Chapter 1

The Age of Invention: Nineteenth Century Technology and Music

> The sounds of music cannot be separated from the technology involved in their conception, performance, transmission, and audience reception because the technology is an integral part of the sounds themselves. (Seeger and Théberge 2001: 235)

On the spark of that very moment in 1877 when Thomas Edison succeeded in capturing his voice on a tin foil covered cylinder and replaying it, the phenomenon of *schizophonia* came to exist. Although it would take one hundred years for this phenomenon to receive its name from R. Murray Schafer in *The Soundscape: The Tuning of the World* (1977: 90), the separation of sound from its original source through acoustic technology quickly impacted the cultures of the world. This *schizophonic split* has arguably been the single most important moment in the history of music. "Originally, all sounds were originals…uncounterfeitable, unique" (Ibid.), and originally *all* sounds were transitory. Edison's phonograph placed technology between the performance and the listener by capturing the sounds for later playback. The once elusive, ethereal sounds now fixed in physical form, were rapidly transformed into the commodities that would drive one of the most powerful industries on earth. Furthermore, the phenomenon of schizophonia has granted technology the power to assume a widening role in the *sound* of our world's music. While the words of Seeger and Théberge clearly ring true, technology has also provided a means by which corporations gain and maintain *control* over what sounds are conceived, performed, transmitted, and received by any audience at any given time (Bishop 2003: 161). Technology, in this sense, operates on a dual level, at once providing a resource for the creative construction, consumption, and use of music by its creators and audiences, while "at the same time providing a mechanism through which corporate profits are realized and social relations affected" (Lull 1987: 12). One hundred twenty seven years after the phonograph, technological mediation defines the sonic qualities of music in human life more than ever before. In the technoculture we now inhabit, most musical sounds are experienced through some form of technological mediation whether it is the record, cassette or CD player, the "walkman," the "boom box," the "piped in" music at the office, MP3s, the computer, television or the radio, the soundtracks in films and video games, or the sound systems at concerts and clubs. No longer are all musical sounds originals. Quite the contrary, the majority of them are not.

The advent of recording technology has certainly altered the sonic characteristics of music in human cultures. However, as part of the telecommunications lineage of the nineteenth century, recording technology was originally conceived as an extension to the telegraph and telephone, to be used primarily in business as a dictograph. (It would be more than a decade before the phonograph would be used for entertainment). The factors that led the inventors of the era toward recording technology, and why the discovery of the phonograph came when it did in 1877, can be explained through an understanding of the nature by which inventions emerge in society.

The Nature of Invention

Technological advances evolve and often overlap along a continuum rather than appearing suddenly as distinct technological revolutions; that is the inherent nature of invention. The inventions of today were built upon those of the past, just as the inventions of tomorrow will be built upon those of today. "Inventions never just appear out of a vacuum in the mind of the inventor," and often several inventors toil simultaneously over similar devices either in competition with, or unaware of, the others, "for it is social, economic and cultural circumstances that motivate the invention and the direction of the inventor's imagination" (Chanan 1995: 2). In his famous work *The Republic*, Plato stated, "necessity is the mother of invention" (Hirsh, et al. 2002: 54), and necessity during the nineteenth century in the United States was defined by many "social, economic and cultural circumstances" that shaped the objectives of the American inventors. New technologies were born of inspiration that combined available technologies with the inventor's imagination, which pursued, through rigorous trial and error, the desired outcome, a new technology. Although the atmosphere throughout the century was quite ripe for innovation, and has been considered, among other things, the age of invention (Thompson 1921), it was not until the discovery of the electric telegraph in the 1830s that the path was laid for the coming of recording technology. However, the success of electric telegraphy had been dependent upon nearly a century of scientific work that preceded it.[1]

The phonograph offers a clear illustration of the advancement of existing ideas transferred from one inventor to another, each contributing unique additions to the ideas along the way. For example, the physical characteristics of the phonograph reveal that the many individual ideas and components that comprised the invention were adaptations of existing concepts or discoveries. The horn as a sound conduit dates back to at least Leonardo da Vinci's sketches of a tube communications system to be installed in the Duke of Milan's fifteenth century palace. The diaphragm as a sound producer had been known since the times of Hippocrates, who made the discovery through the dissection of human and animal ears, while most recently the diaphragm, or membrane, had appeared as the integral component of the *phonautograph*, described below. The stylus had its origin in ancient Egypt as an engraving tool and had most recently been used to engrave telegraph messages onto paper tapes. The cylindric turning surface and crank wheel can be traced back many years to the making of lathes and other machinery; and Archimedes invented the feed screw, while the wheel's origin is lost to antiquity (Read and Welch 1959: 4).

Perhaps the device most influential upon the development of the phonograph was the phonautograph invented by French scientist Léon Scott in 1857. Although at the time seen largely as novel with little practical use, the phonautograph was the first device that could visually register sound waves on a revolving cylinder, but it could not play them back. Essentially Scott created a mechanical "ear" that used a horn as a sound catcher, which funneled the sound to a membrane stretched across the small end. Attached to the membrane was a stiff brush that moved according to the membrane's vibrations to sketch out sound waves onto soot-covered paper wrapped around a rotating cylinder (Steffens 1992: 12-14). Scientists who found interest in the phonautograph sought to develop a device that would reverse the process thus allowing, theoretically, the sounds to be replayed. Fellow Frenchman Charles Cros, the poet, became obsessed with taking the phonautograph to the next level. Finally, after decades of work, on April 30, 1877, Cros deposited a sealed envelope with the Secretary of the Academy of Sciences in Paris. The envelope contained an article titled "Process of Recording and of Reproducing Audible Phenomena" that described a photoengraving process that would etch the recorded groove into a metal disc, which then could be replayed (Berliner 1888: 429). Cros never actually raised the funding to make such a device, but he is credited in a number of sources as the first person to devise a workable method of recording and reproducing sound (Berliner 1888: 429; Du Moncel 1974: 235; Read and Welch 1959: 119; Steffens 1992: 17). Edison, who is solely credited for the eventual discovery of recording technology, just happened to be the first one to make such a device work *and* beat the other inventors to the patent office.

Although physically the phonograph derived from a variety of previous inventions, ideas and influences, the impetus for its discovery came as the inventors of the age worked to further the growth and versatility of the electric telegraph. Had the electric telegraph been delayed, chances are that the innovations to telegraphy would have also been delayed, in turn delaying the discovery of the phonograph. Therefore, the emergence of recording technology at its particular time in history was dependent upon the ongoing developments being made in telegraphy, and later, telephony.

The Telegraph Opens the Door

Most people (at least in the United States) agree that portrait artist Samuel F. B. Morse was the inventor of the telegraph in 1837.[2] Such people are not entirely wrong, nor are they entirely right. Morse, with the help of many others, did develop the telegraph as a large-scale system of communications; however, it was American scientist Joseph Henry who first unlocked the mysteries of electric telegraphy in 1831.[3] Following suit, Henry's work was built upon the discoveries of Volta, Oersted, Sturgeon, Ohm, and Faraday (see note 1), and Morse's work simply advanced Henry's work toward the specific goal of sending encoded messages. Finally, after five years of trial and error, on September 2, 1837, Morse's telegraph was born. To the inventors, the telegraph was the marvel of modern technology. The skeptics, however, were largely apathetic toward the telegraph's reliability and usefulness in everyday life. With the help of builder Ezra Cornell (later to found Cornell University), Morse constructed a working line between Washington, D. C. and Baltimore, Maryland (Dorf 1952: 63). On May 24, 1844, the first intercity message sent by electric telegraph arrived at the Supreme Court. It read, "What hath God Wrought!" (Coe 1993: 32). Despite the Baltimore-Washington line as working proof, popular skepticism and apathy delayed the "arrival" of the telegraph in American society until the end of the decade. By that time, popular skepticism had yielded to enthusiasm as the nation embraced the electric telegraph as *the* means of communication. The growth of the telegraph in the 1850s was nothing short of explosive. The power of telegraphy quickly spread across the country, spawning the massive industry of telecommunications. Out of this new field emerged the corporate giant Western Union, founded in 1856, which quickly gained monopoly control over the new technology. After Western Union completed the first transcontinental telegraph line in 1861 there was no stopping them. By nineteenth century standards "Western Union was huge, one of America's first truly national companies, with offices in every major city and town" and now had "enough money and power to buy or suppress technology outright" (Grosvenor and Wesson 1997: 37). Western Union would enjoy their monopoly privileges for two decades until its nemesis, the American Telegraph and Telephone Company (AT&T), emerged in 1875.

Telecommunications was a lucrative and prestigious field that excited the inquisitive minds of scientists, inventors and entrepreneurs all seeking to earn their fortunes making improvements to telegraphy. Such efforts "provided the nation with an early high-tech industry" (Adams and Butler 1999: 15). Among the bright minds attracted to this new industry was Thomas Edison, who worked for Western Union as an itinerant telegraph operator from 1863 to 1868 (Israel 1998: 20). Itinerant operators, or "tramp" telegraphers, traveled from city to city working as temporary telegraph operators. In 1867, Edison settled for a time in Cincinnati, where he began to turn his attention to the technical aspects of telegraphy. Prior to the Civil War, New York, Philadelphia and Boston were the only telegraphic centers of note. However, after the war, Cincinnati was one of several smaller cities that emerged as hubs of telegraphic activity, providing meeting grounds where inventors and operators "hastened the exchange of information about telegraph technology" (Israel 1998: 35). There, amid the bustling activities of the operating room, Edison began his transition from operator to inventor (Israel 1998: 34).

Some of his earliest work concentrated on relays that switched the incoming signal from the main line to the local sounder, although Edison's "primary interest remained long-distance telegraph improvements that might be wanted by Western Union" (Israel 1998: 36). In 1868, Edison moved to Boston, "one of the oldest and most sophisticated telegraph communities in the country" where his career as an inventor truly began in earnest (Israel 1998: 39). The following year, at the age of twenty-two, Edison made major improvements to the stock ticker, a device that relayed gold and stock prices over the telegraph lines. He opened his own gold and stock quotation service in January that year, and by the end of the month the enterprise enabled him to resign from Western Union in order to "devote his time to bringing out his inventions" (Israel 1998: 48). He subsequently abandoned the ticker tape business in 1870 and sold the rights to use his patent to Western Union for $30,000 (Steffens 1992: 18). The earnings from his telegraph and ticker tape patents funded the construction of his Menlo Park laboratory in New Jersey, which began in 1870.[4] In four short years, Edison's inventions propelled him to the top of his field, made him wealthy and highly respected among the scientific community, and brought him fame with the public at large. Incredibly, his real wealth and fame were still yet to come.

Elisha Gray and Alexander Graham Bell: The Race to the Telephone

In Europe, from the mid 1850s on, there existed a strong drive toward uncovering the mysteries of multiplexing, or sending more than one message at a time across the same telegraph wire. However, American inventors thought this to be unfeasible and did not work toward this goal until a decade later (Israel 1998: 38). Double transmission systems, known as the duplex (sending two messages in opposite directions), and the diplex (sending two messages in the same direction), first appeared in the U.S. in 1865 when noted telegraph inventor Moses Farmer demonstrated such a system on a line between Boston and Portland, Maine (Ibid). Three years later, Joseph Stearns successfully installed a duplex system on the lines of the Franklin Telegraph Company in Boston (Ibid.). In 1872, Western Union had adopted Stearns's system for use on their lines, theoretically doubling their capacity (Adams and Butler 1999: 34). The corporate giant then set its sights on increasing that capacity by multiplexing, or sending several messages simultaneously, and they promised to pay handsomely the inventor who succeeded. If Stearns could make a fortune from the duplex, inventing a multiplex would certainly be a gold mine. Three major inventors of the era turned their attention to working on this problem. In Chicago, Elisha Gray (co-founder of Western Electric in 1872) worked under contract with Western Union. In May 1874, Gray succeeded in transmitting eight separate tones, although not simultaneously, to a corresponding receiver (Grosvener and Wesson 1997: 45). Referred to as the "musical" or "harmonic" telegraph, Gray's invention was an important step forward in sending sound waves via wire. The harmonic telegraph utilized variously pitched tuning forks whose vibrations were transmitted along the telegraph line to a distant receiver. Gray knew that if he could send the vibrations of the tones along the wire, he could send and receive any sound, including the human voice. Surprisingly, Western Union saw no future in a "talking telegraph" and directed Gray to continue working on a multiplex telegraph.

In Salem, Massachusetts, teacher of the deaf Alexander Graham Bell slowly made the transition from teacher to inventor.[5] He began working on the telegraph as early as 1872, and by 1874, in open competition with Gray, Bell began to develop his own version of the harmonic telegraph. Bell, like Gray, was certain that if sound vibrations could travel along a telegraph wire, so could the vibrations of speech. However, Bell's patrons (mainly Gardiner Greene Hubbard) also insisted he continue working toward a multiplex system that they could sell to Western Union (Grosvenor and Wesson 1997: 51). In the meantime, Edison, who was also working under contract with Western Union, had read about Gray's work, prompting him to learn more about "acoustic telegraphy" (Israel 1998: 110). His early experiments in this area were greatly influenced by Gray's work, but rather than using frequencies, Edison concluded that if he could combine a duplex with a diplex he would achieve his goal, the quadraplex (sending two messages simultaneously in each direction). After successfully testing such a system over a two hundred mile loop from New York to Philadelphia, the quadraplex was announced to the public in the *New York Times* on July 10, 1874 (Israel 1998: 98). Only two months after the advent of the harmonic telegraph, Edison had beaten both Gray and Bell to the finish line, reaffirming his stature as the preeminent electromechanician of the age.

During the mid 1870s, the deep pockets of Western Union dictated the direction of technological development. Their research funding and "handsome" payments for advancements in telegraphy attracted the best inventors of the time. Through financial reward, Western Union established the "social, economic and cultural circumstances" that motivated the inventors. This power was played out nowhere better than in the suppression of the “talking telegraph.” Elisha Gray and Alexander Graham Bell both knew they could send the human voice across wires. Neither had yet achieved this feat, but each had worked out the problem theoretically. Advisors to both men insisted that they abandon further research in that area and focus on the telegraph, more specifically a multiplex capable of sending more messages than Edison’s quadraplex (Adams and Butler 1999: 37). Gray was entrenched with Western Union. They not only funded his research, they owned a third of his company. His decade long relationship with Western Union “may have blinded him to a host of creative options” and “prevented him from seizing the possibilities he could see” (Ibid.). Consequently, Gray set the talking telegraph aside and returned to working toward the multiplex telegraph.

Bell’s relationship with Western Union was indirect, through Hubbard, and he was not personally beholden to them. He had greater liberty of choice and rejected Hubbard’s insistence that he return to his work with the multiplex telegraph. Instead, Bell began searching for the secret to sending the human voice across wires. Since 1874, he had been fixated on creating an apparatus by which the “human voice might be telegraphed without the use of a battery” (Grosvenor and Wesson 1997: 51). Finally, on June 2, 1875, and purely by accident, the discovery was made. On that day, Bell and his assistant Thomas Watson were preparing to test some modifications made to the instruments. The moment of discovery is best told in Watson’s own words:

> I had charge of the transmitters as usual, setting them squealing one after the other, while Bell was retuning the receiver springs one by one, pressing them against his ear…One of the springs I was attending to stopped vibrating and I plucked it to start it again. It didn’t start and I kept on plucking it, when suddenly I heard a shout from Bell in the next room, and then out he came

> with a rush, demanding, "What did you do then? Don't change anything. Let me see." (Watson in Wile 1926: 59)

Coincidently, as Watson plucked the spring, Bell's ear had been pressed against the corresponding receiver, at that exact moment, where he faintly heard the complex vibrations of the plucked spring. Bell knew at once that the basic discovery of a talking telegraph had been made. Encouraged by Bell's progress, Gardiner Greene Hubbard (Bell's future father in law), Thomas Sanders and Graham Bell founded the American Telegraph and Telephone Company (AT&T) in 1875. Hubbard, also a patent attorney, checked the U. S. Patent Office for competing research, and found, surprisingly, a caveat filed by Elisha Gray for voice transmission on February 14, 1876. A caveat is filed when an invention is in its working stages, giving notice of a possible patent-bearing concept (Adams and Butler 1999: 37). Hubbard quickly filed a patent on behalf of Bell for "Improvements in Telegraphy," which has been referred to as "the most valuable single patent ever issued" (Wile 1926: 58; Grosvenor and Wesson 1997: 51).[6] On March 10, 1876, Bell succeeded in sending the spoken word across the lines when from another room he said, "Mr. Watson, please come here, I want you" (Wile 1926: 61). When Watson appeared in the doorway Bell knew his day had come and the telephone was ready for public demonstration. However, much like the telegraph, the telephone was slow in winning popular interest. That all changed when, through Hubbard, Bell was given a chance to demonstrate his apparatus at the International Centennial Exhibition held that year in Philadelphia.[7] "There was no better place on earth in 1876 to introduce a new invention" (Grosvenor and Wesson 1997: 69). Bell was given "waste space" off the beaten track next to a stairway in the Department of Education. This apparatus, the device about to change the world, stood on a simple table largely ignored by the masses and judges alike. “No violet was ever more shrinking” (Wile 1926: 61). Then chance intervened. The Centennial’s most august visitors, Emperor Dom Pedro de Alcantara and the Empress Theresa of Brazil, in full imperial regalia and leading a retinue of courtiers and Centennial officials, he strolled over to where Bell was standing. The Emperor, a few years prior, had observed Bell at Boston University teaching his deaf students using the “visible speech” method. In admiration of the Bell system of visible speech Dom Pedro established an institute for the deaf in Rio de Janeiro (Wile 1926: 64). Bell requested that Dom Pedro take up a position on the receiving end and place the receiver next to his ear. Bell went across the room to the transmitter. “An awesome silence reigned” as Bell spoke into the transmitter while on the other end in utter astonishment, the Brazilian Emperor cried aloud, “My God, it talks!” (Ibid.). With the attention drawn to it by the Brazilian Emperor the telephone became an instant success at the Centennial. Even Elisha Gray could not deny the phenomenon and later admitted that the words of Hamlet’s soliloquy, “Aye, there’s the rub,” were “the first words he ever heard on an electric telephone” (Grosvenor and Wesson 1997: 72). The Bell telephone had finally had its day.

The Arrival of Recording Technology

Much like Bell’s discovery of the telephone, Edison accidentally discovered the phonograph while working on improvements to the telephone for Western Union. In July 1877, Edison had been contemplating the possibility of recording telephone messages

(Israel 1998: 144). Thinking of the telephone as an extension of the telegraph, his first thoughts were in the direction of producing a written record of the telephone message, as he had done with the telegraph. He experimented "with a diaphragm having an embossing point and held against paraffin paper moving rapidly" (Ibid.). As the diaphragm vibrated according to incoming sounds it indented the paraffin paper. When Edison slid the indentations rapidly back under the stylus he heard the peculiar humming that reproduced the rhythm of human speech (Steffens 1992: 20). After seeing that the vibrations were "indented nicely," Edison concluded, "there's no doubt that I shall be able to store up and reproduce automatically at any future time the human voice perfectly" (Ibid.). When the discovery was made, Edison was, as usual, engaged in pressing work on his telephone and put aside the phonograph to return to his experiments. The phonograph lay idle until November, when Edison began sketching a series of lathe-like devices. By the end of the month, he submitted the final sketches to his machinist John Kruesi for the creation of a prototype (Ibid.). On December first, Kruesi returned with a device that "astounded Edison and his associates by working the first time they tried it" (Israel 1998: 145). Edison wrapped a sheet of tin foil around the cylinder, set the stylus in place, and as he cranked the wheel, he sang, "Mary had a Little Lamb, Little Lamb, Little Lamb…." He then placed the stylus back at the starting point and as he cranked the handle "Edison's voice – scratchy, but distinct – filled the room" (Steffens 1992: 23). Edison now had his first phonograph and off he went to the New York office of *Scientific American* and the headquarters of Western Union to exhibit "his baby." News spread rapidly throughout the world about the machine that could talk. When the announcement of the phonograph reached Graham Bell in 1878, he was prompted to write in a letter to Hubbard:

> It is a most astonishing thing to me that I could possibly have let this invention slip through my fingers when I consider how my thoughts have been directed to this subject for so many years past. So nearly did I come to the idea that I had stated again and again in my public lectures the fundamental principles of the phonograph. (Grosvenor and Wesson 1997: 110)

Edison's phonograph was not unique in its fundamental principles, and bore remarkable physical similarities to Scott's 1857 phonautograph. It was, however, unique in its method of registering sounds. The phonograph used the so-called "hill and dale," or vertical, method of indenting sound vibrations into a tin foil surface. This meant that the motion of the recording stylus moved on a vertical plane up and down at a ninety-degree angle to the recording surface. The membrane, in response to stronger sounds, caused the stylus to indent deeper grooves into the foil than when responding to weaker ones. And often, the new grooves, if pressed deep enough, disturbed the previous indentations. The result was a very scratchy, distorted sound, "a parody" of the human voice (Wile 1926: 180). However acoustically primitive the reproduction was compared to the original source, the phonograph stood as the pinnacle of man's nineteenth century acoustic achievements. Word of the talking machine continued to spread, stoking popular interest in viewing the marvel first-hand. This popular demand led to the birth of the world's first phonograph company. On April 24, 1878, the Edison Speaking Phonograph Company was organized to exploit such popular interest (Read and Welch 1959: 25). The main purpose of the company was to demonstrate the phonograph to the public far and wide in exchange for a fee (Gronow and Suanio 1998: 2). George L. Bradley, Hilbourne Roosevelt (Theodore's cousin), Uriah H. Painter, Charles A. Cheever, and Gardiner Greene Hubbard were the five stockholders of the company. Interestingly, Cheever and Roosevelt were also involved in the telephone industry having previously secured the New York rights for the Bell telephone from Hubbard (Read and Welch 1959: 25). This reveals that some of the men closest to Alexander Graham Bell were also associated with Thomas Edison and the promotion of the phonograph. The stockholders paid Edison $10,000 for his tin-foil phonograph patent, plus a guarantee of twenty percent of the profits (Read and Welch 1959: 25). However, the company was short-lived, as Edison soon diverted his attention from further developing the phonograph back to his research on incandescent light bulbs and the creation of "community-wide electric power and distribution systems essential for their use" (Read and Welch 1959: 26). In November 1878, Edison entered a five-year exclusive contract with Edison Electric Light Company to develop such a system and a means of mass-producing the incandescent bulb. He purchased the assets of the Edison Speaking Phonograph Company to prevent losses to the stockholders and to facilitate his return to phonograph development when time permitted (Ibid.). A decade would pass before Edison returned to his research on the phonograph.

In 1880, the French Academy of Science awarded Alexander Graham Bell the Volta Prize (named for Alessandro Volta) for his invention of the telephone. The prize, created by Emperor Napoleon III to acknowledge scientific achievement, awarded Bell 50,000 francs, the equivalent of $10,000 (Newville 1959: 72). Upon his return to the

United States, Hubbard encouraged Bell to pick up where Edison had left off. Bell used the prize money to fund the opening of the Volta Laboratory in the Georgetown District of Washington, D. C., "as a research facility to develop a range of ideas relating to the science of sound" (Martland 1997: 16). The laboratory opened the same year and served as the workshop of Alexander Graham Bell; Chichester A. Bell, a British chemist and Alexander's cousin; and Charles Sumner Tainter, a precision engineer. Although Alexander Graham Bell spent little time in the lab, early on he and Charles Tainter experimented with selenium cells, and a variety of ways to transmit sound, including the use of light waves and jets of air (Newville 1959: 75, 78). Simultaneously, C. A. Bell and Tainter began developing a variety of cylinder and disc recording machines. Interestingly, in their flat disc experiments the turntables were mounted vertically. The explanation for this stems from their earliest experiments in which the turntable was mounted on a shop lathe (Newville 1959: 76). By 1881, they had succeeded to some extent in improving the Edison tin-foil cylinder machine. Paraffin wax placed in the grooves of the heavy iron cylinder replaced the tin foil as the recording surface (Newville 1959: 73). This meant that instead of using the indenting stylus of the Edison phonograph, the graphophone used an incising stylus that cut its path into the wax (Read and Welch 1959: 31). (The name graphophone derived from shifting the letter groupings of Edison's invention: Phon-o-graph became Graph-o-phone). Bell and Tainter experimented with the "lateral cut," or "zig-zag" method of recording as early as 1881, but "encountered so much difficulty in getting a form of reproducer that would work with the soft wax records without tearing the groove, we used the hill and valley type of record more often than the other" (Tainter, quoted in Newville 1959: 77). The Volta associates continued making improvements to the graphophone, and by the summer of 1885 they had advanced to the point where a patent application was filed on June 27, 1885, which was granted on May 4th of the following year (Read and Welch 1959: 31).

It was now time to consider full-scale commercial development. Through Hubbard, who contacted his associates with the Edison Speaking Phonograph Company, the Volta associates proposed joining the Bell-Tainter phonograph interests with those of Edison and company on a fifty-fifty basis. Edward Johnson, who negotiated on behalf of Edison, was reluctant to join forces "for an invention that might or might not prove ultimately of real practical value" (Johnson, quoted in Israel 1998: 280). Johnson wanted to wait for further development before making such an agreement. Such delays continued until the end of the year, when the associates decided to strike out on their own and founded the Volta Graphophone Company. Bell and Tainter developed changeable "records" that were constructed of "pasteboard cylinders covered with wax" (Berliner 1888: 435). They mounted the graphophone on a sewing machine base with a foot treadle for power. A governor attached to the treadle that provided uniform rotation speed to the cylinder. In addition, the associates created a stop/start mechanism that enabled the operator to start and stop it while continuing to supply power to the drive mechanism. To record on the graphophone the operator spoke into a funnel that channeled the sound waves toward the diaphragm and the wax-cutting stylus. A second diaphragm to which listening tubes, like those of a stethoscope, were attached created the reproduction. In its current state, the graphophone was destined to become a very popular "dictograph for private and business correspondence" (Berliner 1913: 190). Although Edison certainly made the initial breakthrough in sound recording, it was in the Volta Labs that the phonograph was transformed from the humble tin-foil model, a mere scientific novelty, into a practical commercial instrument.

Meanwhile, across town, Emile Berliner had also been concentrating on the problems of sound recording in his workshop. He had become fascinated by Scott's phonautograph that was on display at the National Museum and he studied it incessantly (Wile 1926: 185). He was well acquainted with Edison's phonograph and the work done to improve it in the Volta Laboratory. He was also very familiar with Charles Cros's 1877 paper describing the photoengraving process of recording sound. He knew that Edison's hill and dale method caused distortion when the stylus indented deeply, and although the carving out or incising the sound vibrations in wax was an improvement, nevertheless "the distortion produced by the engraving [was] sufficient to make the voice unrecognizable" (Berliner 1888: 435). Berliner concluded that the distortion "could never be removed using the method of recording up and down into the wax" (Wile 1926: 187). Building upon Cros's photoengraved grooves, he conceived of combining the lateral cut recording method with grooves of equal depth. In 1887, he patented a simple version of the gramophone and began further development. The gramophone revealed Berliner's revolutionary approach to recording science in several ways: 1) it recorded onto a horizontal, flat disc rather than a cylinder, 2) it used a "lateral cut" rather than the "hill and dale" method, 3) the recording surface was zinc covered with a wax mixture, 4) the spiral groove of the disc propelled the stylus through its motion across the record eliminating the need for a feed screw mechanism, and 5) the flat format made it possible to easily make a reverse matrix from the original recording "from which a reproduction can be obtained, if necessary, within fifteen or twenty minutes" (Berliner 1888: 438). Its main drawback, however, was the poor quality of the sonic reproduction in comparison to the cylinder. In May 1888, Berliner presented to the Franklin Institute his gramophone and a method of recording that he referred to as "etching the human voice" (Berliner 1888). Using "fatty ink," a mixture of one ounce of pure yellow beeswax and one pint of cold gasoline or benzine, Berliner covered a polished metal plate. The benzine or gasoline evaporated quickly, leaving a very thin layer of wax that was "spongy or porous, and extremely sensitive to the lightest touch" (Berliner 1888: 438). However, as the stylus passed through the fatty ink and traced a fine undulatory line, the shavings and dust particles tended to collect at the stylus, blurring the recording. His solution was to pour alcohol over the plate immediately before beginning to record. The alcohol adhered to the fatty ink, keeping it wet enough for the stylus to pass through the material and remain clean (Berliner 1888: 439). Although his etching was a bit complicated, it worked, but Berliner knew he had quite a way to go to improve the sound quality of his recordings.

The advancements made to the phonograph by the Volta Associates must have stung Edison, who promptly returned to phonograph development. After seeing an exhibition of the graphophone at the St. James Hotel in New York in May 1887, Edison was struck with a renewed desire to develop the phonograph (Israel 1998: 280). Upset that Bell and Tainter had copied and improved "his" invention (Steffens 1992: 35), he opened the Edison Phonograph Company in 1888 to produce a line of phonograph models to compete with the graphophone. "His strategy was to make a better machine than the graphophone, regardless of the possibility of infringing on the Tainter-Bell patents" (Schicke 1974:18). Edison knew that the soft ozocerite wax of the graphophone cylinder tended to dull and clog the stylus and to wear down under the pressure of the reproducing stylus. Therefore, he began by experimenting with a variety of materials, seeking a better recording surface. Edison delegated this research to his assistant Charles Batchelor, who experimented by combining resins with "substances such as kaolin, starch, plumbago, paraffin and wood pine tar" (Ibid.). They soon found that a mixture of carnauba wax and oleic acid produced the better surface and concentrated their research in that direction (Israel 1998: 284). They devised a solid wax cylinder made of this mixture, rather than develop the wax covered cardboard cylinders typical of the graphophone. Aside from the improved sound, the solid wax cylinder would resist cracking and could be shaved smooth and reused several times. Edison felt these improvements would give his machine the edge over the graphophone on the market, and he was right. Edison's "perfected phonograph" rapidly became the model of choice for businesses, displacing the once-popular graphophone. During the ensuing battle between the phonograph and the graphophone a battery of lawsuits was launched over alleged patent infringements. The litigation threatened to tie up both Edison and the American Graphophone Company for many years to come. On June 28, 1888, the Edison Phonograph Company and the American Graphophone Company reached an agreement for joint sales in the United States under the North American Phonograph Company (Steffens 1992: 37).

While Edison and Columbia struggled for supremacy in the dictograph business, Berliner focused on the future possibilities of an entertainment industry. His intentions from the very beginning were to develop reliable methods for recording and reproducing records industrially (Gronow and Saunio 1998: 9). Unlike the other inventors of the age, he was a composer and musician, and as such, was more visionary where the future of his invention was concerned. He composed the patriotic "Columbian Anthem" which some believed would be chosen as the "national melody" (Wile 1926: 218-219). Berliner foresaw his gramophone as a device of entertainment, more than Edison and Columbia, which nurtured the dictograph business. At his May 1888 presentation before the Franklin Institute, Berliner predicted the future payment of royalties to artists for their record sales, and what might be considered the first anti-music piracy measures:

> Prominent singers, speakers, or performers, may derive an income from royalties on the sale of the phonautograms, and valuable plates may be printed and registered to protect against unauthorized publication. (Berliner 1888: 446)

Berliner, more than anyone else, knew that the key to the development of such a recording industry depended upon finding the optimum recording surface and a reliable method of mass duplication.

In 1895, Berliner offered a crude, yet commercially acceptable, model of the gramophone to the public. The same year he hired Fred Gaisberg as his pianist and recording technician to begin producing demonstration discs for the gramophone. However, by this time Edison had produced a clockwork driven phonograph (Moore 1999: 26) that made Berliner's hand cranked machine appear toy-like. The following year, Gaisberg contracted the services of Eldridge P. Johnson, a trained mechanical engineer and machine shop owner in Camden, New Jersey, to build him a motor to power the gramophone (Martland 1997: 29). The rudimentary hand-cranked gramophone that Gaisberg presented to Johnson was "poorly designed":

> It sounded like a partially-educated parrot with a sore throat and a cold in the head, but the little wheezing instrument caught my attention and held it fast and hard. I became interested in it as I had never been interested in anything before. (Johnson quoted in Moore 1999: 27)

Johnson redesigned the simple gramophone by inventing a wooden box, which supported the turntable and secured the arm for the stylus and horn. Outside the box, located in the center, was Johnson's newly invented spring-driven motor. The new motor ran with "great regularity of speed, was readily adjustable, and last but not least, ran silently so as not to disturb the sounds of the record by its own noise" (Berliner 1913: 193). Johnson's improvements to the gramophone were comparable to the improvements made to the phonograph by the Volta Associates. His contributions were the turning point in the gramophone's commercial potential. He, however, had little faith in the future of the present gramophone due to its poor reproductive quality. He therefore turned his attention to improving recording and duplication technology by experimenting with an endless variety of materials and processes. Knowing that the Bell-Tainter patents on wax recording were nearing expiration, Johnson began experimenting with a new recording process using wax discs (Martland 1997: 30). He eliminated Berliner's complicated etching process and combined the wax-cutting technique of the graphophone with the lateral-cut, horizontal disc format of the gramophone (Wile 1926: 228). Instead of a wax-covered zinc disc, Johnson's new discs were solid wax. Rather than spend years researching the perfect wax mixture, he simply melted down some Edison cylinders and formed perfectly flat discs from the wax (Millard 1995: 47). Johnson's new discs were free of the surface noise that plagued Berliner's zinc discs and produced a much louder volume than Edison's cylinders (Ibid.). With the addition of Johnson's motor, and the improved recording surface, the "refined" gramophone posed a serious threat to the superior position of the phonograph.

Practically everything was in place for the growth of a recording industry by the 1890s, but two major obstacles plagued the birth of an industry at that time. One had to do with the limits of technological knowledge, while the other was tied to the legal system. First, a reliable, high-quality method of duplicating "records" had yet to be uncovered. It was particularly difficult to duplicate cylinder recordings. Therefore, nearly every cylinder recording made up to this time was an original. Johnson's flat disc offered more promise. From the original recordings, a negative copy could be produced as a matrix from which many duplicates could be "pressed." Both Johnson and Edison dedicated great time to developing methods of mass production. By the end of the decade, both inventors would have worked out the decade-long problems with mass duplication of recordings. The second obstacle was the panoply of patent contestations and lawsuits that threatened to kill the fledgling industry before it could take wing. Of the two, the latter would prove the more difficult to resolve, delaying the development of a music industry in the United States until after the turn of the century. From an objective point of view, the patent wars were a ridiculous waste of time and resources, since the inventors of each device had copied or advanced the ideas of others. However, much was at stake: controlling the technology meant controlling the market. The hypocritical nature of the patent claims eventually led to a legal stalemate out of which the only option was to share patents through a cross-licensing agreement. The effect of the patent wars in the early development of the recording industry is presented with more detail in the next chapter, but before we jump ahead, I wish to offer a brief overview of the nature of patents and the beginnings of patent law in the United States.

The Power of the Patent

Abraham Lincoln once said, "The patent system added the fuel of interest to the fire of genius" (Dobyns 1994: back cover). On May 22, 1849, Lincoln received Patent No. 6469 for a device to lift boats over shoals, an invention which was never manufactured. However, it did make him the only U. S. president to be issued a patent. (A scale model of this invention is on display at the Smithsonian Institute in Washington, D. C.). Since patents played such a central role in the way the recording industry developed, before we move on I wish to address the concept in further detail. According to the description on the United States Patent and Trademark Office:

> A patent for an invention is the grant of a property right to the inventor, issued by the Patent and Trademark Office. The term of a new patent is 20 years from the date on which the application for the patent was filed in the United States or, in special cases, from the date an earlier related application was filed, subject to the payment of maintenance fees. US patent grants are effective only within the US, US territories, and US possessions. (USPTO 2004)

The development of patents in the United States "originates in the same constitutional source as the Copyright Act – the clause in the U. S. Constitution empowering Congress to promote invention and authorship by granting inventors and authors 'exclusive' rights in the 'discoveries' and 'writings'" (Goldstein 1994: 10). The domain of copyright law was more that of written works, loosely defined, while patent law reigned over inventions and technology, "the work that goes into creating new products, whether tractor, pharmaceuticals, or electric can openers" (Goldstein 1994: 9). The Copyright/Patent Act gave the inventor (or the company that owned the patent) the legal means to prevent the manufacture of the invention without the patent holder's permission. In the early days of recording technology controlling patents gave the patent holder monopoly control over the use of the invention in society, and subsequently the market, for a term of fourteen years without the option of an extension term. Patents provided the power upon which monopolies were built. The competitive atmosphere of invention that marked the latter half of the nineteenth century often inspired the inventors to file caveats at the Patent office, prior to the patent application. Caveats according to law were "a description of an invention, intended to be patented, lodged in the patent office before the patent was applied for, and operated as a bar to the issue of any patent to any other person regarding the same invention" (USPTO 2004). Caveats lasted one year and were renewable annually. When a caveat was filed, the Patent Office would make note of the subject matter and secure it in a confidential archive. If within the year someone filed a patent application for a similar invention, the Patent Office notified the holder of the caveat, who then had three months to submit a formal patent application. After this system fell into disuse in the latter years of the nineteenth century, Congress abolished the caveat process in 1910. In 1952 the United States Patent System underwent a general revision, resulting in what is essentially our present system, and in 1999, Congress enacted the American Inventor Protection Act (AIPA), which further revised the laws. The patent law is Title 35 of the United States Code, which governs all cases in the Patent and Trademark Office.

The point of this chapter is to briefly demonstrate the way in which inventions are built upon those before them and the transfer of ideas and discoveries is necessary for societies to insure future inventions. The inventions of Samuel Morse, Alexander Graham Bell, Thomas Edison, Elisa Gray, Berliner and others during the latter half of the nineteenth century were made possible by advances made in electrical knowledge during the century's earlier years, made mainly in Europe. The discoveries of Alessandro Volta (dry volt battery), Hans Christian Oersted (electromagnetism), William Sturgeon (electromagnets), Georg-Simon Ohm (law of resistance Ohm's Law), and Michael Faraday (electromagnetic induction) laid the important scientific foundations upon which the American inventors would build. The European scientists did not file for patents on their discoveries, believing rather that the information would better serve mankind if it were free to circulate. They were right. However, in the United States, inventors, aside from Joseph Henry, were not exactly men of science, and their survival depended on the ownership of patents for their inventions. Unlike copyrights, which were for the most part automatically granted upon application, patents had much stiffer requirements. The inventor had to demonstrate that his invention was new and useful, or made such significant improvements to existing inventions that the resulting invention was essentially new. Patent ownership was the foundation of the monopoly building that marked the earliest years of recording technology and served as the driving force behind the corporate struggles to control it. As recording technology made the transition from business use to home entertainment, patent control played a major role in the development of the recording industry, as we shall see in the next chapter.

1. Inventor **Ben Franklin's** (1706-1790) interest in electricity led him to his now famous stormy kite flight in June of **1752** from which he developed the lightning rod. Many of the terms that we use today when talking about electricity (battery, charge, condenser, conductor, discharge, uncharged, negative (-), positive (+), electric shock, and electrician) are attributed to Franklin's research; In **1764** French scientist and abbé **Jean-Antoine Nollet** (1700-1770) arranged 200 monks in a swaggering line a mile long. Each monk held onto the end of a 25-foot wire that connected him to the monks before and after in the chain. Once the monks were in place Nollet, without their knowledge, connected the wire to a primitive battery and sent a powerful static electrical charge through the wire shocking each the monks. His goal was to observe how rapidly and how far the charge traveled. His experiments were among the earliest to focus on the properties of electricity when conducted through wires; **Luigi Galvani** (1737-1798) is credited with inventing the first electric cell in **1780** in which he utilized bodily fluids of a frog to create a cell powered by "animal electricity." In his now infamous experiments he attached the wires to a frog's severed legs and made them jump; **Alessandro Volta** (1745-1827) a colleague of Galvani, rejected the animal electricity theory and in **1800** proved animal fluids were not necessary to create electrical current by inventing the first direct current battery, or "voltaic pile." Volta's battery produced a continuous stream of current called "galvanic electricity." It became the stalwart energy source for scientific experiments during the 19th century. The electrical terms volt and voltage are in homage to him; Danish physicist **Hans Christian Oersted** (1777-1851) discovered in **1820** that electricity flowing through a wire gave rise to a magnetic field that was detectable by its effect on other objects, a phenomenon known as electromagnetism. Prior to Oersted's discovery, the only magnetism known to exist was in natural iron rich ores; In **1825** British electrician **William Sturgeon** (1783-1850) invented the electromagnet. The first electromagnet was a horseshoe shaped piece of metal around which wire was loosely wound. The wire was connected to a battery and when charged would create a powerful magnetism in the piece of metal. Sturgeon could regulate the electromagnet demonstrating one of the earliest methods of controlling electricity; **Georg-Simon Ohm** (1789-1854) uncovered in **1827**, the relationship between voltage, current and resistance known as "Ohm's law." To this day Ohm's law is used to determine the resistance of any device through which electricity flows. The resistance of any body is given its value in Ohms. The speaker systems in today's stereos are commonly measured as either 4Ω or 8Ω (Ohms); **Michael Faraday** (1791-1867) discovered the law of magnetic induction in **1830** whereby he harnessed the energy of electromagnetism to create electric power. He found that by interrupting the magnetic field of a wire repeatedly and at very high speeds he could produce a reliable source of electricity (electro-magnetic self induction). He is credited with inventing the electric generator.

2. Prior to his fame with the telegraph, Samuel F. B. Morse earned a modest living as a portrait artist and teacher. He might have continued etching his way through life this way, until he was rejected for a commission to paint one of the panels in the new

Capitol building rotunda. Feeling as though the art community had abandoned him, he turned his attention to the telegraph. It was in his office at New York University that the electric telegraph was discovered. (Kloss, William. *Samuel F. B. Morse*. New York: Harry N. Abrams, 1988).

3. Joseph Henry (1797-1878), developed electromagnets and a version of the electric motor. He, more than any of his predecessors, defined the pertinent relationship between electricity, magnetism and mechanical energy as early as 1831. By using an electromagnet and a powerful battery he succeeded in sending an electrical current 1,060 feet. Later, he succeeded sending a charge several miles where it rang a bell on the other end. His work on effecting mechanical action at a distance using electricity was the foundation of the electric telegraph. In 1846, at the behest of English philanthropist James Smithson, Henry became the first director of the Smithsonian Institute and served in that capacity from 1846 to 1878. (Janus, Patricia. *Joseph Henry: Father of American Electronics*. Englewood Cliffs New Jersey: Rutledge Books, 1970).

4. Edison's Menlo Park facility was a large fenced-off compound on which stood a large barn-like structure housing a well-equipped laboratory. Behind the main structure was a fully functional machine shop where ideas could be turned into prototypes. At the front of the property stood a two-story house in which Edison located his library and offices. In this "invention factory" environment, Edison and his assistants worked on many ideas simultaneously. Menlo Park is the birthplace of recording technology and the incandescent light bulb. (Israel, Paul. *Edison a Life of Invention*. New York: John Wiley and Sons, 1998, 193-194).

5. As a teacher, Bell's main interest initially was in visible sound waves. He had seen the phonautograph and reasoned that if he could invent something similar that allowed his deaf pupils to see the sound waves, they might be better able to produce them. He procured a human ear from a cadaver, and used it to build a sound wave recorder, a rather macabre version of the phonautograph. As Bell continued to experiment, his main interest gradually shifted from visible to audible sound waves. (Grosvenor and Wesson, *Alexander Graham Bell: The Life and Times of the Man Who Invented the Telephone*. New York: Harry N. Abrams, 1997, p. 46).

6. When patent number 174,465 was issued to Bell for "Improvements in Telegraphy" on March 7, 1876, Elisha Gray immediately challenged it on several levels. Although his attorneys advised him to let Bell have the telephone, he was obsessed with claiming credit for the apparatus. Despite his efforts, Gray died a broken man in 1901. (Evenson, Edward A. *The Telephone Patent Conspiracy of 1876: The Elisha Gray-Alexander Bell Controversy and Its Many Players.* Jefferson, N.C.: McFarland & Company, 2000).

The International Centennial Exhibition, the largest fair in American history, opened on May 10, 1876, with President Ulysses S. Grant's opening remarks, at Philadelphia's Fairmont Park. The exhibition encompassed 250 buildings and a main building over a third of a mile long. In many state halls and buildings were exhibited the works of thirty-seven foreign countries: "scandalous art and sculpture from Europe, fishnets from Norway, guns from Germany, Venezuela sent a picture of George Washington woven out of Simon Bolivar's hair [and] France's contribution was the actual arm and torch from Bartholdi's still-incomplete Statue of Liberty" (Grosvenor and Wesson, *Alexander Graham Bell: The Life and Times of the Man Who Invented the Telephone*. New York: Harry N. Abrams, 1997, p. 69).