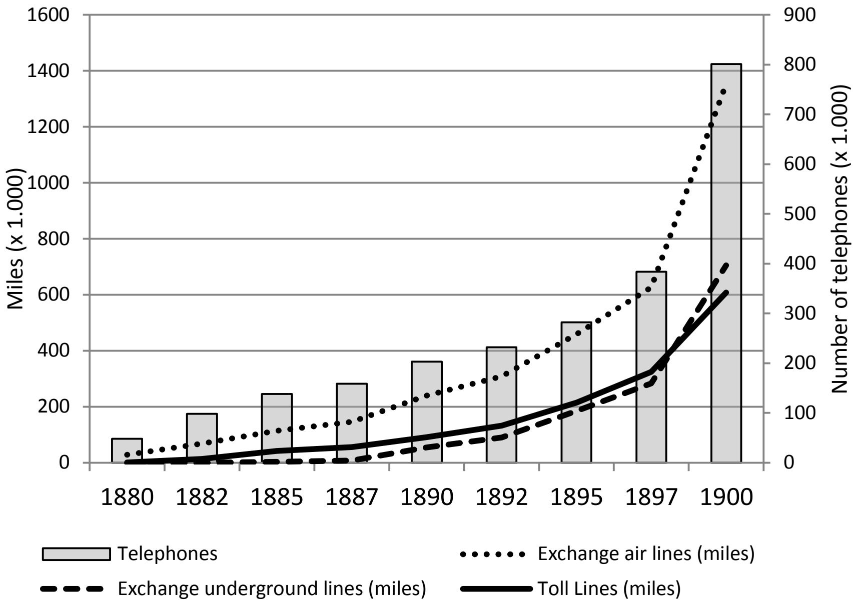


Figure 100: The market development for telephone services of the Bell System in terms of number of telephones and miles of cabling.

Source: (Fagen, 1975) p.232 Table 4-23

> *quickly Bell began to be perceived as another arrogant national monopoly, refusing to upgrade the quality of its local and long distance lines in order to correct poor transmission, and ignoring customer relations.* (Ward, 1997, p. 151)

For a pioneering company, it had been a situation that caused many headaches as the local companies were quite autonomous in their operations. The leasing of the equipment was the only handle the Bell Company had on the operations of those local providers.

> *Hubbard's policy of licensing had resulted in a loose confederation of companies comprising the Bell Company. Some companies were chartered locally, some on a state basis, and others were organized on a regional basis, but with incorporation at a combination of local and state levels.… In addition, any copies or infringements on the equipment could be quickly traced - a major concern to the company since the simple devices could be produced in a small machine shop with a limited amount of technical knowledge.* (Ward, 1997, pp. 124, 129)

Tightening the Grip

The independent local telephone networks, under Hubbard's licensing strategy, developed rapidly. In 1880 American Bell started the execution of a strategy to solidify its position of control over the telephone industry in the United States. In order to attain this goal, Bell crafted a strategy that eventually led to the establishment of hierarchical control over its licensees, and legitimized its patent monopoly status.

> *American Bell Telephone began by changing the terms of existing licenses, and any new licenses granted to provide local telephone service. Under the new policy, exclusive rights to provide service were linked to defined geographical territories. Conditions for territorial rights included; a prohibition on interconnection with any competing companies; and a restriction that the licensee could not participate in any other businesses unless licensed by American Bell Telephone. Another condition placed on the licensees was a prohibition on the licensees right to build and operate any form of long-distance service. Long distance service was reserved, exclusively, to the parent company, American Bell Telephone. The licensee was also required to surrender thirty percent of their stock to American Bell - in time this condition was raised to one hundred percent of the licensee's stock - , and to raise their own capital for the construction of lines and rights-of-ways.* (Ward, 1997, p. 146)

Addressing the issue of the licensing agreements was one element of the new corporate strategy. A second element was more direct control of the manufacturing side of the telephone equipment. One result of this was a more standardized product that was necessary if the local networks were to be linked to each other. From the many small manufacturers that were licensed to manufacture the telephones and related equipment, the manufacturing was concentrated in Western Union's manufacturing organization Western Electric[215]. This resulted in the creation of *Western Electric Mfg. Co.* in 1882.

A third element was the creation of a long-distance telephone network, connecting the local networks. Having this long-distance network under their control, Theodore Vail, General Manager of American Bell Telephone, and William H. Forbes, President of American Bell Telephone, expected that this would create a barrier to competitors entering the field.

And finally, a fourth element of the strategy was to defend its patent position and create a patent wall around their organization. That part of the strategy would result in massive patent litigation (Ward, 1997, p. 146).

---

[215] The independent Western Electric Manufacturing Company, owned by Elisha Gray and Enos M. Barton had a close relation with Western Union. In 1875, Gray sold his interests to Western Union and that sale included his caveat for the telephone.

Bell Becomes Unpopular

In 1885 the new *American Telegraph and Telephone Company* (AT&T) was created. It was originally organized for the realization of long-distance communication, but it became in 1899 the mother company of all the Bell Companies. This company, due to the ownership of the Bell patents that were to expire in 1893 and 1894, created the 'Bell Monopoly' of AT&T.

One has to realize that the context in which AT&T was created was the American capitalist system. It was all about *control* (of the market) and *money* (dividends for the investors in AT&T) for the AT&T management. They charged high license fees to the operating companies providing the telephone services. These, in turn, charged high rates to subscribers who did not have the choice to look for an alternative service. This situation had already, before AT&T's creation, been a conflict between Hubbard and Bell management under general manager William Forbes.

> *For the operating companies to prosper, Hubbard lectured Forbes in 1884, they should be owned by investors in the localities in which they operated, rather than by American Bell. At present rates were too high—the "rock" on which telegraph giant Western Union almost foundered. To best promote the public interest, Hubbard added, American Bell should behave more like a "quasi-public corporation" by lowering the licensing fees it demanded from the operating companies and encouraging the operating companies to lower their rates. American Bell was making too much money, Hubbard warned, and, largely for this reason, was extraordinarily unpopular.* (John, 2005)[216]

The urban operating companies were the core of the telephone industry. They involved the telephone managers (supplying the service), the telephone subscribers (the users of the service) and the city governments (regulating and taxing the services). The managers were loosely organized in the *National Telephone Exchange Association* (NTEA), which was created by the increasingly frustrated operating company managers. These managers were frustrated not only by the attitude from Bell, but also by the local politics they had to deal with in this period of rapid, unpredictable and often bewildering change.

> *The telephone, proclaimed National Telephone Exchange Association president Marshall Jewell, in his inaugural address before the association's members in September 1882, had been projected into our "social and business relations" like a "meteor": it had "seized" all branches of the commerce of this country "quicker than any enterprise, than any great principle has ever been developed in the history of human progress. … the invention, Jewell rhapsodized, promised more for the*

[216] This document does not have page numbering.

> *"accomplishment" of human comfort and human activity than any prior invention had at its inception, "scarcely excepting steam and electricity."* (John, 2005)

Indeed, one has to consider the timeframe in which development took place. It was the time when electricity invaded daily life; the electric light, the electromotor power appliances, the electric streetcar and the telegraph are just a few of the examples[217]. The explosion of urban telephone operating companies created the 'overhead wire menace', which created many political discussions. Laws, ordinances and regulations resulted, which were seen as 'attacks' and 'conspiracies' by the telephone managers.

> *In June 1884, the New York state legislature enacted a comprehensive underground wire law. This law established a timetable for the burial of the overhead wires of every telegraph, telephone, and electric light company in the state that operated franchises in cities with a population larger than 500,000—That is, New York and Brooklyn.* (John, 2005)

The Telephone Market Matures: The Telephone War

Complying with the new laws brought the telephone wires underground. It certainly influenced public opinion. However, there was more that was irritating members of the public: the pricing of the telephone services.

> *The burying of the telephone wires eliminated one of the most visible points of contention between city dwellers and the urban telephone operating company. Out of sight, out of mind: the telephone company somehow seemed less formidable when its presence was not longer trumpeted by a tangle of wires on every major thoroughfare. … No issue perplexed operating company managers more than the pricing of telephone service. Initially, Bell licensees set rates low to compete with Western Union, which had rapidly begun to establish its own telephone operating companies in 1878. This competitive interlude ended in November 1879, when Western Union agreed with the Boston investors who controlled the Bell patents to divide the market.* (John, 2005)

Originally, from the early days on, most operating companies charged a fixed fee for the unlimited use of the telephone for a particular interval (the 'flat fee' concept). Subscribers had the right to use any telephone within the operating company's network (in addition, of course, to their own). That concept had its drawbacks, and when the operating companies wanted to change this approach (a topic that became known as the 'rate question') they had to face 'politics': the user groups, the city councils and the state legislature. They wanted to change the billing system and charge by the call: the 'Measured service' concept. This caused public uproar, political

[217] See also the case studies: 'The invention of the Electro-motive Engine'; 'The invention of Electric Light'. (2015)

lobbying and rate legislation. That public uproar was illustrated by the actions of the *Telephone Subscribers Protective Association*, who launched a boycott as early as 1881.

> *Nothing made more likely the prospect of hostile legislation than the threat of a telephone users' boycott. One of the first user boycotts took place in Washington. D. C. in 1881. ... In the fifteen-month period between November 1886 and March 1888, Rochester telephone subscribers staged an ultimately successful boycott of the telephone company that was unprecedented in the annals of telephone history. The "telephone war," as it was dubbed in the press, was unique: nothing like it had ever happened before, and nothing like it would happen again. Of the city's 900-odd telephone subscribers, over 800 signed a pledge to "hang up" their telephone. … the enthusiast's challenge received a major boost from the Rochester city council, which blocked the Bell-associated operating company from enrolling new subscribers, and hinted that it might even take the even more radical step of tearing down its wires.* (John, 2005)

It resulted in the more extensive involvement of the local and state governments and in a barrage of hostile telephone legislation. And it weakened the position of the Bell Companies considerably as rival companies now gained a foothold; the emerging Bell Monopoly was under attack.

> *The strike went on and on as customers simply canceled service, and in some cases formed their own cooperatives to provide alternative service in different areas. Bell finally threw in the towel 18 months later and restored flat rate service to customers. Rochester never entirely trusted Bell again, and by 1899, Rochester Telephone Company, an independent provider, was granted a license to serve the area and compete against Bell. They promised and delivered flat rate service to customers, and maintained a reputation of excellence for decades, with one of the nation's largest local calling areas at a cost of less than half charged by Bell in nearby Buffalo and Syracuse. Bell eventually threw in the towel as more and more customers chose Rochester Telephone for their respect for customers and their delivery of an essential service at a fair and reasonable price. Bell exited Rochester several years later altogether.*[218]

The result of all this was a negative public awareness, resulting in the unpopularity of the telephone operating companies that the Bell System operated. This explains why Bell's patents were so strongly opposed, as we will see further on.

---

[218] Source: http://stopecap.com/2009/04/11/past-is-prologue-e-great-telephone-strike-of-1886-when-bell-tried-to-eliminate-flat-rate-pricing/

The Tangle of Telephone Lawsuits (1879-1887)

Over the years 'Bell[219]', in different forms of enterprise, had to defend Patent № 174,465 (Figure 101) in some six hundred lawsuits, employing dozens of lawyers, paying hundreds of thousands of dollars in legal fees.

> *In order to protect the existing patent, Vail organized, in 1879, the Patent Department. The Department was staffed with full-time patent attorneys whose primary task was to file lawsuits on infringements, and secure new patents from any work either developing within the research departments of American Bell, or which were purchased by Bell from other inventors. There were the* ***Telephone Patent Interference*** *cases that were related to patent applications that interfered with Bell's patent. It was part of the procedure to get a patent and was handled by the Patent Office. Another group of lawsuits were the cases where Bell's companies filed suits against companies infringing on its patent(s). Some resulted in the judgment of the US Supreme Court in 1888: the* ***Telephone Cases****. But one of the most important lawsuits that would become a close call for Bell, never reached a verdict as the parties concerned settled out of court.* (Ward, 1997, p. 152)(bold by me)

In all these cases, the interpretation of the novelty of Bells patents—as expressed in claims he had made—was at stake. Much depended on how the courts understood the nature of invention, as the invention process is a cumulative process with many moments where someone can 'be the first'. Invention is not the 'eureka'-type of process for a single inventor. Inventors typically advance on the work of earlier experimenters, improving existing devices and analysing problems within frameworks of scientific understanding constructed by others. Then comes the subjective element: the fact if the invention that is patented has the 'novelty' as

Figure 101: Patent №174,465 granted to Alexander Graham Bell (March 7, 1876).
Source: USPTO

[219] Using the name 'Bell' indicates the company, not the person Alexander Graham Bell who withdrew from active management in the company in the early 1880s.

claimed by the inventor. These cases were about 'who invented the telephone'. (C. Beauchamp, 2015, pp. 59-61).

In the case of Bell, it was—as we will see—even more so, as he claimed to have patented more than just a device. Sure, American society would be touched greatly by the effects of telephony, like it had been by telegraphy[220]. But in this early phase—when the seriousness and magnitude of the business opportunities became clear— there was already much discussion about the patenting system and the 'patent monopoly', and especially in Bell's case, the 'priority question'. Bell's future success as a business was grounded on maintaining its patent rights, and he would be facing every challenge to those rights in the Federal Court system.

David against Goliath: Bell Company versus Western Union

After in March 1878 Western Union had filed a block of interferences against patents on behalf of Gray and several other inventors, in September 1878 the management of the Bell Company had decided to fight back in court. It introduced patent infringement[221] into the conflict. The first case that related to Bell's pioneer patent № 174,465 was the Dowd case that started in January 1879 and would set the pattern for the future infringement cases soon to follow.

The first case was an infringement lawsuit against Western Union where Hubbard, acting for the *Bell Telephone Company*, and Sanders, acting for the *New England Telephone Company*, filed suit on September 12, 1878. It was the direct result of the success the agent Peter Dowd had in selling the telephones of the *American Speaking Telephone Company*, owned by *Western Union Telegraph Co.* Between Alexander Bell and his attorneys, there was a disagreement about how to proceed in court. Bell disagreed with his lawyer Chauncey Smith on how to defend his patent:

> *Bell insisted on emphasizing the first four "claims" (formal statements of invention, intended to demarcate the scope of the patent), which outlined methods for generating and transmitting the undulatory current. His attorney, the experienced Boston patent-lawyer Chauncey Smith, had eyes only for the fifth claim, which applied Bell's method specifically to "transmitting vocal or other sounds."* (Christopher Beauchamp, 2010, p. 858)

---

[220] Both the telephone and telegraph operate within the same principles of applied technology but have divided the area of operation by type of service offered. But as they are both engines of communication, their function addresses fundamental human needs for communication.

[221] Patent litigation is part of the patenting process, patent infringement is a prohibited act with respect to a patented invention without permission from the patent holder that breaches the claim(s) of the patentholder.

The Western Union lawyers tried to prove that the Bell patent was invalid because other inventors before Bell had already invented parts of the telephone, like the undulatory current that had been previously known, or the fact that Gray's and Dolbear's —and even Philipp Reis'— inventions of the telephone were prior to Bell's invention. But after the first day in court they were confused, and due to the advice of Western Union's chief council George Gifford, who was convinced that Bell patent was valid, the tables turned: ' He [Gifford] notified the Western Union confidentially, of course, that its case could not be proven, and that "Bell was the original inventor of the telephone." The best policy, he suggested, was to withdraw their claims and make a settlement' (H. N. Casson, 1910, p. 82).

The Dowd case was, after some legal sparring, settled out of court in the late 1879's. It resulted in the previously mentioned agreement in which Alexander Graham Bell was recognized as the inventor of the telephone and his patents were determined to be valid. In one act, the claims of Gray, Dolbear and Edison that they had priority were eliminated. However, there was still no ruling on the scope of Bell's patent.

Western Union agreed to leave the telephone business and assign all its 84 telephone patents to the Bell Company. The Bell Telephone Company would refrain from entering the telegraph business. It would also buy Western Union's existing telephone system with its 30,000 customers, plus pay a 20% commission on the annual rental charges on every telephone the Bell Company installed over the next 17 years of the patent protection. And Bell would direct its telephone licensees through to the Western Union telegraph offices. This way, the customers could speak to the telegraphist to submit their message and avoid going there in person. It would create quite an interesting additional source of income for Western Union.

They also negotiated some additional interests, like those of the *Associated Press* and those of the *Gold & Stock Company*, who did not want to give up their profitable relationship with Western Union. The Bell telephone was not to be used for transmitting news dispatches, nor stock quotes. (Evenson, 2000, p. 135). Therefore, in essence, the companies claimed and got their own 'business territories'.

This agreement, which was to remain in force for seventeen years, was a master-stroke of diplomacy on the part of the Bell Company. It was the Magna Carta of the telephone. It transformed a giant competitor into a friend. It added to the Bell System fifty-six thousand telephones in fifty-five cities. And it swung the valiant little company up to such a pinnacle of prosperity that its stock went skyrocketing until it touched one thousand dollars a share. (H. N. Casson, 1910, p. 84)

Western Union might have considered the agreement a victory, but in hindsight, Bell got the best out of the agreement. The small pioneering telephone company had conquered the mature and aging telegraph company. They did not become adversaries, as they now had a shared interest; the former antagonists were now allies. Nevertheless, the priority-question, 'Who invented the telephone', still had to be answered.

Telephone Patent Interferences

Soon there followed other infringement cases, such as *American Bell Telephone vs. Spencer* (July 1880), the agent of the small Eaton Telephone Company. Again, Bell's attorneys pressed for a ruling on the fifth claim. Judge Lowell ruled that Bell had 'discovered a new art—that of transmitting speech by electricity—and has the right to hold the broadest claim for it which can be permitted in any case.' As Bell's invention was a 'new art', the undulatory current to speech transmission, that meant that his rights were not confined to any particular machinery used. The victory was for Bell (C. Beauchamp, 2015, pp. 67-68).

Next came the infringement case *Edison v. Gray v. McDonough v. Bell*, one of the many infringement cases that would become known as the *Telephone Patent Interferences*. Many of them failed, but the McDonough case proceeded, over a range of years, in an unexpected way. How did that came about? The businessman with an inventive streak, James McDonough, developed in the 1870s a device he called the *Teleloge*. On April 10, 1876, he filed for the patent application. Unlike with Bell's application, he was required by the Patent Office—as was the standard requirement—to submit a working model. In his application, he claimed:

> *'The object of my invention is to provide a means for transmitting articulate sounds from one place to the other through the medium of electricity'* (Evenson, 2000, p. 142).

His design was equivalent to the Reiss telephone; it was a 'lose contact' transmitter, or a make-and-brake contact system, and in essence, it was an early microphone. During the interference hearings McDonough produced witnesses, but they were rejected by the examiner as being mistaken when they declared that they had heard sound being transmitted. Later, after an amendment by McDonough filed on March 4, 1878, the application was turned over to the 'examiner of interferences'. That was the beginning of a lengthy period. The examiner of interferences found—based on a decision of 300 pages—that McDonough's receiver had indeed anticipated Bell's receiver[222]. McDonough seemed to have his victory, and Bell's patent was

[222] In interference actions, the patent goes to the inventor who can prove priority of conception, not necessarily to the one who was first to file.

in grave danger. Clearly, Bell appealed and the case was brought before 'examiners in chief'. This board affirmed the decision of the examiner of interferences on all the applications at hand, except for the McDonough application, which was reversed, and priority was once again awarded to Bell. The McDonough attorneys directly appealed, and the case was placed in the hands of Commissioner of Patents, Benjamin Butterworth (Evenson, 2000, p. 145). He concluded that the invention was based on a 'false theory' in contradiction to known scientific principles. The transmitter could not have transmitted speech (an analogue signal) on the basis of a make-and-break contact, as described in the application. Once again, Bell was restored to the position of the inventor of the telephone (Evenson, 2000, p. 146). But it was a close call.

The Pretenders

Another case would be *Bell Telephone Co. versus Rogers Telephone Co.* As it was clear there was profit to be found in the telephone business, a band of entrepreneurs organized local telephone companies and tried to sell as much stock as possible. One example of this was the *Pan-Electric Company* that was organized in 1883 by Dr J W Rogers, a native Tennessean who had served as rector of several Episcopal churches in Memphis. Its original board of directors included former Tennessee congressman J D C Atkins, as well as the congressman from Memphis, Casey Young. The venture was exclusively based on some telephone patents granted to his son J Harris Rogers (an electrician), including US Patent № 252,255 (January 10, 1882) and Patent № 288,366 (November 13, 1883). The company was capitalized at 5 million[223] dollars, an arbitrary figure based on what the directors thought was the potential value of J H Rogers' patents (Hudspeth, 2005, p. 40). It was quite a gamble, if they could succeed in invalidating the Bell patent, the Rogers patent and the Pan-Electric stock would become very valuable.

Pan-Electric began to sell territorial rights, and companies that used the Rogers instruments were organized while Pan-Electric received a royalty of six-dollar for each telephone and 25% stock in the local companies. Even the *Rogers Telephone Company of Pennsylvania* was created (It was this company that Bell would file a lawsuit against for infringement of its patent rights). In the meantime, Rogers followed also another business strategy. He literally besieged members of Congress with letters and poems and his presence (Williams, 1943, p. 146).

[223] Equivalent to $ 122 million in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

> *Large blocks of shares were distributed as gifts to politically influential people, including a 10% ownership to Augustus H. Garland, a former governor of Arkansas. Then the company sold stock to the public. So far the promoters were ahead of the game, but there came a stroke of luck. In 1884 Grover Cleveland was elected President of the United States and he named as Attorney General none other than Garland. Garland, through his solicitor General [John Goode], filed suit for annulment of the Bell patents, charging that they had obtained by fraud.* (Camenzind, 2007, p. 22)

Thus, US Attorney General Augustus H Garland, with his private interest, became professionally involved. Soon after, the ties of Garland and the Pan-Electric were exposed by the New York Tribune, and the House of Representative decided to investigate the allegations on April 2, 1886. That was the beginning of quite a scandal, involving the president, members of congress and judges. It became a scandal that divided the House along party lines and was front-page news in the press (Figure 102). But it did not influence the decision to investigate Bell's patents, as on March 17, 1886, Solicitor General J Goode decided to bring suit to Bell. The accusations against Bell not only challenged the validity of his patents, but charged unfair business practices as well. It took quite some time—and some legal costs that surpassed $300,000[224] for both sides—but the case ended finally as part of the ruling of the Supreme Court on March 19, 1888 (Williams, 1943).

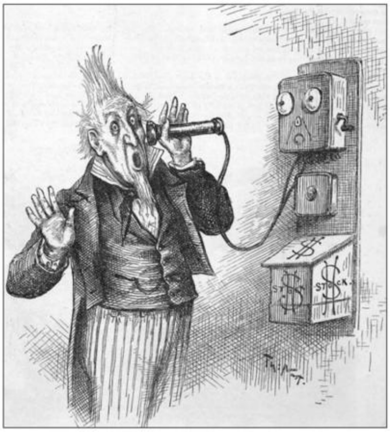


Figure 102: Cartoon related to the Telephone Scandal (1886).

The scandal was bout stocks, as indicating on the batterybox.

Source: Harper's Weekly, 11 February 1886, 107. (Christopher Beauchamp, 2010) p.870

There were more cases related to inventors; such as the cases involving Antonio Meucci. The Italian immigrant Meucci, who had already spent years preparing to defend his priority claim, had often sought publicity in the press. His lawyer sent, in 1883 to the New York Herald, a copy of his letter in which he declared that he would never give up his priority rights. This coincided with the earlier activities of a syndicate that had been

[224] Equivalent to $7,170,000 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

exploring telephone systems other than the poor and expensive services that were provided by Bell. Out of this syndicate's investigation, a new company was created in 1885: the *Globe Telephone Company*.

> *After a few months, in the spring of 1883, the subcommittee [of the syndicate] concluded its investigation with astonishing results, confirming the validity of Meucci's invention. The findings were sent to wealthy businessman Robert Garrett, president of Baltimore & Ohio Railroad Company, who sent them to his lawyers for legal scrutiny. In the meantime, something was happening in Baltimore, where the aforementioned Robert Garrett, after receiving from his lawyers in the fall of 1883 the final report on Antonio Meucci, decided to intervene against the gigantic monopoly of U.S. Bell "in order to break the powerful grip that allowed this company to maintain its isolation in the market." In fact, on January 31, 1884, the Globe Telephone Company of Baltimore was established with capital of $1 million. The newspapers reported that the founding members were capitalists well known in the financial world (one of them was from London) and that they were connected with the Globe Telephone Company of New York* (Catania, 2002, p. 430)

The Globe Telephone Company had acquired the telephone patents of the former Bell employee George E Shaw (and valued them in 1885 at $10 million[225]). However, those patents were issued after Bell's patent. Thus, they looked for earlier evidence of telephone discoveries and found them in the activities of Antonio Meucci. They did not undertake any commercial activity, but news of the creation of the well-financed *Globe Telephone Company*, which had Antonio Meucci as its 'electrician', became public just before the opening of the Philadelphia Electrical Exhibition of 1884.

Telephone Cases

The Telephone Cases were a series of US Court cases[226] in the 1870s and 1880s concerning the priority question of the invention of the telephone as claimed in Bell's first and second telephone patent. Some of them were narrow escapes for Bell's claims. These cases, together known as the *Telephone Cases,* came before the Supreme Court in 1887. In their decision in 1888, by a one vote margin, the court split 4-3 in favour of the Bell patent (Evenson, 2000, p. 153).

---

[225] Equivalent to $254,000,000 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

[226] They concerned the following court cases: 1) Dolbear vs. American Bell Telephone Company; 2) Molecular Telephone Company vs. American Bell Telephone Company; 3) American Bell Telephone Company vs. Molecular Telephone Company; 4) Clay Commercial Telephone Company vs. American Bell Telephone Company; 5) People's Telephone Company vs. American Bell Telephone Company; 6) Overland Telephone Company vs. American Bell Telephone Company.

> *The opinion of the Court was both legally and commercially momentous: legally, as a landmark ruling in the law of patent scope; commercially, because it sustained the monopoly of the American Bell Telephone company, already a "hundred-million-dollar" corporation, whose prominence in American business life would only increase over the years. … Finally, the decision was monumental in two further senses. Printed with the arguments of counsel, it filled an entire volume of the U.S. Reports, the only case ever to do so. It also stood as a headstone to the "Waite Court", whose chief justice, Morrison R. Waite, took ill after completing the opinion and died four days later.* (C. Beauchamp, 2015, p. 58)

Many of these cases started as infringement cases, but they became more when Bell's fifth claim became an issue. After legal hassle, these cases were brought to the Supreme Court. One of them was the case *Overland Telephone Company vs. American Bell Telephone Company.*

One of the men behind the Globe Telephone Company, as well as the earlier *Overland Telephone Company* and the later *Meucci Telephone Company,* was Seth R Beckwi, medical doctor by profession. In February 1883, he had organized the *Overland Telephone Company* in New York and proceeded to organize under it eight other Overland Telephone Companies as the beginning of a network of Overland Companies covering the whole country. He had secured the telephone patents of Myron L Baxter for a transmitter and receiver (US patent № 277,198 and US patent № 277,199), both granted on May 8, 1883, again, quite a while after Bell's telephone patents were granted.

> *The Bell Company instituted proceedings against the Overland Company and the case promptly went to trial. But Beckwi was not the man to neglect provision for future lines, either of retreat or of advance, as might be advisable. As the Overland case progressed during the summer and fall of 1883, Dr. Beckwi realized that his company might lose; he probably became convinced that it would lose. At any rate, on December 31, 1883, he quietly severed all connection with the Overland Company, whether as director, stockholder, or general manager. Accordingly when later the Bell Company won the suit and an injunction issued against the Overland Telephone Company, he had no longer any connection with the company, and no restraining order or injunction issued against the said Se R. Beckwi. He had eluded the pursuit and was free to make another attack.* (Langdon, 1933, p. 131)

The same happened when the *Globe Telephone Company*, where Beckwi became a stockholder in 1885, was brought to justice by Bell.

> *But the prospects in the Globe case proved to be no better than in the Overland case. So, about April 1, 1886, without interrupting the court proceedings,*

> *Beckwi withdrew entirely from the Globe Company, and while testimony was still being taken in that case, went over to Elizabeth, New Jersey and started another company, still using the claims of Antonio Meucci,—for which he offered the old man, but did not deliver, 100 of the 1,000 shares of stock, though retaining for himself 690 shares,—and boldly calling it the Meucci Telephone Company of New Jersey.* (Langdon, 1933, p. 133)

In both cases, when the court proceedings began to indicate that the case could be lost, he withdrew from the companies (Camenzind, 2007, pp. 83-84).

The case known as *Drawbaugh v. Bell* would also be a narrow escape for Bell. It started when the *American Bell Telephone Company* filed a suit against the *People's Telephone Company:* the People's Company was created in 1880 with $5,000,000[227] of capital. It manufactured telephones under patents issued to Frank A Klemm and Abner G Tisdel, and the applications for patents for Daniel Drawbaugh filed on July 21, 1880. When production started, the Bell Telephone Company immediately sued them for infringement.

> *There was a strong suspicion that Drawbaugh merely copied the ideas of others and claimed them as his own. … It seems rather significant that of the 19 telephone patents actually held by Drawbaugh, all were dated after Bell's original patent. The earliest was 1882.* (Coe, 1995, p. 26)

The case was, in a way, special, as so many witnesses testified and because of the testimony of Drawbaugh himself, who claimed that poverty had prevented him from applying for a patent. It was a moving story, but the presiding Judge Wallace believed him to be a charlatan (Evenson, 2000, p. 151).

> *Judge William Wallace concluded the trial by rejecting Drawbaugh's claims and casting aspersions on his inventive ability. Drawbaugh's own words, noted the judge, revealed 'without the aid of extrinsic evidence, the ignorance and vanity of the man, and . . . suggest[ed] also the character of a charlatan.'* (Christopher Beauchamp, 2010, p. 866)

That might having been the case, however, but the legal battle developed into a costly and lengthy one.

> *But the People's Telephone Company would not go away. They dragged out the evidence-gathering phase of the trial for over three years and produced nearly two*

[227] Equivalent of circa $8,000,000,000 in 2014 when calculated in terms of economic power. Calculation based on the historic standard of living would be $ 1,270,000,000. In both calculations a staggering amount. Source: http://www.measuringworth.com/uscompare/relativevalue.php

> *hundred witnesses to testify that they had seen Drawbaugh's telephone and heard people speak through it in the early 1878s. By 1884, the case had generated over eight thousand pages of testimony and cost American Bell more than $500,000*[228]*.* (MacDougall, 2013, p. 104)

In a way, the case was more than just a dispute over priority rights. It was also about the unpopularity (especially among businessmen eager to jump on the bandwagon) of Bell's monopoly. It fitted within the discontent of many against the monopolies that were sweeping across America at that time (like the railroad monopoly, with its fraudulent investment, stock watering and stock market crashes). In addition, the case pitted the well-spoken Alexander Bell against the common man with a rustic manner of speaking, the poor Drawbaugh.

> *Of course, a penniless mechanic could hardly have afforded years of litigation against a multimillion-dollar corporation. But Drawbaugh's backers had deep pockets, and share in the People's Telephone Company sold briskly. According to the New York Times, its investors included Governors of States, members of Congress, and millionaires. These investors hoped to invade the telephone business in competition with American Bell.* (MacDougall, 2013, p. 105)

The Verdict of the Supreme Court

The verdict of the Supreme Court on March 19, 1888, in which Bell's priority over Drawbaugh's and Elisha Gray's claims was acknowledged by a 4-3 vote, was a close call for Bell. There was a majority opinion—supported by four judges—that followed the Bell's Company account, and there was a minority opinion—supported by three judges—that followed Drawbaugh's claim. The verdict stated:

> *It is quite true that when Bell applied for his patent he had never actually transmitted... spoken words so that they could be distinctly heard and understood at the receiving end of his line, but in his specifications he did describe accurately and with admirable clearness his process... and he also described with sufficient precision to enable one of ordinary skills in such matters to make... a form of apparatus which, if used in the way pointed out, would produce the required effort. (Telephone Cases, 126, U. S. Reports 1, 989, 1888)* (Ward, 1997, p. 152)

Bell was given the legal victory. In the wake of this decision, dozens of other patent challenges against Bell collapsed. That was on the positive side, but on the negative side was Bell's damaged public image.

---

[228] Equivalent of circa $705,000,000 in 2014 when calculated in terms of economic power. Calculation based on the historic standard of living would be $ 12,200,000. In both calculations a staggering amount. Source: http://www.measuringworth.com/uscompare/relativevalue.php

But Bell's legal victory was no political triumph. The public had been treated to an eight-year performance of American Bell against the people. While the patents had survived, the company's legitimacy was seriously damaged. (MacDougall, 2013, p. 106)

The 1887 Case: US government v. American Bell

By the early 1880s it had become clear that the Bell patents could not be circumvented by claims of prior art (eg Gray, Dolbear, Reiss), as tried by so many companies that failed in court. The US Government, seemingly alarmed by all the lawsuits contesting Bell's priority, became involved and suspected fraud. Thus, in 1887 the lawsuit *United States v. American Bell Telephone Co.* 128 U.S. 315 (1888) was brought to trial. It alleged:

That up to the time of the issuing of the said [first] patent, the said Bell had never in fact been able to transmit articulate speech by the method or with the apparatus described in this said application, but that he purposely framed this said application and claim in ambiguous and general terms in order to cover both antecedent and future inventions and to deceive and mislead the examiners of the Patent Office and the public, and did not set for or declare that his alleged invention had any relation to the art of transmitting articulate speech by means of electricity, but entitled it an application for 'an improvement in telegraphy,' and made special reference to a then recent application made by himself for a patent for a method of 'multiple telegraphy,' and treated his alleged new invention as another method thereof, and set forth advantages which it had over the other, but did not include or mention its capacity, or claim for it any capacity, to transmit speech. (Justia, page 128, U.S 316-317)

The lawsuit was clearly part of the 'Monopoly syndrome[229]' that had evolved around the monopolistic position of the Bell Companies in the end of the nineteen century (Catania, 2002, p. 427).

Many among the American public generally believed that monopolies and corporations were evil and "destructive to the principle of equal liberty." After monopolies were attacked, so-called "trusts" began to form instead. However, they became known as the "latest version of the monopoly." The situation of concern at the time was perhaps painted by the patent laws that had been created in the late eighteenth century. They appeared to promote monopolies in exchange for what was hoped to be innovation. (Wineke et al., 2014, p. 6)

This is exactly what happened in this case. In the background of the investigation, the priority claims of Antonio Meucci, the agreement with

[229] One could remember that Gardiner Hubbard originally fought against the telegraph monopoly of Western Union. With the expansion of the Bell-imperium, Hubbard created himself the telephone monopoly.

Western Union in 1879, and the *Globe Telephone Company* all played an important role. It is interesting to see that, due to the enormous potential of the telephone business and Bell's role in it, 'politics' came to play an important role.

Figure 103: Cartoon depicting the Bell Monopoly.
Source: http://dialmontana.com/

All the publicity about the attacks on the Bell Monopoly (Figure 103) had the effect that other telephone companies, such as the *National Improved Telephone Company* (1884), which was already pursued in patent litigation with Bell, got involved. They all wanted to get rid of the Bell-Monopoly, so each, in its turn, asked members of Congress to intervene and to annul Bell's patents. The political pressure worked, and on September 9, 1885, the Bill of Complaint of the US government against Bell was filed. It was not only the *Globe Telephone Company* and the *National Improved Telephone Company* that attacked Bell. Other companies, like the *Washington Telephone Company* and the *North American Telephone Company,* came to the aid of the *National Improved Telephone Company*.

Therefore, on January 13, 1887, the United States Government moved to annul the patent issued to Bell on the grounds of fraud and misrepresentation. But in the meantime, after a series of decisions and reversals, Bell won a decision in the Supreme Court, though a couple of the original claims from the lower court cases were left undecided. By the time that the US Government trial wound its way through nine years of legal battles, the US prosecuting attorney had died and the two Bell patents (№ 174,465, dated March 7, 1876, and № 186,787, dated January 30, 1877) in the early 1890s were no longer in effect, although the presiding judges agreed to continue the proceedings due to the case's importance as a 'precedent.' With a change in administration and charges of conflict of interest (on both sides) arising from the original trial, the US Attorney General dropped the lawsuit on November 30, 1897, leaving several issues undecided on the merit. The only ones who had gained from this long and complex trial were the lawyers from both sides, who had charged their clients stratospheric fees.

> *The government's entanglement up to this point amounted to thinly veiled assistance for well-connected private interests. Historians have accordingly regarded the entire episode as one of corrupt adventurism, as did contemporaries… Yet it would be a mistake to see the telephone fraud suit simply*

in terms of Gilded Age "influence." The Bell case was only the most visible of a number of attempts at the time to draw the federal government into fiercely contested patent actions. (Christopher Beauchamp, 2010, p. 869)

1893/1894: End of Patent Protection

From the moment the decision was made to defend the Bell patents against infringement in the late 1870s, after the 1879 agreement with Western Union, to the moment the Supreme Court on March 19, 1888 gave its verdict in favour of Bell's priority, a tangle of lawsuits had dominated the telephone business. Many people, from sincere entrepreneurs to fraudulent pretenders, had tried to get Bell's patent overturned. However, they had failed. Bell had its monopoly well established in the first and second telephone patent (Figure 104).

After the first struggles during the pioneering years up to 1880, Alexander Bell and his associates had their vision and convictions that telephony had any future. Then, in a period of ten years, the American telephone market exploded, from 108,638 installed telephones in 1880 to

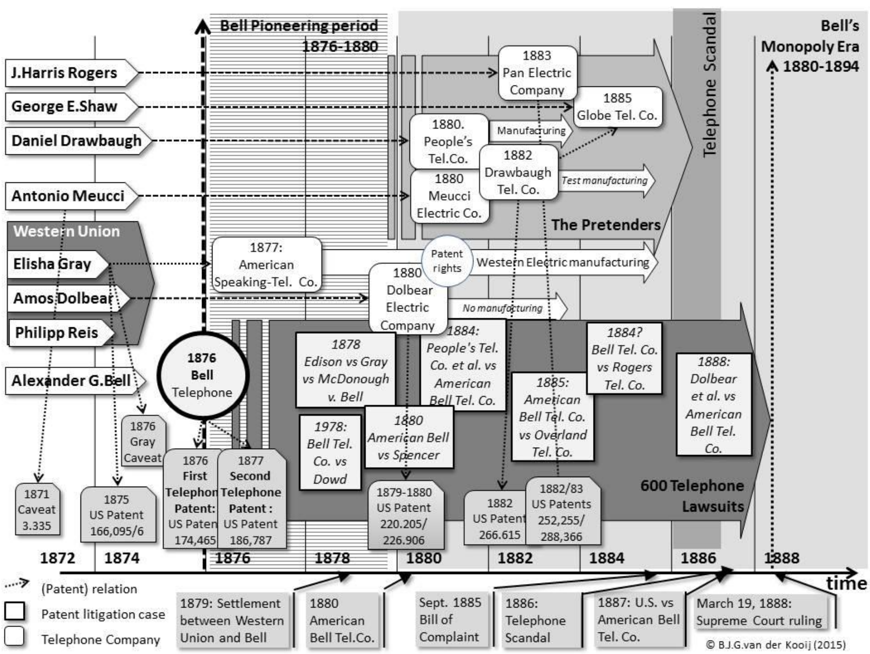


Figure 104: Patent litigation: some of the 600 lawsuits concerning Bell's priority rights on the invention of the telephone.

Shown are some of the litigation cases related to inventors of the telephone (indicative) .

Source: Figure created by author

467,356 in 1890. Also, the number of telephone exchanges increased: from 437 in 1880 to 1,241 in 1990 (Foote, 1892, p. 6). This explosion enabled a telephone use that would continue to grow into the next century (Figure 144). During this period of time, the patent protection had been in place, securing his rights.

When the patent protection for the '465' patent ended in March 1893, and for patent '787' on January 30, 1894, it gave way to a flood of new business activities in telephony. The telephone market now opened to competition, and soon thousands of new telephone carriers started their operations. The increased number of telephones in use, and the numbers of calls that were made with them, jumped up after the patent expired. This would give rise to the Telephone Boom of the independent telephone companies and telephone equipment manufacturers.

The Courts may have decided, and the claims may have been expired, but for some of the main characters in this priority debate, the contest was not over. Both Elisha Gray and Amos Dolbaer would remain their total lives contestants to Bell's claim as the inventor of the Telephone on the basis of his patent of 1876.

> *The most plausible and persistent of all the various inventors who snatched at Bell's laurels, was Elisha Gray. He refused to abide by the adverse decision of the court. Several years after his defeat, he came forward with new weapons and new methods of attack. He became more hostile and irreconcilable; and until his death, in 1901, never renounced his claim to be the original inventor of the telephone. …*
>
> *After Gray, the weightiest challenger who came against Bell was Professor Amos E. Dolbear, of Tufts College. He, like Gray, had written a letter of applause to Bell in 1877. "I congratulate you, sir," he said, "upon your very great invention, and I hope to see it supplant all forms of existing telegraphs, and that you will be successful in obtaining the wealth and honor which is your due." But one year later, Dolbear came to view with an opposition telephone. It was not an imitation of Bell's, he insisted, but an improvement upon an electrical device made by a German named Philip Reis, in 1861.* (H. N. Casson, 1910, pp. 90-93)

Development of Telephone Equipment

With the principle of the speaking telegraph conceptualized, the ideas tested during experiments, the prototypes built, the patent position secured, and the first customers using their telephones, the further development of telephony continued rapidly. On the one hand, there was a rapid development of the equipment, of the telephone apparatus itself. On the other hand, there was a development of the telephone services as companies created local telephone networks.

Alexander Bell was the one who conceptualized the telephone apparatus in detail: (1) the concept of the telephone device, and (2) the system concept of the network infrastructure around the devices. That telephony infrastructure was to be modelled after the telegraphy infrastructure that had matured by then. It would develop in the 'Bell System'. This system was built up on a number of subsystems: (a) the telephone apparatus, (b) the means for conveying messages over long distances, and (c) the switching systems to connect the subscribers, including the telephone exchanges.

Originally—in the pioneering years with the first direct and party lines established, and the first rudimentary exchanges (eg those developed by Holmes)—that development was rather intuitive and primitive. However, that soon changed; after Charles Williams' electric shop was replaced by the Western Electric Manufacturing Company, development and manufacturing become more professionalized. Over time, the telephone developed in a range of apparatus, with new components like microphones, and the telephonic distribution system developed with the telephone exchange as focal point.

Development of the Telephone Apparatus and its Components

Originally, in the pioneering days some 3-4 years in the past, the technical development of the telephone equipment was realized by Watson. Much of the prototype development, and later the manufacturing, was done by Charles Williams—an entrepreneur who supplied everything for telegraphy[230]—in his electric shop. It was the time of early manufacturing of telephones, on a small scale at first, but later, when the *American Bell Telephone Company* was established, and Western Electric became the manufacturer of the telephone sets—and Bell and Watson had already left the company—on a more professional basis.

---

[230] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'.* (2015) pp.430-431

> *The original Experimental Department, established in 1879, quickly gave way to a more organized effort. In 1881 the Electrical Department was created. The purpose of the Department was to study the devices being created by other telephone equipment manufacturers, and conduct experiments in telephone communication theories and possible field applications. The research conducted by the Department allowed Bell to draft infringement lawsuits against other equipment manufacturers, and, at the same time, assess any new developments that either could be patented directly by Bell, or acquired from other inventors.* (Ward, 1997, p. 153)

After the Bell patents had expired, the development of telephone apparatus accelerated. A range of companies developed different design concepts, such as the Desk Telephone (1890s), introduced as an alternative to the wall-mounted apparatus. The desk telephone came in a range of variations. Among those were the Candle Stick Telephone and the Skeleton Telephone (Figure 105). In 1892, Bell introduced the desk version that would be produced into the 1920s. Soon the competition copied the design and offered a range of variations.

It was not only in the USA that the telephone progressed rapidly. Everywhere in Europe, the telephone was manufactured. In Germany, companies such as Siemens & Halske, Zwietusch & Co., C Lorenz, Mix & Genest manufactured the telephone. In Sweden, despite the early stage of the technology, a range of telephones were designed and manufactured by L.M.Ericsson Telephone Company. As Bell had not succeeded to patent his telephone everywhere in Europe, manufacturers were free to copy and improve upon Bell's ideas. After 1894—the Bell patent being expired—that development followed trajectories of its own.

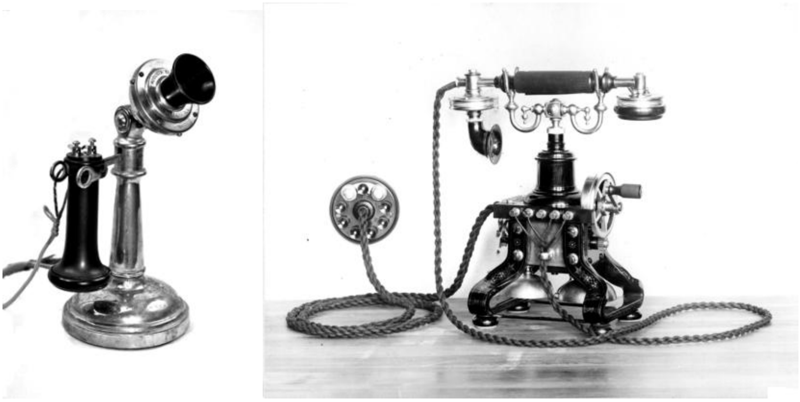


Figure 105: Candlestick Telephones by the Augusta Electric Company (1899, left), and Ericsson's Skeleton Telephone (1892, right).

Source: http://oldtelephones.com/ (left), http://www.ieeeghn.org/ (right)

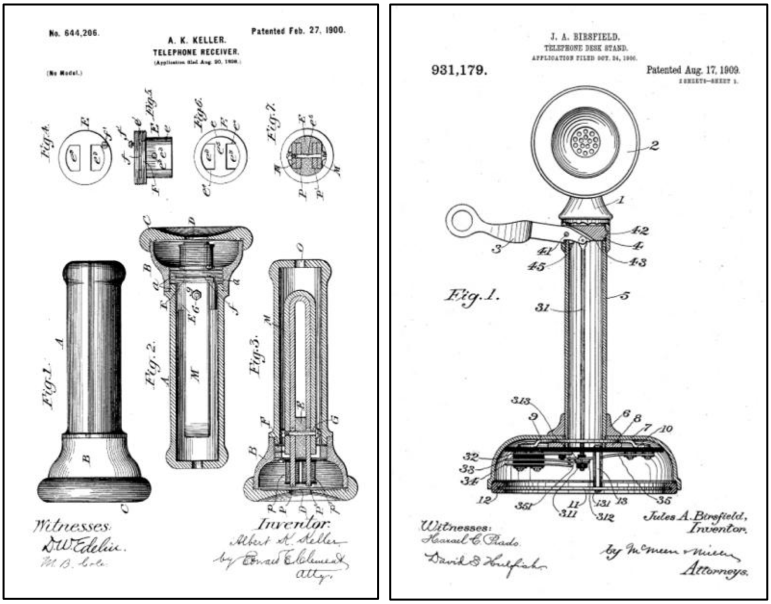


Figure 106: Improvements in Candlestick Telephone.

Source: USPTO

Subsequently, all these companies also improved upon the components of the telephone (Figure 106). Examples include the signalling device that would alert a subscriber that someone wanted to talk to him/her: the bell. Another was the device that would indicate to the operator that someone wanted to make a call: the hook switch. However, the most important parts were the transmitter and the receiver. Originally, they had been similar, but soon many engineers tried to improve them individually. This would result in the development of the microphone.

Development of the 'Loose Contact' Microphone

The device we today call the 'microphone' converts the vibrations of air (aka sound) into variations of electric current. Its counterpart is the loudspeaker. The development of both components is not only important for the telephone, but also for other fields of application where sound is relevant (eg broadcasting). It has its own development trajectory, of which we will only describe some inventions relevant to telephony.

In Britain, it was Professor *David Hughes* (1831-1900), quite famous from his work on telegraphy[231], who read a paper called 'On the action of

[231] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'. (2015)* pp. 386-388

sonorous vibrations in varying the force of an electric current' on May 9, 1878 to the Royal Society in London. He proposed to use a carbon pencil for a device he called a microphone. This was a so-called 'loose contact' transmitter as developed also by Berliner and Edison. Hughes, by purpose, did not patent his idea, and it would be used freely by many telephone manufacturers.

In America, it was *Emile Berliner* (1851-1929), a German who immigrated to the US in 1870, who took the free classes given by the Cooper Institute to get an education. He became interested in acoustics and electricity, and later in the infant science of telephony. Soon after developing this interest, he started experimenting and developed a microphone according to the 'loose contact' concept. It was by accident, a meeting with Alvan S Richards, chief operator at the Washington fire alarm telegraph office, that he became aware of the fact that the pressure exercised on the telegraph-key made a difference in a (telegraph) transmission.

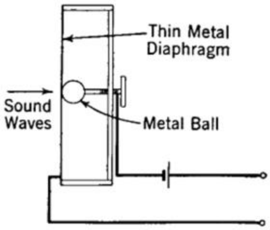


Figure 107: Simplified diagram of Berliner's loose contact transmitter.

Source: http://www.vias.org/ albert_ecomm/ aec01_history_ electrical_communication_011.html

> *"I went home in a highly expectant mood," he has since recounted, in telling of what proved to be the turning point in Berliner's telephonic researches. "I knew I had it. For with I rigged up a diaphragm, made a contact with a steel button, and polished it up so brightly as to insure a clean contact. then I began to adjust it until the galvanometer showed the current. Then I pressed ever so gently. I found that each time I pressed against it the galvanometer deflected a larger angle. I then knew the principle was right."* (Wile, 1926, p. 75)

It took quite a bit more experimenting before he made, in April 1877, an iron diaphragm transmitter in a soapbox housing of seven inches by twelve inches. His 'loose contact principle' proved to be able to transmit sound excellently (Figure 107).

> *I also saw very plainly that I had here an apparatus which would act both as transmitter and receiver of articulate sound electrically; and that I had something analogous to that of Mr. Bell, who also used the same instrument both as transmitter and receiver, but something far simpler and cheaper.* (Wile, 1926, p. 85)

> *The technical principle of the loose contact microphone:* As shown in Figure 107, sound waves/vibrations move the diaphragm. This diaphragm touches the metal ball, covering an increasing surface of the ball, thus changing the contact resistance of the construct. This changing of the resistance creates the undulatory current in the circuit that is the replica of the sound vibrations that move the diaphragm.

In order to save money[232], he filed a caveat application, the precursor to an application for a patent, on April 14, 1877 (Figure 108). Two weeks later, on April 27, Thomas Edison filed a patent application for a transmitter, and in the following years, others would lay claim to precedence in inventing the transmitter. It was only after the decision of the Supreme Court that the matter of priority would be decided upon.

Figure 108: Berliner's microphone of his caveat filed on April 14, 1877.

Source: http://memory.loc.gov/ammem/berlhtml/berlemil.html

Before that was to happen, Berliner added another invention to his microphone: the continuous current transformer. He decided to apply for a regular patent on July 4, 1877, using patent attorney, Charles S. Combs, at the cost of two dollars. But the examiners of the Patent Office had their doubts that so simple an instrument as a plate and a screw in contact with it could act as a telephone receiving apparatus. After some deliberations, Berliner filed a patent application for his invention of the continuous current transformer on October 16, 1877. The patent was granted as US Patent № 199,141 on January 15, 1878 (Figure 109).

> *Within a comparatively few months now, Berliner's unaided struggles were about to come to an end. He had invented the speaking microphone and thus completed the telephone. His rights and theories were indisputable, though soon to be long and bitterly contested.* (Wile, 1926, p. 101)

Berliner next contacted the lawyers of a subsidiary of the Bell telephone Company and offered his patent rights for $12,000[233]. They met him but declined his offer. That changed later when he met with Tomas Watson after Anthony Pollok, Bell's attorney, had arranged a meeting at Berliner's

---

232 An application for a caveat cost that at time $10, an application for a patent $60.

233 Equivalent to $294,000 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

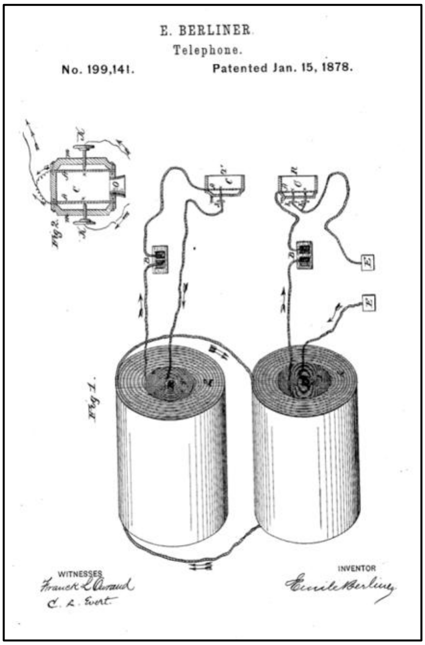


Figure 109: Berliner microphone using a transformer, US Patent № 199,141 (1878).
Source: USPTO

living quarters in Washington. Watson was enthusiastic, and involved Theodore Vail, the general manager of the Bell Telephone Company. Bell was, at that time, competing with Western Union, who had just entered the telephone business and whose telephones, based on Edison's invention, were better than Bell's.

> *"Give us a good transmitter!" became the cry of the Bell Company's eager managers, now almost frantic in their efforts to be first in the telephone field and thwart the Western Union's bold bid for supremacy. The Bells wanted Berliner's ideas, and they wanted him. They were rapidly whipping their affairs into shape under Vail's energetic generalship and, once possessed of a good transmitter, were confident of beating back the Western Union's attack.* (Wile, 1926, p. 116)

Berliner, an amateur inventor and uneducated businessman was facing experienced businessmen like Hubbard and Vail. He only had a caveat and a patent application[234]. Both were the subject of litigation by the Patent Office. On the other hand, the top management of Bell Telephone Company was convinced his invention was valuable to them in their battle against Western Union.

> *Hence, by September they made Berliner the kind of offer that appealed to him. Unknown to his friends or employer, a two-day trip which he made to New York that month was for the express purpose of signing an agreement with the Bell Company. It provided for a moderate salary and a royalty on export transmitters. All that Berliner was able to turn over to the Company was the control of his caveats, and his patent applications that were still pending in the Patent Office, as well as the use of his induction coil, or transformer, patent.* (Wile, 1926, p. 117)

[234] Berliner's patent application was granted as US Patent № 222,652 on December 16, 1879.

Several years later the Bell Company paid Berliner a lump sum of $50,000 and largely increased his annual retainer, which took the place of salary, because he later left Boston and went to work for himself.

> *Unbeknown to Berliner himself, he had become an almost indispensable factor in the Bell Telephone Company's calculations. Indeed, what he had invented, and that which the Bells acquired from him—the control of Berliner's caveats and patent applications, as well as the use of his induction coil patent—seemed to be the rocks to which the whole Bell enterprise was about to cling for security and for the realization of its uncharted future.* (Wile, 1926, p. 122)

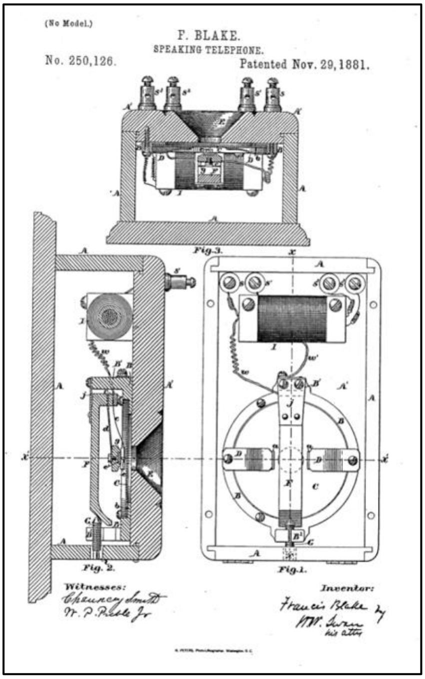


Figure 110: Blake's microphone US patent № 250,126 (1881).

Source: USPTO

Berliner's interest was broader than the invention of the microphone. He wanted to commercialize his ideas, as we have seen from his negotiations with the Bell Telephone Company.

> *Although he was now an American citizen, Berliner kept in touch with his family in Germany. In 1883 he demonstrated a version of his single-contact transmitter in Austria. Interest was strong so he set up a company, J Berliner Telephone Factory (Telephon-Fabrik Berliner AG) in Hanover in Germany, to be run by his brother Jacob. The other brother, Joseph, returned from the United States to become the factory's technical director. He had spent several years studying the telephone in the Bell laboratories under the sponsorship of his brother Emile, and was a competent technician and designer. Jacob became the company's business manager because he was the only one who had experience running a business.* [235]

Another engineer, *Francis Blake* (1850-1913), working as scientist attached to the United States Geodetic Society, had developed another

[235] Source: http://www.telephonecollecting.org/Bobs%20phones/Pages/BerlinerTelephoneFactory/ Berliner%20Telephone%20Factory.htm

single contact transmitter based on the 'loose contact' concept that Emile Berliner had developed and that was now owned by Bell. His design used two flat springs, a hard carbon button and a bead of platinum in such a way that the two would not easily separate when vibrated by the diaphragm against which they leaned. He had been granted US Patent 250,126 on November 29, 1881, for his invention (Figure 110).

His work was also sold to Bell and, while he was sick, perfected by Emile Berliner. It became an important part of the Bell telephones that were manufactured at that time.

> *As soon as Berliner reported that it had been perfected, orders were given that two hundred a day should be made. Berliner himself, with his assistant, Eichards, tested each of them minutely. Once adjusted, they remained in first-class working order. Berliner personally inspected and tested the first twenty thousand transmitters for the Bell Company. … the Blake transmitter as perfected by Berliner was vastly superior to the Edison lampblack transmitter, which was being put out by the rival telephone concern, the Gold and Stock Telegraph Company, for use of subscribers. 130* (Wile, 1926, p. 130)

Development of the Carbon Microphone

The principle of the 'loose contact' microphone had originated with Phillip Reis. As seen before, over time it had been adapted, but it still had its drawbacks in terms of quality of the speech it transmitted. That changed when another principle—that of the variable resistance created by carbon granules—was investigated. This principal was about the change in resistance when compacting/vibrating a carbon compound. As shown in Figure 111, sound waves/vibrations move the diaphragm. This diaphragm touches the metal stamp that compacts the carbon granules, thus changing the contact resistance of the construct. This changing of the resistance creates the undulatory current in the circuit that is the replica of the sound vibrations that move the diaphragm.

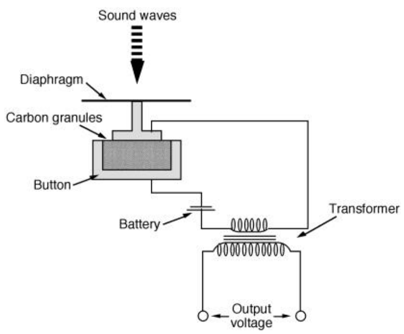


Figure 111: Simplified diagram of carbon transmitter.

Several inventors, over time, contributed to the carbon microphone, a microphone that would become the major component in the telephone for decades to come.

In the US, it was *Thomas Edison* who exploited the fact that the electrical resistance of graphite (plumbage) varied with pressure of vocal sounds. He applied carbon powder from compressed lamp black. On April 27, 1877, he filed for a patent. However, it was not before May 3, 1892, that he was awarded US patent № 474,230 for a graphite microphone (Figure 112). It had taken fifteen years for the Patent Office to decide upon the famous priority question, as the patent had been the subject of much legal wrangling. It was all about the two claims he had made:

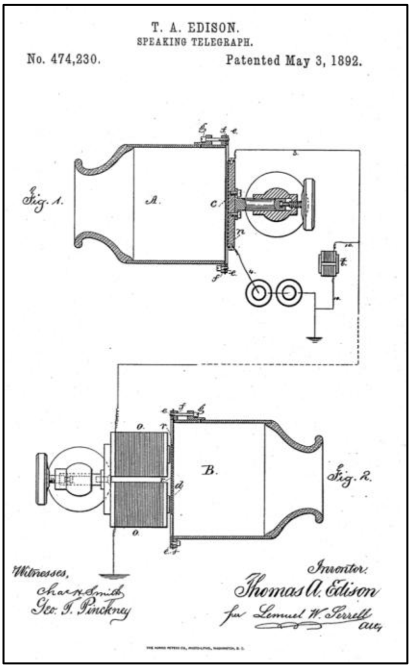


Figure 112: Edison's microphone US Patent № 474,230 (1892).

Source: USPTO

> *1. In a speaking-telegraph transmitter, the combination of a metallic diaphragm and disk of plumbago or equivalent material, the contiguous faces of said disk and diaphragm being in contact, substantially as described. 2. As a means for effecting a varying surface contact in the circuit of a speaking-telegraph transmitter, the combination of two electrodes, one of plumbago or similar material, and both having broad surfaces in vibratory contact with each other, substantially as described.* (text from patent)

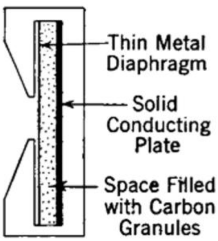


Figure 113: Simplified diagram of Hunnings' carbon granules transmitter.

Source: http://www.vias.org/albert_ecomm/ aec01_history_electrical_communication_011.html

This would become the device that, with its variable resistance as the consequence of the sound vibrating the membrane, would replace the loose-contact microphone.

Another variation on the theme of variable resistance, that of the carbon granules, was developed by a member of the clergy, the Englishman *Henry Hunnings* (1858-1935). This curate at All Saints Church in Bolton Percy, England, experimented with carbon granules placed between two metal diaphragms (Figure 113). He was granted a British patent № 3,647 on September 18, 1878. His patented device was then converted to a manufactural product by the entrepreneur Edward Cox-Walker. It would be used in the Hunnings Telephone manufactured in 1880 by Harrisson Cox-Walker Ltd. in Darlington. As they were infringing on the Edison patent, the Universal Telephone Company (UTC) filed a lawsuit that they won. The patent was sold to UTC for £ 1,000[236].

These were some of the many improvements that were made to one of the important components of the telephone: the microphone. Many inventors contributed to its development (Table 8).

Table 8: Some of the patents related to the microphone.

Patent №	Granted	Inventor	Description
GB 2,9091	July 30, 1877	T Edison	See note
Fr 121,687	Dec 19, 1878	T Edison	See note
Ge 14,3081	Jan 23, 1878	T Edison	See note
US 199,141	Jan 5, 1878	E Berliner	Improvement in telephones: the use of a transformer in telephone lines.
US 203,016	Apr 30, 1878	T Edison	Improvement in Speaking Telephones (compressed lamp black button insulated from diaphragm)
GB 3,647	Sep 18, 1878	H Hunnings	Microphone based on carbon granules
US 222,390	Dec 9, 1879	T Edison	Improvement in Speaking Telephones (compressed lamp black button insulated from diaphragm)
US 222,652	Dec 16, 1879	E Berliner	Improvement in Electrical Contact Telephones (carbon diaphragm with carbon contact pin)
US 250,126	Nov 29, 1881	F Blake	Speaking Telephone (use of springs in combination with diaphragm)
US 474,230	May 3, 1892	T Edison	Speaking Telegraph (graphite microphone)
US 485,311	Nov 1, 1892	A C White	Telephone (solid back carbon microphone)

Note: These three patents were similar to the US Patent № 474,230 that was filed on April 27, 1877. Other countries where a patent was obtained were Belgium, Italy, Spain, Austria-Hungary and Canada.

Source: USPTO

[236] Equivalent to £ 88,910 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

Developments of the Telephone System (1877-1900)

Developments in the components like the microphone, were complemented by developments that were related to the total system of telephony: the telephonic infrastructure that connected the telephone apparatus. That infrastructure was improved upon continuously—often by seemingly small contributions—as illustrated by the following example.

> In Russia, it was *Pavel Michailovich Golubitskiy* (1845-1911) who, as a graduate from the Physics and Mathematical Faculty of the Peterburgskiy University, worked on improvements of the telephone. As the telephone connections over longer distances (eg more than 10 km) of those day were quite poor, he designed a technically better apparatus by using a multipolar magnet instead of a bar magnet. Devices with his design were successfully tested in 1883 during calls of distances exceeding 350 km[237]. Pavel contributed many other inventions to telephony[238]. One such invention was the 'common battery', where the individual batteries placed in each telephone apparatus were replaced by one big wet cell, placed in the central exchange. The common battery facilitated the large urban networks that were to come.

There would be more of those seemingly small contributions having quite a bit of impact, not only technically, but also economically. One example is the Pupin-coil we will describe further on (the Pupin-Campbell controversy). For now let's pay attention to a crucial element in each telephone system: the exchange at the central office.

The main development trajectory in the telephone system was the 'telephone exchange'. This important subsystem of the telephone system was the interconnection point between subscribers, who were individually connected by an individual telephone wire to a 'central office'. This system had created a maze of cables covering rooftops and clogging streets, and it failed regularly, for example, when the weather conditions (eg snow blizzard, ice rain) broke the lines (Figure 139) [239]. Soon, like in the case of electricity distribution[240], in 1882 the first underground cabling was realised in the larger cities. This was just the start of the process that would take some decades before the wire nerves of the telephone were out of sight under the roadway instead of blackening the streets.

---

[237] Source: http://old.telmuseum.ru/en/history/golubitsky.htm (Accessed October 2015)

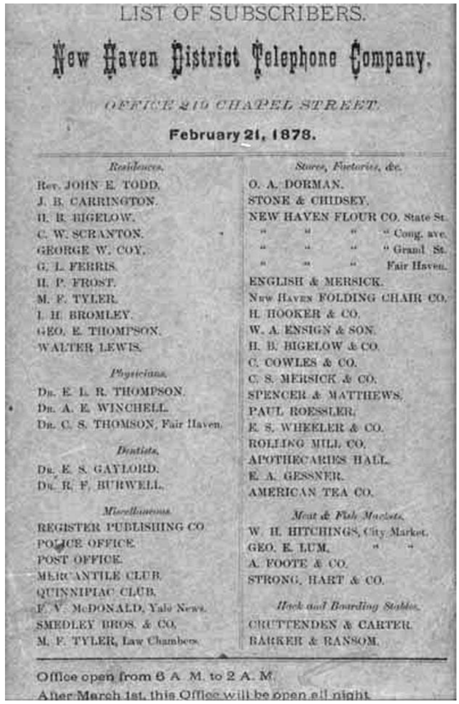
[238] Source: http://telhistory.ru/en/telephone_history/russkie-izobretateli/ (Accessed October 2015)

[239] Anno 2015, in not-so-rural areas in the south of France, telephone and internet communications still depend on the 'wire-on-pole' system. Disruptions are frequent when the wires are broken due to snapping branches, etc.

[240] See: B.J.G. van der Kooij, *The Invention of the Electro-motive Engine* (2015), p. 199

Telephomania: The Manual Exchange

Telephony started with a simple telephone line with telephone equipment (a transmitter, a receiver and a signalling bell or caller) at both ends. This was the so-called *point-to-point* private connection. When more parties were connected to that line, the 'party-line' came into existence, and everybody on the line could speak to each other at the same time (obviously without any privacy, Figure 3). But soon the idea of a central switching point was developed. All the different (party) lines would be brought to a central point, where they could be connected at will with the help of a switchboard; the *telephone exchange* became the hub of telephone activity. Now the connection could be established between two callers at random for the duration of the call.



LIST OF SUBSCRIBERS.

New Haven District Telephone Company.

OFFICE 219 CHAPEL STREET.

February 21, 1878.

Residences.

Rev. JOHN E. TODD.
J. B. CARRINGTON.
H. B. BIGELOW.
C. W. SCRANTON.
GEORGE W. COY.
G. L. FERRIS.
H. P. FROST.
M. F. TYLER.
I. H. BROMLEY.
GEO. E. THOMPSON.
WALTER LEWIS.

Physicians.

Dr. E. L. R. THOMPSON.
Dr. A. E. WINCHELL.
Dr. C. S. THOMSON, Fair Haven.

Dentists.

Dr. E. S. GAYLORD.
Dr. R. F. BURWELL.

Miscellaneous.

REGISTER PUBLISHING CO.
POLICE OFFICE.
POST OFFICE.
MERCANTILE CLUB.
QUINNIPIAC CLUB.
F. V. McDONALD, Yale News.
SMEDLEY BROS. & CO.
M. F. TYLER, Law Chambers.

Stores, Factories, &c.

O. A. DORMAN.
STONE & CHIDSEY.
NEW HAVEN FLOUR CO. State St.
" " " " Cong. ave.
" " " " Grand St.
" " " Fair Haven.
ENGLISH & MERSICK.
New Haven FOLDING CHAIR CO.
H. HOOKER & CO.
W. A. ENSIGN & SON.
H. B. BIGELOW & CO.
C. COWLES & CO.
C. S. MERSICK & CO.
SPENCER & MATTHEWS.
PAUL ROESSLER.
E. S. WHEELER & CO.
ROLLING MILL CO.
APOTHECARIES HALL.
E. A. GESSNER.
AMERICAN TEA CO.

Meat & Fish Markets.

W. H. HITCHINGS, City Market.
GEO. E. LUM. " "
A. FOOTE & CO.
STRONG, HART & CO.

Hack and Boarding Stables.

CRUTTENDEN & CARTER.
BARKER & RANSOM.

Office open from 6 A. M. to 2 A. M.
After March 1st, this Office will be open all night.

Figure 114: List of subscribers of the New Haven District Telephone Company (1878).

Source: Archives of Thomas J.Dodd research Center, University of Connecticut. http://doddcenter.uconn.edu/asc/exhibits/snet/firstfifty/earlyhistory/index.htm

The first local telephone exchanges were created in 1877-1878. It was July 1877 when Isaac Smith, a Hartford druggist, established a telephone network for connecting his store with several doctors and livery stable operators. Also in 1877 the 'Bridgeport Social Telegraph Association' adapted to telephones and connected its members with a simple switchboard.

The first commercial service was established in January 1878 in New Haven by George W Coy, who created the *New Haven District Telephone Company*. With $600 of borrowed money, he built the switchboard with carriage bolts, handles from teapot lids, wire, and other spare parts. The twenty-one original subscribers to the eight lines of the exchange each paid

$1.50 per month[241]. The hand telephones at the subscriber's house or office were connected to the central office by party lines. From there, the caller could be connected to another party line on which the desired subscriber was situated. Not much later he created the first directory when he printed the names of the 50 subscribers on a one-page flyer (Figure 114).

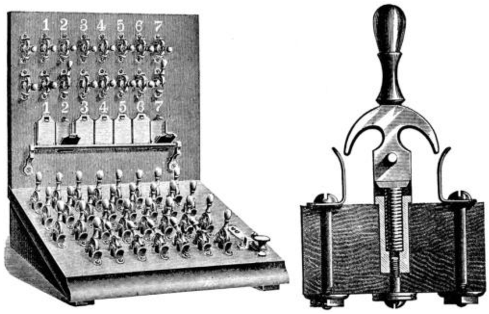


Figure 115: Snell telephone switchboard and contact jack (ca 1878).

Switchboard (left) made by Mr Snell, with Snell jack (right) enlarged

Source: Wikimedia Commons. Land, F. de; Notes on the development of telephone service. Popular Science, 1907, p.234

Figure 116: Wall switchboard made by Viaduct Manufacturing Co. (1890s ?)

Source: http://www.telephonearchive.com/phones/switchboard-pbx/viaduct-wall-switchboard-phone.html

Soon his enterprise started expanding, with more subscribers, more wires and expanding switchboards such as the one built by Snell (Figure 115).[242]

This is just one of the many examples of the numerous manual switchboards that were being developed, one example being the wall switchboard manufactured by Viaduct Manufacturing Company based in Elk Ridge, Maryland (Figure 116). The 'Telephomania' had commenced.

The manual telephone switchboard grew out of the mechanical switchboards developed for the telegraph and operated by boys. Telephone switchboard development followed its own trajectory; soon they connected not just a few (telegraph) lines, but hundreds of (telephone) lines.

---

[241] Equivalent to $36 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

[242] Source: Land, F.de ; Notes on the development of telephone service. Popular Science, 1907, pp.234-242

Originally, a switchboard was—also operated by boys—a noisy and quite rude affair. That changed when, not much later, the female operators, who were much politer and gentler in their interaction, replaced them (Figure 117).

Figure 117: Law system switchboard at Richmond Exchange, Virginia (1882).

Source: (Joel & Schindler, 1975)

Connecting larger numbers of subscribers proved a problematic affair with long waiting times. This problem would only be solved by replacing the manually operated central office by the 'automatic exchange' (although with a less charming dial service). The following gives a glimpse of those who contributed to this early development.

One of the early engineers who was involved in the creation of the switchboard was the Hungarian *Tividar (Theodore) Puskás* (1841-1893), who worked for Thomas Edison. In 1877, he conceptualized a manual switchboard that was built for the Bell Telephone Company in Boston. He would implement some years later the telephone exchanges in Paris (1879), where he looked after Edison's European affairs, and Budapest (1881).

At the same time *George C Coy,* of New Haven, who, after noticing that the switchboard was quickly wearing out its contacts, adapted the switch pins and plugs with the 'jack knife' switch. He was granted US patent № 224,653 on February 17, 1880, for a 'Switch for Telephone Exchanges'. As early as 1878 *Charles Ezra Scribner* (1858-1926) had developed the 'jack switch' that was to become a main component of the switchboard. He filed on December 1880 and was—quite some time later—granted US patent № 489,570 on January 10, 1893. The jack switch made the *multiple switchboard* possible. At Western Electric, the Bell manufacturer of telephone equipment, several inventive people, but not well educated as electrical engineers, were working in the late 1870s and early 1880s on the connection of subscribers to each other. All these activities (again) resulted in priority conflicts, such as the case between Charles Scribner and Leroy B Firman. Scribner had obtained British patent № 4,903 in May 14, 1880, for a switchboard, a patent that would be defended in the case of *Western Electric*

Table 9: Some of the patents granted to Charles Scribner.

Patent №	Granted	Description
GB 4,903	May 14, 1880	System of multiple switchboard
US 254,389	Feb 28, 1882	Electrical Switchboard
US 262,701	Au 15, 1882	Circuits for multiple switchboards of telephone exchanges.
US 271,279	Jan 30, 1883	Circuit for multiple switchboards for telephone exchanges.
US 321,390	June 30, 1885	Duplicate Switchboard for Telephones.
US 321,391	June 30, 1885	Multiple switchboard for telephone exchanges.
US 330,057	Nov 10, 1885	Telephone Exchange signal
US 346,708	Aug 3, 1886	System of Telephonic Communication
US 367,670	Aug 2, 1887	Electric Light switchboard.
US 427,121	May 6, 1890	Multiple swithchboard testing apparatus.
US 489,570	Jan 10, 1893	Spring-jack Switch.
US 496,907	May 9, 1893	Testing apparatus for multiple switchboard systems.
US 552,725	Jan 7, 1896	Plug and spring-jack for telephone-switchboards.
US 572,218	Dec 1, 1886	Needle plug test system for multiple switchboards.
US 596,625	Jan 4, 1896	Plug and spring-jack for telephone-switchboards.

Source: USPTO

v. Capital Telephone & Telegraph[243] where Leroy B Firman claimed priority, although he was granted US patent № 252,576 on January 17, 1882. The judge ruled that Firman reduced his invention to practice before the first step was taken to secure the Scribner patent. Therefore, Scribner lost the priority. However, as Firman left the employment of Western Electric, Scribner would become the *wizard of the switchboard* as he obtained 600 of the total nine thousand switchboard patents issued in the US (Table 9).

Scribner also changed the power supply concept. Originally, the electric power for the telephone equipment was at the telephone end. The 'wet cells' (ie the original Volta chemical battery) were placed in the Coffin models. That changed when, in the 1890s, the central battery, located in the exchange and feeding from there to the individual telephones, was applied. This saved hundreds of thousands of wet cells a year. Then after some more time, the 'wet cell' was complemented by the 'dry cell', the electromagnetic dynamo[244].

---

243 Western Electric Co. V. Capital Telephone & Telegraph Co. et al. (Circuit Court, N. D. California. March 29, 1898). Source: https://law.resource.org/pub/us/case/reporter/F/0086/0086.f1.0769.pdf; the Bell is ringing (Times, May 29, 1964). Source: http://claytwhitehead.com/ctwlibrary/Box%20066/001_Research%20Articles-%20Reviewed.pdf

244 See: B.J.G. van der Kooij, *The Invention of the Electro-motive Engine* (2015), pp. 87-153.

The first US telephone exchange was built in New Haven (USA) in 1878. Soon there followed the Telephone Boom all over Europe. The next exchange was established in Paris (1879), then in Moscow (1881), St. Petersburg, Odessa, Berlin, Riga and Warsaw. Thanks to these exchanges, the first wired telephone devices could connect to each other and perform their main function: the transmission of the human voice across long distances.

Figure 118: Telephone exchange operator in Richardson, Texas (1900).

Source: Wikimedia Commons, Richardson Historical and Genealogical Society

Soon the concept of the central station switchboard would be used everywhere, often as part of shops or other public facilities, and operated by female operators (Figure 118). It was the basis for all those small 'telephone providers' that soon popped up everywhere, serving an area with a radius of some twenty miles. Or it were the existing telegraphy services, such as the *American District Telegraph Company of Chicago*, that added a telephone service to their telegraphy services in 1878.

An example of early telephone service providers was the *Denver Dispatch Company* (1879), founded by Frederick O Vaille and Henry R Wolcott, that began telephone service in Denver in 1879. With 161 customers (including the Rocky Mountain News), this was the seventeenth exchange in the nation to open, and it was one of the largest in the world at that time. It was also the seventeenth Bell franchise. In 1881 Vaille and Wolcott turned Denver Dispatch into the *Colorado Telephone Co.,* as the company had grown from the initial 161 subscribers making local calls in Denver to more than 1,200 in places including Boulder, Golden, Central City, Colorado Springs and Pueblo (Figure 119).

In 1880 they reported having 700 'circuits' and net earnings of $18,178, of which they paid $18,000[245] in dividends to the shareholders (Shuman, 1883, p. 794). In 1888 Horace Tabor sold his *Leadville Telephone Co.* (founded in 1882) to Vaille and Wolcott, giving them telephone service to Colorado's second-largest city at the time. Later their telephone company would become 'Mountain Bell', but before that had happened Vail retired from business in 1903, a wealthy man[246].

Figure 119: Denver Central Office, Colorado (1879).

Source: G Archives. http://www.telcomhistory.org/vm/LHLocalPhones.shtml

The next step was to connect the individual exchanges (located in the central offices) with each other, thus connecting close-by cities with each other. These manual exchanges were the first elements that would be the building blocks for Bell's 'Grand System'. Bell created in 1885 a special company for it—the *American Telegraph & Telephone Company* (AT&T)—a company that would, in time, become one of the largest corporations in the world (1981: more than 1 million employees, $138 billion in assets).

[245] Equivalent to $423,000 in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

[246] Source: Bunch, J.: *Colorado telecommunications pioneer's lucky strike outlasted gold and silver.* Denver Post, November 2012.

The Automatic Exchange

Even at this early stage, engineers tried to develop a system that would connect subscribers without the intervention of an operator. These became known as the dial telephones, a concept borrowed from the dial telegraph. The first dial telephone exchange, patent №. 222,458, was applied for on September 10, 1879, and issued on December 9, 1879, jointly to M D Connolly, of Philadelphia, T A Connolly, of Washington, D. C., and T J McTighe, of Pittsburgh. Although this first system was crude in design and limited to a small number of subscribers, it nevertheless embodied the generic principle of later dial systems. It was exhibited at the Paris Exposition of 1881, but never became employed in commercial service (Hill, 1953, p. 22)

> *Between 1879 and 1900, a great many patents covering dial switching systems were issued, but except for the Strowger patent (No. 447,918) of 1891 and subsequent patents pertaining to the Strowger system, none resulted in a successful commercial system. … the twenty-six patents … that were issued between the Connolly and McTighe patent of 1879 and Strowger patent No. 447,918 of 1891 all related to the operation of small exchanges, and for the most part employed complicated electromagnetic step-by-step arrangements, constantly*

Table 10: Patents granted for early Automatic Telephone Exchanges*

Patent №	Granted	Patentee	Description
US 222,458	Dec 9, 1879	Connolly & McTighe	Improvement in automatic telephone-exchanges
US 223,201	Dec 30, 1879	G Westing-house Jr	Improvement in auxiliary telephone exchanges
US 248,138	Oct 11, 1881	Charles E Buell	Telephone Exchange Apparatus
US 269,130	Dec 12, 1882	Frank H Snell	Automatic Telephone Exchange
US 281,613	July 17, 1883	Gerge A Cardwell	Automatic Telephone Exchange
US 283,806	Aug 28, 1883	Irwin M O'Donel	Telephone Exchange
US 290,730	Dec 25, 1883	Jacques V M Bartelous	Switching apparatus for telephone lines
US 310,282	Jan 6, 1885	William A Jackson & William R Cole	Telephone System
US 372,378	Nov 1 ,1887	Thomas D Lockwood	Automatic Telephone Exchange
US 408,327	Aug 6, 1889	John R Smith	Telephone System
US 447,918	Mar 10, 1891	A B Strowger	Automatic telephone-exchange

* ie systems working without the intervention of attendants at the central office.

Source: USPTO; (Hill, 1953) Table 1. http://www.historyofphonephreaking.org/docs/blr-1953-01-early-work-on-dial.pdf. Classification; H04Q3/00 *running synchronized clockwork mechanisms, reversals of current direction, changes in current strength, and the like. None of them can be said to have advanced the automatic switching art in any practical manner, nor did any of them, so far as is known, go into commercial use. (*Hill, 1953, p. 23)

Obviously, many inventors were busy with the exchange concept (Table 10). However, it was the undertaker *Almon Brown Strowger* (1839-1902), who suspected a female operator directing potential clients for his funeral business to a competitor[247]. Therefore, he developed a system that could function without human interaction. After experimenting with some ideas he designed a system where a rotary dial on the telephone apparatus would give commands (impulses) to electromechanical switch equipment in the central station.

Thus, he invented the 'Strowger Switch', a rotary switch with a two motion system that was patented on March 10, 1891, as US patent № 447,918 (Figure 120).Figure 120: US patent № 447,918 for the 'Strowger Switch' (1891). It stated: 'The object is to provide means whereby a person at one station may make connection with any other station in the system, by the aid of electrical appliances, without the assistance of an operator at the central station' (text of patent).

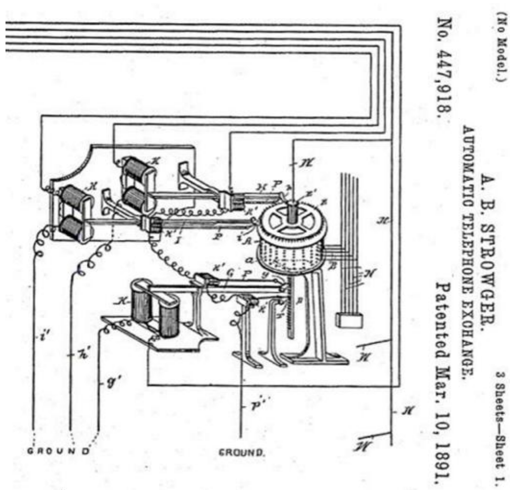


Figure 120: US patent № 447,918 for the 'Strowger Switch' (1891).

Source: USPTO

To exploit his patent, and after he had invested $4,000[248] in the first working model, together with the salesman Joseph Harris, Moses A Meyer and a number of others, he formed a company called the *Strowger Automatic Telephone Exchange* in 1891. Soon it created

[247] The story is as follows: "At the same time, he discovered that a friend had died and he had not been called about the funeral services. He attributed the problem to a telephone operator who was romantically involved with a rival undertaker. Strowger reportedly became angry, believing that the woman was diverting Strowger's calls to the rival." Source: http://www.strowger.net/conspiricy-behind-strowger-as-an-inventor/

[248] Equivalent to $107,000 in 2014; calculation based on historic opportunity costs. Source: http://www.measuringworth.com/

its first automatic exchange in La Porte, Indiana, on November 3, 1892.

> *Despite some setbacks, the first automatic telephone exchange was installed successfully in La Porte, and it debuted on Nov. 3, 1892. The system's public demonstration was greeted with much fanfare, including a brass band and a special train run from Chicago. Guests included power company executives, journalists, entrepreneurs, inventors, and two representatives of the Russian czar. Strowger called his system "girl-less, cuss-less, out-of-order-less, and wait-less."*[249]

The people from Bell did not like the development at all. Each time an installation based on the Strowger System opened in a new location, the Bell Company protested the opening and threatened lawsuits against the operating company and all subscribers.

There was a technical flaw in the system as it required users to be accurate in the number of times they tapped each of the buttons on the phone, required users to press a release button after the call was completed, and did not prevent users from being connected to a line that was already in use. Also, the system at first could only serve 99 telephone lines, and required that each telephone have a strong battery and be connected to the central office by five wires. But that problem was solved when in 1891 his employees Alexander Keith, John Ericksson, and Charles Ericksson invented the dial telephone. They received US patent № 638,249 on December 5, 1899, for the enhanced Strowger Switch (Figure 121) that could be operated with a rotary dial placed on the telephone apparatus; it became the Dial Candlestick model (Figure 122).

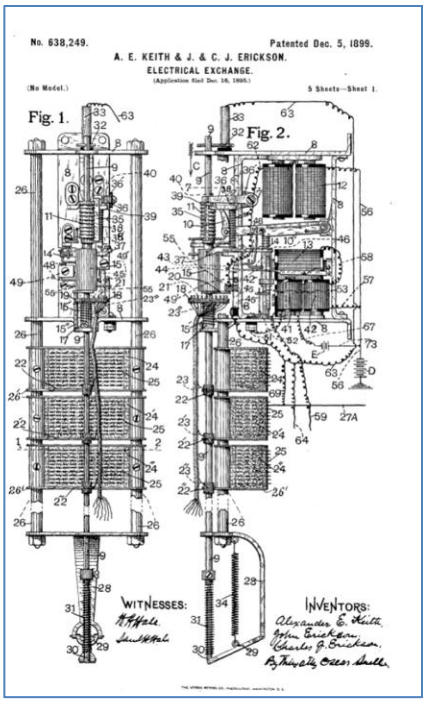


Figure 121: US patent № 638,249 for the 'Strowger Switch' (1899).

Source: USPTO

[249] Source: The Strowger Switch, The Company. http://www.strowger.net/strowger-automatic-telephone-exchange/

The first dial telephones began operating in Milwaukee's City Hall in 1896. Independents were quick to start using the new switch and phones. Strowger's company, renamed in 1901 as the *Automatic Electric Company*, in licensing the Strowger patents, would become the largest telephone equipment manufacturer for the independent telephone companies.

Figure 122: Strowger 11 digit Potbelly Dial Candlestick.

Source: http://www.sparkmuseum.org/

In the fall of 1896 A B Strowger left the *Strowger Company* and went to Florida for his health. He took no part thereafter in the development of the system which bore his name, and he died in St. Petersburg, Florida, in May, 1902. He had sold his patents in 1896 for $1,800 and sold his share in Automatic Electric in 1898 for $10,000. His contributions to the automatic exchange proved quite valuable, as his patents subsequently sold for $2.5 million[250] in 1916.

In the meantime, some additional, but quite important, improvements related to the system would be made. First, it was *John J Carty* who solved the problem of all the irritating background noises that one heard on a telephone connection. He replaced the single-wire line by a twisted pair of wires, and gone was the 'cross talk'. On March 12, 1889, he was granted US patent № 399,377, followed by US patent № 442,856 on December 16, 1890.

Goliath against David: The Pupin-Campbell Controversy

A major problem for the development of telephony was the cost of communicating over longer distances. As the signal would soon become too weak as the result of the attenuation on the line, it took—expensive—copper wire of increasing diameter to be able to communicate over longer distances. By 1900, long-distance telephony had reached what seemed to be a practical limit in a 1,200-mile circuit between Boston and Chicago. On average, a quarter of the capital invested by the telephone companies was in these wires. Many scientists and engineers worked on the problem of 'the attenuation of the electric waves'.

250 Equivalent to $55.6 million in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

One of those scientists was *Michael Idvorsky Pupin* (1858 - 1935), an Austrian citizen of Serbian origin who immigrated to the US in 1874 at the age of 16. He was one of all those immigrants that poured into the US from Europe, some of them becoming famous later in life (eg Nicolas Tesla). His early years in the US were characterized by hardship and poverty doing manual labour jobs, working on farms and in factories. After educating himself through evening classes at the Cooper Union Institute, he managed to go to Columbia College. There, he not only excelled in sports, but he became fascinated with physics. On graduation in 1883, and the day after he became US citizen, he was appointed first Tyndall Fellow in Physics from Columbia College. The next six years were spent at the University of Cambridge, England, and the University of Berlin, Germany, where in 1889, he got his degree of Doctor of Philosophy under Hermann von Helmholz. Returning to America, he joined the teaching staff of his alma mater, Columbia University.

> *Pupin engaged in mathematical investigations on the vibration of elastic strings loaded at successive intervals with uniform lumps of matter, and obtained the solution of this problem in 1895. It led him later to the solution of a co-related electrical problem—the propagation of alternating electric currents over a uniform conductor, containing lumps of inductance, i.e. inductance coils inserted in the conductor at regular intervals. The solution showed that a telephone circuit might be greatly improved by inserting inductance coils at specified distances.* (Kennelly, 1935, p. 337)

Thus, Pupin invented the 'pupin coil' that made communication over longer distances possible on thinner lines: the 'pupinised telephone lines'. The economic importance would be considerable as long-distance calling was a hot topic in telephony at that time.

> *The coil-loaded telephone circuit may seem deceptively simple, since it consists of inductance coils connected in series with the conductors of telephone wires that periodic intervals. However, an examination of the historical details reveals that this was one of the most sophisticated electrical innovations of the nineteenth century. It is significant that each of the claimants to priority of discovery was proficient in mathematical physics.* (Brittain, 1970, p. 36)

For his earlier work on telegraph communication, he had already been granted US patent № 519,346 on May 8, 1894 (Figure 123). That patent involved series capacitors, rather than inductors, which were not to be distributed along the line. Then it had already been figured out that, next to the ohmic resistance of a wire, other factors influenced its transmitting capacity as well[251]:

> *'By "impedance" as everywhere herein employed, I do not mean electromagnetic impedance, but the combined reaction of the ohmic resistance, self induction, electrostatic absorption and the attenuating effect of distributed capacity of a long cable' (text of '346' patent).*

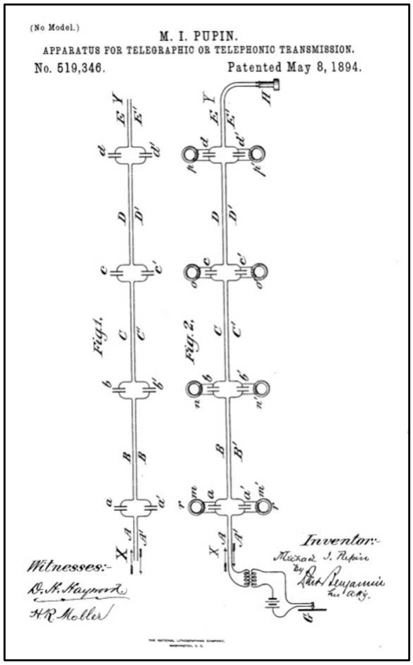


Figure 123: M Pupin's US patent № 519,346 (1894).

Source: USPTO

Pupin added to that the mathematical calculations and introduced a coil as a means to reduce attenuation. He claimed: 'What I claim as new, and desire to secure by Letters Patent of the United States, is—the method of diminishing the attenuation constant of a uniform wave-conductor which consists in increasing the inductance of the conductor sufficiently to secure the required diminution of the attenuation constant, by distributing along it inductance sources at periodically-recurring points, the distance between consecutive points being such as to preserve approximately its character as a uniform conductor/with respect to the waves to be transmitted, substantially as described' (text of '231' patent, emphasis added). He obtained US patent № 652,230 and № 652,231 on June 19, 1900, for 'reducing attenuation of electric waves' (Figure 124). These were the 'loading coil patents'.

Another invertor working at AT&T, *Georg Ashley Campbell (*1870-1954), a civil engineer from MIT who had studied at Harvard, Gottingen, Vienna and Paris, worked also on the same problem. He was a member of the engineering staff in the Boston laboratory of the American Bell Telephone

---

[251] When one deals with 'alternating current' (AC) of telephony, there are two additional impeding mechanisms to be taken into account besides the normal resistance of 'direct current' (DC) circuits: the induction of voltages in conductors self-induced by the magnetic fields of currents (inductance), and the electrostatic storage of charge induced by voltages between conductors (capacitance). Technically, it works as follows: the (1) basic resistance ('ohmic resistance') of a wire set of two cables is complemented by (2) a 'capacity impedance' as the long wires create a capacitor. To eliminate this effect, one adds (3) 'inductive impedance' created by a coil.

Company. There, he worked on the problem of long-distance transmission and explored the usage of coils. The solution he found seemed patentable, but it took quite a long time to process the patent application with AT&T. Finally, he applied for a patent on March 5, 1900. (Joel & Schindler, 1975, p. 243). This would start another of the priority claims in the telephone's troubled history.

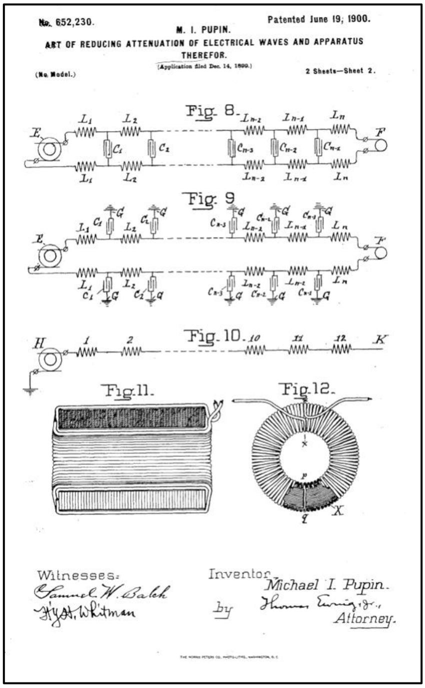


Figure 124: M Pupin's US patent № 650,230 (1900).

Patent shows the 'Pupin coil'.

Source: USPTO

> *When questioned about the reason for the delay, Campbell later explained it had been necessary for him to spend a considerable amount of time in attempting to explain the loading graphs in his July report to Swan. He stated that they had also undertaken an extensive survey of the relevant literature, including American and foreign patents. Finally, Swan had insisted that the patent specification not contain mathematical formulas but that it be written "in language which would be at once understood by telephone engineers."* (Brittain, 1970, p. 44)

The priority-claim: Next to Pupin's invention, in the same period, a similar invention had been made by George Campbell, working for the American Telegraph & Telephone, and Pupin, professor of Electromechanics at Columbia University. But who had the priority? Pupin, working as a professor, or Campbell working at AT&T? It seemed the 'David versus Goliath battle' all over again, as now AT&T was the rich giant who opposed a professor with limited funds. As Pupin stated later in his autobiography:

> *Two other inventors had applied for a patent on the same invention. One of them was an American, and the other a French inventor, and each of them was backed by powerful industrial organization. A college professor with a salary of two thousand five hundred dollars per annum cannot stand a long legal contest when*

> *opposed by two powerful corporations; but it is a curious psychological fact that when one's claim to an invention is disputed he will fight for it just as a tigress would fight for her cub.* (Pupin, 2005, pp. 300-301)

The conflicting claims of the Puppin patents and the Campbell patent application resulted in extended interference proceedings. Campbell was slow in his response, and finally, on April 6, 1904, the patent was issued to Pupin.

> *Following extensive testimony on behalf of each claimant, the examiner's decision favoring Pupin was handed down in December 1903. The Bell company president, Frederick P. Fish, then contacted Campbell to request that he read over the examiner's decision and give advice on what further action the company should take. Fish stated that it was his wish that "there should be no cloud upon the title of the successful contestant." Apparently, Campbell recommended that the matter be pursued, since the examiner's decision was appealed to the board of examiners-in-chief in January. The board's decision was handed down in April and also awarded priority to Pupin. The board decision might then have been appealed to the patent commissioner and, if necessary, to a federal appeals court. However, Fish decided against further action in the case, leaving Pupin the legal winner.* (Brittain, 1970, p. 55)

The invention was of enormous value to AT&T. Telephone cables could now be used to twice the distance previously possible, or alternatively, a cable of half the previous quality (and cost) could be used over the same distance. It has been estimated that AT&T saved $100 million[252] in the first quarter of the twentieth century (Brittain, 1970, p. 36). These figures illustrate the staggering amounts of money that were related to the Bell Monopoly.

The litigation ended on April 6, 1904, as AT&T withdrew. Fearing that there was a risk that the battle would end with the invention being declared unpatentable, they decided to buy an option on Pupin's patents for a yearly fee so that AT&T would control both patents. They paid $185,000 up front and $15,000 for each year the patent stayed in force. By January 1901 Pupin had been paid $200,000, and by 1917, when the AT&T monopoly ended and payments ceased, he had received a total of $455,000[253] (Brittain, 1970, p. 54). The result was that he became a wealthy man. Pupin achieved a financial success which has seldom, if ever, been equalled by a full-time engineering professor.

[252] Equivalent to $2.740 million in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

[253] Equivalent to $8.4 million in 2014; calculation based on historic standard of living. Source: http://www.measuringworth.com/

Overview Early Improvements

Bell's invention started, as we have seen, a flood of technological developments. Developments that followed two trajectories. One trajectory that related to the improvement of the components of the telephone itself: the Component improvements. Another development trajectory resulted in improvements that covered the system as a whole: the system improvements (Figure 125). It started with the simple improvements in those early years, but over the years—as telephony was also faced with the capacity problems telegraphy had encountered—it was the development of a complex telecommunication infrastructure.

Patent Activity

As inventors who think their invention has a specific novelty that is worth protecting have the habit of applying for a patent, the resulting patent activity in a specific technological field indicates the importance of that field. In the case of the development of electric speech, the patents issued were related to two trajectories: the component trajectory and the system trajectory. The component patents covered parts of the system, such as the patent of the transmitter/receiver that started with Bell's transmitter and receiver. The system trajectory saw the patents that related to the

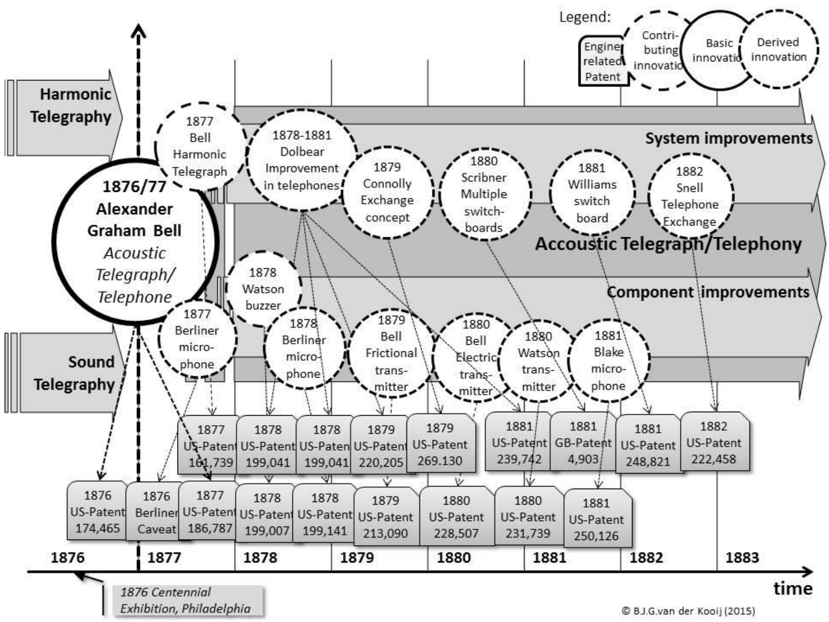


Figure 125: Derived innovations from Bell's invention of the telephone.

Figure created by author

manual, and later the electromechanical, exchanges. Here, it was Scribner and Strowger who were early contributors. They were soon followed by many others.

In Figure 126, the patent activity up to 1920 is graphically presented. The graph shows clearly that the total number of telephony related patents increased considerably after Bell's patent protection ended in 1894, especially the patents for the total telephone system (including the exchanges).

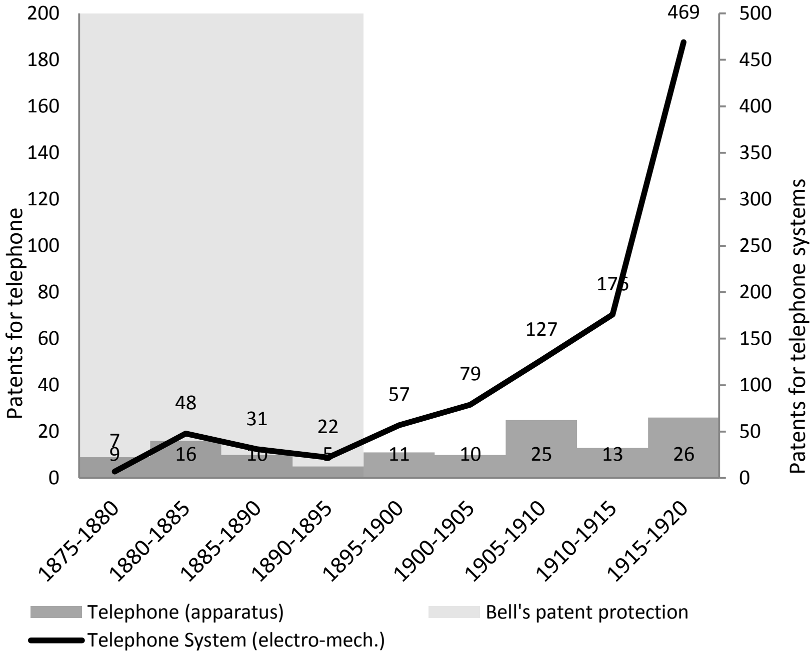


Figure 126: Growth of number of US patents for telephony (1875-1920)

Telephone apparatus: Patents in the same class as Edison's patents: CCL/379/167.01 or CCL/379/453 or CCL/379/9. Telephone Systems: Patents in the same class as Strowger's patent.: CPC/H04Q3/00 and ISD/1/1/1875->01/01/1880

Source: USPTO

Other Developments in Telephony

Just as the telegraph had not only developed in Britain and America, the same went for the telephone. Soon after Bell's telephone monopoly started to conquer the American communication market, the same happened in Europe. This is not the place to cover that development in detail, as it has been done by many others[254], but we will explore one specific country as it is so closely related to the US: Britain. Though closely related to the US, Britain had a totally different societal context than America. Consequently, in Britain, the introduction of telephone services followed another path.

Obviously, the early use of the speaking telegraph was for person-to-person communication. After a few decades, in addition to the development of the market for purely telephonic conversation, another kind of service was also offered using the telephone infrastructure: the early broadcasting services, for news, for theatrical performances and for the church services. Again, purely for the purpose of illustration, we will mention them here briefly.

England: The Post Office strikes again

In Britain, telegraphy had, after its early development, become a monopoly of the Post Office[255]. Traditionally, 'communications', for much of British history, had been a monopoly of the Crown. Her/his Majesty's mails were transported and delivered by her/his Majesty's servants. In addition, telegrams were considered a kind of mail. So, in the Telegraph Act of 1869 the exclusive right to transporting, receiving, collecting and delivering telegrams was reserved to the Post Office. And as a telephone conversation was considered to be a message like a telegram, the Post Office should have the monopoly for telephony.

As both Bell and Edison were getting quite active in the British telephone business, the Attorney General, on behalf of the Crown, filed in November 1879 a suit against the Edison Telephone Company: *Attorney General vs. Edison Telephone Company of London Ltd.* (Law Report 6 Q B D244). The telephone companies were infringing on the Post Office privilege. It was on December 20, 1880, that a court judgment was issued in favour of the Post Office. The result was that the telephone conversation became legally and officially a telegram within the meaning of the Act (Robertson, 1947, pp. 21-24).

---

[254] Such as Huurdeman, A.: *The Worldwide History of Telecommunication* (Huurdeman, 2003); Holzmann, G.: *The Early History of Data Networks* (Holzmann & Pehrson, 1995).
[255] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'* (2015) pp. 327-337.

The next question was whether or not the State should take over the development of telephony in the United Kingdom, as it had taken over telegraphy, or whether it should grant licenses to private companies. The Post Office was not really interested in the new phenomenon of the telephone as a threat to its telegraph business. This became clear before a hearing of the Select Committee of the House of Commons on May 2, 1879. When asked by Lord Lindsay: '...but do you consider that the telephone will be an instrument of the future which will be largely adopted by the public?' William Pierce of the Post Office Engineering staff replied:

> *I think not. It will not take the same position in this country as it has already done in America. I fancy that the descriptions we get of its use in America are a little exaggerated; but there are conditions in America which necessitate the use of instruments of this kind more than here. Here we have a superabundance of messengers, errand boys, and things of that kind. In America they are wanted, and one of the most striking things to an Englishman there is to see how the Americans have adopted in their houses call bells and telegraphs and telephones, and all kinds of aids to their domestic arrangements, which have been forced upon them by necessity. … Few have worked at the telephone much more than I have. I have one in my office, but more for show, as I do not use it because I do not want it. If I want to send a message to another room, I use a sounder or employ a boy to take it; and I have no doubt that is the case with many others, and that probably is the reason why the telephone has not been more adopted here.* (Kingsbury, 1915, pp. 208-209)

He was quite wrong. In Britain, the telephone market would also explode, but quite some time later. But for the moment, in the coming decade, the development of the British telephone system would become a balancing act between government regulation and the development of private enterprise within a rapidly evolving telephone technology.

The Post Office was now faced with the challenge of developing the telephone system along with its telegraph system. With some reluctance, the Post Office made known that it had the intention to offer telephone services for those who had telegraph lines connected to the telegraph offices. On Christmas day 1880, they published this in an

Figure 127: British Gower-Bell Telephone as used by the Post Office (1881).

Source: http://www.britishtelephones.com/ gowerbell.htm advertisement and invited renters to apply for the telephonic instruments. As, in the meantime, a newly established company, the *United Telephone Company Limited* (UTC), had taken over the patent licensing from both Bell and Edison, it became a confrontation of private business and the Post Office. United responded and warned potential users of carbon transmitters, and accused Bell-telephone of infringement and threatened it with legal proceedings. The *Gower-Bell Company*, in its turn, advertised the superb quality of its telephone—made under license from Bell— that it supplied to the Post Office (Figure 127). These were the disputes that were typical for that time when electrical communication was in its infancy.

Having confirmed its monopoly (Figure 128), the Post Office could itself have developed and operated the telephone service as a unified system over the whole country. However, the government did not follow this course, but arranged to license telephone companies to carry on business (for a 10% license fee of the gross income) or to start telephone services, such as the *United Telephone Company*.

> *The United Telephone Company began to operate under a licence valid for 31 years from the end of 1880, the Postmaster General reserving the right to purchase the company's exchange system that the end of 1890, 1897, and 1904.* (Hazlewood, 1953, p. 14)

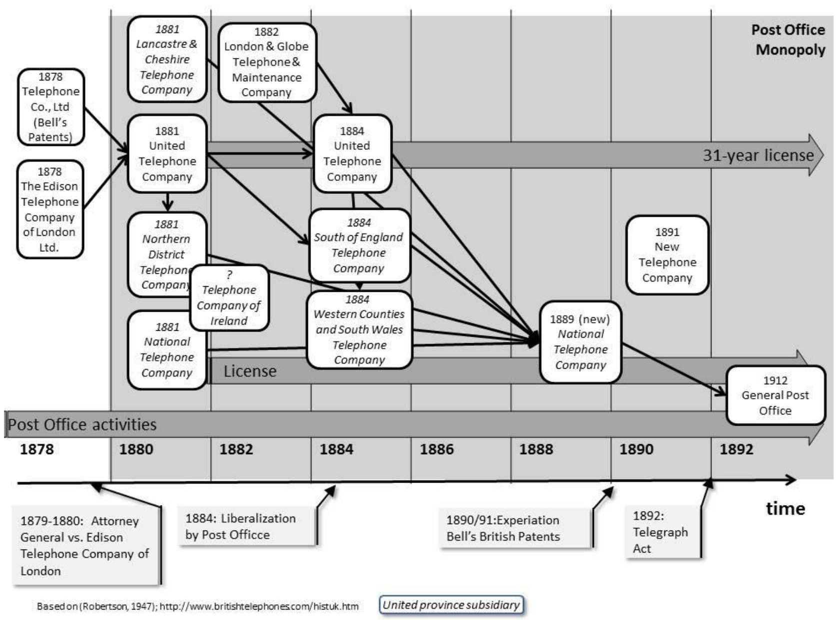


Figure 128: Mergers and Acquisitions during the British Post Office Monopoly.

Figure created by author

Next to licensing, the Post Office started creating telephone services and offered telephone equipment in competition with the commercial companies. 'At March 31, 1882, for example, the Post Office maintained thirty-five exchanges, serving 4,691 subscribers in addition of 691 users of official lines. [...] a sort of creeping paralysis now invaded the industry' (Robertson, 1947, pp. 27-29). However, this dual approach was not successful, and something had to be done.

> *The Postmaster General, …, declared that 'The Department were going to allow free competition - competition not only among the Telephone Companies themselves, but between the Companies and the Post Office'.* (Hazlewood, 1953, p. 15)

This 'liberalization' resulted in the fact that several new telephone services were started, such as, in 1882, the *London and Globe Telephone and Maintenance Company Ltd.* But again, it did not have the desired effect.

> *By 1884, as a result of this dour dualism of policy, it was clear that the telephone industry was being dragged to disaster. There were only 3,800 telephone subscribers in London, and 9,000 in the rest of the United Kingdom. At the same time there were 135,000 subscribers in the United States.* (Robertson, 1947, p. 34)

But, as the nearby expiration in 1890/91 of the British patent protection for Bell's patent was approaching, several mergers and acquisition took place, such as the new and larger *National Telephone Company* that in March 1891 took over the old *National Telephone Company*, the *United Company* and the *Lancashire and Cheshire Company*. In the meantime, the Post Office development of telephone services was just enough to render it a troublesome competitor to the outside companies, yet it never attained vast proportions: 'The Post Office was still a competitor against private enterprise—though not, so far as local exchange facilities were concerned, a blazing successful one' (Robertson, 1947, p. 44). The private companies were restricted to specific exchange areas and renting from the Post Office—limited by political constraints—the long-distance connections.

> *At the same time there was much public agitation against the National Telephone Company, both on account of its alleged high charges and poor service and because of the growing mass of overhead wires which disfigured large cities. … the Government were also influenced by the repeated demands of the companies for further powers to enable them to meet the public's requirements; and again the Government were concerned that the effect which the competition of the telephone companies was having on the telegraph revenue.* (Hazlewood, 1953, p. 17)

The situation at the end of the century was becoming ready for a change in which the words 'nationalization' and 'monopoly' would be used.

> *Again and again in the early history of telecommunications in this country [Britain] this dichotomy is revealed. Policy direction was short-sighted, acquisitive, blundering, and ignorant; technical and engineering work was based on sound, scientific principles, and was far-sighted and highly intelligent. That was the root of the trouble for years; the engineers knew their jobs, and the others did not. …*
>
> *But in the early years, the constant obsession with the value of competition – slap-happy, catch-as catch-can competition, too – led to trouble after trouble. … the telephone system, which had begun with such bright hopes, was becoming a kind of a standby national joke, like Wigan pier and mothers-in-law. … Throughout the nineties dissatisfaction with the telephone service of this country was steadily on the increase.* (Robertson, 1947, pp. 48-51)

It also was evident that the 31-year license of the National Telephone Company would expire within a decade. And that paralyzed the development of private enterprise even further.

> *At midnight on 31 December 1911 the systems of the National Telephone Company passed to the control of the Post Office. The company at that time had 561,000 telephones in service, while the Post Office had something like 120,000, of which nearly 80,000 were in London.* (Hazlewood, 1953, p. 23)

Since the introduction of telephony in Britain in the early 1880s, the actual development in Britain had to balance between different grades of government regulation (eg Telegraph Acts), governmental competition (eg by the Post Office) and the monopolistic tendencies of private enterprise (eg the National Telephone Company). This was a not too successful situation that would, some three decades later, result in a State-operated affair when the license of National Telephone Company expired in 1911.

New Applications for the Telephonic System

That summarises the early development of person-to–person communication—also called *point-to-point communication*—in Britain. Soon another type of telephonic communication would arise. One of those developments was the idea of a speaking, singing, lecturing and concert-giving newspaper. The telephone offered that possibility as it could transmit the spoken word as well as music. So, the property to transmit sound across a wire within a telephonic system opened a range of new applications.

The Telephone Newspaper

It was *Tividar Puskas* (1844-1893), working for Bell as his European representative, who developed the concept of the *Telephone News Service*, which announced news and broadcasted 'programs'. It was an application of the telephone in a new way; instead of reaching one subscriber, now—at the same time—the communication was distributed to many subscribers (who were not supposed to answer the communication). It was a wired *single way point-to-many distribution.* Puskas, with his experience in telephone switchboards and patent applications, developed the system and demonstrated the concept at the Electrical Exhibition in Paris in 1881. Later in 1892 he was granted an Austro-Hungarian patent for 'A new method of organizing and fitting a telephone newspaper'. In September 5, 1893, he was granted a Canadian Patent № 44,152 for a Telephonic News Dispenser. Puskas founded the *Telefon Hirmondo* (the Telephone Herald) in (Buda)Pest that started its service on February 15, 1893 (Figure 129).

From the editorial office, a daily stream of 'online content' was distributed: stock information, sports results, newsroom with late-breaking news, and music and programs for children. In a way, it was a precursor to the radio broadcasting that would become so dominant in the wireless age.

Figure 129: A stentor of the *Telephone Herald* reading the day's news to 6,200 subscribers (1901).

Source: Wikipedia Commons, Dennison, .S.: the Telephone Newspaper'.

> *It worked with four editors and a hundred-member staff. 'Like in a beehive, correspondents are swarming in and out and the staff are working up the arriving telegraphs, news and foreign newspapers. There is a separate room for the communication between the editorial office and the outside world through the telephone. There are nine phones available to the correspondents and shorthand writers. There is a connection between the office and the House of Representatives, and a separate line broadcasts the reports from the stock-market. The news arriving from these sources are worked up and written down before the announcers get them, who read the issues in turn, in a room especially furnished for this purpose, in front of telephone sets used only for this purpose,'* [256]

On the other end of the communication line the recipients were able to listen to the programs. They listened either by using ear tubes, headphones or by listening to a 'loud speaker', a new device that made the transmission loudly available to more people gathered around it.

[256] Source: http://web.archive.org/web/20080621055805/http://people.clarkson.edu/~ekatz/scientists/puskas.html (Accessed March 2015)

> *One of the most praiseworthy features of the "Telefon-Hirmondo" is its extraordinary cheapness. Each subscriber pays but a penny a day for its many advantages, and there are no fees for having a receiver fitted to a house. No one need continue subscribing to the speaking newspaper for longer than four months. On these favourable terms each station is provided with the receiving appliance, having two ear tubes, so that two people can listen at the same time. The apparatus can be fixed wherever the subscriber pleases--at a bed or sofa, at a writing-desk, or in a special room.*[257]

The reason the service could be offered cheaply was the use of advertisements that were broadcast between programs of news items[258]. Among its subscribers were the elite of Budapest.

Also, in the United States, the concept of the Newspaper Telephone was picked up as the 'Telephone Herald Companies' were organized. One example is the *United States Telephone Herald Company* and its associated companies: the Boston Telephone Herald Syndicate, Inc.; the California Telephone Herald Co. (San Francisco); the Central California Telephone Herald Co. (Sacramento); the Massachusetts Telephone Herald Co. etc. [259] In 1911 US patent № 984,235 was granted on February 11, 1911, to the Hungarian Árpád Néme (and assigned to the United States Telephone Herald Company) for 'a telephone system... adapted for supplying innumerable subscribers... general news, musical compositions, and operas, sermons, correct or standard time and other happenings at stated intervals of day and night.' However, in the United States the small number of telephone-based news and entertainment services that were introduced before 1915 were all extinct by the time radio broadcasting began. The associated companies of the US Telephone Herald Company were short lived, and the organization was dissolved in 1918.[260]

The Theatrophone

The Telephone Newspaper was not the only new application for the telephonic distribution system. Another example was the *Theatrophone,* a telephonic distribution system available in portions of Europe that allowed the subscribers to listen to opera and theatre performances over the telephone lines. The wealthier subscribers had in their home special music rooms where they received their guests to listen to a concert.

---

[257] Source: Katscher, L. the Telephone Newspaper. Pearson's Magazine, August, 1901, pages 216-218: http://earlyradiohistory.us/1901.htm. (Accessed March 2015)

[258] The concept of free use of internet services goes back to this idea of including advertisment.

[259] Source: White, H.: *Early U.S. Telephone-based Entertainment Companies.* http://earlyradiohistory.us/.htm#

[260] Source: White, H.: *U.S. Developments.* http://earlyradiohistory.us/sec003.htm#part050

The service originated from the telephonic transmission system that was shown at the 1881 Electrical Exhibition in Paris. The Frenchman Clément Ader (1841-1925) was one of the people, together with Tividar Puskas, who were involved in the creation of the telephone network in Paris in 1880 by the *Compagny Generale de Telephone de Paris*. To demonstrate his theatrophone at the exhibition, he placed a range of transmitters (24 pairs) before the opera stage and developed a system where—in separate rooms at a distance—each ear received the performance separately, thus creating a stereophonic effect (Figure 130). In 1890 his invention was commercialized in France by the *Compagnie du théâtrophone* (Figure 131).

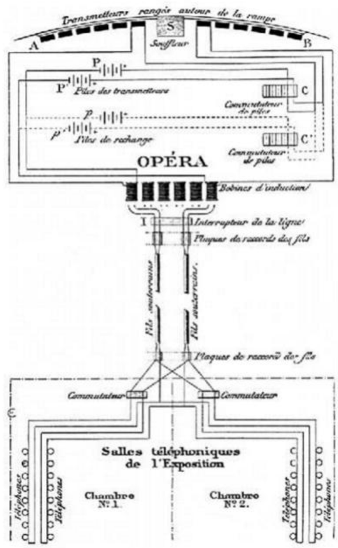


Figure 130: Floor plan of the Theatrophone as implemented at the Paris Electric Exhibition (1881).

Source: . du Moncel, Le Téléphone le microphone et le phonographe, Paris, Hachette, 1878. p.312

Figure 131: Advertisment for the Theatrophone (1896).

Source: . Wikimedia Commons

The theatre-phone had by that time also been exploited in other European countries: from Brussel (Belgium, 1887) and Stockholm (Sweden, 1887), and not much later also in London (England, 1891).[261] In the US, the concept was applied under the name 'Televent' by the *American Televent Company* in 1907. But it did not survive its demonstration stage as the company was soon dissolved. In England, it became known as the 'Electrophone' and was from 1895 organized by the company *Electrophone Ltd.* The system was used for relaying live theatre and music hall shows from Paris and, on Sundays, live sermons from churches via special headsets connected to conventional phone lines. In 1925 the company Electrophone Ltd. ceased its operations and gave the following notice to its subscribers:

[261] Source : *Le Premier Medium Electrique de Diffusion Culturelle.* http://histv2.free.fr/eatrophone/eatrophone.htm

> *In consequence of a large number of our subscribers having given up the electrophone in favour of wireless, the revenue has so largely decreased that the Postmaster-General has decided to withdraw the license granted to this company, and has served notice that the electrophone service is to be terminated on the 30 inst. We have, therefore, no option but to hereby notify you with extreme regret that after the 30 of this month we shall no longer be in a position to continue the electrophone hearings.*[262]

That might have been the end of this kind of entertainment broadcasting services[263] by telephonic distribution, but later in the 1920s 'radio broadcasting' was also available through telephone lines, with often a better quality than its wireless equivalent. In the mid-1920s a new service arose in numerous British towns, 'wireless relay exchanges', where subscribers could listen to radio broadcasts, received at a central location, distributed over telephone lines, avoiding the need to purchase an expensive radio receiver. In the Netherlands, it was, during World War II, the only broadcasting permitted by the German occupants, and after WWII it became part of the State monopoly PTT until it ceased its operations in 1975.

With the progress of the wireless radio, the telephonic distribution system became obsolete. The *Compagnie du Théâtrophone* stopped its activities in 1932. But in many European countries, some form of telephonic distribution continued well into the twentieth century, like in the Netherlands, where a special service, the 'Kerk Telefoon' (the Church Telephone) was still in operation in 2003, and 3,000 churches were connected with 50,000 subscribers.

---

[262] Source: *Electrophone: license withdrawn by Postmaster-General.* London Times, June 17, 1925, p.18. http://earlyradiohistory.us/1925elec.htm

[263] In 2006 the modern version of opera broadcasting was realized by the Metropolitan Opera in New York with its broadcasting service 'The Met: Live in HD', a series of live opera performances transmitted in high-definition video via satellite from the Metropolitan Opera in New York City to select venues, primarily movie theaters, in the United States and other parts of the world. Even in a small village in the south of France, Montauroux, in 2015, operas like Mozart's *La Nozze di Figaro*, could be enjoyed.

The Invention of the Telephone

It is obvious that the invention of the telephone was a momentous event in the development of telecommunication. Many contributed to its development, but trying to answer who was/were the inventor(s) of the telephone is a complex affair. This priority-question about the telephone has been a topic of discussion among historians[264] since Alexander Graham Bell obtained his US patent №. 174,465 in 1876. We will not attempt to mingle in this discussion as it is not relevant to our explorations, but we will just try to present the different points of view within the context of that period of time.

Thinkers and Tinkerers

Basically his invention was a contribution that has to been seen in the context of his time, when many people were thinking about applying

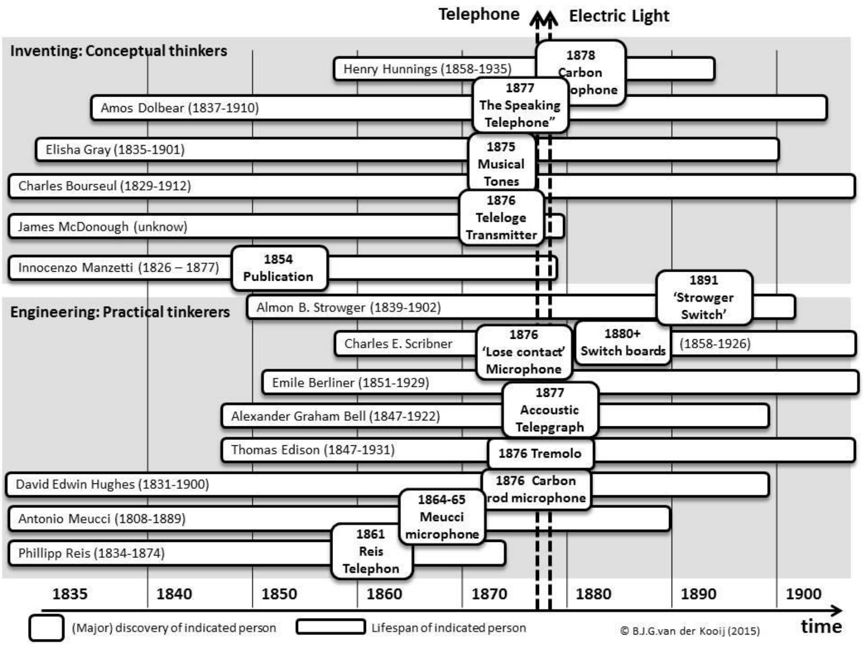


Figure 132: Thinkers and tinkerers developing acoustic telegraphy.

Source: Figure created by author.

[264] Such as: A. Edward Evenson, The Telephone Patent Conspiracy of 1876: The Elisha Gray–Alexander Bell Controversy and Its Many Players (Jefferson, N.C., 2000); Burton H. Baker, The GrayMatter: The Forgotten Story of the Telephone (St. Joseph,Mich., 2000); Seth Shulman, The Telephone Gambit: Chasing Alexander GrahamBell's Secret (NewYork, 2008).

undulating electricity (aka AC) to communication at distance (ie harmonic telegraphy), and some were exploring and conceptualizing how sound could be transmitted over distance (ie acoustic telegraphy). The development of telephony —like telegraphy, the steam engine and even the railway system— was a gradual development due to the experiments and devices of a long train of both thinkers and tinkerers. All in all, a massive number of experimental scientists and engineers were involved in the early years of telephony (Figure 132).

The 1870s were in many respects the period of incubation of the new electric technologies, as by then many basic phenomena of electricity had been discovered and explained. But it took a while before their efforts created the electric telephone networks that erupted in cities all over the world, and even longer to realize the interconnection between those urban networks— many of them along railway lines— at the end of the nineteen century. One of those thinkers and tinkerers was the 'teacher of the deaf' Alexander Graham Bell (1847-1922). In the 1870s he contributed to the development of telecommunications in a fundamental way. In short, this is what happened (Figure 133).

Bell, like his famous predecessor, the painter Samuel Morse (1791-1872), did not have a background in electricity. Bell was educated in acoustics and even in a specific area of acoustics by his work with deaf people. He had been following in his father's footsteps after the family had immigrated to Canada in 1870. Then he commenced on an endeavour that would change his life in less than a decade. In a remarkably short time his tinkering with electricity, and his acoustic experimenting—for example with the human ear—resulted in the 'Concept of Electric Speech' realised by the undulatory electric current(July 1874). This was a period where Bell was fascinated by idea of applying sound into distant communication by means of electricity. At the age of twenty-six, it was a very dedicated person who was fanatically at work in the basement of the Sanders' house he was boarding in.

Then it took another three years of experimenting and demonstrating to reach the stage where his ideas became patentable (1876). Even with the distraction from his financial backers, who wanted him to follow the trajectory of the harmonic telegraph, Bell managed to add his work on the trajectory of the acoustic telegraph. Then came the moment of birth when he created the devices, although quite crude in their implementation, that transmitted speech electrically. The telephone was born with the "Watson-come here' sentence was transmitted. It resulted in the two telephone patents granted to him in 1876 and 1877. Consequently, his invention was baptised by the Patent Office.

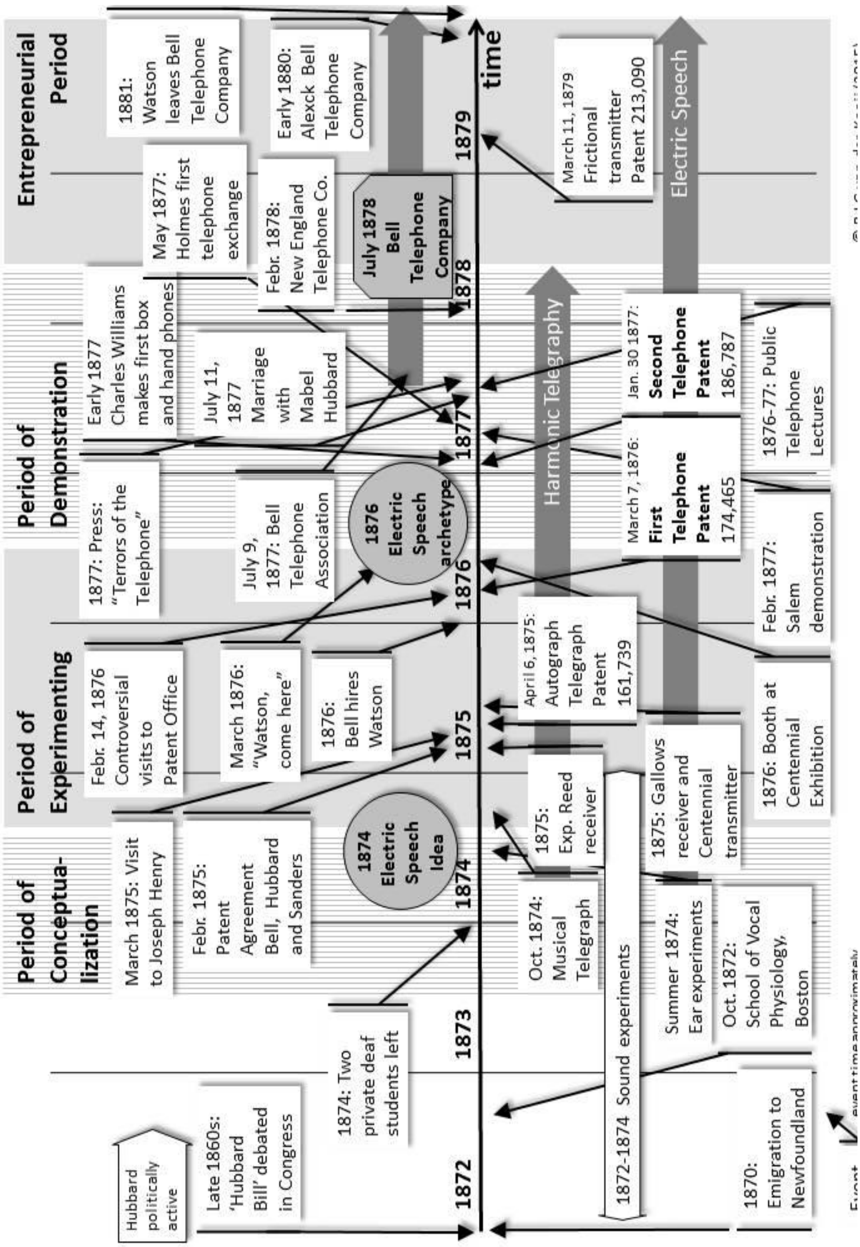


Figure 133: Timeline of Bell's act of invention.

Source: Figure created by author.

> *What he was granted by the Patent Office, later upheld by the courts, was a remarkably broad claim to transmission of voice by undulating currents, as well as to the induction forms of transmitter and receiver.* (Finn, 2009, p. 199)

From the moment the patents were granted, it was just a short time for his invention to become commercialized, as the associates in the Patent Agreement of 1875 organized the Bell Telephone Company in 1878. It were the entrepreneurial contributions of his associates Hubbard and Sanders that started the pioneering period with further business development. Bell went on a yearlong honeymoon to Europe that was more of a business trip than a romantic holiday. By the end of the 1870s the world started to be confronted with the new phenomenon of telephony.

By the early 1800s it was over for Bell, and not much later for his associates, Hubbard and Sanders. After a decade of hectic development, Bell resigned from the pioneering business. A business that was now taking off and needed others to enter the next phase of its development. The 'Bell System' as the corporate offspring of their pioneering years would continue to bring their vison into reality. It had been less than a decade from those first experiments to the Bell System that would dominate telephone in the decades to come…

Who Invented the Telephone?

Trying to find an answer to the question of 'who invented the telephone'—the priority question—one has in fact to find an answer to two questions. The first being the question 'what is an inventor consequently, what is an invention', the other is the question 'what is a telephone'. Trying to find an answer to the first question, requires another study as so many different definitions can be found (Kooij, 1988, 2013). However, all those interpretations of invention and innovation have 'change and novelty' in common. Thus the invention is the result of the process of invention as carried out by the specific person—the inventor—that creates change and novelty[265]. However, then again, confusion arises. Is it the original 'idea' (as in the mental picture), is it the first model (as in the prototype), or is it the product/production process that is successfully commercialized/ implemented? We leave this discussion for another moment.

Trying to find an answer to the second question should be easier, as it has been tried in many court cases. One of them being Dolbear vs American Bell Tel Co. that related to the fifth claim of Bell's patent № 174,465 of March 1876:

---

[265] In Patent Laws the words novel and useful can be found, although without an exact definition of the word. (Potts, 1944)

> *'The method of; and apparatus for, transmitting vocal or other sounds telegraphically, as herein described, by causing electrical undulations, similar in form to the vibrations of the air accompanying the said vocal or other sound, substantially as set forth.'* (Text of patent)

Bell's concept of 'electric speech' was simple: air vibrations as the result of sound are converted into an analogue (that is multifrequency) electric current that is transmitted and reproduced into air vibrations of a similar nature.

> *Bell discovered that it could be done by gradually changing the intensity of a continuous electric current, so as to make it correspond exactly to the changes in the density of the air caused by the sound of the voice. This was his art. He then devised a way in which these changes of intensity could be made, and speech actually transmitted. Thus his art was put in a condition for practical use. In doing this, both discovery and invention, in the popular sense of those terms, were involved: discovery in finding the art, and invention in devising the means of making it useful. For such discoveries and such inventions the law has given the discoverer and inventor the right to a patent, as discoverer, for the useful art, process, method of doing a thing, he has found; and, as inventor, for the means he has devised to make his discovery one of actual value. … In the present case the claim is not for the use of a current of electricity in its natural state as it comes from the battery, but for putting a continuous current, in a closed circuit, into a certain specified condition, suited to the transmission of vocal and other sounds, and using it in that condition for that purpose.* [266]

In today's vocabulary one would say that he created an electric system consisting out of a microphone, transmission cable and earphone. In the vocabulary of those days: he created a 'speaking telegraph'. In legal terms he was 'the inventor of the new art' as stated in the (American) Patent Act.[267]

There was a slight problem though, as the Patent Act also has the requirement of being the first and the art being useful. That latter requirement could be disputed as Bell did not have a working model at the moment the patent application was filed. In legal terms: 'He had not completed the discovery and thus could not obtain the patent.' The Supreme Court ruled differently.

---

[266] Supreme Court, DOLBEAR v. AMERICAN BELL TEL. Co. MOLECULAR TEL. CO. v. SAME. AMERICAN BELL TEL. Co. . v. MOLECULAR TEL. Co. . CLAY COMMERCIAL TEL. CO. v. AMERICAN BELL TEL. Co. PEOPLE'S TEL. Co. . v. SAME. OVERLAND TEL. CO. v. SAME. Source: https://www.law.cornell.edu/supremecourt/text/126/1

[267] In the language of the statue it is described that 'any person who has invented or discovered any new and useful art, machine, manufacture, or composition of matter' may obtain a patent therefor. Rev. St. § 4886.

> *It is quite true that when Bell applied for his patent he had never transmitted telegraphically spoken words so that they could be distinctly heard and understood at the receiving end of his line; but in his specification he did describe accurately, and with admirable clearness, his process, that is to say, the exact electrical condition that must be created to accomplish his purpose,—and he also described, with sufficient precision to enable one of ordinary skill in such matters to make it, a form of apparatus which, if used in the way pointed out, would produce the required effect, receive the words, and carry them to and deliver them at the appointed place. … The law does not require that a discoverer or inventor, in order to get a patent for a process, must have succeeded in bringing his art to the highest degree of perfection; it is enough if he describes his method with sufficient clearness and precision to enable those skilled in the matter to understand what the process is, and if he points out some practicable way of putting it into operation. This Bell did.* (ibidem)

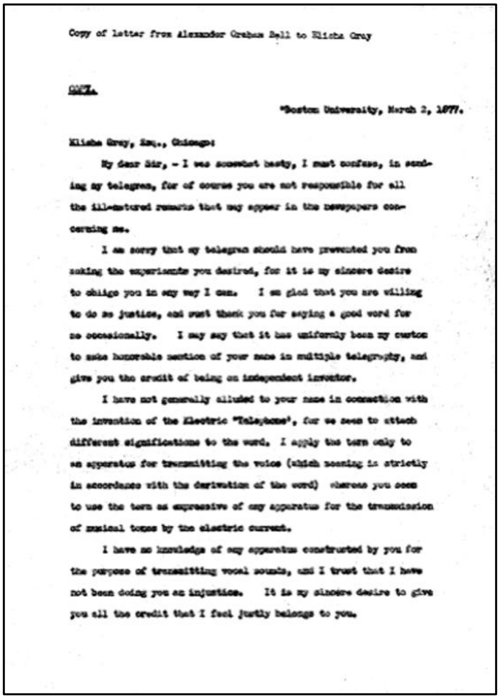
That all being said, in the case of the speaking telegraph certainly many individuals have contributed to its early discovery and infancy. The developments went either along the trajectory of the 'harmonic' telegraphy, or along the trajectory of the 'acoustic' telegraphy. In the first trajectory the focus was on solving the capacity problem of the telegraph lines. It resulted in multiplex solutions (those of Stearns, Edison and Gray), among which some touched at the acoustic solutions (Gray's). Other contributions came from different fields of knowledge: speech and vocal sounds. They created solutions in the trajectory of 'acoustic' telegraphy (those of Bell).

Looking at the priority question from a human point of view, the opinion of those involved in the discovery sequence could be worth considering. Leaving aside the freeloaders, opportunists and the dubious ethics of some businessmen, one can observe that the major players were Elisha Grey and Alexander Graham Bell, who both were in the race for the invention of the 'speaking telegraph'.

In March 1877, both men corresponded about this subject. After Bell had obtained his patent, and after some misunderstanding as the result of articles in the Chicago Tribune, he wrote: 'I have not generally alluded to your name in connection with the invention of the electric "telephone", for we seem to attach different significations to the word. I apply the name only to an apparatus for transmitting the voice [...], whereas you seem to use the term as expressive of any apparatus for the transmission of musical tone by an electric current. I have no knowledge of any apparatus constructed by you for the purpose of transmitting vocal sounds, and I trust I have not been doing you an injustice.'[268] (Figure 134).

Gray responded by stating: 'I give you full credit for the talking feature of the telephone. … I do not, however, claim even the credit of inventing it, as I do not believe a mere description of an idea that has never been reduced to practice – in the strict sense of that phrase – should be dignified with the name invention.'[269] (Figure 135)

That Bell had used inside information, supplied by patent examiner Zenas F. Wilbur on the caveat, was not known to him at that time. But this letter would be used later, during the Patent War, against him in the Dowd Case.


Copy of letter from Alexander Graham Bell to Elisha Gray

COPY.

"Boston University, March 2, 1877.

Elisha Gray, Esq., Chicago:

My dear Sir, - I was somewhat hasty, I must confess, in sending my telegram, for of course you are not responsible for all the ill-natured remarks that may appear in the newspapers concerning me.

I am sorry that my telegram should have prevented you from making the experiments you desired, for it is my sincere desire to oblige you in any way I can. I am glad that you are willing to do me justice, and must thank you for saying a good word for me occasionally. I may say that it has uniformly been my custom to make honorable mention of your name in multiple telegraphy, and give you the credit of being an independent inventor.

I have not generally alluded to your name in connection with the invention of the Electric "Telephone", for we seem to attach different significations to the word. I apply the term only to an apparatus for transmitting the voice (which meaning is strictly in accordance with the derivation of the word) whereas you seem to use the term as expressive of any apparatus for the transmission of musical tones by the electric current.

I have no knowledge of any apparatus constructed by you for the purpose of transmitting vocal sounds, and I trust that I have not been doing you an injustice. It is my sincere desire to give you all the credit that I feel justly belongs to you.

Figure 134: Typed version of handwritten Letter from Alexander Graham Bell to Elisha Gray, March 2, 1877.

Source: http://www.loc.gov/resource/magbell 12300205/?st=gallery

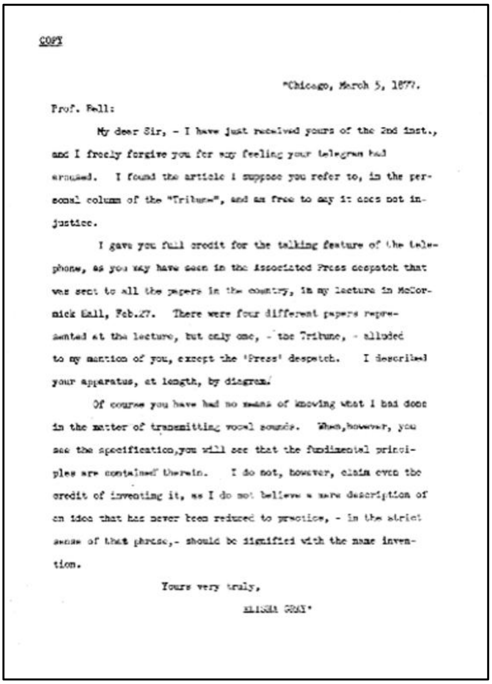
In addition to these personal declarations of the major players in this act, there was quite a situation regarding to the moment the applications were filed by Bell and Gray on February 14, 1876. It resulted in the controversy who was the real inventor:

> *Was it simply a coincidence that both men filed applications with the United States Patent Office - Bell for a patent, Gray for a caveat - covering electrical transmission of voice sounds, on the same day? If not, was Bell's claim for a variable-resistance transmitter using water as a medium improperly "borrowed" from Gray's caveat and even more improperly inserted into Bell's patent document? Or - less frequently argued - did Gray borrow from Bell?* (Finn, 2009, p. 193)

---

[268] Letter from Alexander Graham Bell to Elisha Gray, March 2, 1877. Source: http://www.loc.gov/item/magbell.28500114/

[269] Letter from Elisha Gray to Alexander Graham Bell, March 5, 1877. Source: http://www.loc.gov/resource/magbell.12300205/?st=gallery


COPY

"Chicago, March 5, 1877.

Prof. Bell:

My dear Sir, - I have just received yours of the 2nd inst., and I freely forgive you for any feeling your telegram had aroused. I found the article I suppose you refer to, in the personal column of the "Tribune", and am free to say it does not injustice.

I gave you full credit for the talking feature of the telephone, as you may have seen in the Associated Press despatch that was sent to all the papers in the country, in my lecture in McCormick Hall, Feb.27. There were four different papers represented at the lecture, but only one, - the Tribune, - alluded to my mention of you, except the 'Press' despatch. I described your apparatus, at length, by diagram.

Of course you have had no means of knowing what I had done in the matter of transmitting vocal sounds. When, however, you see the specification, you will see that the fundimental principles are contained therein. I do not, however, claim even the credit of inventing it, as I do not believe a mere description of an idea that has never been reduced to practice, - in the strict sense of that phrase, - should be dignified with the name invention.

Yours very truly,

ELISHA GRAY"

Figure 135: Typed version of handwritten Letter from Elisha Gray to Alexander Graham Bell, March 5, 1877.

Source: http://www.loc.gov/resource/magbell 12300205/?st=gallery

Again, returning back to the question of priority, one could also consider the opinion of those contemporary authors that looked into the case too, such as George Prescott—the Chief Engineer of Western Union at that time—who, originally, explicitly credited Gray with the invention in the first version of his 1878 book titled *The Speaking Telephone, Talking Phonograph, and Other Novelties*:

> *All the Speaking Telephones which we have described possess certain common characteristic embodied to* ***Mr. Gray's*** *original discovery, and are essentially the same in principle although differing somewhat in matters of detail.* (Prescott, 1878) (emphasis added)

However, in his 1884 version of the same book, which was published after the settlement of the Dowd lawsuit, and now titled *Bell's Electric Speaking Telephone: Its Invention, Construction, Application*, it was stated differently (Shulman, 2008, pp. 164-165):

> *All the Speaking Telephones which we have described possess certain common characteristic embodied to* ***Mr. Bell's*** *original discovery, and are essentially the same in principle although differing somewhat in matters of detail.* (Prescott, 1884) (emphasis added)

Was this curious about-face caused by the fact that the Dowd case between Bell and Western Union was settled? Was it part of the agreement? And did the fact that Prescott was president of the Gold & Stock Company, a Western Union subsidiary, play a role (Evenson, 2000, pp. 196-198)?

Another noteworthy event underscores the opinion of contemporaries that Gray was the inventor of the telephone. It was a reception and banquet given on November 15, 1878, to laud Gray for his invention of the telephone (Shulman, 2008, p. 127). A report on the reception stated:

> *It should be known that Elisha Gray, a resident of Highland Park, and a gentleman of superior scientific attainments, which have led him chiefly into the investigation of electrical subjects, is the individual to whom, beyond all doubt, the world is indebted for the original invention of the speaking and the musical telephone. It is not the intention to here enter into any discussion of this subject, which has, since the claim of another scientist was advanced, been taken to the cognizance of a judicial tribunal for the purpose of deciding the claim of priority of invention; but only that is stated which Dr. Gray's associates maintain, and which nearly all the scientists in the country concede, that to his brain is attributable the invention of that idea which has fairly worked a great revolution in telegraphy, and has demonstrated the startling capacities and the wonderful adaptability of electricity in that simple and yet almost marvelous instrument, the telephone. The patient labor, the persistent study, the multitudinous mishaps, the failures, and the final success which crowned so many months of research and experiment, are known alone, possibly, to Dr. Gray and a few who were associated with him ; but that he did eventually produce a telephone which transmitted music hundreds of miles, in nearly its full volume and original harmony, and that he presented to the public a speaking telephone, by which messages might be transmitted great distances with the clearness of enunciation of close and personal communion, is testified to by the columns of this and other papers, which, as the "right hand of popular science," as one of the toasts of this evening designates the press, were ever ready to recognize the fact and herald it to the world of the dawn of a new light on the scientific horizon.* (n.a., 1879, p. 4)

From a technical point of view, it is remarkable that Alexander Bell, with no education as an 'electrician', but having his expertise in a totally different field (elocution, acoustics), was able to create the archetype of the telephone. His work was modelled on the accumulated knowledge of telegraphy. In addition, the needs of telegraphy—such as the need for solutions to increase the transmission capacity of telephone line from the efforts to create the harmonic telegraph—were clearly identifiable. Many more technically gifted people, with a solid knowledge of 'electricity' (eg Stearns, Edison and Gray), contributed to that development trajectory. However, they did not enter the trajectory of the acoustic telegraph as they were more pressed in the trajectory of the harmonic telegraph. The few that did (eg Amos Dolbear) did not complete the trajectory on their own. Obviously, his experimental work on the membrane concept created the foundations that others improved upon, before the telephone could become a workable device.

From a legal point of view, much concerns the discussion of 'priority'. The priority right granted with Bell's '465' patent and his '787' patent were, soon after their issue, challenged by a range of companies who tried to jump on the bandwagon of the booming telephone business. It resulted into more than 600 lawsuits for infringement on Bell's patent in the next decade. As always, when the stakes are high—and when the personal interests are financially fuelled—lies and deceit, conflicts and controversies, trickery, fraud and embezzlement, are the order of the day. That is the case in common life, and that is the case in business life, and that is even the case in science. It gets even worse when themes like honour, prestige and scientific peer recognition are introduced. Moreover, when the stakes are high, as in the case with the invention of the telephone, then the courts are flooded with requests for justice.

> *During the 1880s, in one of the largest and most controversial litigation campaigns of any kind during the nineteenth century, Bell's attorneys won a string of patent cases that brought the entire telephone industry under a legal monopoly. Courts accepted Bell's claim to have pioneered the technology and responded by granting him broad rights over electrical speech communication. "Who invented the telephone?"—far from being a mere matter of scientific curiosity—became the key to control of the entire telephone industry. …*
>
> *More fundamentally, "Who invented the telephone?" became a question defined by law. Legal rules shaped the types of claim that a would-be Great Inventor needed to assert; lawyers argued bitterly about the nature of the telephone itself.* (Christopher Beauchamp, 2010, pp. 855, 857)

Litigation started in 1878 with the 'Dowd case', and it ended in 1888 with the verdict of the Supreme Court. The arguments were that the scope of the claim in Bell's patent was too wide, or that it lacked novelty as there were already earlier inventors of the speaking telegraph (from Reis, Meucci to Gray). Other lawyers argued that Bell's filing of his patent on the same day that Elisha Gray had deposited his caveat had been fraud.

There were some remarkable moments, like the verdict in the case against Spencer that regarded the scope of the patent. There, the judge ruled that Bell had created New Art:

> *Judge Lowell's reading of the fifth claim, handed down in June 1881, made Spencer a foundation stone of monopoly. Bell had, in the judge's words, "discovered a new art—that of transmitting speech by electricity— and has a right to hold the broadest claim for it which can be permitted in any case." In ruling Bell's invention a "new art," Lowell set the patent firmly in the pioneer category.* (Christopher Beauchamp, 2010, p. 863)

In other cases, the arguments were that Bell's invention lacked novelty, as there were already earlier inventors of the speaking telegraph (from Reis, Drawbaugh, Meucci to Gray).

> *These men and others like them could point to extensive personal histories of electrical experimentation. But their central qualification was prior obscurity, accompanied by pleas of poverty to explain why they had not publicized their discoveries sooner. … Not all rival telephone companies uncovered their own claimant. Many invoked the work of the German Reis, whose scientific reputation enjoyed a remarkable posthumous resurgence in the mid-1880s.* (Christopher Beauchamp, 2010, p. 864)

Also, people with completely different objectives became involved in the lawsuits. Many telephone venture companies were created with the sole purpose of speculation. Here, the lawyers related their defence to minor inventions made by others inventors (eg Rogers, Shaw).

> *…, the most determined infringers—those who led the legal fight against Bell—adopted a characteristic speculative model. After incorporating with a collection of minor telephone patents and a large paper valuation, these ventures promoted operating companies in multiple states, aiming to profit from the sale of licenses and stock. Thus the New York-based Molecular Telephone Company licensed an offshoot in Cleveland, while the Overland Telephone Company promoted subsidiaries in Pennsylvania, New Jersey, and Kentucky. The Pan-Electric Telephone Company, formed in Tennessee, marketed its patents to parties in Missouri, Illinois, Alabama, Texas, and the area around Washington, D.C. Some of these ventures resulted in the construction of actual telephone lines, while others remained on paper. All shared a common aim, however: to stave off the inevitable infringement suit from Bell.* (Christopher Beauchamp, 2010, pp. 855-856)

And then there was the claim of fraud that tarnished Bell's reputation. It was stated that Bell's filing of his patent on the same day that Elisha Gray had deposited his caveat had been a fraud in cooperation with officials from the Patent Office.

> *The legal attraction of claiming fraud was twofold: it provided Bell's challengers with new defences once their other arguments were spent, and it drew the federal government—the only entity authorized to sue for the cancellation of fraudulent patents—into the fray.* (Christopher Beauchamp, 2010, p. 868)

Bell remarkably survived these cases, and his priority right was upheld up to the Supreme Court's decision of March 19, 1888. However, it was a split decision among the judges, with four voting in favour and three opposed.

> *When the justices chose to consolidate the various pending appeals into a single hearing, Bell's lawyers had reason to be confident. Every rival claimant had lost in the lower courts, and several speculative bubbles had been pricked; … All of this muckraking ensured that fraud accusations took a large role in arguments before the Supreme Court. … When the Supreme Court issued its verdict over a year later both assessments proved correct: the contest came down to a straight fight between Bell and Drawbaugh, and Bell won. …*
>
> *The great mystery of The Telephone Cases is whether the justices responded to other pressures, in particular, to the heated politics of the Bell Company's monopoly. The composition of the minority suggests that some did. … Both legally and historically speaking, the most notable aspect of The Telephone Cases is not that the courts accepted Bell's priority of invention, but that they granted vast scope to his patent and thus endorsed a unitary theory of telephone technology and its origin.* (Christopher Beauchamp, 2010, pp. 872, 873, 875, 876, 877)

The judges rule. Nevertheless, one has to realize that the question of priority, if we should be inclined to address it at all, is a matter of interpretation. We started this discourse with the topic of defining invention. Does one consider the invention to be the moment the 'idea' for a concept is conceived (in written form of as a mental brainwave like the famous 'Eureka-moment')? Or is the moment when that idea gets proved by considerable experimenting? Alternatively, could it be the moment the proven concept is transformed into a working artefact: the working prototype or 'model'? Even closer to final realization, could it be the moment the concept is transformed into a commercial product? We do not have an answer to these questions, but they illustrate that the answer of priority lies in the way one defines 'invention'.

A Cluster of Innovations for Telephony

As observed before, Alexander Graham Bell was not an 'electrician', nor a 'mechanic'. He was a teacher of the deaf who conceptualized the acoustic telegraph that would turn out to become the archetype for the telephone. Looking at the cluster of innovations that surround his invention (Figure 136), one observes the coming together of two development trajectories: the trajectory of the Harmonic Telegraphy and the trajectory of Sound Telegraphy. In each trajectory, quite a few contributions patented by other inventors can be identified. As described, Bell's invention was both by his contemporaries and by those involved in the legal judgments considered to be patentable. It was even considered to be a pioneering patent as it was about 'new art', which indicates a basic innovation in present parlance. The question on hand is if his innovation was a basic innovation.

Related to the basic innovation is the aspect of impact. Part of the reasons to single out a specific innovation as being important (ie being 'basic') is the 'impact' it is having. This can be a technical impact, as the innovation sets the standards for the technical developments that follow. It can also be an economic impact; ie an impact on the economy. Examples of this would be creating new business activity, or being entangled in sizable patent conflicts. Obviously, as analysed before, in the case of the invention by Alexander Bell, we can observe quite a bit of impact.

Technical impact: One could wonder if the contributions from Bell were that revolutionary in its technical aspects. The electric speech concept with the membrane was certainly a new concept borrowed from nature—a 'new art' as some of the courts described it. The technical realization of the apparatus itself was done by others much more technically gifted than Bell himself (eg Watson, Berliner). In addition, the development of the telephone was facilitated by the earlier developments of telegraphy. Both technologies had quite similar problems to solve. There was one big different though: telegraphy was a system using Direct Current (DC), telephony a system using multi-frequency Alternating Current (AC). The basic innovation of Alexander Bell would be the start of a long and winding trajectory of technical development, both in components (the telephones) and in systems (the network) (Figure 136)

That being the case, his invention set the path for massive further development, both along the trajectory of components as well as the trajectory of the system. And Bell was at the crosspoint where acoustics met telegraphy and created 'electric speech'.

Economic Impact: There is no doubt that Bell's patent had an enormous economic impact: first—as the result of the patent protection—under Bell's control, and later, in the booming period as a self-propelling economic development resulting from massive entrepreneurial activities, as we will see further on.

Societal Impact: Although ridiculed in its infancy as a scientific toy, the rapid acceptance by the market proved that telephony fulfilled an obvious need for 'speaking over distance'. It explosive growth in the following decades indicated that the basic need of communication was served in a new way, influencing the way people socially interfaced, got their news. The telephone invaded both professional and private life in a way hard to foresee at the moment of Bell's invention. Just looking at present day's use of the 'smartphone' could make the point.

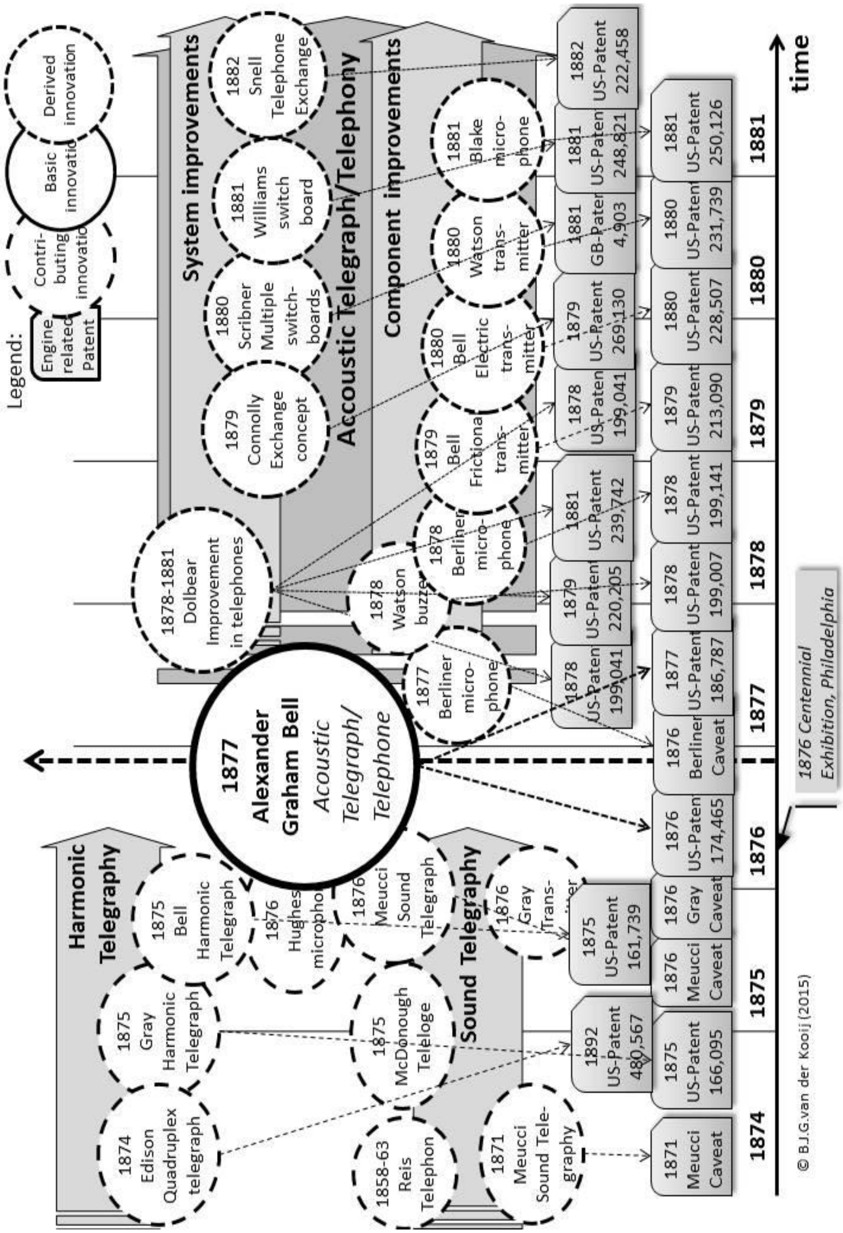


Figure 136: Cluster of innovations around Alexander Graham Bell’s telephone.

Source: Figure created by author.

Industrial Bonanza: Telephone Service Providers and Manufacturers

After the Bell patent had expired in 1894, the door was wide open for the competition of the Bell System. Within a decade more than 12,000 independent telephone companies would launch competing telephone services in cities across the United States. Hundreds of manufacturers were designing and producing beautiful, improved telephones to supply these independent telephone companies so that they could compete with Bell Telephone. It was an Industrial Bonanza in the making.

Already in 1885 Bell's patent in Canada had been overturned, due to the fact that the telephones sold in Canada were to be manufactured in Canada (as required by the Canadian patent law). After Bell lost a Canadian lawsuit new companies started to emerge after 1885, and Bell was facing stiff competition in Canada from companies such as the Federal Telephone Co. (1888). However, it was not after 1894—the year the US patent protection ended—when a second wave of independents emerged, that Bell's monopoly was seriously challenged. Then, in the US, the *Telephone Boom* really started.

> *The growth which characterized this early competitive era was both intensive and extensive. It was intensive in that it was marked by a higher saturation of development, particularly of residential services, than had been attempted during the period of patent monopoly. It was extensive in that service was extended for the first time to suburban and rural areas. This vigorous pursuit of new markets, engaged in by Bell as well as by the independents, was greatly facilitated by substantial rate reductions bringing the telephone within the financial grasp of a larger consumer group.* (Gabel, 1969, p. 345)

Industrial Bonanza: The Telephone Boom

As previously illustrated, the popularity of telephony increased tremendously in the early 1880s. In the report of the US Census of 1880 (Vol. 4, pp. 787-96), we find a clear indication that, soon after Alexander G Bell was granted his patents in 1876-1877, the local telephone market picked up and showed signs of rapid increase. In the late 1880s it had settled into a moderate annual grow of some 5-10%. That changed when the patent protection ended in 1893-1894. Then, in the second half of the 1890s, the telephony market grew even more rapidly: the telephone market in the US boomed with two-digit percentages (Figure 137).

Clearly, the communication device that had originally been seen as a scientific toy, had proved its value in professional and private use. The telephone was ready to conquer the world.

Cluster of Businesses serving the Telephone Market

As the number of installed telephones rose, so did the number of companies supplying telephone services and manufacturing the equipment need for telephony:

> … *the census year 1879-1880 was the year in which the telephone business passed through the stages of unprecedented development. At the beginning of that year this business amounted to little or nothing; at the end of the year it represented one of the great interests of the country.* (Armin E. Shuman, US-Census 1880)

The census reported, for 1880, the existence of 148 operational companies and private concerns who transmitted over a length of 34,305 miles of wires with 54,319 telephones (Shuman, 1883).

As indicated, the fierce pursuit of entrepreneurs who wanted to circumvent the Bell patents, resulting in a patent war with over 600 cases, had kept the 'pirates' more or less at bay. The growth of telephony was mainly due to the 'Bell System' companies (Figure 138). They were

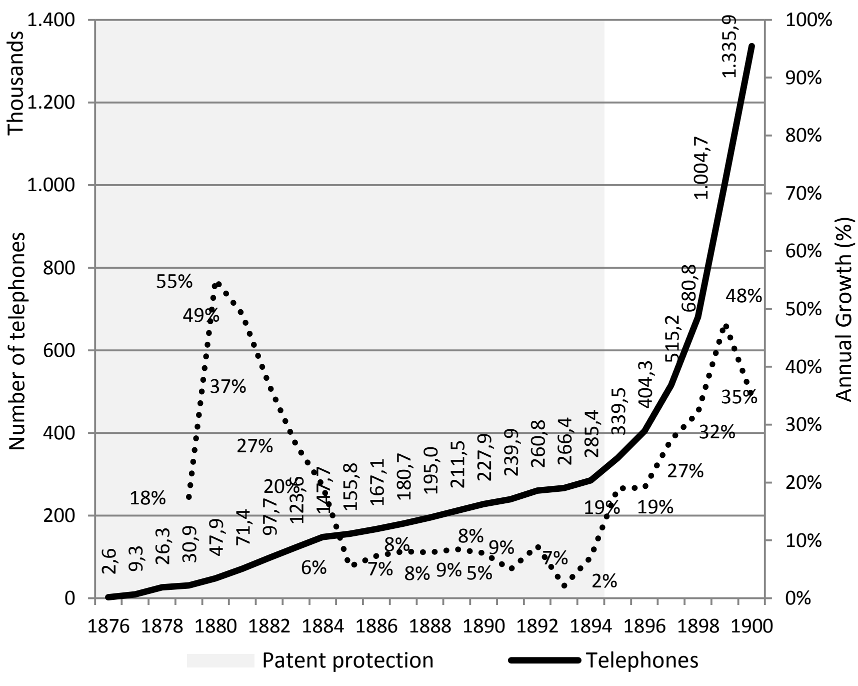


Figure 137: Growth of number of telephones in the USA (1876-1900)

Source: Early US Telephone industry data. http://galbiink.org/telcos/telephones-1876-1981.xls identifiable by the fact that they used 'Bell' in their name: eg the *Bell Telephone Company of Buffalo*, *Bell Telephone Company of Philadelphia*, etc. These were the companies that obtained a license to operate a telephone network with Bell-manufactured equipment. To pay for that right, the licensees had to give shares in their company to American Bell Telephone Co.

After 1895 their local and regional expansion was enormous, with double-digit annual growth percentages. From some 48,000 subscribers in 1880, the Bell System grew to 203,000 subscribers in 1890 and 801,000 subscribers in 1900 (Figure 138). These telephones originally were all located in the larger towns, and the companies operating locally or within limited regional areas. The rural areas were hardly covered by telephone services. That was not by accident, but the result of the corporate strategy of Bell.

> *The Bell System in the 1880s was modelling itself after the telegraph system of the 1870s. The telegraph was a nationwide, 'universal', business-oriented message*

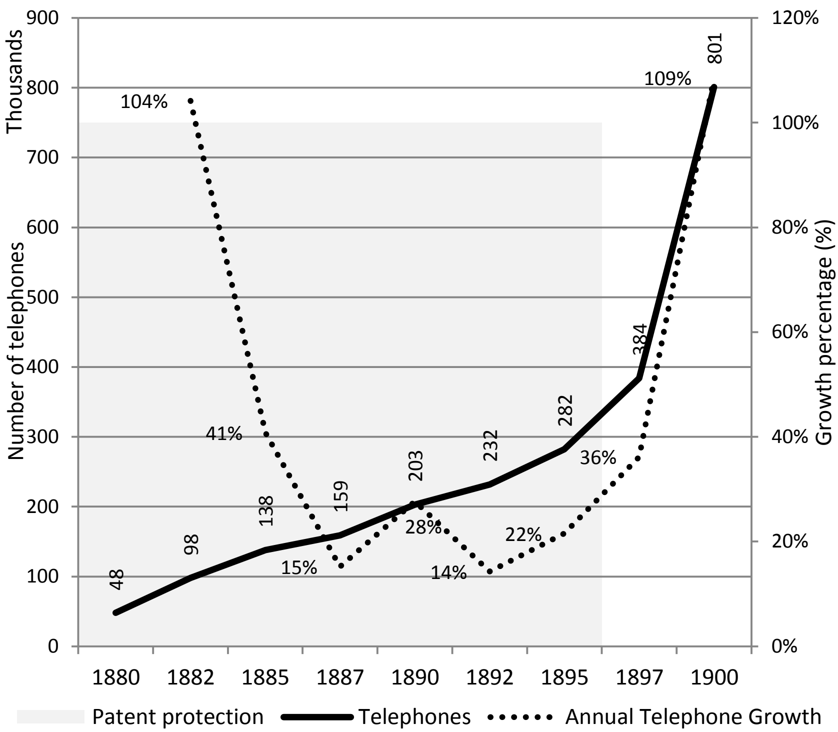


Figure 138: Growth of number of telephones of the Bell System (1880-1890)

Source: (Joel & Schindler, 1975) Table 4-23, p. 232

communications network linking terminals in all the principal commercial centres. It started in the largest cities and gradually spread to smaller ones, but it never reached households or rural areas. 'One system, one policy, universal service' meant a nationally interconnected, centrally coordinated monopoly like Western Union. …

Western Union achieved its dominance of the industry by being the first to develop a nationally interconnected network. It used its leverage over interconnection to isolate and destroy its rivals.' Bell planned to follow in its footsteps. When Vail claimed that Bell's concept of universal service preceded the telephone business he meant it quite literally - the concept was drawn from his experience in and observations of the telegraph business. (Mueller, 1993, p. 357)

Table 11: Distribution of exchanges by size of the cities in the US (1895).

Population Category	No. of places	Places with exchanges	% served
Cities over 50,000	72	72	100%
Cities 10,000-50,000	294	288	98%
Towns 2,500-10,000	1297	474	37%
Rural areas	7710	259	3%

Source: (Mueller, 1993) Table 1 , p.356

In Table 11 and Table 12 are shown the distribution of exchanges and telephones over the US in 1895 by size of the cities. Most people lived in areas that were not covered by telephone services. It was these rural and less populated areas that were going to be covered by the so called 'independent companies' after Bell's patents expired. The independents achieved their initial successes by establishing exchanges in the medium and small market towns Bell had ignored.

In the first four years after the patent expiration, the independents rapidly established a presence in the small towns and rural areas neglected by Bell. Interconnection with the Bell System would have taken away their exclusive control of connections to these areas. The independents came to believe that they could beat the Bell System and had no need to join it. In combination, these

Table 12: Distribution of telephones by size of the cities in the US (1895).

Population Category	% of US population	No. Of telephones	% of all telephones	Penetration rate
Cities over 50,000	21%	143.455	57%	1.00
Cities 10,000-50,000	9%	71.536	28%	1.11
Towns 2,500-10,000	8%	28.411	11%	0.51
Rural areas	62%	8.562	3%	0.02

Source: (Mueller, 1993) Table 1, p.356

decisions ensured that competition would take the form of rivalry between separate, unconnected systems. (Mueller, 1993, p. 358)

Developments of this magnitude —such as electricity, the telegraph, the railroads—all have a similar pattern of development. They start 'where the money is'. Therefore, for all infrastructures (gas, water, telegraphy, electric light) their first operations are in densely populated areas. This applies also to the commercially based spreading of the telephone systems: first in the big cities and much later in the rural areas. For commercial companies—quite understandably—their focus is where they expect a profitable market.

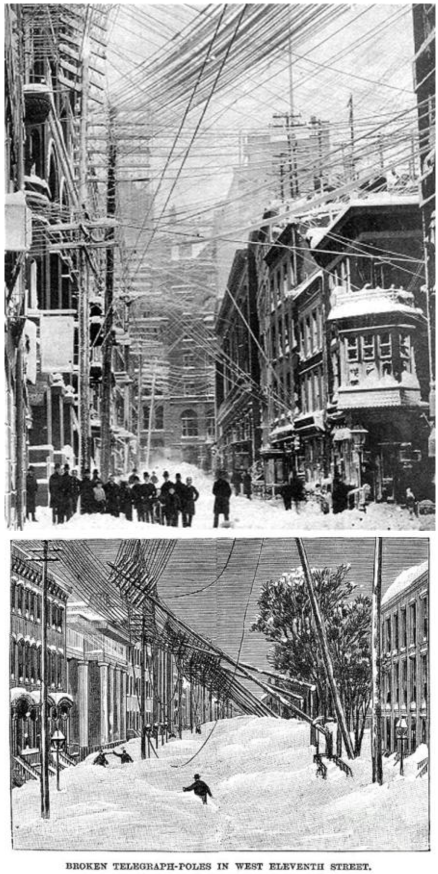


Figure 139: Telephone lines in New York after snow blizzard (1888).

Source: Wikimedia Commons. New York Historical Society

The consequences of this focusing of new systems on populated areas are multi-fold. One of them has to do with the infrastructure that they need. In this case, an infrastructure of telephone cables in the open air that could be quite vulnerable to weather conditions. Such as the blizzard of 1888 that took over four hundred lives (Figure 139).

As the people in more rural areas, such as farmers, also wanted to enjoy the fruits of telephony, they solved this problem by creating *mutual companies*.

Typically, a rural mutual system or farmer line was organized by a group of leading farmers, or a small-town merchant or doctor, whose efforts to solicit service from a major commercial company had failed. For an initial investment of $15 to $50 and often their time and materials, roughly 15 to 50 farmers would combine as shareholders in a mutual stock company, receive a telephone, and connection to

> *others in the rural neighborhood. Annual rental fees might run from $3 to $18 a year, less if the subscriber was a shareholder. (Shareholders, however, were often assessed for needed capital.) If the system had a switchboard, a farm wife or daughter typically served as operator during the daytime. Often, the shareholders arranged a connection to a commercial, or larger mutual, company's switchboard in town, and through that, to the wider world.* (Barnett & Carroll, 1987, p. 403)

By ignoring the rural areas, Bell had left open the door for competition. Next, when Bell's second telephone patent expired in 1894, the number of companies active in telephony would again increase rapidly as many 'independent' telephone companies (both commercial and mutual) were organized. Some independent companies viewed the venture as a way to network and advance the relationships within the community, ignoring profit and financial interests altogether. Many operated under the name of Home Telephone Company, to indicate their independence.

> *... by the end of 1894 over 80 new independent competitors had already grabbed 5 percent of total market share. The number of independent firms continued to rise dramatically such that just after the turn of the century, over 3,000 competitors existed. Illinois, Indiana, Iowa, Missouri, and Ohio each had over 200 telephone companies competing within their borders.* (Thierer, 1994, p. 270)

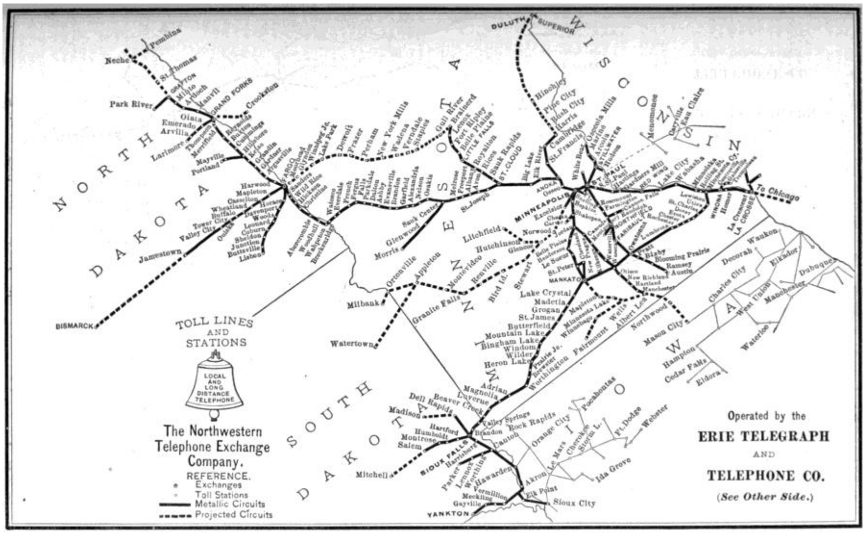


Figure 140: Toll lines and 'telephone plants' of the Northwestern Telephone Exchange Company (1897).

Source: Wikimedia Commons. Poor's Manual of the Railroads of the United States

In 1902, roughly 3000 such [commercial] companies operated in the United States, and roughly 6000 mutual companies were counted by the US Census. (Fischer, 1994, p. 43)

So, at the end of the nineteen century there were to be found at least two rival telephone systems in many cities of over 5,000 people: the telephone lines of the Bell-System and the telephone lines of the 'independents'. As they did not connect to each other, it forced customer to 'dual service': subscribing to both service providers. As for the competition, it was even worse, as they fought each other constantly. It took some years, but after the rise and fall of the independents, Bell would restore its monopoly.

> *The independent movement peaked in 1907, when it accounted for almost half of all telephones in the country. Five years later, however, Bell operating companies controlled 55 percent of the telephone market directly and an additional 30 percent through sublicense agreements.* (Weiman & Levin, 1994, p. 104)

Overall, the Bell companies were a dominant factor in the telephone business at that time. Companies such as the North-western Bell Telephone Company that served the upper Midwest of the US (Figure 140).

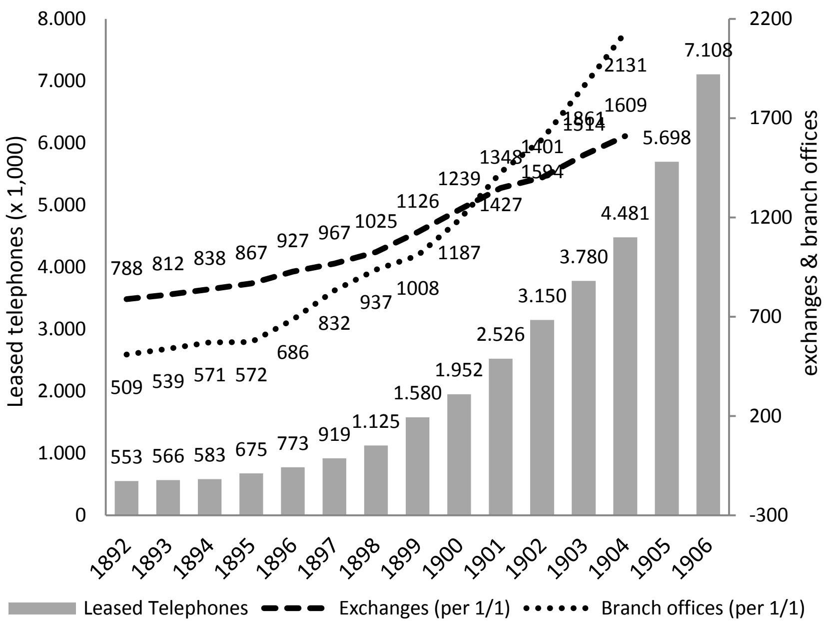


Figure 141: AT&T's expansion 1892-1906

Source: Annual Reports

The growth of AT&T since 1885 had already been staggering, and it looked even more promising after the turn of the century. In the annual report of 1902, AT&T's president Frederick P Fish wrote:

> … *the active development of the business which had been characteristic of recent years still continuous, nor are there any signs of a diminution of the demands upon this company and its operating companies for increased construction to meet the call for telephone services throughout the United States. There is hardly a section of the country in which can be said that the point has been reached at which supply of telephone facilities equals the demand. During the past year the operating companies have made larger gains in their list of subscribers than in any previous year, and, almost without exception, they look forward to a still greater increase in the near future.* (Fish, 1902, pp. 4-5)

He was right; the growth continued exponentially until there were more than seven million leased telephones in 1906 by AT&T (Figure 141). That number was only 55% of the total US telephone market of that year! All those telephone had to be made, sold and kept in good working order, creating the equipment makers of the telecommunications industry.

Cluster of Businesses serving the Telephone Companies

From 1880 on the Bell Monopoly, that had the *American Bell Telephone Company* as its license holder, had created a vast business empire of Bell Telephone Companies. These were the service providers licensed by Bell that started to serve urban telephone networks within arrange of forty-fifty miles. They got their telephones and other equipment from Bell's manufacturing unit Western Electric, a company that originated from the early entrepreneurial activities of Charles Williams and the manufacturing facilities of Western Union (Figure 142).

In addition, there were the suppliers of the earlier mentioned independent telephone companies, not part of the Bell System, that operated in the more rural areas. Their size ranged from the small mom-and-pop companies run by a husband and wife team—with the husband doing the outside line work and the wife operating a manual switchboard—to much larger companies. As Bell refused to sell its equipment to the independent service providers, much of this equipment was manufactured by the non-Bell related companies. Such as:

Automatic Electric Company (1901) had grown out of the Strowger Automatic Telephone Exchange Company that was founded in 1891. It was located in Chicago, and would become one of the larger suppliers of automatic telephone exchanges both to independents and Bell Companies.

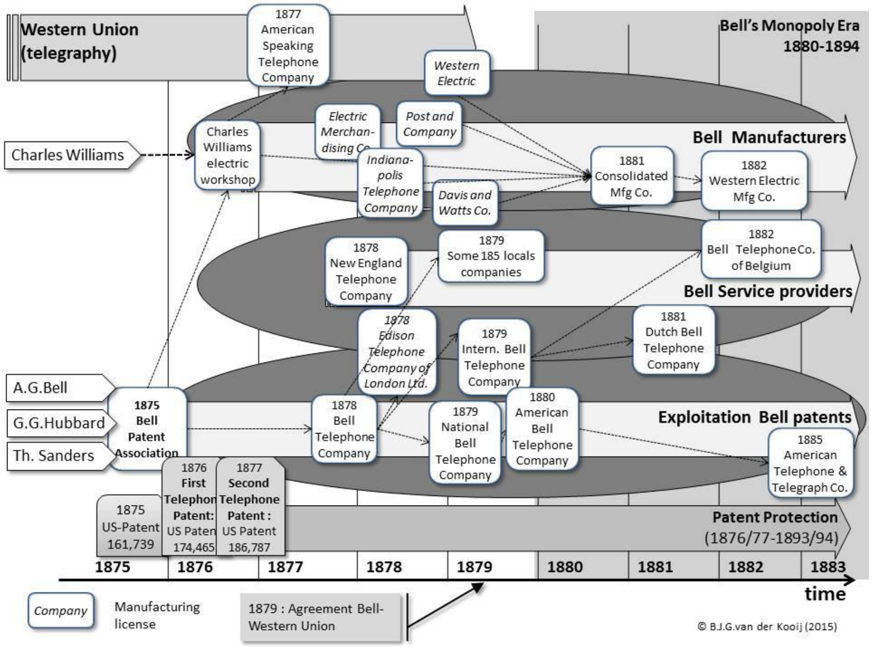


Figure 142: Bell's telephone monopoly: early clusters of businesses.

Source: Figure created by author.

Stromberg-Carlson Company (1894) was formed as a partnership by Alfred Stromberg and Androv Carlson. These Chicago employees of the American Bell Telephone Company each invested $500 to establish a firm to manufacture equipment, primarily subscriber sets, for sale to independent telephone companies. In 1899 they were bought out by the Rochester Home Telephone Company to insure a steady supply of switchboards and telephones (Grosvenor & Wesson, 1997, p. 165).

Kellogg Switchboard & Supply Company (1897) was founded in Chicago, Illinois, by Milo G Kellogg, an electrical engineer and former manager at Western Electric. Kellog, holder of more than 150 patents himself, also supplied to the independents.

These were some of the manufacturers in the US. Also in Europe Bell's invention of the telephone resulted in existing industry adding telephone equipment to their product like (eg Siemens & Halske in Germany) or it created whole new industries (eg LM Ericsson in Sweden).

Telephony: A Social Affair

The telephone changed daily life in more than one way. No part of society was left out; every sector was influenced by the new communication medium, as was already observed in 1910 by Casson:

> *What we might call the telephonization of city life, for lack of a simpler word, has remarkably altered our manner of living from what it was in the days of Abraham Lincoln. It has enabled us to be more social and cooperative. It has literally abolished the isolation of separate families, and has made us members of one great family. It has become so truly an organ of the social body that by telephone we now enter into contracts, give evidence, try lawsuits, make speeches, propose marriage, confer degrees, appeal to voters, and do almost everything else that is a matter of speech. ...*
>
> *Public officials, even in the United States, have been slow to change from the old-fashioned and more dignified use of written documents and uniformed messengers; but in the last ten years there has been a sweeping revolution in this respect. Government by telephone! This is a new idea that has already arrived in the more efficient departments of the Federal service. And as for the present Congress, that body has gone so far as to plan for a special system of its own, in both Houses, so that all official announcements may be heard by wire. ….*
>
> *In news-gathering, too, much more than in railroading, the day of the telephone has arrived. The Boston Globe was the first paper to receive news by telephone. Later came the Washington Star, which had a wire strung to the Capitol, and thereby gained an hour over its competitors. To-day the evening papers receive most of their news over the wire a la Bell instead of a la Morse. This has resulted in a specialization of reporters --one man runs for the news and another man writes it. Some of the runners never come to the office. They receive their assignments by telephone, and their salaries by mail. There are even a few who are allowed to telephone their news directly to a swift linotype operator, who clicks it into type on his machine, without the scratch of a pencil. this, of course, is the ideal method of news-gathering, which is rarely possible.* (H. N. Casson, 1910, p. 199)

These were just a few of the many sectors of society that were affected by the invention of telephony. True, many inventions had already influenced life before. Take the example of electric light[270], in the same period, which changed private and professional life as humankind became independent of natural light sources (eg the sun, candles, and fire). Alternatively, take the telegraph that made distant writing with lightning speed possible. However, telephony was considered to be, already in the

[270] See: B.J.G. van der Kooij: *The Invention of the Electric Light*. (2015).

early twentieth century, much more fundamental.

> *This effort to conquer Time and Space is above all else the instinct of material progress. To shrivel up the miles and to stretch out the minutes--this has been one of the master passions of the human race. And thus the larger truth about the telephone is that it is vastly more than a mere convenience. It is not to be classed with safety razors and piano players and fountain pens. It is nothing less than the high-speed tool of civilization, gearing up the whole mechanism to more effective social service. It is the symbol of national efficiency and cooperation.* (H. N. Casson, 1910, p. 237)

Figure 143: Postcard illustrating a social function of telephony.

Source: postcardiva.blogspot.com

As both telegraphy and telephony are related to information and communication (ie exchange of information), they touch on a fundamental aspect of human society. Communication fulfills a basic need, along with the needs for food, protection and safety. Telephony connected people in a way nobody had dreamt of, by the residential services between people's homes, by the professional services between enterprises, and by connecting with public organizations (eg police stations, fire stations). As telephony facilitated personal communication—aka social calling (Figure 143)—it broke social isolation and augmented social contacts (eg in the rural areas), and it informed larger social circles (eg from gossip to news).

> *Most people saw telephoning as accelerating social life, which is another way of saying that telephoning broke isolation and augmented social contacts. A minority felt that telephones served this function too well. These people complained about too much gossip, about unwanted calls, or, as did some family patriarchs, about wives and children chatting too much. Most probably sensed that the telephone bell, besides disrupting their activities, could also bring bad news or bothersome requests. Yet only a few seemed to live in a heightened state of alertness, ears cocked for the telephone's ring - no more, perhaps, than sat anxiously alert for a knock on the door. Some Americans not only disliked talking on the telephone but also found having it around disturbing, but they were apparently a small*

minority. Perhaps a few of the oldest felt anxious around the telephone, but most people ... seemed to feel comfortable or even joyful around it. ... Sociologist Sidney Aronson may have captured the feelings of most Americans when he suggested that having the telephone led, in net, to a 'reduction of loneliness and anxiety, and increased feeling of psychological and even physical security'. (Fischer, 1994, p. 247)

Telephony: The Highway of Communication

By the start of the twentieth century, the telephone had been widely accepted in the Western world. The use of the telephone was more and more replacing the use of the telegraph for communication over distance. The telephone had penetrated not only into private live, but also into professional life. Doctors used telephones to be reachable at all times; fire stations and police stations were reachable in case of emergency. Businesses started advertising their telephone numbers so that customers could contact them—for example, to order fresh oysters to be delivered at home. (Fischer, 1994, p. 178) Clearly, telephony had conquered a place in society and it would replace telegraphy over time.

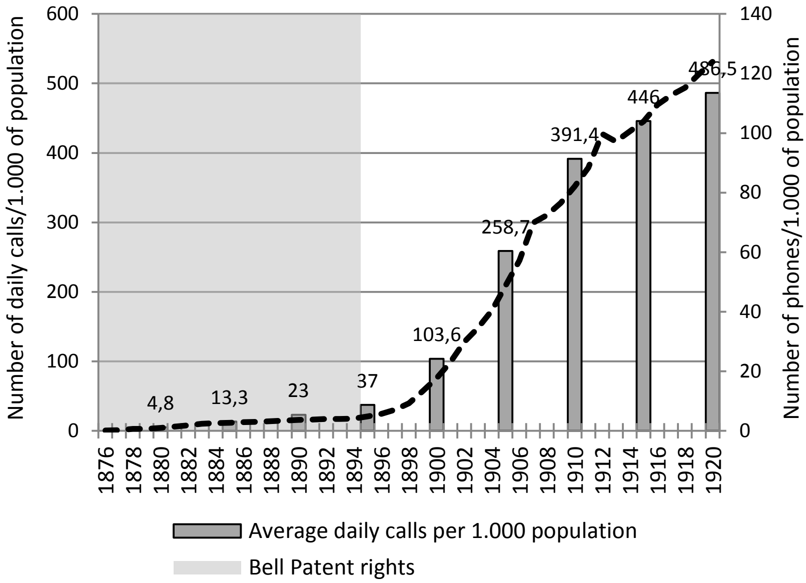


Figure 144: Telephone use in the United States (1880-1920).

The graph shows the number of average daily calls and number of telephones, per 1,000 people. In 1893-1894 Bell's patent rights expired.

Source: (Thierer, 1994) p.270

Throughout the remainder of the 1800s, the telegraph became one of the most important factors in the development of social and commercial life of America. In spite of improvements to the telegraph, however, two new inventions-the telephone (1800s) and the radio (1900s)-eventually replaced the telegraph as the leaders of the communication revolution for most Americans.

At the turn of the century, Bell abandoned its struggles to maintain a monopoly through patent suits, and entered into direct competition with the many independent telephone companies. Around this time, the company adopted its new name, the American Telephone and Telegraph Company (AT&T).[271]

By 1900 the communication engine 'telephone' had started its rapid ascent (Figure 144). In the coming decades telephony would continue its turbulent development. From its early focus on urban areas, Bell would—competing with all those independent telephone companies—create the interconnection between the regional and rural telephone systems. By 1915 the coast-to-coast connection was realized. The first transcontinental telephone call being between Alexander Graham Bell in New York City, and Thomas Watson in San Francisco, California.

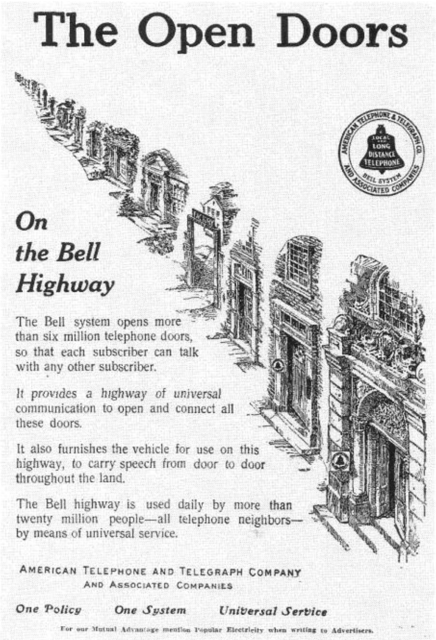


Figure 145: 'One policy, one system, universal service'.

Source: (Grosvenor & Wesson, 1997) p.242

The Bell System played an important, and quite monopolistic, role in this development. That role changed over time, due to governmental pressure, as telephony was more and more seen as a public service. Bell opened its doors to the independents and created a communication 'highway' under the motto 'One policy, one system, universal service' (Figure 143).

[271] Source: History of the Telegraph. http://historywired.si.edu/detail.cfm?ID=248 (Accessed December 2015)

> *It is believed that the telephone system should be universal, interdependent and intercommunicating, affording opportunity for any subscriber of any exchange to communicate with any other subscriber of any other exchange within the limits of speaking distance, giving to every subscriber every possible additional facility for annihilating time or distance by use of electrical transmission of intelligence or personal communication.* (Vail, 1911, pp. 22-23)

Soon telephony was to become the Highway of Communication that would influence society in a way undreamed of. From Bell's invention in 1877, the telephone had come a long way in quite a short period of time. Within those few decades it had already had a profound influence as, in 1910, Casson had already written:

> *To the United States, especially, the telephone came as a friend in need. After a hundred years of growth, the Republic was still a loose confederation of separate States, rather than one great united nation. It had recently fallen apart for four years, with a wide gulf of blood between; and with two flags, two Presidents, and two armies. In 1876 it was hesitating halfway between doubt and confidence, between the old political issues of North and South, and the new industrial issues of foreign trade and the development of material resources. The West was being thrown open. The Indians and buffaloes were being driven back. There was a line of railway from ocean to ocean. The population was gaining at the rate of a million a year. Colorado had just been baptized as a new State. And it was still an unsolved problem whether or not the United States could be kept united, whether or not it could be built into an organic nation without losing the spirit of self-help and democracy. … With the use of the telephone has come a new habit of mind. The slow and sluggish mood has been sloughed off. The old to-morrow habit has been superseded by "Do It To-day"; and life has become more tense, alert, vivid.* (H. N. Casson, 1910, pp. 223-224, 231-232)

Conclusion (Part 2)[272]

For somebody living today—2016—in a world where people are always, one way or the other, 'online [273]', it is hard to image what the world looked like without those communications engines we have available today. What would the world be without today's smartphone, the device that brought distant writing (formerly known as telegraphy) and distant speaking (presently known as telephony) without cables (wireless communication) in one device together? How can one imagine those days that the girls would chat without even using any form of telecommunication engine (Figure 146)?

Figure 146: Chatting girls not using telephones (1895).

Source: library.lindenwood.edu

[272] This conclusion is preceded by Part I that related to the development of the communication engine 'Telegraph'. See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'.* (2015) p.442.

[273] The expression 'online' in our Computer Age indicates a state of being connected by means of a communication engine (aka the smartphone) to a communication infrastructure (aka the Internet).

The early telephones of the 1900s had already brought quite a bit of excitement to the youngsters of those days (Figure 147). Today it is not that different. What would the young people of today do without their modern communication facilities? Devices that enable their social interaction at a distance, often at the expense of face-to-face social interaction (Figure 148)?

Figure 147: Chatting girls using cabled telephone (1900s).

Source: https://pbs.twimg.com/media/Bic1FDLCQAAiQRi.jpg

Figure 148: Chatting Girls using mobile phones (2015).

Source: https://sallyguo.wordpress.com

It is not only the young people who embraced telephony to facilitate their social life. The older generation is discovering the smartphone too. What would the older generation do to stay in touch with their social environment, when the physical possibilities are limited, without going 'online' for some video-chatting on their personal computers? Like the long-distance grandparents? The examples are endless, but to cut a long story short: today's world is unthinkable without modern communication engines.

The roots for this 'online' phenomenon and the 'smartphone' development, which came into existence recently in the twenty-first century, are to be found quite a while ago. It was in the dawn of the Era of Communication in the early nineteenth century[274]. Telegraphy, at that time, would create the context for the later development of telephony. A context that would see the creation of the technical devices and the technical infrastructure, But also a context that would see a business boom and monopolistic business practises. The invention of electric telegraphy occurred in a period of time when much of the Old World was in the aftermath of periods of considerable turmoil, including the French Revolution and the American Revolution. These were the times that the world changed and experienced the First Industrial Revolution.

[274] See: B.J.G. van der Kooij: *The Invention of the Communication Engine 'Telegraph'.* (2015)

The Human Element in Innovation

In this analysis, we looked at the *spawning* of the General Purpose Technology of Electricity. Along with Electric Light and Electrical Telegraphy, Telephony was one of the many inventions that originated from the General Purpose Technology of Electricity, a technology that proved to be very pervasive to spawn into new application areas. This development was to become one of the many factors that contributed to the Second Industrial Revolution.

In this case study we observed how the development of telephony expanded the Communication Revolution, a period in time where communication over distance was transformed from the classical means and methods—such as the classic postal mail and the optical semaphore—into communication with the new electric telegraphic instruments. With the telephone, again, it was 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.

While 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 on telephony.

Human Curiosity, Ingenuity, 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, engineering and entrepreneurial behaviour of people resulted in all these individual contributions—contributions that created the 'clusters of innovations' and the 'clusters of businesses'.

The drive force behind that behaviour is curiosity—one of the dominant characteristics of human nature. 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 opens new vistas of thought. It is curiosity in man's nature that drives him to wonder and ponder and understand different phenomena in life.

However, being curious is not enough. More is needed to realize invention and innovation. After obtaining knowledge and insight, there is the creative act, where ingenuity[275] creates the new combination: the moment the invention is born or the innovation is conceptualized. That creative act is only the beginning. The 'idea" may be conceived, but before

[275] The ability to invent things or solve problems in clever new ways (Oxford Dictionaries).

the concept is converted into an innovation that is ready to be introduced to the market, quite some additional efforts have to be made. The analogy with the creation of new human live comes to mind. After the moment of conception, the pregnancy period is needed to create the new human being. After its birth, however, it needs quite some time of development before it 'can stand on its own'. Similarly, when innovation is the case, after the prototype is developed and before it is to be put as a product on the market—especially a market that does not exists at that moment—quite some additional creativity and entrepreneurial efforts are needed.

In addition, one has to realize that all this curiosity, ingenuity, creativity and entrepreneurship happen in the context of its time. That context dominates the developments to come, as a world in turmoil (as in the American Revolution and the French Revolution, but also other Times of Madness) has a different influence on human behaviour than a world at peace. This case clearly shows how this human curiosity, ingenuity and creativity resulted in the contributions of so many people towards the development of telephony in the second half of the nineteenth century.

Curiosity into the Nature of Sound

In a relatively short period of time, after Volta's discovery in 1800 of the electrochemical battery and the subsequent discoveries of electric phenomena, one of the early applications of electricity as a carrier of power was in early power applications: the DC-motors. This was soon followed by the use of electricity as carrier of information: the invention of the telegraph (Figure 149, top). Both developments were hampered by the intrinsic problems of the electrochemical battery as source of power. It would take until the second half of the nineteenth century before these limitations were overcome and the electric dynamo took over as an abundant source of electric power.

The early application of electricity as carrier of information was in the field of 'distant writing' later called telegraphy. This had resulted in the development of the communication engine 'Telegraph' in the late 1830s. In addition to these explorations, there was also another field of interest for scientists. Soon the explorations into the 'Nature of Sound' had resulted in contributions of theoretical scientists creating insight in the nature of sound and explaining the mechanisms of sound (Figure 51). Their efforts were complemented in the second half of the nineteenth century by experiments executed by a range of the more practically oriented engineering scientists (Figure 149, bottom). In other words, the curiosity of so many created an insight in the characteristics and mechanics of both electricity and sound.

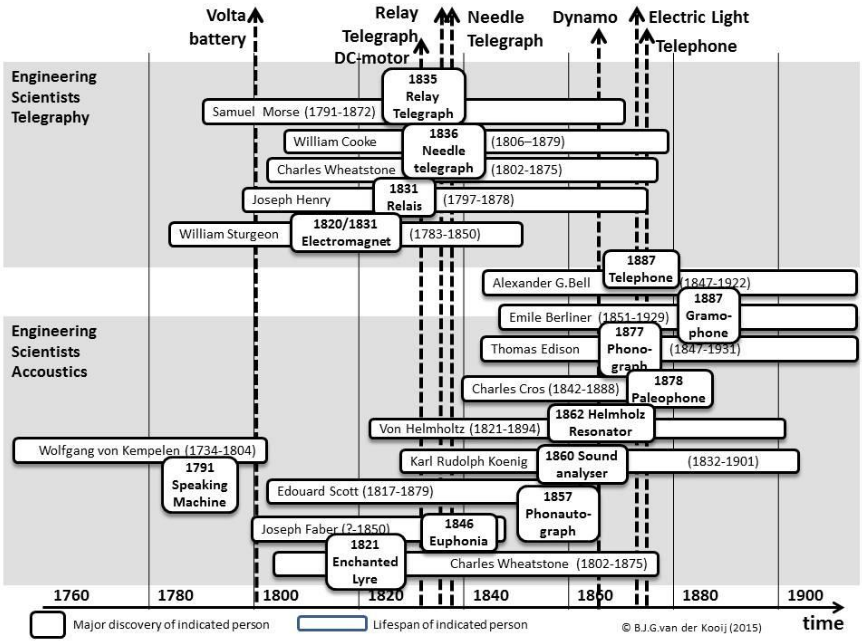


Figure 149: Engineering scientists contributing to the application of electricity in communication.

Source: Figure created by author.

Many of those acoustical experimenters had a background in sound, eg musical instruments. Their experiments led to inventions in a range of trajectories, with some related to the recording of sound (eg Edison's Phonograph) and others leading into the trajectory of the 'harmonic telegraph' (ie Gray's Musical Telegraph). It was this trajectory of the harmonic telegraphy that would have a spin-off leading to the acoustic telegraphy that gave birth to Alexander Graham Bell's telephone (Figure 150).

Ingenuity in science and engineering

Where curiosity caused people to study the phenomena and resulted in discoveries, it was another factor that led people to wonder what they could do with their observations and discoveries. They started to experiment, investigate and find ingenious solutions to the problems their curiosity had produced. The results came in different shapes and forms: from failures to inventions. Whatever the case, it resulted in a considerable body of knowledge.

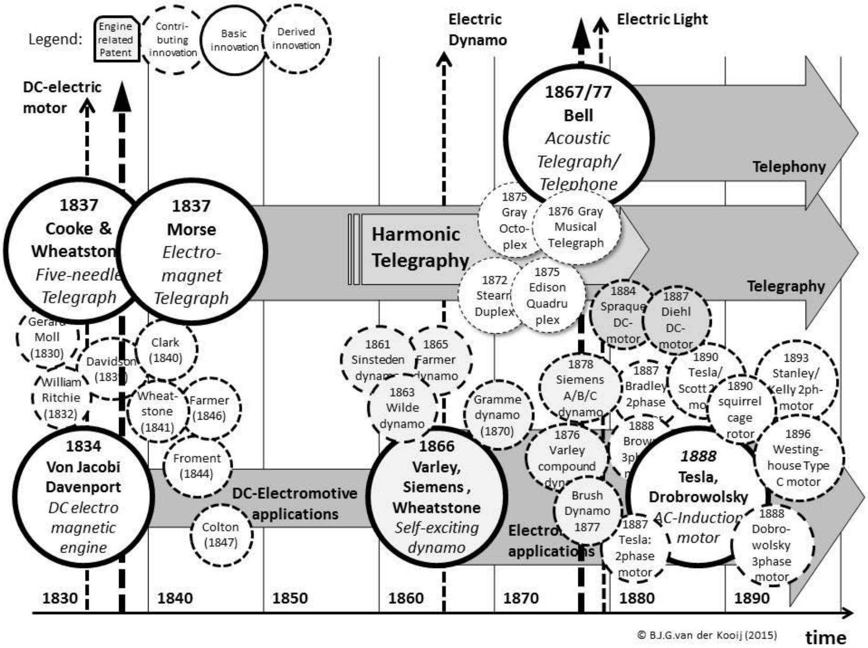


Figure 150: Development of telephony and telegraphy related to the clusters of electro-motive engines.

Source: Figure created by author.

Sound/Acoustics: The theoretical scientists had created insight into the 'Nature of Sound', creating early artefacts to record sound (Figure 149, top). And the work of the experimental scientists had already resulted in artefacts like Edison's 'Phonograph'. The time was ready for the combination of 'electricity' and 'sound'.

Electricity as carrier of information: There had evolved a new means to carry information very fast over a long distance. Previously it had been coded information transmitted by the telegraph; now it was the integral information of human speech that came to the attention of engineering scientists (Figure 149, bottom). In addition, development in electricity had resulted in the self-exciting electric dynamo creating (1866) an abundance of electricity, overcoming the barrier of the electrochemical battery (Figure 150, bottom).

Cabled Telegraphy Network: There also had evolved a system of transmitting coded information over an extensive communication infrastructure of telegraphy (ie the cabled network and the telegraph exchanges). With the creation of this communications network, a lot of experience was built up in the telegraph industry. Experience that could be used when other communication engines where developed. In addition, it was the telegraph industry where the need to optimize the transmission of information had led to the search for the harmonic telegraph (Figure 150).

By the way, it is noteworthy that the development of telephony was in the same period of time (the late 1870s, the period in the US called the Gilded Age) as the development of the electric light (ie Edison's incandescent lamp). However, as telegraphy and telephony were both about using electricity as a carrier of information, the development of telephony was more related to telegraphy, than to the electric light (where electricity was the carrier of power).

This situation as it existed in the second half of the nineteenth century, resulted in two developmental trajectories that contributed to Bell's invention. In one trajectory, the inventors were more or less focussing on the transmission of sound: their work was in sound telegraphy. In the other trajectory, they were focussing on multiplexing several transmissions, each with a different frequency: their work was in harmonic telegraphy. The subjects of the contributions may have been different, all these activities had something in common. They were the result of contributions with a technological nature: the *technical contributions from science and engineering*.

Competition: the Race to the Patent Office

Human curiosity and ingenuity always take place in a context. From the protected context of a growing child, to the competitive context of the natural world. There we touch on the third aspect of 'competition' in biology and sociology. In this case we observed competition in a rather specific form: the competition who was the first to invent the telephone.

As we have seen, there was a range of technical contributions by other inventors before Bell developed his prototypes of 'accoustic telegraphy'. Some of the contributors were not inclined, or in the situation, to protect their contribution by a patent (ie Reiss), others became entangled in a race to the Patent Office. Some of them failed due to a range of circumstances, mostly outside their control (eg Meucci). Some others, working more in a scientific environment, were not too alert on patenting (eg Dolbear). Others came too late due to a variety of reasons. Maybe because they were also heavily involved in other application areas (eg Edison with his incandescent lamp).

As described earlier the background of these people was quite divers, as they originated from quite a broad spectrum in the American society. From the tinkering Italian immigrant Antonio Meucci to the well-schooled theoretical scientists like Amos Dolbear, and the professional inventors such as Elisha Gray and Thomas Edison. Each of them was having his own different personal 'operational context': from their financial situation to their experimenting facilities. Take for example the harsh economic/business context in 1860s-1870s New York where the poor English-speaking Antonio Meucci struggled and hardly survived. A context that was quite in contrast with the academic context of physics professor Amos Dolbear, chair of the physics department at Tufts University in Medford. He operated in the academic world where time is abundant, but funds are scarce. Or look at the rather professional context where Thomas Edison invented his quadruplex telegraph. He had funds at his disposal, and the revenues of this invention—Western Union had paid him a lump sum of $40.000—he created his workshop/laboratory in Menlo Park in 1876 and invent there the incandescent lamp in 1879[276].

Looking at the individual persons one can imagine they must have had different personalities. From the biographies[277] one gets impressions of totally different persons. Personalities that range from the 'scientific inventor' (aka known as the professor–type), the tinkerer (aka the engineering-type) to the 'inventor/entrepreneur' (aka the business-type). In the first category one would expect people working in an academic setting, who are focusing on the phenome at hand, and being fascinated by what is learns them. Commercialization is not their first idea. And patenting their discoveries—aside from the cost involved—was not their first objective. In the second category one finds dedicated and driven people without specific education but who were tinkering with electro-mechanics (like Meucci). And in the third category we see the quite entrepreneurial spirit of which some others were operating.

Take for example the mostly self-educated engineer Elisha Gray, an inventive man from a poor background with entrepreneurial aspirations. Despite his bad health he became—after patenting an invention for the self-adjusting relay and selling the rights—associated with a former Western Union telegraphist, Enos Barton. Their company Gray & Barton became active in the manufacturing of telegraphic instruments. Thus he became involved in the developments of telegraphy, and in 1872 creating the *Western Electric Manufacturing Company*, manufacturing telegraph equipment. Alternatively, look at a man such as Thomas Edison, who originally funded his development work by selling many of his inventions and patent rights. He was America's most prolific inventor who would end up with more than

---

[276] See: B.J.G. van der Kooij: *The Invention of the Electric Light.* (2015) p. 124

[277] For example: Grosvenor, E.S. & Wesson, M.: Alexander Graham Bell. The Life and Times of the Man who invented the Telephone. Schiavo, G.E.: Antonio Meucci. Inventor of the Telephone (Schiavo, 1958)

a thousand patents on his name. A man who was working in a range of different application fields. Such as the *Universal Stock Ticker* in 1869: a telegraph-like device to transmit stock price information in 1869. And the *Phonograph* (the 'writing with sound' application of sound recording), as well as the *incandescent lamp* (application of electric light). A man who, not much later in time—the late 1870s and early 1880s— became involved in the business development of a range of companies that would bear his name: eg the *Edison Speaking Phonograph Company* (1878), and the *Edison Electric Light Company* (1878)[278].

In the mid-1870s we find these people—all with their different individual backgrounds, personal contexts and personality characteristics, sharing the same interest with an outsider: Alexander Graham Bell. A driven man, knowledgeable in acoustics, but quite ignorant in electricity, who was supported by his powerful associates Hubbard and Sanders who knew law and business. They had created a Patent Agreement Association in February 27 of 1875 to exploit Bell's invention of the harmonic telegraph

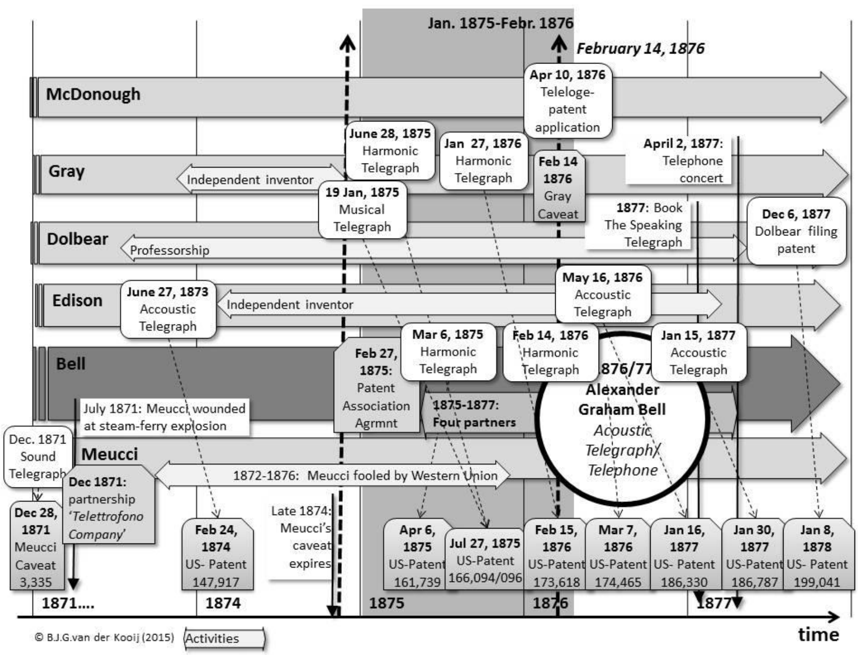


Figure 151: The Race to the Patent Office.

Source: Figure created by author.

[278] See: B.J.G. van der Kooij: *The Invention of the Electric Light.* (2015) p. 191

for which he granted a patent on April 6, 1875. Obviously, Hubbard was seeing the importance of protecting Bell's invention, and Sanders paid for it. The fourth partner, the instrument maker Thomas Watson, completed the team.

Early 1875, it was quite busy on the issue of patenting (Figure 151). Gray, Dolbear and Edison were active with their own solutions for the harmonic telegraph and started filing their patents. Especially the work of Gray and Bell coincided when on February 14, 1876 they (that is, their attorneys) both filed their invention at the Patent Office. For Gray it was in the form of a caveat, for Bell it was in the form of a patent application. Although not known on Bell at that time, Meucci had failed to keep up his Caveat. McDonough, also active in sound telegraphy, also filed—in April 1876—for a patent, but it took him eight years before he was granted a patent. Dolbear came at the end of the year with a patent application.

However, two contributors competed with each other to establish their priority right: Alexander Bell and Elisha Gray. They were well aware of each other's activities. Their race to the Patent Office on 14 February 1876 resulted in a close victory for Bell; it was a matter of hours, cunning lawyers and interpretation of the Patent Law. The Patent Office granted Alexander Bell his patent for the invention of a 'new art': the telephone. This patent—with its broad claim—would later proof to be very valuable. So much that it resulted in a costly Patent War, that dragged over years.

The Act of Invention

Our analysis shows clearly that the invention of the telephone was not the famous Eureka-moment of a lonely inventor. It was a complex process that took considerable time in which the contributions of many persons came together in what could be called the individual *Act of Invention*. In this case, the Act of Invention of the telephone was the result of the range of (technical) creative acts as performed and executed by Alexander Graham Bell. As we have seen in the preceding analysis (Figure 133), Bell's invention of the telephone was conceptualised in 1874, materialized in 1874-1875 and was formalized in his '465' Patent and his '787' Patent in 1876-1877. This indicates that the timeframe of the total 'Act of Invention of the Telephone' covered several years.

What was the context in which this Act of Invention took place? Bell's endeavours were certainly the quest for a solution that was opportune in those days where the telegraph industry —due to the explosion of telegraph use—were facing a 'transmission capacity' problem. Moreover, the telegraph industry in those days in America was dominated by one company: the Western Union Telegraph Co.

> *Yet in building a nationwide telegraph network, Western Union was hampered by a severe technical and economic problem: As the volume of messages grew, the cost and complexity of the network grew even more quickly. In response, the telegraph giant encouraged inventors to develop a variety of new devices, including schemes whereby several messages could be sent simultaneously over a single wire. In 1872, Western Union adopted Joseph Stearns's duplex (two-message) system and it was soon clear that fortune and fame awaited the inventor of a four- or eight-message system.* (Gorman & Carlson, 1990, p. 137)

For a capital-intensive industry like the telegraph industry, the major cost was in the communication infrastructure of expensive transmission lines (both local, regional and national). To offer a cost-economic and speedy service to the growing demand for their services, the companies had to use the long distance transmission lines more efficient. That means transmitting more messages at the same time over the same cable (a technique also known as multiplexing). Therefore, the quest for the 'harmonic telegraph' was a response to an urgent need.

Market pull versus technology push

Looking back in time, one can observe that an important aspect of the telephone was the degree of novelty that its invention represented. Application wise, 'distant speech' was a completely new concept. Technically, 'electric speech' was also a completely new concept. For the world it was a never heard of phenomenon as speaking by electric wire over considerable distance had not been possible in those days. What were then, seen from a helicopter's point of view, the contributing factors for this invention?

In the first place, the basic human need to communicate—not only locally and person-to-person, but over distances as well, and on a larger scale from person-to-group (eg information spread by newspapers)—existed as proven by the success of the telegraph. A success that had resulted in the described 'capacity problem'. Therefore, on the one hand there was this 'market-pull effect' as the result of the capacity problem of the telegraph industry. On the other hand, it was the potent electro-mechanical technology that would offer a solution. The inventors knowledgeable in electricity, the 'electriciens' who were engaged in this quest—like Dolbear, Gray and Edison who were stimulated, paid and facilitated by the telegraph monopolist Western Union—were looking for multiplexing[279] solution that could be developed with electro-mechanical technology of those days.

[279] Multiplexing is the modern word used for a method by which multiple message signals are combined into one signal over a shared medium (ie the telegraph wire).

Telegraphy was after all nothing but switching a relay at a distance by sending a DC-pulse over an electric wire. One of the solutions was time-division multiplexing; different digital DC-signals—the dots and dashes—were enabled each at a time to use the wire. This needed complex synchronization on both sides of the line, the transmitter and the receiver. Another solution was to distinguish between the analogue signals based on frequency (ie the dots and dashes being AC-signals with different frequencies). Now the individual frequency had to be generated (at the transmitting side) and detected (at the receiving end). In this later method, different techniques were used. Such as the vibrating reed (creating the induction telephone) and the variable resistance (creating the microphone that varied the electrical current).

Hence, it was electric technology that was to offer a solution to the capacity problem of the telegraph industry. It represents the 'technology push effect'. The quest for the *harmonic telegraph* was the search for an electro-mechanical solution to a capacity-problem. The combination of this 'market pull' and 'technology push' was the first contributing factor to the coming birth of the telephone (Figure 152).

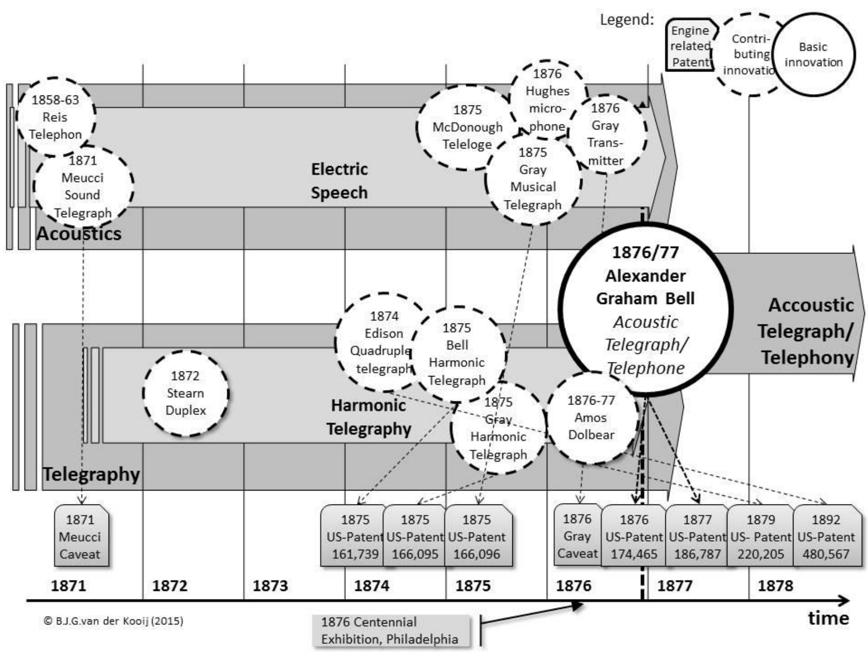


Figure 152: Overview of the contributing innovations leading to the basic innovation of Alexander Bell.

Source: Figure created by author.

Knowledge and knowhow

Technology being such an important contributor, one can wonder in what way it contributed. In the 1870s the electric technology was quite developed, due to the contributions of scientists and engineers (Figure 44). The theoretical scientists unravelled the fundamental mechanisms of electricity, and engineering scientist had applied that knowledge extensively. For example in the field of telegraphy. That being the case, for the quest of the *harmonic telegraph* to jump into the *acoustic telegraph*, a second contributing factor was needed. A factor that originated from the field of acoustics (Figure 152).

Next to the telegraphic development there was in the late eighteenth and early nineteenth century another technical development. From a different field of scholarly interest, those active in the unravelling of human speech had come insight in the 'Nature of sound'. Experimenting with the visualisation of sound (Cladni) , the recording of sound vibrations (eg Scott), creating sounds (eg the Helmholtz Resonator, Faber's Euphonia) and the transmission of sound (Biot with his tubes, Wheatstone's Chanted Lyre, the Lover's Telephone), a collective knowhow of the nature of sound was developed. The scholarly contributions of the acoustic scientists had created insight that stimulated the experimental acoustic scientists.

> Take the example of Charles Wheatstone, a scientist and electrician that had played an important role in telegraphy, who had in his early experimenting created the 'Enchanted Lyre', a variation on the principle of the Lover's telephone. It consisted of a mimic lyre hung from the ceiling by a cord, and emitting the strains of several instruments—the piano, harp, and dulcimer. In reality, it was a mere sounding box, and the cord was a steel rod that conveyed the vibrations of the music from the several instruments that were played out of sight and earshot.[280]

The totality of this scholarly interest in acoustics was can be considered as the 'scientific' contribution of the thinkers of those days. It had created an understanding in the 'Nature of Sound' and the acoustic 'knowledge'. In addition, there had been those early tinkerers who experimented with sound recording, sound generation, and sound transmission. They created their early apparatus that created, recorded and transmitted sound. The totality of their work can be considered as the 'engineering' contribution that had created 'know how'. Together they contributed to the 'Act of Invention'.

It was this knowledge and knowhow that had been accumulated over time in a family of persons active in teaching deaf; the Bell family where

[280] For more detail, see: The Invention of the Communication Engine 'Telegraph' (2015) p. 233-234

grandfather (also Alexander), father (Melvile) and son (Aleck) were ‘elocutionists[281]’. As deafness was related to human speech, they were highly interested in everything related to creating sound. One of those developments was the electric tuning fork where Helmholtz created different tones by an electromechanically stimulated tuning fork (Figure 47). It was the combination of electro-mechanical techniques and sound-creation, later know as acoustic engineering that opened news doors of experimentation for Aleck.

> *Drawing on his experience with the Helmholtz tuning fork apparatus, Bell thought it would be possible to assign an acoustic tone produced by a tuning fork to each message and convert that into an electrical pulse. This pulse could then be sent over a wire and received by a special relay with a steel reed tuned to vibrate at the frequency of the original tone…. By sending each message at a different tone, one could theoretically transmit and receive several simultaneous messages on a single wire.* (Gorman & Carlson, 1990, p. 138)

The new combination

Then came the moment ‘when the time was ready’ for the Act of Invention. On the one side there was the momentum of the development of ‘harmonic telegraphy’, on the other hand the growing understanding of sound generation and transmission in relation to electric techniques: the so-called ‘electric speech’. Surprisingly, the ‘harmonic’ solution—the technique of using separated frequency signals—led to an unforeseen result in the form of the conversion and transmission of speech. As sound is by nature an analogue, multi-frequency signal, and human speech is sound, the conversion and transmission of those acoustic signals created the *acoustic telegraph*. The device that would be called ‘telephone’.

This collective Act of Invention was the fusion of the contributing factor of the ‘Harmonic Telegraph’ and the contributing factor of ‘Electric Speech’ (Figure 152) into a device that could handle the analogue multi-frequency signal. It only needed a man with a drive and a vision who was able to create the revolutionary new device. His individual Act of Invention of the *Acoustic Telegraph* was the result of different individual ‘creative acts’, each of them a combination of the ‘act of insight’ (a result of developing knowledge) and the ‘act of skill’ (a result of the developing knowhow).

The early experimenting done by Bell has all the characteristics of a random search-process. Searching how the human body converted the vibrations of sound (ie the ear-experiments), searching if electricity could be used to convert the vibrations into an undulatory current, and so on. It was a path of combinations: how to combine the vibrations of sound and with

[281] Elocution is the study of formal speaking in pronunciation, grammar, style, and tone.

the transmission capability of electricity. His experimenting with the membrane-concept and the variable resistance-concept resulted in the prototypes of the early transmitters.

That about sums up the creative act of combination on the individual level, but there more to make the Act of Invention succesfull. Such as the combination on the team level. Bell might have had the knowledge (as an elocutionist and professor of speech), but Watson was the one with the (technical) knowhow (being an instrument maker). The combination of these two young people—they were in their late twenties—was needed to get the technical result. Next, that Bell-Watson combination was complemented by the Hubbard-Sanders combination. Again there was a combination, in this case with the complementary entrepreneurial skills of Bell's elder—being in their fifties—partners.

And finally, on a more abstract level, it was also the combination of new opportunities filling latent needs. In this case, it was the combination of the potent technology of electricity that created a flood of new solutions that fulfilled the latent needs for communication over distance. In the same way the telegraph had fulfilled the need for distant writing, the telephone fulfilled the need for distant speech. This was all the result of human ingenuity and creativity combining the opportunities offered by the new phenomenon of electricity with the needs that were present in society—like the timeless and universal human need for communication over distances.

Looking at Bell's invention, this pattern of creative combination is recognisable. The speech elocutionist Bell was not a scientific thinker, as were many of those people described before. Neither was he a businessperson. He fitted more closely, with all his experimenting, in the category of the scientific tinkerers. Having his expertise and knowhow in the field of sound, he needed to find additional expertise elsewhere. This can be noted by his consulting of people like the 'electrician' Joseph Henry, or by employing people like the 'mechanic' Thomas Watson. His concept of 'electric speech' was typically the result of his expertise of sound combined with the, for him unknown, new field of electricity.

Bell was awarded the patent protection based on his act of invention. An act that consisted out of a range of technical activities. There was another type of activities though, that made his invention such a basic one. Those were the entrepreneurial activities of two people who were closely related to Bell during his early experimenting: Gardiner Greene Hubbard, father of his deaf pupil Mabel Hubbard, and Thomas Sanders, father of this deaf pupil Georgie Sanders.

Business Contributions to Telephony

We talked about human curiosity, ingenuity and creativity that focused on technical aspects. However, 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. Also 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 is not enough to realize a tangible artefact that can be applied in the real world. Moreover, 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 venture business.

Alexander Bell found these complementary capabilities in both Hubbard and Sanders. Hubbard, a lawyer and politician, knew the ins and outs of the business world of the telegraph companies, as he had fought their monopoly for years. Sanders, as a leather merchant and an experienced entrepreneur, knew how to run a business. Both became heavily involved, not only in the early experimental period (Figure 133), but also when it was decided to commercialize Bell's patents and they created the Bell Patent Association.

> Just imagine that Alexander Bell would not have been acquainted with Hubbard and Sanders on such a personal level. As he was quite poor—he had neglected his School for Deaf to devote his time to experimenting—, where would he have found the money he needed for living and covering the cost of his experimenting? The potential sources for investment—such as traditionally the rich individuals—did not see a investment opportunity in the scientific toy. Nor did the telegraph companies—ic Western Union—think that 'distant speech—was interesting at all. Even worse, it potentially threatened their existing, and profitable, business.

Vision and courage

It is obvious that Bell was, at the moment his experiments had resulted in the first tangible proof that his concept worked—let say that was the "Watson come here"- moment in March 1876—a happy man. An important part of his vision that one-day 'electric speech' would be possible, had been accomplished. As he wrote to his parents:

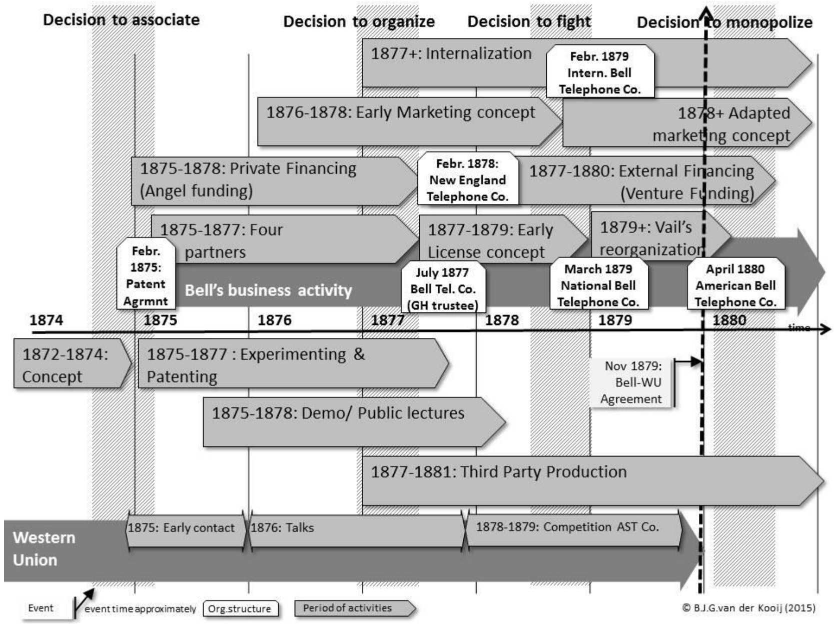


Figure 153: Important decisions during the early years of Bell.

Figure created by author

> *I feel I have that last found the solution of a great problem and the day is coming soon when telegraph wires will be laid on to houses just like water and gas is, and friends will converse with each other without leaving homes."* (Shulman, 2008, p. 15)

Before that moment it had just been a vison —although he had added, the concept to his '465' Patent—that still had to be proven. And that was not a one-man job. It meant that Bell, over a period of time, had to make some quite important decisions. One of them being the decision to associate, another important decision—later in time—was the decision to go and venture into the business world.

Decision to associate

One can imagine that the decision for Bell to go and associate with Hubbard and Sanders, who he both knew well and admired, was a practical one. Bell had a vision, and that vision was 'distant speaking'. It was a conceptual driven fascination originating from his background in 'sound'. If he wanted to try and make something of his concept of 'electric speech', he had to find additional competences (technical resources), and to afford those he had to find money (financial resources). One can see that both associates had complementary competences to offer. Hubbard, lawyer and politician, was familiar with political world and the business world of the telegraph. Sanders, a businessman, was familiar with running a company, doing business, organizing. They both where well informed with what was happening in telegraphy, and they both believed that multiplexing telegraphy had potential. Their cooperation was facilitated by the fact that they knew Alexander Bell very well, as he was tutor for their deaf children.

The Association they created was facing some major problem areas. The prototyping phase was not even yet finished, a lot of additional experimenting and technical development was needed. The solution was found to hire the 'mechanicien' Watson who would work together with Bell. Next, it was the question if they would be able to protect Bell's invention by obtaining a patent for it. In addition to this all, for all their activities they needed money. Who was going to pay for the patent, the instrument maker making the prototypes, the first production run? The found the solution in the 'angel' Sanders who decided to provide 'angel' money to get the idea into a workable prototype. Even more, in the coming years, it would be Sanders who put up the majority of the funds needed.

The partners in the Association Agreement had a vision. For Hubbard it was a way to realize his earlier plans to curtail the telegraph monopoly. Hubbard, with his history of opposing the telegraph monopoly (his telegraph-issue), saw in the Harmonic Telegraph a means to attack Western Union's monopoly. For Bell realizing the concept of electric speech was the result of his long time association with elocution. He wanted to create 'distant speech' by means of electricity. Sanders, one can imagine seeing the potential of the new product, wanted to develop a business. However, at that moment in time they did not have the idea that they would have to create a business themselves to reach their objectives.

The partners had started to work together. Then there is this moment that the concept—with the technical assistance of Watson—is transformed in a workable prototype. There is a now—more or less—a basic product to be protected. So a patent application is filed. That protection for 'electric speech' was an add-on (the famous Figure 7 of the '465' Patent) to another idea to be protected (the harmonic telegraph). However, after some time it became clear that the option to sell the rights of the patent to a third party, was not that realistic. Therefore, soon approaches the moment for the next decision of undertaking a business venture.

Decision to start the Bell Telephone Company

One can imagine that for the four associates there came a moment in which they had to make a quite fundamental decision about 'how to continue' now the selling of the patent rights did not seem to succeed. What was the situation in which they found themselves?

Patent-position: Telegraphy was hot in those days. Other inventors were busy with trying to find a solution to the capacity-problem of telegraph lines (the 'multiplex issue'). Some of them were more engineering oriented (eg Edison), some were more conceptual oriented (eg Gray). Both understood the importance of getting a patent for their work. There was clearly a financial issue as such a patent could be of enormous value for the industry (ie Western Union) that soon caused others to jump on the bandwagon. So there is time pressure. However, there is more than the timing aspect. Experimenting does cost money, Watson had to be paid. An also getting a patent was a costly affair (eg lawyer, patent fees).

Technical position: Bell did not have a model (for the telephone) that worked at the moment he applied for his patent. (That was not any more required by the Patent Office after U.S.Congress had amended the Patent Law in 1870). He had a concept based on 'undulatory' currents to transmit different frequencies over an electric wire. When he developed his primitive inductive telephone, it resulted in a system with limited performances. However, the communication infrastructure— that of the telegraph network—was already in existence. Initially he did not have to develop a separate infrastructure, but there was lot of 'product development' to do. Again, getting the prototypes made, even the first production run of 25 telephones, that all did require considerable financial funds.

Market-position: There was no market for telephony at the time Bell obtained his patent. There was a market for telegraphy, sure. Telegraphy had grown majestically from its early conception by Morse in the late 1830's and the business was monopolized in a couple of decades. Originally, Bell's invention was seen as a scientific toy and sometime later, as a short-distance additional service to long-distance telegraphic services. However, for Bell—having his vision—there may have been the recognition of a latent need for electric speech. Therefore, the market had to be developed by demonstrations to leaders in the community (members of congress, the president, royalty, etc.) at exhibitions, at meetings. Again, also 'market development' was a costly affair that needed financing.

Business position: How to start a business for such a novel product as the telephone nobody had seen before? How do you sell something to somebody who does feel the need to buy such a product? You have to try and find 'early innovators'; people who get excited by the new product, envision its potential and are willing to try it (eg Holmes and soon the other first customers). Moreover, you have to find a way to facilitate those early buyers. Thus, an adequate business model has to be developed. In this case it would be the leasing of the equipment (rental fees) and the right to use it (license fees). And to realize that all, one has to pay attention to the 'business development'.

This all shows that, from a business point of view, the associates were faced with a complicated situation. A situation that was even more complex due to its economic context. In the economic situation of the mid 1870s the venture was to be launched. Additional investors for a non-proven and immature product destined for a non-existing market had to be found. A tough job even more as the investment climate at that time was negative. The Bank Panic of 1873, the railroad manipulations by the robber barons, the stock market crash, understandably people with money to invest were not too eager to take on high-risk profiled investments.

The totality of all these activities can be considered as the Act of Creation of a business. It was a decision that would have massive consequences. The Associates, who by now had formed a trust that operated a company under the name *Bell Telephone Company*, started organizing their activities. Hubbard's instinct that there was market for local telephony had proved to be right. The sales started to pick up. Soon the telephones were leased to parties which had to organize the services themselves.

Decision to fight Western Union

In the meantime, Western Union had changed tack and decided that the telephone could maybe offered to their customers as a complementary service 'to call in the telegrams'. However, Western Union woke up. The *American Speaking Telephone Company* —that was to market telephones based on Gray's and Edison's work, was organized in December 1877. It started to operate quite aggressively attacking the weak point of Bell's activity: the quality of the telephone. In the meantime attacking Bell's priority in the patent— publically accusing Bell of stealing Gray's idea— and buying up some of Bell's service providers. One can imagine the discussions between the associates on how to cope with this massive competitor and the ugliness of the competition.

The associates were faced with the Goliath of the telegraph industry, Western Union, entering the telephone market. Hubbard, as a politician used to politically-fighting the telegraph monopoly, preferred to fight back. The best line of attack seemed to be their patent position. So, in the fall of 1878 the Bell Company filed a lawsuit against an agent of Western Union (ie the Dowd Case) for violating Bell's patent rights. The company's live depended on the outcome as it could not afford to compete with Western Union for the telephone business.

This decision had quite some consequences. The fact that Western Union had entered the telephone business was a signal to the financial world that the new invention could have a future. It gave an unforeseen credibility to Bell's invention. Next, as waging a lawsuit was expensive, and the associates had limited funds at their disposal, they had to look for additional financing. Sanders had already found those in a group of Boston investors, It meant that they had to give up even more of their ownership. In addition, they realized that their company was in need of professional management, so they hired Theodore Vail. He started a campaign to inform the market of their original patent, and reorganized the relation with the service providers who leased Bell's equipment.

One can image that the decision to confront Western Union took some courage of the associates. Undertaking legal action was not without risks. Next to the cost involved, losing the patent protection would not only serve Western Union's interest but it could open the market to a multitude of competitors. Surprisingly enough in November 1879 the lawsuit was settled outside the court when an agreement was reached in 1879 in which the two parties divided the communication market: Bell would serve the Telephone market, Western Union the Telegraph market. That Western Union decided to an agreement, had much to do with things that were going on in the telegraph business.

Decision to Create a Monopoly

Again, the development of telephony has to be seen in the societal context of its time. One aspect of that time was the rise of 'Business Monopolies' in which one company effectively maintained a monopolistic situation to keep the competition at bay. In nineteenth century, in America corporate behavior had created some monopolies. Such as the monopoly of the railroad networks and their operators. Also, the telegraphic infrastructure was by the 1870s dominated by one company: Western Union. These were the extreme cases of the emerging capitalism that dominated American business culture in the Era of Monopolies. It was the time of the industrial tycoons and the robber barons.

After the Bell Patent Association of 1875 had become the American Bell Company in 1880—and had made in November 1879 an agreement with the only effective competitor, Western Union— management of the Bell-company pursued a monopolistic strategy based on Bell's patents. They licensed the right to use their telephones—supplied under a lease contract—to service providers that were created in large numbers in the urban areas. Also, licenses were issued to European companies.

Next, in 1885, came the creation of the American Telegraph and Telephone Company (AT&T). It provided the long-distance services that the emerging local telephone networks needed, contributed to the monopoly. Until the end of the period of patent protection (1894) Bell effectively controlled the telephone business, both in terms of licensing agreements and the manufacturing of patented telephones (Figure 142). In the case of telephony, the monopolistic behaviour of Bell's companies held the competition at bay. But that changed after the patent protection ended and all those independent companies that were not part of the Bell System were created.

This ends our observation of the decisions Alexander Bell and his associates had to make. The totality of these major decisions, illustrate that, next to the important technical contributions, more is needed to create an innovation like the telephone. It is the range of complementary business contributions that complements all those technical contributions. Together these business contributions and technical contributions created the Invention of the Telephone. An invention that took place in the context of that period of time.

Context for the Invention of Telephony

Earlier, in the chapter about Technical Change, we formulated some assumptions for the development of the communication engine 'Telephone'. In short, we hypothized that, again, technology would be the driving force (*'Technical Change was the center of change');* that social change would facilitate the coming Technical Change related to telephony *('It was Social Change that facilitated Technical Change';* and that Technical Change would induce Social Change *('It was Technical Change that resulted in Social Change').* One could wonder if these hypotheses do find any proof in the analyzed situation in this case of the invention of the telephone. To find out, let's first try to draw some conclusions from the extensive contextual analysis we made.

The Age of Revolution: The First Industrial Revolution

The historic context for the development of the telephone was founded in the First Industrial Revolution. After the dramatic social changes of the American Revolution (1765-1783) and the French Revolution (1789-1799), the overall context for invention and innovation had changed considerably. In the early nineteenth century—when Volta presented his invention of the chemical battery to the world—there was a new societal context in which industrial entrepreneurship could develop. The contributions of all those thinking and tinkering people, free from feudal constraints, had created an increasing understanding—both knowledge and knowhow—of that new, fascinating technology of electricity. This culminated in the 1830s when early inventors succeeded in using electricity for rotative power (the DC-motor) and for electric communication: the Telegraph (Figure 154).

While the social and economic context may still have carried the remnants of older times (eg. Mercantilism and Protectionism), the Napoleonic Era implemented much of the revolutionary ideals in Europe, and the post-war societies experienced major economic effects. The political context heralded the changing times. Europe, over time, experienced massive societal changes, in which the old aristocratic powers had to make a place for the citizens and the entrepreneurs, unleashing their cumulative creative powers. Britain had even become the forerunner in the Industrial Revolution, America followed suit, and France accepted the inevitable developments sometime later. It was the Age of Revolutions (Hobsbawm, 2010a), fueled by the rivalry of the Brits and French:

> *The great revolution of 1789–1848 was the triumph not of "industry" as such, but of capitalist industry; not of liberty and equality in general but of middle class or "bourgeois" liberal society; not of "the modern economy" or "the modern state,"*

but of the economies and states in a particular geographical region of the world (part of Europe and a few patches of North America), whose center was the neighboring and rival states of Great Britain and France. The transformation of 1789–1848 is essentially the twin upheaval which took place in those two countries, and was propagated thence across the entire world…The historic period which begins with the construction of the first factory system of the modern world in Lancashire and the French Revolution of 1789, ends with the construction of its first railway network and the publication of the Communist Manifesto (Hobsbawm, 2010a, pp. 1-4)

One could say that the first half of the nineteenth century was shaped by the First Industrial Revolution[282]. Technically and economically, European societies had dramatically changed, each in its own way and constrained by its own history, over the period of half a century. Just to give an example, after the Revolutions of 1848, by early 1850, Britain's economy looked completely different from the way it had looked in the eighteenth century.

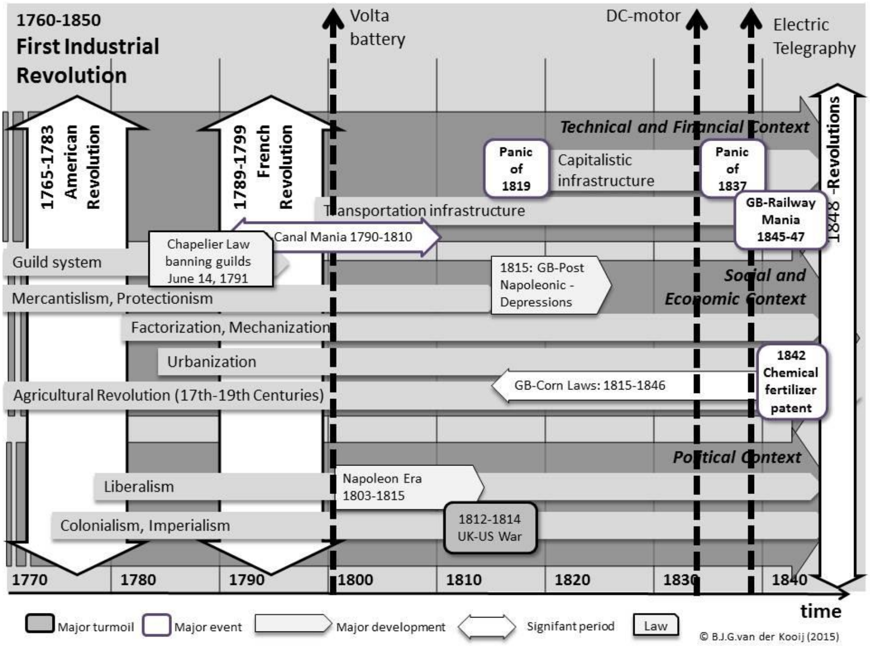


Figure 154: The context related to the invention of telegraphy (First Industrial Revolution).

Source: Figure created by author.

[282] For details see:: B.J.G. van der Kooij, *The Invention of the Steam Engine.* (2015)

> *The Great Crystal Palace Exhibition of 1851 marks the crowning achievement a century of technological progress and economic advance, but also of the growing integration and collaboration of the advanced economies. … By 1850, according to most statistics, Britain was the most sophisticated economy in the world. … Technological progress in Britain during the Industrial Revolution had owed a lot to "unscientific tinkerers" and dexterous and clever mechanics…* (Mokyr, 2011, pp. 475, 476)

Other Western economies were following suit, and were built on the revolutionary legacy from the times in which the French dominated a large part of Europe, even long after Napoleon was defeated at Waterloo:

> *In all these territories…the institutions of the French Revolution and the Napoleonic Empire were automatically applied, or were the obvious models for local administration: feudalism was formally abolished, French legal codes applied, and so on. These changes proved far less reversible than the shifting of frontiers. Thus the Civil Code of Napoleon remained, or became once again, the foundation of local law in Belgium, in the Rhineland (even after its return to Prussia), and in Italy. Feudalism, once officially abolished, was nowhere re-established…*
>
> *But changes in frontiers, laws, and government institutions were as nothing compared to a third effect of these decades of revolutionary war: the profound transformation of the political atmosphere…It was now known that revolution in a single country could be a European phenomenon; that its doctrines could spread across the frontiers and, what was worse, its crusading armies could blow away the political systems of a continent. It was now known that social revolution was possible; that nations existed as something independent of states, peoples as something independent of their rulers, and even that the poor existed as something independent of the ruling classes.* (Hobsbawm, 2010a, pp. 90-91)

This period in time has been called the *Age of Revolutions* (Hobsbawm, 2010b). Sure, it had been the time of revolutions (Figure 154). The political and social revolutions had changed the structure of societies, but the industrial and technological revolutions had changed the economies and societies as well. The feudal societal and industrial restrictions had been lifted, Enlightenment thinking had penetrated government, and the 'thinkers and tinkerers' had been given room to exploit the properties of nature. It was a period of massive *Social Change* that occurred in different parts of the Old World and in the New World of America by the 1850s. It would create the foundation for the times to come: the Second Industrial Revolution, where the General Purpose Technology of Electricity would play an even more important role.

The Age of Capital: Prelude to the Second Industrial Revolution

After the Age of Revolution, in the midst of the nineteenth century, the world started to change again. The last Europe-wide revolutions, the Revolutions of 1848, had created the context for the changes to come. It was going to be the *Age of Capital* (Hobsbawm, 2010a), which would create the foundation for the next Industrial Revolution. This was, again, a period that experienced economic and technical progress of a magnitude not seen before (Figure 155). Now the accumulated wealth (eg from mercantilist and colonial trade) was not so much used for warfare, but for entrepreneurial and industrial activities.

The period after the Revolutions of 1848 is often called the Second Industrial Revolution. It was the successor of the Age of Revolution with its social, political and industrial revolutions. In different countries, the Second Industrial Revolution had its own characteristics. But they all had one thing in common: the rapid economic growth after the Revolutions of 1848, and the Technical Change that fueled it. Take, for example, the following countries:

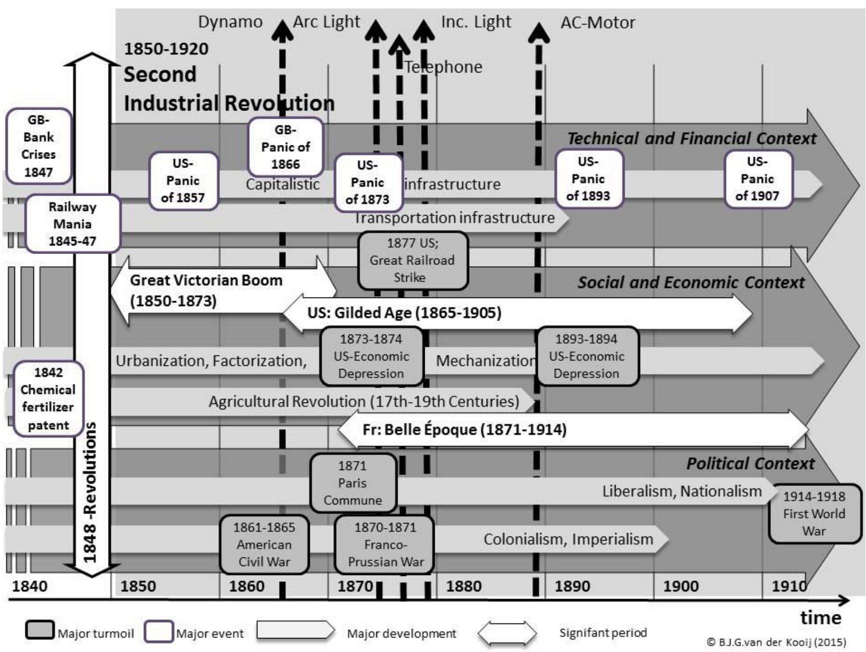


Figure 155: The context related to the invention of telephony (Second Industrial Revolution).

Source: Figure created by author.

Britain: Although Britain had no equivalent to the Revolutions of 1848 on the continent, the *Great Victorian Boom* (1850-1873) saw the pace of British economic growth accelerate significantly. The wild fluctuations in the economy that prevailed before 1850—with the Bank Crisis of 1847 (the Victorian equivalent of the 1929 Wall Street Crash) at the end of the Railway Mania—were replaced by relatively smooth, but considerable, growth. The Railway Boom had created massive employment, the growing transportation infrastructure was facilitating transportation, and steam powered transportation was everywhere. Export of goods like cotton piece goods had doubled. Private enterprise, fuelled by Industrial Capitalism, was expanding as result of the great wealth transferred over decades from the colonies. Cheap capital was widely available. Former mercantilist practises—like the Corn Laws—were replaced by free trade policies. It was the early phase of the transformation from the First into the Second Industrial Revolution. The 'Great Exhibition of the Works of Industry of all Nations' in London in 1851 (Figure 156) may have flabbergasted its visitors with—among the many other exhibitions—the new wonders of electricity: telegraphy and DC-motors. But it was just a prelude to the times to come.

America: In America, it was the *Gilded Age* (1870-1900), with its rapid economic and industrial growth that picked up in the late 1860s. The Civil War was over, labor was scarce and jobseeking immigrants came by the millions to find jobs in farming and mining. Railroad projects were a major business, its lines opening new areas to farming. Mining, oil and steel production were booming, and monoplies were being created. It was the time of the business tycoons, who dominated the oil (John D Rockefeller, Standard Oil), steel (Andrew Carnegie), railroad (Jay Gould) and financial service industries (John Piermont Morgan). The electric dynamo—created in the 1860s—supplied an abundance of electricity distributed by local and regional electricitity networks. The telegraph had penetrated society, and electric light increasingly illuminated households, public places and factories. The Centennial Exhibition of 1876 in Philadelphia showed ten million people—among many other exhibits—the miracles of electricity: Edison's giant dynamo and Bell's first telephone (Figure 156). America also saw the rise of the labor unions, and the first labor strikes (like the Great Railroad Strike of 1877).

France: On the continent, France saw the period of the *Bell Épogue* (1871-1914). After the French lost the Franco-Russian War at the Battle of Sedan (1870), a period of peace, politcal stability and economic prosperity began. Again, it had been the Paris Commune that had revolted in 1871, and the Second Empire was succeeded by the Third Republic. Soon, railroads were constructed radiating from the heart and soul of France, Paris. The city of light (ie 'gaslight') was renewed by the urban architect Hausmann, and the department stores became 'en vogue' stimulation of consumerism. And the Expositon Universell of 1867 in Paris flabergasted the millions of vistors with the wonders of industry (Figure 156). Among which the magic device of the Telegraph.

Both the Gilded Age and the Bell Epoque started in the late 1860s, and they encompassed a remarkable period that saw massive technological innovation. In many fields—such as metallurgy, chemistry, transportation, tooling, etc—but certainly in the application of electricity, technological innovations had great societal impact. These include the invention of the arc light and the incandescent lamp[283], the AC-induction motor and the AC-distribution network[284], the telegraph and the telephone. It was the upbeat to the next technological revolution: the Second Industrial Revolution (aka known as the Technological Revolution). This was a period of massive *Technical Change*, in part caused by the General Purpose Technology of Electricity that was the offspring of the social changes of the decades before (Figure 156).

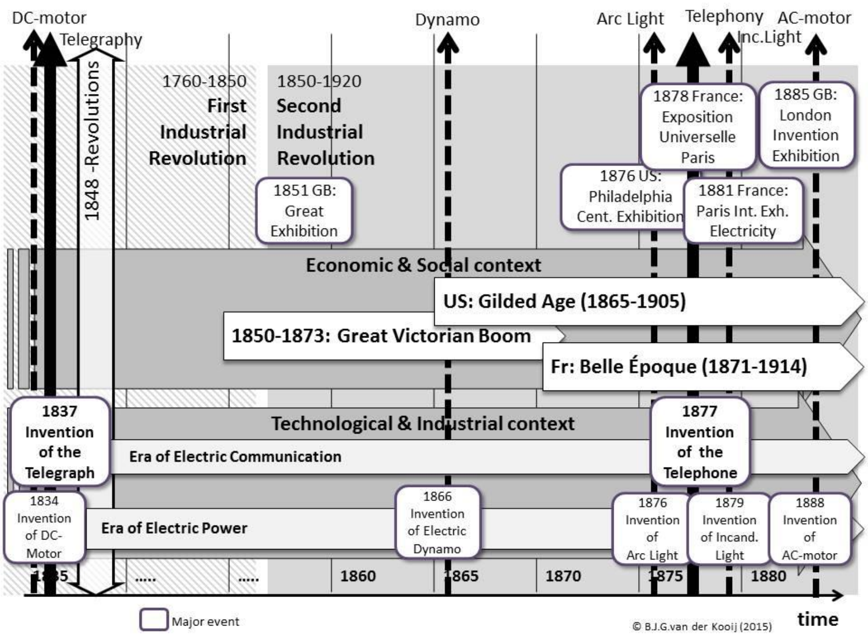


Figure 156: The context related to the General Purpose Technology of Electricity (First and Second Industrial Revolution).

Source: Figure created by author.

---

283 See: B.J.G. van der Kooij: *The Invention of the Electric Light.* (2015)

284 See: B.J.G. van der Kooij: *The Invention of the Electromotive Engine.* (2015)

Future to Come

This concludes of our analysis of the Invention of the Telephone and the context in which that invention took place. We looked in quite some detail at the events around Bell's act of invention. The contextual picture is painted in rather rough brushstrokes, specifically looking at the developments that led to the Invention of the Telephone. The totality illustrated though the context for change that existed in the second half of the nineteenth century. This was a context created by social and political revolutions, and the Technical Change resulting in technological and industrial revolutions.

Although we have focused on technological innovations related to electricity, one has to realize that it was not electricity alone that ceated the Second Industrial Revolution.

> *The most obvious drama of this period was economic and technological: the iron pouring in millions of tons over the world, snaking the ribbons of railways across the continents, the submarine cables crossing the Atlantic, the construction of the Suez Canal, the great cities like Chicago stamped out of the virgin soil of the American Midwest, the huge streams of migrants. It was the drama of European and North American power, with the world at its feet* … (Hobsbawm, 2010a, p. 16)

At first sight, Technical Change and Social Change seem to be entirely dependent on one another; that is, each is the cause and effect of the other. But there is more, as they also seem to have a sequential pattern where Social Change prepares for Technical Change, and Technical Change in its turn causes Social Change. At the centre of all those technical changes are curious and ingenious minds living in the social context of their time. In the words of Alexander Graham Bell:

> *Great discoveries and improvements invariably involve the cooperation of many minds. I may be given credit for having blazed the trail, but when I look at the subsequent developments I feel the credit is due to others rather than to myself. (Letter from Bell to Hubbard, date unknown)*

Indeed, his 'creative act' for electric speech may have been limited; it was like the spark in the waiting tinderbox. Its impact was going to change the world.

The invention of the telephone, thus, was part of a 'cluster of innovations'. At its core was Alexander Graham Bell's basic innovation. Again, just as with the creative efforts of Samuel Morse, William Cooke and

Charles Wheatstone, with their basic innovation in telegraphy[285], it was a relatively short period of time from conception to business. Roughly half a decade passed between Bell's early experimenting (1872-1873) and the creation of the first business enterprise: the trust of Bell Telephone Company (1878). The result was several clusters of businesses. Along with the Bell-Company (Figure 142), which dominated the market with its patent-based monopoly, in the 1890s additional 'clusters of businesses' appeared: the independent service providers and the independent manufacturers. They all served the telephone market that boomed at the end of the nineteenth century, not only in the US, but all over the world.

The twentieth century would see the rise of telephony, and by the 1920s it had already replaced telegraphy. Then the continuing *Communication Revolution* would hit society in full force. Line based telephony was just a start, as there was much more to come. Such as the wireless communication engine. Then further development of the wireless or 'mobile' telephony would result in the 'smartphone' of the early twenty-first century, the communication device that dominates the social and business lives of our day. The days everybody is always 'On-Line'. But that is another story…[286]

----

[285] See: See: B.J.G. van der Kooij: *The invention of the Communication Engine 'Telegraph'.* (2015) Figure 220, p.454

[286] See: Case study on the Invention of the Wireless Engine.

References

Andrews, C. M. (1904). Colononial Self-Government 1652-1689 *The American Nation: A history* (Vol. 5). New York, London: Harper.

Barnett, W. P., & Carroll, G. R. (1987). Competition and Mutualism among Early Telephone Companies. *Administrative Science Quarterly, 32*(3), 400-421. doi: 10.2307/2392912

Beauchamp, C. (2010). Who Invented the Telephone?: Lawyers, Patents, and the Judgments of History. *Technology and Culture, 51*(4), 854-878.

Beauchamp, C. (2015). *Invented by law: Alexander Graham Bell and the patent that changed America*: Harvard University Press.

Bell, A. G. (1876). *Researches in telephony.* Paper presented at the Proceedings of the American Academy of Arts and Sciences.

Bergek, A., Jacobsson, S., Carlsson, B., Lindmark, S., & Rickne, A. (2008). Analyzing the functional dynamics of technological innovation systems: A scheme of analysis. *Research Policy, 37*(3), 407-429. doi: http://dx.doi.org/10.1016/j.respol.2007.12.003

Bray, G. A. (1994). Lavoisier and Scientific Revolution: The Oxygen Theory Displaces Air, Fire, Earth, and Water. *Obesity research, 2*(2), 183-188.

Brittain, J. E. (1970). The introduction of the loading coil: George A. Campbell and Michael I. Pupin. *Technology and Culture*, 36-57.

Brown, R. D. (1972). Modernization and the Modern Personality in Early America, 1600-1865: A Sketch of a Synthesis. *The Journal of Interdisciplinary History, 2*(3), 201-228. doi: 10.2307/202285

Bruce, R. V. (1990). *Bell: Alexander Graham Bell and the conquest of solitude*: Cornell University Press.

Busick, S. (n.d., April 2015). The American and French Revolutions Compared Retrieved April 2015, 2015, from http://www.theimaginativeconservative.org/2013/09/american-vs-french-revolution.html

Camenzind, H. (2007). *Much Ado about Almost Nothing: Man's Encounter with the Electron*: Hans Camenzind.

Carlson, B. W. (1994). Entrepreneurship in the early development of the telephone: How did William Orton and Gardiner Hubbard conceptualize this new technology? *Business and Economic History*, 161-192.

Carp, E. W. (2015). The Wars of the American Revolution. Retrieved from American Revolution website: http://revolution.h-net.msu.edu/

Casson, H. N. (1910). *The history of the telephone*: Books for Libraries Press.

Casson, H. N. (1910). *The history of the telephone.* Chicago: A.C.McClurg & Co.

Catania, B. (2001). Antonio Meucci: Telephone Pioneer. *Bulletin of Science, Technology & Society, 21*(1), 55-76. doi: 10.1177/027046760102100107

Catania, B. (2002). The US Government Versus Alexander Graham Bell: An Important Acknowledgment for Antonio Meucci. *Bulletin of Science, Technology & Society, 22*(6), 426-442.

Coe, L. (1995). *The telephone and its several inventors: A history*: McFarland.

Condorcet Caritat, M. J. A. N. (1795). *Outlines Of An Historical View Of The Progress Of The Human Mind* PhilPapers.

Coopmans, J. (1983). Het Plakkaat van verlatinge (1581) en de Declaration of independence (1776). *BMGN-Low Countries Historical Review, 98*(4), 540-567.

Cummings, W. A. (2012). *Groping in the dark: An early history of WHAS radio*: University of Louisville.

Devezas, T. C. (2005). Evolutionary theory of technological change: State-of-the-art and new approaches. *Technological Forecasting and Social Change, 72*(9), 1137-1152. doi: http://dx.doi.org/10.1016/j.techfore.2004.10.006

Dolbear, A. E. (1877). The Telephone: Bost.

Dosi, G. (1982). Technological paradigms and technological trajectories: a suggested interpretation of the determinants and directions of technical change. *Research policy, 11*(3), 147-162.

Douglas, P. (n.d.). The Man who took back New Netherland. Retrieved from New Netherland Institute website: http://www.newnetherlandinstitute.org/files/2813/5680/0659/Man_Who_Took_Back_NN.pdf

Duijn, J. J. v. (1983). *The long wave in economic life*: Allen & Unwin London.

Evenson, A. E. (2000). *The telephone patent conspiracy of 1876: The Elisha Gray-Alexander Bell controversy and its many players*: McFarland.

Fagen, M. D. (1975). history of engineering and science in the Bell System.

Finck, W. M. (2007). *English Seventeenth Century Colonial Expansion as a Form of*

Rent-Seeking: ProQuest.

Finn, B. S. (2009). Bell and Gray: Just a Coincidence? *Technology and Culture, 50*(1), 193-201.

Fischer, C. S. (1994). *America calling: A social history of the telephone to 1940*: Univ of California Press.

Fish, F. P. (1902). Annual Report of the Directors of American Telephone $ Telegraph Company. Boston: AT&T.

Fogleman, A., S. (1998). From Slaves, Convicts, and Servants to Free Passengers: The Transformation of Immigration in the Era of the American Revolution. *The Journal of American History, 85*(1), 43-76. doi: 10.2307/2568431

Foote, R. A. (1892). *Census Bulletin* Washington: Retrieved from http://www2.census.gov/prod2/decennial/documents/1890d5-13.pdf.

Gabel, R. (1969). The Early Competitive Era in Telephone Communication, 1893-1920. *Law and Contemporary Problems, 34*(2), 340-359. doi: 10.2307/1191094

Gorman, M. E., & Carlson, W. B. (1990). Interpreting invention as a cognitive process: The case of Alexander Graham Bell, Thomas Edison, and the telephone. *Science, Technology & Human Values, 15*(2), 131-164.

Graham, J. (1995). Revolutionary in Exile: The Emigration of Joseph Priestley to America 1794-1804. *Transactions of the American Philosophical Society, 85*(2), i-213. doi: 10.2307/1006644

Grosvenor, E. S., & Wesson, M. (1997). *Alexander Graham Bell: The life and times of the man who invented the telephone*: Harry Abrams.

Harari, Y. N. (2014). *Sapiens: A brief history of Humankind*: Random House.

Hartenberg, R. S. (2015). Robert Fulton, American inventor *Enceclopaedia Brittanica*.

Hazlewood, A. (1953). The Origin of the State Telephone Service in Britain. *Oxford Economic Papers, 5*(1), 13-25. doi: 10.2307/2661863

Heilbroner, R. L. (2011). *The worldly philosophers: The lives, times and ideas of the great economic thinkers*: Simon and Schuster.

Henderson, L. J. (1914). The Fitness of the Environment. *The American Journal of the Medical Sciences, 148*(3), 433.

Herman, A. (2001). *How the Scots invented the Modern World: the true story of how* *western Europe's poorest nation created our world & everything in it*: Crown.

Hill, R. B. (1953). Early Work on Dial Telephone Systems. *Bell Laboratories Record, 31*, 28.

Hobsbawm, E. (2010a). *Age of Capital: 1848-1875*: Hachette UK.

Hobsbawm, E. (2010b). *Age of revolution: 1789-1848*: Hachette UK.

Holzmann, G. J., & Pehrson, B. (1995). *The early history of data networks*: IEEE Computer Society Press.

Hounshell, D. A. (1975). Elisha Gray and the Telephone: On the Disadvantages of Being an Expert. *Technology and Culture, 16*(2), 133-161. doi: 10.2307/3103488

Howe, D. W. (2007). *What hath God wrought: the transformation of America, 1815-1848*: Oxford University Press.

Hubbard, G. G. (1873). The Proposed Changes in the Telegraphic System. *The North American Review*, 80-107.

Hudspeth, H. G. (2005). "One percent inspiration and 99 percent tracing paper": the Pan-Electric scandal and the making of a circuit court judge, April-November 1886. *Essays in Economic & Business History, 23*.

Hughes, T. P. (2004). *American Genesis: a century of invention and technological enthusiasm, 1870-1970*: University of Chicago Press.

Hume, D. (1789). *The history of England: from the invasion of Julius Caesar to the revolution of 1688* (Vol. 8): Printed for T. Cadell and sold by T. Longman.

Hume, D. (2012). *A treatise of human nature*: Courier Corporation.

Huurdeman, A. A. (2003). *The worldwide history of telecommunications*: John Wiley & Sons.

Israel, J. (2014). *Revolutionary Ideas: An Intellectual History of the French Revolution from the Rights of Man to Robespierre*. Oxford & Princeton: Pinceton University Press.

Joel, A. E., & Schindler, G. (1975). *A history of engineering and science in the Bell System: The early years (1875-1925)* (Vol. 1): The Laboratories.

John, R. (2005). Telephomania: The Contested Origins of the Urban Telephone Operating Company in the United States, 1879-1894. *Great Cities Institute, College of Urban Planning and Public Affairs. University of Illinois at Chicago. Publication Number: GCP-05-02.*

Justman, M., & Gradstein, M. (1999). The Industrial Revolution, Political Transition, and the Subsequent Decline in Inequality in 19th-Century Britain. *Explorations in Economic History, 36* (2), 109-127. doi: http://dx.doi.org/10.1006/exeh.1999.0713

Karlsson, S., & Lugn, A. (2009). *Changing the world: the story of Lars Magnus Ericsson and his successors*: Sellin & partner.

Kennelly, A. E. (1935). Michael Idvorsky Pupin. *Proceedings of the American Philosophical Society, 75*(4), 335-338. doi: 10.2307/984636

Kingsbury, J. E. (1915). *The telephone and telephone exchanges: their invention and development*: Longmans, Green, and Co.

Klein, D. B., & Majewski, J. (2008). Turnpikes and toll roads in nineteenth-century America. *EH. Net Encyclopedia*. Retrieved from EH.net website: http://eh.net/encyclopedia/turnpikes-and-toll-roads-in-nineteenth-century-america/

Kohn, R. H. (1970). The Inside History of the Newburgh Conspiracy: America and the Coup d'Etat. *The William and Mary Quarterly, 27*(2), 188-220. doi: 10.2307/1918650

Kooij, B. J. G. v. d. (1988). Innovatie gedefinieerd; een analyse en een voorstel. Repository: University of Technology, Eindhoven.

Kooij, B. J. G. v. d. (2013). Innovation Defined, a Survey. Repository: University of Technology, Delft.

Kurinsky, S. (n.d.). Emile Berliner - An Unheralded Genius. Part I - The Early Years. http://www.hebrewhistory.info/factpapers/fp027-1_berliner.htm

Land, F. d. (1907). Notes on the Development of Telephone Service *Popular Science, 70*(May 1907).

Langdon, W. C. (1933). *Myths of Telephone History*.

Lipsey, R. G., Carlaw, K. I., & Bekar, C. T. (2005). *Economic Transformations: General Purpose Technologies and Long-Term Economic Growth*: Oxford University Press.

Locke, J. (2013). *Two Treatises on Government: A Translation Into Modern English* (Vol. 5): Industrial Systems Research.

Lucas, S. E. (1998). The rhetorical ancestry of the Declaration of Independence. *Rhetoric & Public Affairs, 1*(2), 143-184.

MacDougall, R. (2013). *The People's Network: The Political Economy of the Telephone in the Gilded Age*: University of Pennsylvania Press.

Mark, I. (1942). Agrarian Revolt in Colonial New York, 1766. *American Journal of Economics and Sociology, 1*(2), 111-142. doi: 10.2307/3483742

McCabe Jr, J. D. (1872). *Great Fortunes, and How They Were Made.*

McCurdy, C. W. (2001). *The Anti-Rent Era in New York Law and Politics, 1839-1865*: Univ of North Carolina Press.

Mensch, G. (1979). *Stalemate in technology: innovations overcome the depression*: Ballinger Cambridge, Mass.

Miller, J. C. (1959). *Origins of the American Revolution: With a New Introd, and a Bibliography*: Stanford University Press.

Millikan, F. R. Joseph Henry and the telephone. *Smithsonian Institution Archives.*

Mokyr, J. (1990). *The lever of riches: Technological creativity and economic progress*: Oxford University Press.

Mokyr, J. (2003). Why was the Industrial Revolution a European Phenomenon? *Supreme Court Economic Review*, 27-63.

Mokyr, J. (2011). *The enlightened economy: Britain and the industrial revolution, 1700-1850*. London: Penguin UK.

Mueller, M. (1993). Universal service in telephone history: A reconstruction. *Telecommunications Policy, 17*(5), 352-369. doi: http://dx.doi.org/10.1016/0308-5961(93)90050-D

n.a. (1879). Elisha Gray Reception and Banquet. Highland Park, Public Library, Historical Collection: C. E. Southard, Printer.

n.a. (1886). Mr.Wilber Confesses, *The Washington Post*. Retrieved from https://en.wikisource.org/wiki/Mr._Wilber_Confesses

Nettels, C. P. (1952). British Mercantilism and the Economic Development of the Thirteen Colonies. *The Journal of Economic History, 12*(2), 105-114. doi: 10.2307/2113218

Osborne, H. (1943). *Biographical Memoir of Alexander Graham Bell.* Paper presented at the Annual Meeting 1943.

Page, C. G. (1837). The production of galvanic music. *Sillimans Journal, 32*, 396-397.

Pizer, R. A. (2009). *The Tangled Web of Patent# 174465*: AuthorHouse.

Potts, H. E. (1944). The Definition of Invention in Patent Law. *The Modern Law Review, 7*(3), 113-123.

Prescott, G. B. (1878). *The Speaking Telephone, Talking Phonograph, and Other Novelties*: D. Appleton and Company.

Prescott, G. B. (1884). *Bell's Electric Speaking Telephone: Its Invention, Construction, Application, Modification, and History*: D. Appleton.

Pupin, M. (2005). *From immigrant to inventor*: Cosimo, Inc.

Rens, J.-G. (2001). *Invisible Empire: A History of the telecommunications industry in Canada, 1846-1956*: McGill-Queen's Press-MQUP.

Robertson, J. H. (1947). *The story of the telephone: A history of the telecommunications industry of Britain*: J. Pitman.

Schiavo, G. E. (1958). *Antonio Meucci: inventor of the telephone*: Vigo Press.

Schoolcraft, H. L. (1907). The Capture of New Amsterdam. *The English Historical Review, 22*(88), 674-693. doi: 10.2307/550138

Schumpeter, J. A. (1939). *Business cycles; a theoretical, historical, and statistical analysis of the capitalist process (Fels)* (1st ed.). New York, London,: McGraw-Hill Book Company, inc.

Schumpeter, J. A., & Opie, R. (1934). *The theory of economic development; an inquiry into profits, capital, credit, interest, and the business cycle*. Cambridge, Mass.,: Harvard University Press.

Settle, T. B. (2001). Experimental sense in Galileo's early works and its likely sources. *Largo campo di filosofare*, 831-849.

Sheridan, R. B. (1960). The British Credit Crisis of 1772 and The American Colonies. *The Journal of Economic History, 20*(2), 161-186. doi: 10.2307/2114853

Shulman, S. (2008). *The telephone gambit: chasing Alexander Graham Bell's secret*: WW Norton & Company.

Shuman, A. E. (1883). Report on the statistics of Telegraphs and Telephones in the United States (pp. 765-798). Washington: Department of the Interior, Census Office.

Smith, G. H. (2011). Americans with Attitudes: Smuggling in Colonial America. Retrieved from Libertism.org website: http://www.libertarianism.org/publications/essays/excursions/americans-attitudes-smuggling-colonial-america

Smith, N. (2011). The Influence of the Enlightenment on The Formation of the United States. *History Archives*. Retrieved from Articlemyriad website: http://www.articlemyriad.com/influence-enlightenment-formation-united-states/

Sosnowski, T. (2005). Revolutionary Emigrés and Exiles in the United States: Problems of Economic Survival in a New Republican Society. *French History and Civilization, 1*.

Spooner, W. W. (1907). The Van Renseselaer Family. *American Historical Magazine, 2*(1), 1-23.

Staff, H. c. (2009). Battle of Lexington and Concord. Retrieved from History.com website: http://www.history.com/topics/american-revolution/battles-of-lexington-and-concord

Thierer, A. D. (1994). Unnatural Monopoly: Critical Moments in the Development of the Bell System Monopoly. *Cato J., 14*, 267.

Thompson, S. P. (1890). The Electro-Magnet. *Science, 16*(October 10, 1890), 107-202.

Thompson, S. P., & Reis, P. (1883). Inventor of the Telephone. *E. and FN Spon, London*.

Thomson, E. (1920). The epoch-making discoveries of the years 1819 and 1820. *American Institute of Electrical Engineers, Journal of the, 39*(12), 1021-1027.

Towers, W. K. (1917). *Masters of space*: Harper.

Turner, F. J., & Abbe, E. (1966). *The significance of the frontier in American history*: University Microfilms Ann Arbor, MI.

Tushman, M. L., Anderson, P. C., & O'Reilly, C. (1997). Technology cycles, innovation streams, and ambidextrous organizations: organization renewal through innovation streams and strategic change. *Managing strategic innovation and change, 34*(3), 3-23.

Usher, A. P. (1929). *A history of mechanical inventions*. New York: McGraw-Hill Book Company.

Vail, T. N. (1911). Annual Report AT&T 1910.

Walton, G., & Rockoff, H. (2013). *History of the American economy*: Cengage Learning.

Ward, R. C. (1997). *The Chaos of Covergence: A Study of the Process of Decay, Change, and Transformation within the Telephone Policy Subsystem of the United States.* (PhD Dissertation), NC State University, Electronic Theses and Dissertations (ETD). Retrieved from http://scholar.lib.vt.edu/theses/available/etd-0698-91234/

Weidenaar, R. (1995). *Magic Music from the Telharmonium*: Reynold Weidenaar.

Weiman, D. F., & Levin, R. C. (1994). Preying for Monopoly? The Case of

Southern Bell Telephone Company, 1894-1912. *Journal of Political Economy, 102*(1), 103-126. doi: 10.2307/2138795

Whewell, W. (1858). *History of inductive sciences*.

Wile, F. W. (1926). *Emile Berliner, maker of the microphone*: The Bobbs-Merrill company.

Williams, F. B. (1943). The Pan-Electric Telephone Controversy. *Tennessee Historical Quarterly*, 144-162.

Wineke, S. J., Caudill, S. B., & Mixon Jr, F. G. (2014). Simultaneous Invention and Rent Seeking in the Development of Telephony. *Journal of Politics and Law, 7*(3), p1.

Wood, G. S. (2011). *The radicalism of the American Revolution*: Vintage.

About the author

Drs.Ir.Ing. B. J. G. van der Kooij (b. 1947) in 1975 obtained his MBA (thesis: Innovation in SMEs) at the Interfaculteit Bedrijfkunde (nowadays part of the 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 started his own company, Ashmore Software BV, 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 till his retirement in 2013. Innovation being the focus of attention 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 the TU-Delft by Prof. 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 information engines, and the computing engines. He studies their characteristics from a multidisciplinary perspective (economic, technical, and social).

Van de Kooij is married and spends a great deal of his time working in the South of France.