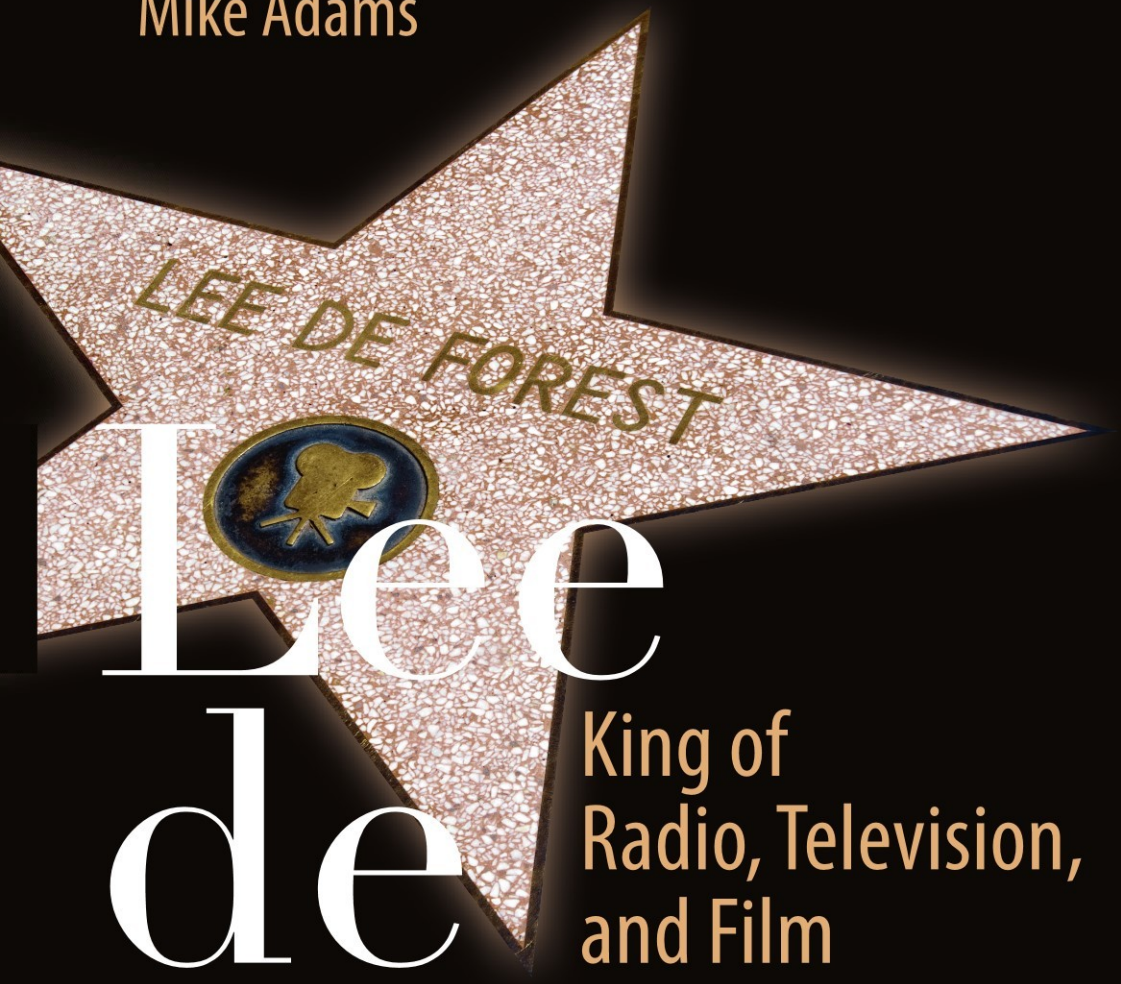
Mike Adams



Lee de Forest

King of Radio, Television, and Film

Springer

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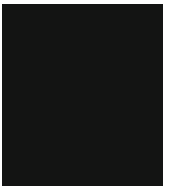
For Barbara Adams, who always encourages me to be better

Foreword



Lee de Forest could hold in one hand one of the most important devices of the twentieth century, the triode vacuum tube that he had invented in 1906, and in the other hand, a gold Oscar that the American Academy of Motion Pictures awarded him mid-twentieth century for his pioneering work in bringing sound, voices, and music to movies. De Forest's driving fascination with the power of sounds to carry intelligence, and hearing those sounds, links the two. Mike Adams tells Lee de Forest's story in a new and compelling way. De Forest's story ranges from an early technical mastery of flame, to the final mastery of sound. It is a splendid tale of a definitive twentieth century life. De Forest is the paradigm inventor, perhaps all-too-human. Mike Adams' story is well told. De Forest went through fortunes and he went through wives. But in the end, his technical legacy astonishes, and his last marriage to young movie star, Marie Mosquini, sustained them both into his ripe old age.

Lee de Forest discovered "an Invisible Empire of the Air" just as he claimed. It is now the Empire of Electronic Media in which we live. But radio provided the foundation for it all. De Forest, more than anyone else, deserves the title "Father of Radio" just as he also claimed. For de Forest *heard* the world as much if not more than he saw it. His was the Aural World, not the Visual World. He knew great music and wrote good poetry. He heard and wanted to help others, millions of others, also to hear.

The wireless telegraphy born around him printed its messages. But de Forest conquered that technology by hearing the signals sent out by the early spark transmitters. He improved that art by making its signals tones of higher frequency, more easily heard in poor conditions (and in retrospect on primitive equipment). We think of the twentieth century radioman wearing earphones. For that we can thank de Forest. He moved on, a restless man and a restless inventor. He invented one of the most important devices of the twentieth century, the three-element vacuum tube (the "radio tube") working first with flame. He did so in order to *hear* signals. He leapt at the suggestion of the name "Audion" for his device. To him, there was the near

magic in "audible ions." He put those audible ions to work so we could hear the wireless telegraphy, otherwise so hobbled by slow unreliable printing devices. For success, de Forest turned to skilled telegraphers who had long worked by ear. Vast networks of such audible signals soon evolved.

But restless he was, so he turned to another device (the continuous wave "arc"). His goal was sending out music in the ether, to be heard by all. In 1908 that was a revolutionary act, with few antecedents but world-historical consequences. Those consequences flowed from the use of de Forest's own Audions to provide the continuous waves to carry radio, that is, voices and music, around the city, around the region, around the nations, and around the world. De Forest first perfected his device to provide these powers in 1913: amplification and oscillation. In less than a decade, radio, heard by millions every day nearly everywhere, changed the world.

Yet, one twentieth century medium of entertainment and information, the "movies" was silent. Actors could speak with their facial expressions but not their voices. Lee de Forest created the "soundtrack" giving voice (and music) to the movies. To be sure, others worked to the same effect, just as many others had perfected the radio arts. But once again, de Forest's focus on sound carried the day. In our day, it's all Internet and multimedia, but the roots of it all come from Lee de Forest's seedlings, the Audion, the radio transmitter and receiver, and the film soundtrack.

About the Audion, de Forest later said: "I held in my hand the long-sought Aladdin's Lamp of our new world, 'a lamp by which one might hear instead of read'… and all but remake our world." He had earlier written: "The Audion is … to the sense of sound, what the microscope is to the sense of sight." We can hear so much now because Lee de Forest dedicated his life to helping us do so. If the real "bottom line" is, as inventor Edwin Land suggested, in heaven, then Lee de Forest is a rich man indeed.

Thus, Lee de Forest invented the "radio tube" more than 100 years ago, making modern electronics possible and perhaps inevitable. Yet, he failed in "Radio" after striving mightily – nobly or ignobly, depending on one's point of view. He turned to Hollywood in the middle of his life, in about 1920. Lee de Forest then pioneered the "Talkies" by bringing sound to motion pictures and their industry. Having brought the sound of radio – voices of entertainment, news, and history, music good and bad, real and imaginary events conveyed by the nuance of audio – into millions of homes in America and in the world, he then brought sounds to the movies, in thousands of theaters, again for millions of Americans and the world. He called his first radio tube the "Audion" precisely because it enable us to hear what was otherwise undetectable and invisible – radio waves – and he

devoted his life to helping us hear music and people in what we now call "the media" – two of which, radio and movies with sound, he practically invented single-handedly. Mike Adams has a most interesting story to tell.

Bart Lee
San Francisco, CA, USA

Preface

The applause has died out. The audience has left the theater.

It is the year 1930 and inventor Lee de Forest is all washed up. The inventions that should have defined him do not add to his income, and they have not brought him fame. The man who invented the radio tube and radio itself, the scientist who developed the first successful talking picture technology has seemingly lost everything. He is now in court daily, and he is estranged from his third wife, his daughters, and the scientific community. He has spent the previous decade developing a theory for the technology of synchronized sound-on-film into patents, practice, and public notice, only to lose it all. He is alone. He is penniless. These are the worst of times for Lee de Forest.

Lee de Forest could "hear" but he could not "see." In the 1920s, he had found a way to add sound to the then silent motion picture. His technology was solid, the one that Hollywood would eventually adopt, but he made a big mistake. He made films and invited audiences to see them. These films clearly demonstrated that while the cinema could be made to speak, the "talkies" as created by de Forest showed that he had no understanding of the visual content, or the art that had already defined the successful cinema. Nevertheless, he made hundreds of films and created an unsuccessful business based on his flawed vision of filmmaking. The audience reaction was unenthusiastic, a collective, "so what."

If the life of Lee de Forest can be compared to a three-act screenplay, the sound film may have been his final act. First he tried, succeeded and then failed to make a go at a wireless telegraph business. In the second act, he invented the three-element vacuum tube, and applied it to the development of radio broadcasting and sound amplification. In the final act he tried the film business. The Yale Ph.D., who invented some of the most important technologies of the twentieth century, now believes that he has just wasted an entire decade on a system to bring sound to the movies, only to have it virtually disappear into a haze of legal briefs and betrayal.

Lee de Forest was prominent in those important years when the mass media was actively being imagined by him and others. It was a time when the cinema evolved from recording simple outdoor scenes and stage performances into a mature media, and radio developed from the experimental to the popular. It was during de Forest's time, the first three decades of the twentieth century, when the silent film and radio found their technology, their language, and their audiences. The de Forest influence on radio was significant: as early as 1907 he told of his plan for sending music into homes using a wireless telephone he had invented. After he created the "voice" for the wireless, he turned to the movies, believing they also needed a voice. What followed was a period in which he both created and learned about the evolving relationship between science, art, business, and audience.

More than just the story of how sound came to the movies, Lee de Forest: King of Radio, Television, and Film is a broad and sweeping perspective on the inventing process and the life of inventor-scientist Lee de Forest. Beginning with his fascination as a student with the "speaking flame" and its application in physics and electricity, de Forest not only invents technology for the entertainment media but he also creates its content and consumers. But this is not the story of how a lone inventor has an "aha" moment, creates a technology, and reaps both monetary reward and everlasting fame. What becomes evident in this story is how the invention process really happens, how each new device builds on those previous to it, and how patents are developed, granted, and then challenged in a number of increasingly higher courts, where they are upheld or overturned as invalid by judges who may or may not fully understand the technology upon which they are ruling.

Mostly you will know Lee de Forest as the tortured lone inventor. But in his quest for a sound-on-film system he actually made a friend for the first time in the person of fellow Yale alumni Theodore Case. They collaborated. They worked together. They invented. In the beginning there was mutual respect. Even though de Forest was the alpha, the senior scientist, he and Case had a unique relationship, much of it documented in hundreds of letters exchanged between the two leading to their final legal showdown. Previous de Forest biographical writings have missed the real story of de Forest and Case. Some have ignored it altogether, while other authors have lined up on one side or the other. Some believed that de Forest simply stole the inventions of Case and attempted to profit from them. Others have written that Case was merely a de Forest employee who took his boss's invention and sold it to Fox Pictures under the name of Movietone. The truth about the de Forest–Case relationship is a complex one. Neither inventor could have succeeded alone. De Forest had the original theory

and the early patents, but he needed Case's components to make his system, he called Phonofilm, work well enough to gain serious audience attention. The de Forest–Case relationship culminates at the end of the 1920s in a place familiar to all inventors – the courthouse. In the end, neither de Forest nor Case will be considered victorious, both having been swallowed up by the big business of the movies, both clearly overshadowed by the frenetic rush to the talkies.

There is no question that Lee de Forest was an important scientist. In his story you will meet inventors with whom he collaborated, learned from, took from, agreed and disagreed with, confided in and impressed with his technical tenacity, yet at the same time angered with his aggressive audacity. In his first three inventing decades, 1900–1930, he was actively melding and expanding electricity, physics, chemistry, optics, and basic mechanics. Working without computer and intricate fabrication machinery, the scientists and inventors of de Forest's time must have fascinated the public with their magical construction of inventions. For him these included wireless, the vacuum tube, the amplifier, broadcast radio, and a sound-on-film process. And significantly, all of the twentieth century inventions of de Forest and his contemporaries will be shown to have their scientific roots in the latter half of the nineteenth century.

Controversy surrounds Lee de Forest. Many called him dishonest and unethical, and tried to prove through the legal system and in the court of public opinion that he really didn't deserve credit for some of his inventions. It was claimed that he stole the ideas of others and exaggerated his inventing prowess. Like Richard Nixon in the 1970s, de Forest too had an "enemies list," those he believed had wronged him in some way. As an inventor some of his success derived from his manic habit of working hard and continuously on many projects at once, reaching emotional highs to achieve invention and falling into depression upon failure. Adding to the inventor's story is the fact that during his development of Phonofilm, from its concept on a scrap of paper in 1918, to its first public showing in 1923, to its demise in 1930, he began his second family. In this decade, he sired two daughters, yet lost a son and a wife only to marry again, all the while writing countless poems, corresponding with hundreds of people, seeking publicity for his films, starting and losing several companies, spending time in court depositions and hearings, and traveling internationally. This is a rich and interesting story, placing him within the larger history of science and invention.

He is a man whose life will seem a perpetual drama. Between 1900 and 1930 he both succeeded and failed, won and lost, yet was ever active in promoting his ideas about the new electronic mass media. But now in 1930 Lee de Forest at age 57 is pretty much finished with his contributions. He will spend the final decades of his life telling and retelling his story and defending his legacy.

He will not go quietly.

Contents

1 Born to Invent

In my isolation there in the Talladega parlor I felt in my heart that I was, not that I was to be, an inventor![1]

In this story of the three important decades of Lee de Forest, it is his inventions of the vacuum tube and the radio that will make the talking picture possible. But this is not just the story of one inventor or a single invention. It is about many interesting and influential people and how they transformed Nineteenth Century science into Twentieth Century art. In this story of invention the film is shown to evolve from a chemical process into entertainment, and wireless telegraphy into radio broadcasting. Lee de Forest puts it all together and creates the sound motion picture. While this story concentrates on the decade of the 1920s and talking pictures, it is also about the creation of the electronic entertainment media and its audiences.

The Century of the Inventor

The latter half of the Nineteenth Century is very important to the story of Lee de Forest and sound movies. While the sound-on-film system that technically supported Hollywood's greatness in the 1930s began in the early twentieth Century, its roots go back to a time before the electric light, the automobile and the telephone, and before film, radio and television. These three great entertainment media began as theories and evolved as crude devices based on incomplete and vague ideas developed in the years between 1875 and 1900. It is in this era that an Edison, a Hertz, a Marconi, and a de Forest were born into a time when they would begin to

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study the science of the past in order to create future inventions. The Morse telegraph of 1835 did not become a wireless telegraph until 1895, so it did take 60 years of wired communication before that first publicly reported breakthrough known as wireless. Faraday's 1831 discovery of electrical effects and Maxwell's theories of electromagnetism did not find a practical use until after Hertz's experiment of 1886, 55 years later. It seems that there is no moment when a useful device appears fully formed. Each important invention evolved very slowly, its success often postponed until another inventor discovered or improved a related needed piece.

Of course, important inventions have always displaced existing technologies and caused jobs and trades to disappear. As the electric light made the gas lamplighter unnecessary, sound films replaced the piano player and orchestra that accompanied silent films. The cinema threatened its progenitor, live theater, and the radio and record player had an effect on concert attendance and reduced the sale of sheet music and pianos. The entertainment technologies of de Forest's time were revolutionary, and are important enough that they remain viable today. The phonograph of Edison became the iPod of today, the radio continues and gained pictures for television, and the motion picture has been continuously improved.

The Significance of Edison

There are striking parallels between Thomas Alva Edison, 1847–1931, and Lee de Forest, 1873–1961. Both inventors were born in the Midwest into comfortable middle-class homes. Both of their families endured geographically challenging moves in their early years, the Edison's family from Ontario, Canada to Northern Ohio, and de Forest's from Iowa to the post-Reconstruction South. Both were attracted to science: As a boy Edison was interested in chemistry while de Forest began with mechanical devices. Both were fascinated by trains, with the teenaged Edison eventually working for the railroad, while the younger de Forest was creating a toy wooden model of a steam train in the family back yard. Because of the difference in their ages Edison worked with wired telegraphy in early adulthood, while de Forest reached a similar age in 1900 and moved directly into wireless telegraphy. Edison was not a good student and he dropped out of school at an early age. While never formally educated, he did read voraciously and independently of a school structure and was said to have been a self-taught, self-educated man. Conversely, de Forest earned a respected Yale Ph.D. in physics and electricity.[2]

Both Edison and de Forest used the written word to communicate to a larger audience. As a teenaged telegraph operator on the Grand Trunk Railway, Edison purchased a printing press and published a newspaper he sold to train passengers. "It contained gossip, news and advertisements of

people and businesses in the towns along the rail line, including such items as the price of agricultural products, mail express and stage service information, and notices of births and military recruitments."[3] De Forest wrote scientific articles for journals and his autobiography.[4] The evidence suggests that in the main Edison was respected by those who worked under him at his companies. But it was also reported that he could be impatient with his staff, that he pounded the table and shouted angrily, and that he often showed high spirits, later to be depressed. De Forest was said to be a loner, aloof, and difficult to please, and like Edison he too had bouts of depression. In later years former de Forest lab assistants spoke well of their experiences working with him. As inventors both men were driven, tenacious, hard working, and sober. De Forest excelled at mathematics and Edison did not, perhaps making de Forest better suited as a research scientist while Edison was decidedly an applied scientist. Edison was good at running a collaborative laboratory and business, de Forest was not.[5] Edison often said once he invented something truly spectacular: "it is so simple, why didn't someone think of it before?"[6] And both men endured the brunt of adult punishment in their youth for their exuberance in the service of inventing. Edison was expelled from a train for keeping dangerous chemicals in one of the cars, while de Forest nearly burned down the family home with his blast furnace experiments.[7] Genius is often not fully appreciated.

Edison found monetary success as an inventor early in his career, selling in 1870 a stock ticker to Western Union for the then giant sum of $40,000, an amount he invested into new companies for new inventions. Edison's influence was broad: while Alexander Graham Bell received the patent for the telephone in 1876, it was Edison's transmitter that both improved the telephone and introduced both men to a patent infringement lawsuit for the first time.[8] In the 1920s Bell graciously and finally admitted that Edison's improvement to the original Bell telephone device made a positive difference, and that it would not have been a success without it.[9] By 1880 Thomas Edison had begun to perfect the incandescent electric light, a technology that would replace the arc lights used for large buildings and street lights, and the natural gas lights used in homes. This invention took years and thousands of men working hundreds of thousands of person-hours. And this points to a major difference between Edison and de Forest: While de Forest was more of a lone, pondering, thinking inventor, Edison hired and surrounded himself with the best and brightest and made them work long hours toward an inventing goal.

More important, both inventors were attracted early to the possible uses of electricity in personal and business communications and entertainment media for an audience. In 1874 when de Forest was a 1-year-old baby, Edison was experimenting with a primitive wireless device, sending a tiny spark a

few feet to be "received," or detected visually using two closely spaced carbon rods. He called this phenomena "Etheric force," and it was a primitive precursor to wireless signaling.[10] Soon after that, Heinrich Hertz would build on the electromagnetic theories of James Clerk Maxwell and send a spark an even greater distance, thus beginning the very long progression of the development of the radio. By 1920 Radio would be seen as a line from Edison's curiosity to Maxwell's theory to Hertz's experiments to practical applications by Marconi, Fessenden, de Forest and Armstrong, with de Forest inventing one of the key components that made it possible for wireless communication to evolve into the entertainment media of broadcasting by radio. It would also directly influence the science of the sound film.

According to Edison's biographers, it may have been in the year of the birth of Lee de Forest, 1873, that Edison thought about the possibility of having moving pictures with sound. Even if this is true, such an invention was not possible at that time as there were no sound recording and reproducing devices, and the only images were chemically coated glass and metal plate photographs. Nevertheless, in the last decade of the Nineteenth Century Thomas Edison had become the first and most important inventor in the development of the motion picture, in both its silent and sound version.[11]

Edison's First "Baby"

In 1878 another device that Edison always considered his most important and favorite was patented, one that forever would remain an important support technology for radio broadcasting, home entertainment, and the early sound film experiments. It was a device that recorded, stored, and played back sound for the first time. He called it the phonograph. As a telegrapher Edison had developed a device that recorded and played the dots and dashes of telegraph messages, using a spinning disc onto which the code was embossed, later to be read, and resent or transcribed. It was on this device he based his phonograph. His early versions used a spinning wax-like cylinder on which grooves representing sound vibrations were made by a needle connected to a diaphragm coupled to a horn. The reverse was used for playback. Very simple. Oddly, Edison did not reap the benefits of the phonograph until many years later. It may have been because of the uses he saw for it: "Letter writing and other forms of dictation, records of books as read by elocutionists, educational purposes, music, family record, toys, musical boxes, annunciator attachments on clocks, advertising, preserving the voices as well as the words of our Washingtons, our Lincolns, our Gladstones."[12] Buried in that long list is the word "music," a use that years later would overtake all others in importance.

Figure 1.1 Closeup of early Edison cylinder phonograph showing diaphragm and needle, from Paul Bourbin collection.

His views about the phonograph reveal another important comparison that can be made between Edison and de Forest, and that is their differing concepts of how their inventions should be used and how they could be marketed to the public. De Forest sees entertainment using the new media in a public, consumer-driven way. He sees an audience and hears their applause. Above all he believes that the content of these media should be of "high brow" character, like opera, and that its main purpose should be to uplift the masses. The more practical Edison saw a commercial market for his devices rather than the entertainment uses for which they would mostly be known. As an example he "expected his phonograph to fit into an expanding market for business machines such as typewriters and telephones."[13] Edison would continue to assign the development of the consumer entertainment uses of the phonograph to his assistants (Fig. 1.1).

The phonograph is a very simple device based on sound vibrations. When you speak into the horn, the air currents caused by the voice vibrate the diaphragm and the needle, creating "grooves" in the wax that are a copy of the sound wave. To play it back you simply reverse the process and the squiggles embedded in the wax vibrate the needle, in turn vibrating the diaphragm which is often connected to a horn for louder sound. Prior to this breakthrough, there were scientists who had discovered that sound waves could be recorded and viewed visually as squiggles exposed on film or scratched into lampblack, but none could play this visual information

back as an audio replication of a sound wave. You could see it but you could not hear it. One such device was the 1857 Phonautograph of Leon Scott which was invented 20 years before the Edison phonograph.[14] So even though Edison did receive plenty of public and press acclaim as a result of the first phonograph demonstration, it remained on the laboratory shelf for 10 years. In 1887 he began to work on it again and by 1910 he had received 100 patents for phonograph improvements.

Try this at home: Pick up a piece of tissue paper and hold it a few inches in front of your mouth. Talk in a normal voice and observe what happens to the paper. What you are "seeing" is the result of your vocal chords moving the air which in turn moves the paper as a reaction to the sound waves. Here is another experiment to try the next time you are near a record player: Put a record, preferably an old one you do not care that much about, onto your spinning turntable. Take a piece of 8.5 × 11 printer paper and roll it into a funnel shape, and secure the small end by sticking a large hat pin through it. If you carefully and lightly place this needle at a slight angle on the spinning record, you will hear the music. It will sound similar to the way your great-great-grandparents would have heard it, and you will have replicated the 1880s music listening experience. The act of writing with sound on a phonograph record by creating a physical analogue of the sound as grooves, as opposed to sampling and converting to digital bits, 1 and 0 s, is a very old acoustic recording process. It is the first and original way to record and reproduce sound.

There were improvements made to the phonograph between the first Edison cylinder in 1878 and the later versions, but until electrical recording and amplification in the middle 1920s, the basic process of the record player in all its iterations was not that different from the first time Edison sang, "Mary had a little Lamb." Emil Berliner improved the Edison phonograph in the early 1900s by introducing a flat disc to replace the cylinder, and that format prevails to this day. But it would take Edison almost 25 years from the time it was invented and patented before he could claim that his phonograph was a useful invention. It is like all new entertainment media: it has to be a simple and quality technology that a person would use in the home. There has to be a reason to buy a phonograph. By 1900 recorded music became the content and a system for duplicating cylinders was in place, and the sales of the phonograph topped over 100,000. "The growth of the phonograph business had been the result of a long period of innovation in the development of both a market and a technology suited for it."[15]

The significance of the recording and storing of sound using the phonograph is that it is an early first step toward the sound film, but it will be

decades more before the related pieces would all be in place and work in a practical way that would allow the full commercialization of the talkies. The phonograph is just one piece of the many needed, but the realization that it is now possible to transform sound into a stored entity to be played back and listened to on demand, is how the sound motion picture will begin.

Toward Communication Without Wires

Before the publicly acclaimed 1900 world premiere of practical two-way communication without wires, there was desire. There was a perceived need to get beyond the limitations of the wired telegraph and telephone. Before these relatively recent technologies, two-way communication was accomplished by archaic methods such as smoke signals and semaphore flags, systems that were limited to a mile or two, so-called line of sight. After the wired telegraph was introduced, the "wireless" signaling technology remained visual for a long time, like a device that employed arc lights with shutters that could be opened and closed to send Morse Code from ship to ship or to shore. As with similar devices it was always weather-dependant. If the skies were clear you might actually signal for several miles, but only if the person on the receiving end had his binoculars aimed in the right direction, and if he had 20–20 vision. This was communication by light waves. If it was a foggy day your "wireless" signal might only be able to be seen for a few 100 yards. These are the communications technologies of the Nineteenth Century, imperfect, limited, and frustrating to be sure. Merchants, yachtsmen, shipping companies, and the navies of the world long clamored for a system that was useful over longer distances as well as consistent and dependable.

Wired communication technology was also limited but less so. The telegraph, invented and introduced in America in 1837 by Samuel F. B. Morse and improved upon by Edison, was a system of wires, poles, batteries, keys, and a receiver called a sounder that used an electromagnet to reproduce dots and dashes (Figs. 1.2 and 1.3). A switch called a key would open and close to represent the dots and dashes of the Morse code and this would pass battery voltage that would cause a device at the receiving end to "click" and be translated into a message, one letter at a time. It was only practical if the operators along the telegraph lines were awake and if the wires did not blow down in a storm, or cut by a nefarious criminal, or chewed by the random animal. But it was a system that lasted for nearly a century. Telegraph signals could be relayed from station to station, and getting a message across several

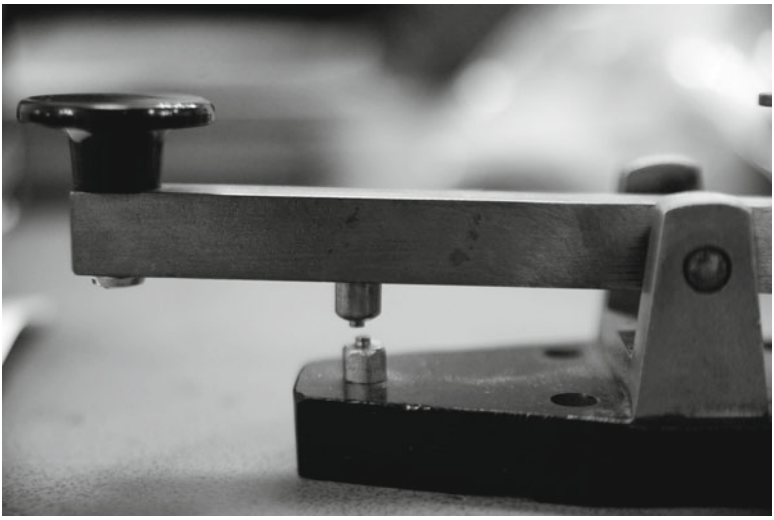

Figure 1.2 A telegraph key. The key is just an on-off switch that is operated by hand. When the key is closed or pushed down, the circuit closes and the battery current flows to the receiver. Author photograph from the Antique Wireless Association.

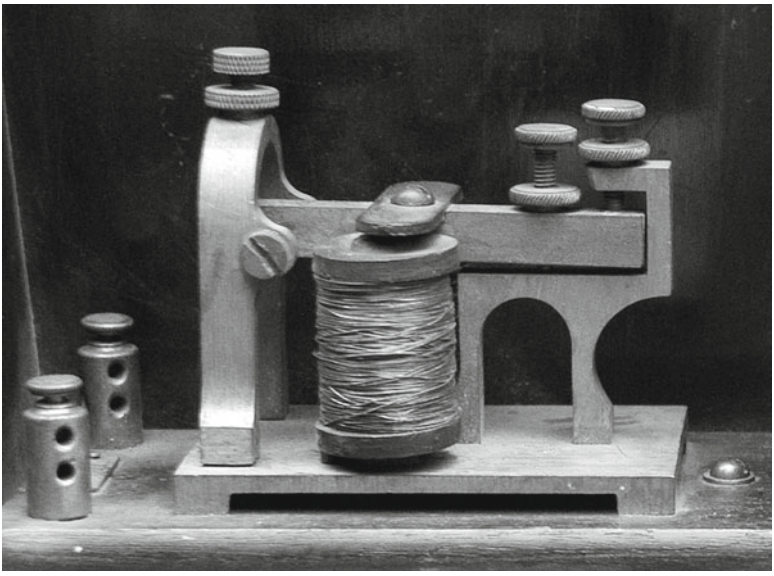

Figure 1.3 A sounder, a device that acts as the receiver of the dots and dashes of the telegraph. The sounder is an electromagnet that receives current from the battery when the key is closed, and makes a mechanical clicking sound which the operator reads as code. Author photograph from the Stewart Oliver Collection.

states and even across the country became routine. The various undersea transatlantic cables were an early form of the wired telegraph.

And while actual wireless communication by radio was yet to be realized, there were a number of experiments that demonstrated the usefulness of two-way electrical transmission and reception of voice messages without wires. One of the earliest and best known technologies was the 1878 Photophone of Alexander Graham Bell. This early version of wireless telephony used a carbon telephone microphone and a battery to modulate or cause to flicker a beam of light, which was received using a selenium-like cell, and a battery, and earphone.[16] This technology was never practical because its range was limited to line-of-sight, and though electrical in nature it still relied on the visible spectrum of light waves. In this technology the audio is converted to fluctuating light which is picked up by a sensitive cell and converted back into sound. The significance of Bell's experiment is that it provides a prelude to the sound-on-film inventions of the twentieth Century, all of which initially used some form of selenium cell to read the light images recorded on the film's sound track. Bell's less-than-practical device is another piece of the many that will be needed for films with sound, movies good enough to satisfy a yet-to-be created audience.

Another failed communications technology relied on the properties of the earth which can act as a carrier of electrical current. Called ground conductivity, it was used for both voice and code. It was described in 1909 as having been discovered by a Steinhill of Bavaria and later on experimented by Preece who was able to communicate over a distance of five miles: "In the conductivity method the terminals of a strong battery in series with the key are grounded with the two legs a distance of 50 ft apart. Directly opposite at a distance of 50 ft the receiving end is placed, the grounds being the same and the receiving end device is a telephone receiver or galvanometer. On pressing the key the current is sent out in the ground and will cause indication at the receptive end."[17] This was basically a short-range telegraph using the wetness of the earth in place of the wires, and based on the theory that the current of the battery will travel through the ground to seek the shortest path to the receiving end. It was never practical, but it did lead to claims of "first broadcaster" by Nathan Stubblefield of Murray, Kentucky, who used a similar system for voice, using telephone equipment and the earth acting as the "wires." There were similar systems using above ground air conductivity, with large inductors (transformers) placed a few feet apart, and while wireless they were never practical.[18]

The various experiments using modulated light or ground conductivity or inductance in open air were interesting but of no practical value.

And while they were wireless they would never be good enough to replace the existing and mature technologies of the telegraph and telephone for long distance communication. What was needed was a system that did not depend upon wires, or clear skies or the earth after a heavy rain. Needed was a true wireless signaling system that would allow dependable communication over long distances on both land and sea. Early nonwired systems depended upon "seeing." You can see light waves, and you can hear sound waves, and this is known as the visible or audible spectrum, or what a human can perceive with his or her eyes and ears. It is what you cannot see or hear, an unknown and unseen force called radio waves that will be discovered to be useful in two-way communication over long distances. Radio waves were first believed to be some sort of electrical disturbance in what was called the "aether" or "ether." A major thinker in this area was James Clerk Maxwell whose theory "implied that all forms of electromagnetic radiation, including light, traveled through space in the form of transverse waves, and that the wavefront moved with a finite velocity."[19]

This was first demonstrated by the German physicist Heinrich Hertz, Ph.D. (1857–1894). Hertz in 1887 created an early practical wireless application in the form of a verifiable experiment based on the combined theories of the scientists Maxwell, Faraday, Henry, and Lodge. What Hertz did was very simple: he charged with electricity a "Leyden Jar," which was a glass vessel with two plates of metal foil separated by air, an early version of the condenser or capacitor found in all electronic devices. This jar stored the electrical charge for a short time. Wires connected to the two metal plates were connected through a telegraph key to closely spaced electrodes so when the key was closed a spark appeared between the electrodes. On the other side of the room a metal circle with both ends just about touching would "receive" or indicate a spark visually when one was "sent" from the Leyden jar, key, and spark gap. This needed to be improved upon but it did confirm that Maxwell's theory had validity. Hertz proved that this unseen electrical force is transmitted through space and received without connecting wires, and that it had a wave-like nature that could be measured.

Historian Hugh Aitken says this about the Hertz experiment, "Three related Hypotheses were involved: that electromagnetic fields could be generated by the acceleration of electrical currents, as for instance when a spark jumped across a gap; that these fields could be propagated through space; and that their velocity of propagation was finite-specifically, that it was identical to the speed of light."[20] This describes radio communications, the sending of a message using interruptions in the electromagnetic spectrum, and over distances never before realized using previous technologies. Hertz's experiments proved Maxwell's theories of the presence of an

electromagnetic field and demonstrated the very beginnings of what we now call radio. Sadly Hertz lived a short life, a mere 36 years, and so he never saw how his imaginative experiments were improved upon, organized, realized, and commercialized for communications in the future work of Marconi, de Forest, and others. These small pieces will play their parts in the future of film, radio, and television.

The works of the theorists and practitioners were not inventions as much as they were discoveries of elements already existing but not fully understood: "Such waves as proven by Hertz are always present on a sudden electric discharge as from the Leyden jar, a flash of lightening, induction coil or other high tension discharge. It was further proven that these waves had all the properties of those of light and heat and were capable of reflection, refraction and diffraction."[21] Many of these elements were waiting for the great minds in their laboratories to put the pieces in the correct order for a usable result. And it would happen quickly between 1887 and 1900, as Nicola Tesla, Alexander Popov, Guglielmo Marconi, and thousands of lesser-known experimenters in schools and universities and laboratories would all attempt the sending and receiving of wireless signals from a few feet to a few miles. But Hertz did start something – his simple work attracted the interest of a cadre of Nineteenth Century scientists who would be responsible for the communications revolution. Its importance was summed up by another inventor important to this story, Reginald Fessenden: "Great interest was excited by the experiments of Hertz, primarily on account of their immense scientific importance. It was not long, however, before several eminent scientists perceived that the property possessed by the Hertz waves of passing through fog and material obstacles made them particularly suitable for use in electric signaling."[22] The significance of Hertz is that he inspired others to move into the inventions that made communication without wires possible. These individuals discovered better transmitters, receivers, and antennas, all of it leading to more reliable communication without wires.

The inventors of the next century will turn these embryonic experiments into commercially viable communication businesses. The Nineteenth Century scientists created the basis for voice communication by radio which will evolve out of wireless telegraphy, and in turn make possible a starting point for a companion technology, sound for motion pictures. While the invention of the phonograph demonstrated that sound could be recorded, stored, and played back, the technology of wireless will lead to the development and understanding of modern electronics, including devices such as amplifiers and improved microphones, and loud speakers. The silent motion picture, which will evolve out of the technology of still photography, will be