"Let Her Have Brains Too": Commercial Networks, Public Relations, and the Business of Invention

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> A great inventor must also be a great salesman, if he wants his discovery to be understood and welcomed in his own time.
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> *Popular Mechanics Monthly*, 1931

In a 1931 article entitled "How to Sell an Invention," a *Popular Mechanics* writer argued that all successful inventors and patent commercializers shared one important trait: business sense. From the Civil War era through World War II, both journalists and technical experts advised patentees on the "business of invention," or the process of developing new inventions and finding the means to market them. Inventors with business sense used their intuition, knowledge, and personal contacts in order to diffuse and commercialize their inventions. Since patenting represented only one logical step in the profit-seeking process, most market-oriented inventors had to anticipate practical uses for their inventions well before they were perfected or even patented. These aspiring business people attempted to sell their new ideas to friends or strangers, and often secured financial support from outside sources as a means to ensure continued commercial interest in their inventive pursuits ["How to Sell an Invention," 1931].

For most inventors, business sense also included the ability to delegate specific tasks to patent attorneys, manufacturers, and other professionals who were better qualified to handle some well-defined inventive problem or commercial hurdle. Many "advanced" or well-known inventors, such as Thomas Edison (1847-1931) and Henry Ford (1863-1947), hired experienced individuals to tend to the business of invention while they focused on the process of developing their inventions. Those patentees who entered the technological market for the first time faced the formidable challenges of establishing good

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business relationships and raising the funds to retain patent attorneys and other relevant professionals. Some inventors started their careers by "inventing to order" for other people, and only began to direct their own inventive activities once they achieved commercial success through the financial support of their patrons ["How to Sell an Invention," 1931]. If an inventor patented his or her invention and sought to market it, there were many business junctions that could break down and thus hinder the already complicated processes of technological diffusion. Inventors frequently failed to sell their patents because they placed inordinate price tags on their inventions. A few inventors made sizable fortunes from their patents, but those who refused decent offers in the hopes of gaining exceptional wealth often made financially fatal mistakes ["Selling Patents," 1901].

Between the Civil War and World War II, a second group of scholars and popular writers examined the psychology of inventors in order to identify the personality traits of those patentees who commercialized their inventions. In the same year that *Popular Mechanics* analyzed business sense, assistant patent examiner Joseph Rossman published a pioneering study entitled *The Psychology of the Inventor.* Rossman surveyed 176 patent attorneys who described the most pervasive mental characteristics of their inventor-clients. Their responses, in rank order, included originality (64), analytic ability (44), imagination (34), lack of business ability (26), perseverance (20), observation (18), suspicion (12), optimism (12), and mechanical ability (6). Rossman then proceeded to question some 710 inventors to determine the most common pitfalls that they encountered on the road to patent commercialization. Their responses included impracticability (166), overconfidence (120), lack of knowledge (112), (expensive) patent attorneys (72), lack of thoroughness (46), dishonest promoters (43), discouragement (30), hope of riches (28), and disclosure to others (23) [Rossman, 1964]. Women inventors faced many of these same challenges in the commercial world, but my analyses suggest that overconfidence and hope of riches were two rather notable exceptions. For women inventors, lack of knowledge, limited access to capital, and restricted involvement in established commercial networks proved to be three of the most frequently reoccurring inventive problems [Marovich, 1998].[2]

The two groups of writers who explored business sense and the psychological characteristics of patentees made no systematic attempts to differentiate women from men inventors. This paper analyzes the business of invention by tracing the commercial experiences of three female patentees who attempted to market and diffuse their inventions during the Civil War, World War I, and World War II.[3] I target wars because historians of technology –

[2] I base this observation on my own analysis of the relevant literature, which includes autobiographies written by women inventors, biographies of women inventors, and the popular writings on women inventors from each respective war era.

[3] Both Smith [1977] and Hounshell [1984] traced the roots of the American System of Manufactures to the federal armories and public funds allocated to these institutions to promote a military bureaucracy [Hoke, 1990, p. 4]. Other pioneering studies that explore the relationships among war, economic development, and technological progress include Beard

including Turner Prize winner Merritt Roe Smith [1977] and David Hounshell [1984] – associate wars with significant bursts of invention and technological change, particularly in the fields of industrial development and military enterprise. Many social and women's historians – including Karen Anderson [1981] and Susan Hartmann [1982] – have also argued that modern wars stimulated women's market activities. Since women's labor force participation rates typically increased during American war eras, I hypothesized that other market-oriented activities such as invention, innovation, and entrepreneurship, followed similar patterns as women were exposed to new industrial materials and work environments [Marovich, 1998].

The case histories reveal that neither business sense nor specific psychological factors alone adequately explain why some female patentees were more effective in their efforts to market, commercialize, and diffuse their inventions than other women inventors. I argue that who they were, who they knew, and how they networked in social and political circles (or related to the general public) often determined why some female patentees commercialized or marketed their inventions while other women did not. The primary relationships that women inventors developed with individuals in the market for new technologies were not necessarily based on business first. Women's commercial relationships typically stemmed from their complex social lives and various personal contacts. Women inventors used their relationships and reputations as respected members of the community to bolster support for their economic activities and business pursuits. The fact that such personal relationships often assumed commercial significance suggests that the firm is not necessarily the best unit of analysis for tracking the history of women inventors in specific sectors of business and industry.

The women who commercialized their inventions represented a relatively small proportion of total female patentees.[4] Patent assignment rates

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and Beard [1930], Beard [1933], Ropp [1962], van Door [1975], Brenner [1985], Hacker [1994], Hacker and Hacker [1987], Mendelshon et al. [1988], Kaempffert [1924, 1941], Condliffe [1943], Mumford [1967, 1970], Nef [1950], McNeill [1982], Sokoloff [1988], Romer [1989], Higgs [1992], Nelson and Wright [1992], Roland [1993, 1995], Smith [1985]. The U.S. Patent Examiner and engineer Joseph Rossman [1936], however, maintained that a military environment was conducive to war inventions, but detrimental to other types of inventions.

[4] For a useful review of the most recent books on women inventors, see McGaw [1997]. The most notable studies on women inventors in America include Merritt [1991], Macdonald (who holds U.S. patent #4,548,055 for a knitting device) [1992], Stanley [1995], and Khan [1996]. Khan provides the most systematic and scholarly treatment of women inventors based on an analysis of the patent data and qualitative sources. Stanley's "Once and Future Power: Women as Inventors" [1992] provides an overview of her book. Macdonald's *Feminine Ingenuity* is the best social history of women inventors, but it does not provide quantitative data or a systematic analysis of the patent records. *Notable American Women* contains the names and biographies of only three women who were inventors. Ethlie Ann Vare and Greg Ptacek's *Mothers of Invention* [1988] claims to be the first book on women inventors. Though not a scholarly or referenced work, it offers brief sketches of popular female inventors. I have found that not all of the women included, however, actually received patents. Vare and Ptacek used this same approach in their second book, *Women*

allow us to estimate (albeit underestimate) how many women marketed or sold their inventions over time. During the Civil War era, 6.6% of all female patentees assigned their patents at the time that their patents were issued. This figure climbed to 9.9% during World War I, and more than doubled to reach 25.6% during World War II [Marovich, 1998]. For the purposes of this paper, I selected three patentees from a larger group of women inventors who left autobiographies, personal letters, and/or popular accounts that chronicle their inventive activities. Autobiographies and personal letters illuminate the internal characteristics of women inventors, including their thought processes, personal traits, and business frustrations. Popular accounts, on the other hand, allow us to analyze society's cultural perceptions of those women who ventured into the technological territory of the commercial world. While the "paper trail" makes these three women a rather atypical representation of female patentees, important features of their inventive activities reflect the larger trends detailed in the patent data (which I compiled and analyzed in my dissertation) and contemporary literature [Marovich, 1998].

Most women patentees are preserved in this historical literature because some unrelated event or personal experience made their lives particularly notable. Women inventors functioned as suffragettes, social reformers, psychics, political activists, artists, educators, and wives or relatives of prominent male figures [Macdonald, 1992; Khan, 1996]. Since female patentees performed multiple roles at various points in their life cycles, their social and cultural experiences typically supplanted their inventive activities and technological significance in the larger scheme of American history. Retracing women's commercial experiences reveals the extent to which their inventive activities intersected with their responsibilities as wives, mothers, and widows. Moreover, the tone of each woman's writings typically reflected the state of her personal life and her relative level of commercial success. Those women who encountered substantial opposition, resistance, or obstacles in their social circles and business environments typically grew increasingly bitter and disillusioned over time. Other more successful patent commercializers developed innovative methods that used their feminine identity as an asset that served their greater economic ambitions.

Most of the patentees that I tracked in the historical literature and popular writings shared several striking characteristics. Many inventors came

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Inventors & Their Discoveries [1993], which offers biographies of prominent businesswomen-innovators such as Madam C.J. Walker and Ruth Handler. The earliest scholarly essay dealing specifically with women patentees is Pursell [1981]. For a specific though preliminary study of women inventors in one geographical area, see Lachman [1992]. For a study of international women inventors, see Moussa [1991]. For work on African-American inventors, see Ives [1980, 1987], Piper [1989], Hambrick [1993], and Jenkins [1991].

Recent government publications on women patentees include Mossinghof and Luxembourg [1984], and U.S. Department of Commerce, "Buttons to Biotech," [1990, 1994]. For an early anthropological-oriented study of women's roles in social and technological development, see Mason [1911] and a review of the original edition of this book entitled "Woman as an Inventor and Manufacturer" [1895]. Also see Mozans [1913].

from white middle- to upper-middle class backgrounds, and had at least some form of education or technical training needed to convert their ideas into inventions. Women inventors often received encouragement from male family members (such as fathers, brothers, and cousins) in their educational development and business ventures. Yet many female patentees were not married at the time that they patented (single, married, or divorced) [Macdonald, 1992, *passim*; Khan, 1996, p. 374]. They often turned to their inventive pursuits in the wake of great tragedy, such as the death of a husband or child, or when they faced some stressful life situation or identity crisis. Women patentees also typically resided in geographical areas, such as western urban centers and eastern port cities, that had laws, political policies, and cultural attitudes that were conducive to women's market activities in general.

As a distinctive group, women inventors were more shrewd and strategic than the popular writings of the war eras suggested. A 1906 article in *Inventive Age* argued that by definition, all inventors "...are suspicious and entertain a lively distrust for everyone" ["Too Much Secrecy," 1906]. Patentees had good reasons to be paranoid because the patenting process trapped them in a psychological bind. If inventors wanted to protect their ingenious ideas, they had to disclose their secrets to a potentially-infringing public in exchange for adequate legal protection. For women inventors, however, there were additional factors that fueled paranoid or strange behaviors. Many of the most notable women inventors were flamboyant, socially deviant, idiosyncratic, or just plain "crazy" by contemporary standards. They typically masked their economic ambitions and profit motives by claiming that their inventive activities were the products of good will, divine intervention, or fervent patriotism. Since women inventors were less likely to realize substantial returns on their inventive activities as compared to their male counterparts, they had to be exceptionally protective of their ideas and even more strategic in their plans for patent commercialization. Moreover, those women inventors who crossed traditional gender boundaries or defied pervasive cultural expectations were easier to label as social deviants.

Some famous male inventors of the nineteenth and twentieth centuries also shared significant personality quirks or suffered from occasional (though rarely publicized) emotional problems. Abraham Lincoln, America's only "inventor-president," fought repeated bouts of melancholy and depression. In 1920, Edison explored the possibility of building a new technology that facilitated communication between the living and the dead [Livesay, 1979]. Other prominent businessmen concerned themselves with the bacteriological world, and actively played "hide-and-seek" from dirt. Howard Hughes (1905-1976), the famous oil-well and aerospace manufacturer, filmmaker, and financier, once dubbed by *Fortune* as "the Spook of American capitalism," was a germ-paranoid recluse during his golden years. In a 1997 television interview with Stone Phillips, the hotel tycoon Donald Trump joined the antiseptic ranks when he admitted that he avoids hand-shaking for fear of some unknown but dreadful contagion. It is difficult to dismiss men such as Edison or Ford as crazed characters because they entertained wild theories and displayed various forms

of bizarre behavior. The historical record clearly reveals that their accomplishments outweighed their shortcomings, and that their personality "quirks" triggered the bursts of invention and ingenuity that made them celebrated technological icons [Sifakis, 1984].

Though lesser-known, women inventors developed their own distinctive culture and commercial patterns as they attempted to invent, patent, and market their new technologies in a constraining environment. Their writings articulate a tension between the individual inventor and the large corporation; between divulging inventive secrets and protecting intellectual property rights; and between being a woman and acting as a strategic profit-seeker. In response to these pervasive pressures, women patentees forged their own support networks that included "women-only" inventors clubs and business meetings. They solicited patent agents and attorneys who specialized in practical inventions and women's inventive activities. They also circulated publications that were designed to inform and encourage aspiring female inventors and businesswomen. Women inventors used the World's Fairs, technological exhibitions, and social gatherings as forums to advertise and sell their inventions. Some patent-watchers even argued that political events ranging from presidential elections to immigration restrictions fueled patenting rates among all inventors – male and female ["World's Fair," 1892; "Presidential Election," 1892; and "Immigration and Invention," 1927]. A few "patentees-turned-entrepreneurs" formed small businesses or companies that issued corporate stock to women only. Still others turned to the modern corporation, the research laboratory, or the federal government as rapidly expanding markets for their patented inventions. Yet despite these noteworthy developments, men and women patentees still shared a larger inventive environment that was shaped by the social, political, and economic currents of three distinctive American wars.

The Civil War Era

The Civil War marked a turning point in the history of women's inventive activities because more women received patents during the four years of the war than during the entire seventy-one-year period between the Patent Act of 1790 (which established the patent system) and the onset of the war in 1861 [Marovich, 1998]. Martha Hunt Coston (1828-1902) stands as one of the most well-known and widely-respected female inventors of the Civil War era because she manipulated a network of relatives, businessmen, and politicians to develop her inventions and bolster her commercial activities. As a sixteen year-old Philadelphia school girl, she fell in love with Benjamin Franklin Coston, an ingenious navy inventor who had successfully developed a variety of new technologies for the military. A year later, the couple eloped and made their home in Washington, D.C., where they enjoyed busy social lives and distinguished political circles that included Henry Clay and General Winfield Scott. Early in their marriage, Congress made appropriations for Benjamin to direct a pyrotechnic laboratory at the Washington Navy Yard. Benjamin's

health was so adversely affected by the constant inhalation of chemical gases during his scientific experiments that he resigned as director of the laboratory, and accepted a position as the president of the Boston Gas Company.[5]

After four sons and nearly five years of marriage, Benjamin died from a three-month respiratory illness. Shortly thereafter, both Martha's mother and her second oldest son, also named Benjamin, became sick and died. The young widow was in a state of emotional distress and financial turmoil. She described her ordeal in her autobiography.

> To be brief, through my own ignorance and the duplicity of others, trusting too much to an improvident relative who misplaced my money, I found myself at twenty-one a widow with three little children and penniless. I knew not how to dig, I was ashamed to beg; and long and intently I pondered upon the course I should pursue, and earnestly I wished that nature had bestowed upon me a little of that brilliant genius so liberally given to my husband [Coston, 1886, pp. 37-38].

While mourning her relatives, Martha remembered a box where her husband stored his business papers. There, she found rough sketches of his pyrotechnic night signals. Benjamin first began testing the signals under the navy auspices at Hampton Roads, Virginia and Washington Navy Yard some two decades before the Civil War. The system, in completed form, was intended to employ different colored pyrotechnic fires in an arrangement that allowed maritime senders and receivers to communicate between distant points. Martha decided to try to develop her husband's ideas into a viable new technology. Over the course of several years, she corresponded with various chemists and scientists to obtain the much-needed technical information that she lacked. Martha "...opened communication with several of them, under a man's name, fearing they would not give heed to a woman..." [Coston, 1886, p. 45].

In 1859, Martha finally patented the "Pyrotechnic Night-Signals." As the administratrix of Benjamin's estate, she filed the patent in her husband's name even though she developed and improved the original sketches herself. This proved to be a very strategic business maneuver. Martha manipulated her husband's commercial relationships and used his prestigious reputation as a decorated naval inventor to attract a buyer for the signal. The well-connected widow even had John Quincy Adams, an old family acquaintance, witness and sign her patent application. Once she secured the patent, Martha followed in her husband's footsteps and sold three hundred sets of signals to the navy for six thousand dollars. She also struck a deal with a New York manufacturer, Gustavus A. Lilliendahl, who agreed to mass produce the signals for the newly formed Coston Supply Company. Lilliendahl patented several improvements

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[5] For information on Martha Coston and the pyrotechnic night signals, see Coston [1886], *Coston's Telegraphic Night Signals* [1873], "The Coston Telegraphic Signals" [1876], Stebbings [1876], and "The Coston Light" [1978].

on the signal, which Martha purchased in order to maintain both financial and legal control over her innovative product [Coston, 1886, p. 54].[6]

When Confederate forces opened fire on Fort Sumter in 1861, Martha organized the wartime production of her signals. She explained that

> the thought also occurred to me that in case of war, what a valuable auxiliary my signals would prove for the navy! The night would lose half its terrors at sea, when in the darkness and through the storm ships could talk to each other as though gifted with the tongue of man, and victories won largely through the common understanding, that could never have been achieved by the Fresnel lanterns, which up to this time had been the only means of naval communication at night, and consisting merely of three colored lanterns run up a pole, and in a mist undiscernible [*sic*]; while the Coston Signals could easily be seen at a distance of fifteen or twenty miles, and in the fiercest gales of wind and rain at a distance of several miles [Coston, 1886, p. 84].

When Martha prepared to ask Congress to purchase her patent rights as a war measure, she learned that several other parties were forming companies to manufacture the signals for the military, and thereby infringe on her patents. Accompanied by a prominent member of the Senate, Martha attended a business meeting at one of the companies and defended her rights as the owner of the Coston Signal.

> ...I presented myself before them, and, apologizing for the intrusion, said, "I came to warn you that I am aware of your intention, and shall not interfere unless I find that you are infringing on my patent, which I shall defend to the utmost extent of the law, unless I receive full recompense for the use of it." I then read them a copy of the patent, which I had brought with me [Coston, 1886, p. 89].

This bold visit stopped the infringing company and stimulated the Secretary of the Navy to recommend that Congress purchase the patent so that the Union could manufacture the signals. In a narrow vote that turned on the ballot of Senator Breckenridge, Congress purchased Coston's patent rights for $20,000 (as opposed to the initial $40,000 that she originally requested). Of that sum, eight thousand dollars immediately went to Martha's manufacturer who had already devoted years of work and money to perfecting the signals. During the war, the Coston Signal Company continued to manufacture the signals for the military for a marginal profit because the government lacked the appropriate machinery, laborers, and finances needed to produce such technologically sophisticated and reliable devices in the wake of a national crisis [Coston, 1886, pp. 89-92].

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[6] Coston's autobiography never refers to Lilliendahl by name, but he is listed as the inventor on some of the relevant patents.

The Coston Signals were a tremendous wartime success. The Union used the signals to order gunboats into action on the Mississippi River, send the North Atlantic Squadron against Fort Fisher, and announce the capture of the Confederate bastion. When the *Monitor* began to sink in 1862, the navy used a Coston Signal to summon help and save the lives of at least ten persons on board. At the end of the war, the U.S. Lifesaving Service provided a domestic market for the signals because the value of the new technology made them standard equipment at lifeboat stations on the sea coasts and Great Lakes ["The Coston Light," 1978, pp. 1-2].

The Coston Signals also grew increasingly popular in the postbellum era because Martha networked in order to secure a market for her inventions. In New York City, she wined and dined with Professor Samuel L. Morse, Commissioner of the 1867 Paris Exposition on Telegraphy, who later referred to the work of "the accomplished inventress" in his report to Congress [Coston, 1886, pp. 75-76]. She also circulated a technical booklet entitled *Coston's Telegraphic Night Signals* [1873], that recounted the history of the signal and advertised it as a life-saving maritime wonder. Several popular journals, including *Harper's Monthly Magazine* [1863], *Demorest's Monthly Magazine* [1876], and the *New York Tribune* [1879] reported on the wartime utility of the Coston Signals, and praised Martha's work as an innovative businesswoman and patriotic inventor. In *New Century for Woman* [1876], Martha also wrote a public letter to the President of the Women's Department of the 1876 Centennial Exposition to lobby for a space for the signals in the exhibition hall. The signals were ultimately displayed at the Centennial, as well as at the Chicago World's Columbian Exposition in 1893. In 1886, Martha published her detailed autobiography aptly entitled *Signal Success*, where she chronicled her wartime business ventures and impressive inventive pursuits.

Martha Coston eventually retired from active management of the company and her son William, who received a formal business education, acquired the family enterprise. Under William's direction, the company designed and marketed a popular line-throwing gun that allowed the firm to flourish into the twentieth century. The Coston Signal, however, remained the company's claim to fame. During 1902, the same year that Martha died, the signals saved some 210 vessels that were in immediate danger. The devices remained a standard piece of equipment in Coast Guard lifesaving equipment through the 1930s, but slowly gave way to electric lanterns powered by new and more dependable batteries. As recently as the 1970s, the original Coston Supply Company, headquartered in New York City, still manufactured and marketed a variety of lifesaving products ["The Coston Light," 1978, pp. 1-2; Stanley, 1987, p. 121].

World War I

Unlike the Civil War, World War I did not fuel a substantial increase in the number of patents granted to female inventors. It did, however, provide some women inventors with an opportunity to market their inventions and thereby aid the larger war effort. Harriet Strong (1844-1926), a flamboyant inventor and feminist, was a master at building commercial networks and

orchestrating shrewd public relations campaigns. She launched a horticultural business on her Southern California farm in 1883, and received five patents between 1884 and 1894. Her inventions grew more technologically advanced over time, beginning with three simple domestic tools and culminating in two sophisticated irrigation structures. Harriet spent the years between 1884 and 1917 establishing business relationships, and used the war to develop her national irrigation plans and bolster public support for her pioneering water inventions.[7]

Harriet Williams Russell was born in Buffalo, New York and spent her youth traveling the West with her parents. Harriet attended Mary Atkin's Young Ladies Seminary (Mills College in Benicia), and married the banker, publisher, and mining tycoon, Charles Lynman Strong (1826-1883) in 1863. Charles and Harriet moved to Oakland, California in 1864 when Charles had the first of many nervous breakdowns that forced him to resign his lucrative position as the superintendent of Nevada's Gould & Curry Mining Company. In 1867, the Strongs and Harriet's brother William Henry Russell bought 220 acres of the land tract known as the "Ranchito" on the San Gabriel River in Whittier from Don Pio Pico, the last Mexican governor of California.[8] Charles and William launched a farming business until Strong left to work in the Sumner Mine, Kern County, in January 1873. Charles wrote that "The farming business proved to be very unprofitable to the firm owning [*sic*] mostly to droughts and loss of crops and several unsuccessful attempts to supply the Ranch with water for irrigating purposes, consisting of making ditches, dams, ...artesian wells, etc."[9] Harriet did not participate in these irrigation activities, but she learned invaluable lessons from observing her husband's financial losses and agricultural failures.

Harriet spent most of her married years raising four daughters while her husband immersed himself in his mining business.[10] During most of their "absentee marriage," Harriet grew depressed and began to suffer from back pain and chronic fatigue.[11] Her physical condition became so unmanageable

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[7] For the most comprehensive collection of primary source materials, see Harriet Williams Russell Strong Manuscript Collection, The Henry E. Huntington Library, San Marino, California, hereafter cited as HS. For biographical information on Harriet Strong, see *Business Folio*, 1 (Boston: January 1895), HS Box 18, *Dictionary of American Biography*, vol. 9 [1964], Jensen [1987], Lothrop [1978], *National Cyclopedia of American Biography, Volume 17* [1927], Paul [1971], Smith [1911], "The Work of One Woman" [1926], *Who's Who in the Pacific Southwest* [1913], and Vare and Ptacek [1988] among many other scattered accounts and newspaper articles.

[8] While some secondary accounts claim that the land purchased was 320 or 325 acres, both Charles and Harriet Strong wrote that the ranch was 220 acres. See Charles Lynman Strong, hereafter cited as C.S., "Business Affairs of C.L. Strong." 1 June 1876, Whittier, California, HS Box 7, Folder 723; and Letter, Harriet Strong, hereafter cited as H.S., to S.S. Gage, 7 November 1887, Los Angeles, California, HS Box 11, Folder 767.

[9] "Business Affairs of C.L. Strong."

[10] See "Grade Books from Young Ladies Seminary," November 1859 and 13 February 1860, Benicia, HS Box 1, Folder 852; and Macdonald, [1992, p. 164].

[11] Letter, H.S. to C.S., 28 June 1865, Nebraska City, Nevada, HS Box 4, Folder 378.

that in November 1882, she traveled to Philadelphia to seek help from the famous Doctor Silas Weir Mitchell.[12] Harriet's convalescence allowed her to escape from domestic chores into the world of reading and intellectual excitement. Charles was equally burdened by his familial role as financial provider. In 1867, he accidentally shot and killed his stage driver, but the final blow came from a "salted" California mining investment.[13] In February 1883, Charles committed suicide. Still in Philadelphia, Harriet learned of her husband's death but her illness kept her away from her daughters until June 1883.[14]

Harriet's widowhood marked the beginning of her "separate" market activities [Scadron, 1988, pp. 241-270]. With the help of her brother, she planted a variety of crops including walnuts, oranges, citrus fruits, pomegranates, and pampas plumes to provide a steady income from her ranch.[15] Discussing the relationship between her physical limitations and her inventive activities, Harriet explained that "...for a long time I was an invalid from spinal trouble, and I believe my scientific studies which I took up then to pass the time have helped me greatly."[16] These studies, along with her early observations of Charles' agricultural failures, contributed to the development of her elaborate irrigation systems.

In 1887, Harriet patented the dam and reservoir construction, an invention designed for irrigation, impounding debris, and saving water in steep valleys. Living in a desert where water was scarce, Harriet sought to store water on the slopes of the Puente Hills to increase the productivity of her farm. Instead of using one dam, she designed a series of ascending dams. The highest dam in the series, for example, would irrigate the highest area of land. The advantage of this system was that a dam asserted backward pressure on the dam above it, thereby avoiding the danger of a total collapse.[17] In 1894, Harriet received her final patent for the method of and means for impounding debris and storing water. This invention provided an effective means of impounding debris from hydraulic mines, and storing the water for irrigation and other purposes.

At the World's Columbian Exposition in 1893, Harriet displayed her inventions. She also spoke at a congress on business training for women, and claimed that "When the majority of women understand the business methods

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[12] See Letter, C.S. to Mary Lynman Strong Mason, 10 November 1882, HS Box 10, Folder 326; Letter, C.S. to Harriet [Russell] Strong, HS Box 11, Folder 338; Letter, John Taintor Coe to [Bishop] Ozi William Whitaker, 9 February 1883, San Francisco, HS Box 11, Folder 30; Letter, H.S. to C.S., 21 December 1882, Philadelphia, HS Box 10, Folder 844; and Letter, H.S. to [Eben Erskine] Olcott, 20 September 1883, Oakland, HS Box 11, Folder 786.

[13] Letter, C.S. to H.S., 4 May 1867, Hardyville, Arizona, HS Box 5, Folder 404.

[14] Letter, H.S. to [Eben Erskine] Olcott, 20 September 1883, Oakland, HS Box 11, Folder 786.

[15] See Flier of "National Republican Emblem" for 1888, 1892, 1896, HS Box 13, Folder 58; Letter, Georgina Pierrepont Strong Hicks to Harriet Russell Strong, 22 July 1893, Chicago, HS Box 13, Folder 90, and Smith [1911], *passim.*

[16] Quoted in "She's Boss of the Ranch," newspaper article, 26 October 1896, HS Box 18.

[17] U.S. Patent #374,378 and untitled newspaper article, 4 December, c. early 1890s, HS Box 18.

of the world, they will be asked to assist in the affairs of government."[18] For Harriet, knowledge of business matters served as a springboard for women to achieve a role in government and politics. Harriet gathered prominent women at the Fair and organized the Business League of America.[19] This club was not limited to female membership, and men frequently contributed to the group. The Business League published a modest journal entitled *The Business Folio* [1895], which provided business advice for women and offered a strategic justification for the League's existence.

> This is not a league of business women for mutual benefit and profit, but the object in starting the movement was to encourage the ladies of America to study business methods in order to preserve their homes and fortunes in the case of death of husband or father, or to meet with him, intelligently and helpfully any reverses which misfortunes might bring.[20]

Regardless of their blatant denial of "mutual benefit," Business Leaguers *were* business-minded profit seekers. They realized that women had to be educated in business methods to advance socially and to guarantee the survival of the family in the absence of a male provider. Harriet frequently argued that "As woman has always been accorded spirituality and heart, let her have brains too."[21] Many men were willing to support improvements in women's education for such emergency situations, but a blatant mission for women's financial success would have labeled their group as a social threat to the traditional nineteenth-century divisions of labor.

After the Fair, Harriet incorporated the Business League's principles into her own enterprises. In 1897, she drilled several artesian wells on the Ranchito and purchased 1,000 acres of land known as the Laguna Ranch some five miles away. There she installed a pumping plant and incorporated the new property under the name of the Paso de Bartolo Water Company in 1900. Harriet served as the corporation's president and her four daughters acted as corporate directors. To raise the capital to support the new business, Harriet issued $110,000 worth of bonds to women only. Since most businessmen did not welcome women into the business world, Harriet solicited only women stockholders. She later sold the Laguna property to make a handsome profit for herself and her investors.[22]

Harriet's water technologies culminated in an ambitious attempt to achieve a national irrigation system during World War I. In 1917, she appealed to the federal government to dam the Colorado River at the lower portal of the

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[18] Harriet Williams Russell Strong, "Speech Delivered Before Congress of Representative Women, World's Fair," printed in *Business Folio*, 3.

[19] See, for example, Letter, Peter Henderson & Co., Seedsmen to H.S., 6 February 1890, New York, HS Box 12, Folder 79.

[20] *Business Folio*, [1895] 2.

[21] Quoted in "The Household Realm," newspaper article, September 1896, HS Box 18.

[22] *National Cyclopaedia of American Biography* [1927, p. 34], *Who's Who in the Pacific Southwest* [1913, p. 358], and State of California [1898].

Grand Canyon. Harriet was among the first citizens to advocate harnessing the river to control floods, conserve water, and generate electricity.[23] Linking her experiences with water technologies to the international problems posed by the war, she argued that America could not send troops to Europe without supplying them with adequate food and water supplies.[24] Harriet argued that since the lower portion of the Grand Canyon was made of 1000 to 1500 feet of solid granite that could be blasted with dynamite, the physical structure of the "tank" easily lent itself to dam construction. The dams were to be built across the Colorado River, ranging in height from 150 to 250 feet. These restraining structures would form storage reservoirs and harness electrical power for use in surrounding areas. This method would fill the canyon at a relatively low cost while a system of dams stored and clarified reservoir waters. As part of the dam campaign, Harriet called for the construction of a $6,000,000 American Canal built on the Panama Canal model to ensure the safety of the entire irrigation system.[25]

Harriet described her irrigation project in a manner that appealed to the common person and the elected official in a war environment. Her project would allow the building of new homes and the employment of millions of people.[26] Politicians tried to convince the American people that crop management and food rationing were the domestic weapons needed to win the war. Adopting this same rationale, Harriet sought to aid the war by building an infrastructure that would ensure stable supplies of food and water. Any excess revenue raised from the plan would pay the national war debt. On the surface, Harriet's progressive argument rested on social issues, political policies, and national security concerns. She had seemingly little to gain from the project because the patents on her irrigation systems lapsed by the onset of the war. However, the adoption of Harriet's war measures would have boosted her agricultural business by providing cheaper water at a time when the demand for food was great.[27] Moreover, her plans would have won her national recognition as a gifted inventor, engineer, and civic-minded citizen.

Harriet wrote numerous essays and delivered many speeches urging women to support a flood-control bill in Congress [e.g., Strong, 1914]. She also used her familial connections to gain political attention. With the help of her son-in law New York Congressman Frederick C. Hicks, who pressed the water conservation project as a federal war measure, Harriet testified as an "expert witness" about her irrigation plans before the House Congressional Committee

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[23] At the turn of the twentieth century, Arthur Powell Davis of the U.S. Geological Survey, later of the U.S. Reclamation Service, argued that the Colorado River should be harnessed to supply water to seven American and two Mexican states [Hundley, 1992, pp. 203-209].

[24] H.W.R. Strong, "Should Grand Canyon Be Dammed," *Times Illustrated Magazine* (1 July 1917), HS Box 12, Folder 850.

[25] Ibid., 3-4.

[26] Quoted in "Use Grand Canyon As Mammoth Irrigation Tank, Urges Woman," reprint of the article in the *Los Angeles Tribune* (1 July 1917), HS Box 12, Folder 850.

[27] Harriet W.S. Strong, "Can the United States Feed the World?" *New American Woman* (December 1917), 3-4, HS Box 14, Folder 854.

on Water Power. In May of 1918, she began her testimony: "I come before you unheralded, except where my voice has been heard for the 'greatest good to the greatest number'" [Water Power Hearings, 1918, p. 787]. She then proceeded to detail her plan for the Colorado River.[28]

Congress rejected Harriet's plan in the wake of the 1918 armistice, when they determined that it was unnecessary to spend so much money on a massive war measure [Jensen, 1987, p. 50]. The government may have been especially cost-conscious during the war, but Harriet attributed the project's failure to male resistance to a woman's ingenious ideas [Macdonald, 1992, p. 281]. It was only after Harriet's death in 1926 that her "mammoth irrigation tank" became a national reality. Congress passed a Boulder Canyon Act in December 1928, which authorized the country's first multipurpose water project known as the Hoover Dam. The massive structure was completed in 1935, and started to supply hydroelectric power to surrounding areas in 1936. The act also called for an All-American Canal, which began construction in 1942 [Hundley, 1992, pp. 201-222].

This course of events would have pleased Harriet Strong. Congress finally implemented the technological descendants of her water designs, and created the massive dam and canal system that she once proposed. It is difficult to exaggerate the historical significance of Harriet Strong's irrigation systems. Her inventions did not make her rich, nor did she earn the public recognition or historical attention that she deserved. One might even argue that her case represents a "technological failure study" because her inventions were not diffused throughout society. The historical literature still ignores Harriet Strong's irrigation crusade. She is never mentioned in the histories of western agriculture or water development, nor is she ever cited as a key figure in the domestic war effort or the Boulder Canyon Project. Harriet's inventive activities demonstrate that invention and innovation are gradual processes, not necessarily dictated by a coherent set of choices. Rather, factors such as timing, access to capital, social connections, political maneuvering, and technological preferences shape the business of invention during wartime.

World War II

World War II also offered new business opportunities for those inventors who adapted to the dramatic changes brought about by the command economy. In October 1942, Carl Dreher of *Popular Science Monthly* offered "...some hints for the free-lance inventor in wartime." He explained that inventors who wanted to make money during the war should avoid "superman ideas," and other high-technology inventions such as anti-submarine nets and floating air mines, that would likely be developed by military experts. Rather, Dreher argued that wartime inventors should

[28] See also, H.W.R. Strong, "Should Grand Canyon Be Dammed," "Problem of Conserving and Controlling Water," *Whittier Register* (c. 1905), and "Water Sources and Supply, Conservation of Storm Water," *Whittier Register* (10 March 1905), HS Box 12, Folder 850.

concentrate their mechanical efforts on less sophisticated inventions, including protective equipment for the battlefield and illumination devices for airplane landing-fields [Dreher, 1942].

Dreher could have cited Hedy Lamarr to argue that women inventors should have also avoided "superwoman ideas" during the war. Lamarr (Hedwig Eva Maria Kiesler) was born in Austria in 1915 as the only child of a prominent Viennese banker, Emil Kiesler and an aspiring concert pianist, Gertrud Lichtwitz. She attended Max Reinhardt's renowned acting school in Berlin and married the wealthy industrial magnet, Friedrich (Fritz) Mandl, at age eighteen. Lamarr's new husband, known as a rather shady character throughout Europe, owned one of Austria's "big four" munitions manufacturers called Hirtenberger Patronen-Fabrik Industries – the same company that supplied "pompous little Mussolini" with weapons to invade Ethiopia in 1935 [Lamarr, 1966, p. 21].[29]

During their brief but tumultuous marriage, Lamarr entertained the great social and political dignitaries of the day, and nurtured a genuine fascination with military technology. The young actress grew to resent her entrepreneurial husband, who often left her under the watchful eyes of his servants while he embarked on commercial ventures all over the world. He was jealous because she starred in the erotic 1933 Czech movie *Ecstasy*, which had been denounced by Pope Pius XI, banned in Germany by Hitler's regime, and protested in the United States [Young, 1978, p. 17]. After numerous attempts at leaving both Mandl and a politically turbulent Vienna, Lamarr fled to Paris and then to London while her husband was on a hunting trip in Hungary. In 1937, she obtained a divorce and finally settled in Hollywood to pursue her film career with MGM.

The Nazi invasion of her Austrian homeland in 1938 channeled Lamarr's military interests and prewar business experiences into the world of invention and technological change. At a 1940 Hollywood dinner party hosted by the singer-actress Janet Gaynor, Lamarr met the author and American film-score composer, George Antheil. The two inquisitive minds enjoyed each other's company and spent the evening engaged in conversation. The multi-talented Antheil had written a book on endocrinology in 1937, and Lamarr solicited his "expert" advice to augment her breast size and enhance her promising film career [Antheil, 1937]. When Lamarr left the party late that night, she used lipstick to scribble her telephone number across the windshield of Antheil's car. Antheil called the intriguing actress the next morning, and she

[29] In her autobiography, *Ecstasy and Me* [1966], Lamarr emphasized her Hollywood experiences and never mentioned Antheil, her inventive activities, or the communication device (discussed below). Instead, the actress wrote a remarkably candid account of her impressive film career, her turbulent love life, and her challenging real life role as the mother of three children. There was a heated lawsuit surrounding the validity of the autobiography. In September 1966, Lamarr filed an unsuccessful $9.6 million suit against her publisher in an attempt to stop publication of the book. She asserted that it contained accounts of adultery, lesbianism, and perversion that were "false, obscene and libelous" ["Lamarr Autobiography Prompts Plagiarism Suit," 1967, p. 18].

invited him to dine at her Benedict Canyon retreat [Antheil, 1981, pp. 327-332; Meeks, 1990].[30]

The couple spent the evening discussing the Nazi occupation of Austria and the munitions expertise that Lamarr developed at business dinners while Mandl "didn't think she knew A from Z" [Antheil, 1981, p. 330]. Lamarr confessed that she felt guilty making so much money in Hollywood while the rest of the world suffered such great turmoil. The actress explained that she was entertaining the notion of quitting MGM to relocate to Washington, D.C. to offer her technological services to the National Inventors' Council (NIC), a celebrated branch of the commerce established in 1940 to facilitate wartime invention and innovation among the American public. "They could just have me around and ask me questions," she announced. Antheil discouraged Lamarr's overconfident though patriotic gesture, and argued that the star would do more good in Hollywood by making public appearances and boosting morale, than by serving as an ad hoc advisor to the NIC [Antheil, 1981, p. 330].

Lamarr proceeded to articulate her inventive plans for an anti-jamming device for radio-controlled torpedoes that she believed could help win the war. Ships under naval attack, she explained, typically wasted several torpedoes to successfully hit a single target. This lack of precision proved to be profitable for munitions manufacturers like her ex-husband, but disastrous for financially-strapped nations embroiled in total war. Lamarr's solution relied on a radio-controlled torpedo that responded to shifting targets, rising tides, and unstable weather conditions. Her idea sounded promising, but also posed formidable technological challenges because even the best radio signals of the 1940s frequently jammed. Antheil listened carefully as he sat on Lamarr's living room floor, took copious notes, and sketched diagrams of the developing communication system. The invention struck a patriotic chord with the composer, and he suggested that she patent the device and give it to Uncle Sam in support of the war effort [Antheil, 1981, pp. 327-332; Meeks, 1990].

The innovative pair spent several weeks refining the invention and discussing its utility until they were "...both blue in the face" [Antheil, 1981, p. 331]. In his 1945 autobiography, Antheil credited the entire invention to Lamarr, but he was probably being too modest. Antheil proved to be the ideal co-inventor to develop the radio device because he had engineered elaborate European musicals with synchronized player pianos that operated on the same technical principles that Lamarr described. The final Lamarr-Antheil system detailed the use of a communication process that came to be known as "frequency hopping" across 88 radio frequencies, the same number of keys on a synchronized player piano [Meeks, 1990]. In 1940, Lamarr and Antheil sent their plans to the NIC, which immediately encouraged the two inventors to patent their device. The Patent Office issued the resulting patent for a "Secret Communication System" to Hedy Kiesler Markey (the actress had married Gene Markey in 1939) and George Antheil in 1942 [Meeks, 1990; Braun, 1997; Antheil, 1981, p. 331].

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[30] For Antheil's biography, see Whitesitt [1983].

The co-patentees were shocked to learn that the War Department declined their patriotic invitation to use and develop the invention free of charge. Antheil took his quest for technological diffusion a step further and lobbied for more research support from William C. Bullitt, Special Assistant of the Navy. Antheil argued that the Germans were far superior to Americans in naval technology and that the secret communication device would help narrow the gap. His efforts fell on deaf ears largely because the invention was well beyond the technological capabilities of the time. The navy rejected the invention and claimed that the mechanism would be far too bulky to fit into any torpedo. Antheil disagreed, insisting that the system could be made small enough to fit into a watch. In retrospect, he pondered the invention's cultural and technological shortcomings.

> In our patent Hedy and I attempted to better elucidate our mechanism by explaining that certain parts of it worked like the fundamental mechanism of a player piano. Here, undoubtedly, we made our mistake. The reverend and brass-headed gentlemen in Washington who examined our invention read no further than the words "player piano." "My god," I can see them saying, "we shall put a player piano in a torpedo" [Quoted in Braun, 1997, p. 14].

Antheil implied that the reason for technological rejection rested in an inherent cultural clash between two creative entertainers and a traditional military elite, who were incapable of comprehending the potential adaptation of musical technologies for the art of warfare. Moreover, the innovative couple lacked applicable knowledge of the electronics business. Antheil himself attested to this fact when he titled a chapter in his autobiography "I Am Not a Businessman."

Rather than join Antheil and pursue technological diffusion via another business route, Lamarr abandoned her role as a frustrated patentee and resumed her film career. She spent the rest of the war era just as Antheil and her other famous peers once suggested, entertaining military officers at the Hollywood Canteen and thereby giving "...a big boost to the boys' morale" [Bette Davis quoted in Lamarr, 1966, p. 113]. Antheil remained quick to admit that the Hollywood establishment intentionally marketed his colleague as a cultural icon and world-class beauty, rather than an intelligent woman who could not only light up the silver screen, but the Patent Office.

> The Hedy whom we know is not the Hedy you know. You know something which the M.G.M. publicity department has, in all its cunning, dreamed up. There is no such Hedy. They have long ago decided that, in order to give her sufficient sex appeal, they will make her just faintly stupid. But Hedy is very, very bright. Compared to most Hollywood actresses we know, Hedy is an intellectual giant. I know I'm crabbing the M.G.M. publicity department's act, but it's true [Antheil, 1981, p. 332].

The federal government was equally predisposed to manipulate Lamarr's glamorous image as a movie star rather than a patriotic inventor. Just one month after the patent was issued, she sold over $7 million worth of United States war bonds in a single day [Lamarr, 1966, p. 115; "Hedy Lamarr a Hit," 1942; "Food Stamps," 1942; "Foreign Groups," 1942; "Heady Date," 1942].

For Lamarr and Antheil, the prevailing cultural biases about who should invent – coupled with the technical limitations of contemporary military technology – delayed the commercialization of their communication system. Ironically, the end of World War II marked the military-industrial diffusion of their pioneering technology. Two engineers working in the Electronic System Division at Sylvania, a New York corporation centered in Buffalo, adapted and commercialized a version of the original system in 1957. The War Department also implemented frequency hopping in 1962, three years after the Lamarr-Antheil patent expired, when it contracted Sylvania to install the system on ships sent to safeguard the Cuban blockade during the missle crisis. By the mid-1980s, the military declassified spread-spectrum ("frequency hopping") technologies, and the commercial sector began to develop related devices for use in the electronics industry. Today, spread-spectrum technologies are used in a myriad of consumer devices ranging from cellular phones to radio transmissions [Couey, 1997]. Competing corporations still use a technological descendant of the 1942 patent to speed satellite communications across the globe, and the federal government also relies on the principle of frequency hopping as the foundation of its $25 billion Milstar defense communication satellite system [Meeks, 1990].[31]

Conclusions

Between the Civil War era and World War II, popular writers and social critics clearly empathized with the plight of individual inventors who tried to commercialize their patents because the business of invention was riddled with financial pitfalls and psychological risks. The difficult process often reaped emotional distress, and put more that one inventor in the poor house. At the turn of the twentieth century, a group of socially conscious citizens attempted to build "a home for indigent inventors" who failed at the business of invention. The home was to be constructed in New York City, but one columnist argued that its proper place was in Washington, D.C., "near the Patent Office – the graveyard of many an inventor's hopes and air castles." The poor house was designed to function like any other charitable institution, except it would provide inventors with free legal advice in the "atmosphere of a clubhouse."

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[31] On 15 January 1997, David R. Hughes, the Principal Investigator for several National Science Foundation (NSF) Projects involving digital forms of wireless communications for education and Third World data communications, nominated Lamarr and Antheil for the 1997 EFF Pioneer Award for their invention of frequency hopping. Hughes' nomination letter is reproduced on a Hedy Lamarr web site. See Phillip Pessar, "Welcome to the Hedy Lamarr Page," 1996; http://www.geoworld.com/Hollywood/Hills/1797/hedy.htm.

Apparently, all destitute patrons shared a common psychological bond because they hit rock-bottom as a result of the same economic woes ["A Home for Indigent Inventors," 1906].

Some thirty years later, in an article entitled "First Aid to Inventors," a *Business Week* writer carried the same depressing theme into the World Wars, and argued that "Ignorance of patent procedures has robbed many an inventor of profit justly due him." The columnist did not limit this discussion to men. Many women inventors stumbled onto "golden discoveries" that arose from using practical devices and household equipment. By the 1930s, however, female inventors in need of inventive assistance could enroll in free classes sponsored by the Inventors Foundations, Inc., which was funded by the Gillette Safety Razor Company. The objective of the course was to "remove the romance and carelessness from inventing, to reduce it to sound business." Training was not confined to adolescents with a propensity for the mechanical arts, but also included executives who understood the importance of safeguarding machinery and products to avoid possible infringement. Students, including a sizable number of women, learned how to file patent applications, and how to retain patent lawyers who would not extract astronomical fees for themselves ["First Aid to Inventors," 1934].

In the midst of such philanthropy and free-flowing inventive advice, access to reliable information about patenting and marketing inventions proved to be a persistent challenge for women inventors through the postwar era. For women who sought to market their inventions, commercial advice from their female peers represented a means to gain reliable information about gender-specific problems, and an opportunity to associate with a network of women who shared the same personal anxieties and financial challenges associated with the business of invention. Business sense involved the manipulation of social and familial relationships as means to serve their economic interests and commercial needs. Other important factors, including the quality of the invention, the costs of developing the patent, timing, and even luck, helped to determine the relative level of commercial success that each individual woman enjoyed. After analyzing the inventive histories and business frustrations of three notable female inventors, it is clear that patent commercialization stood as an overwhelming challenge for women who lacked the versatile social connections and public relations that fueled the business of invention.

References

Anderson, Karen, *Wartime Women: Sex Roles, Family Relations, and the Status of Women During World War II* (Westport, CT, 1981).

Antheil, George, *Bad Boy of Music* (1945; New York, 1981).

Antheil, George, *Every Man His Own Detective: A Study of Glandular Criminology* (New York, 1937).

Beard, Charles A. and Mary R. Beard, *The Rise of American Civilization* (1927; one vol. ed., New York, 1930).

Beard, Charles, ed., *A Century of Progress* (Chicago, 1933).

Braun, Hans-Joachim, "Advanced Weaponry of the Stars," *American Heritage of Invention & Technology*, 12 (Spring 1997), 10-14, 16.

Brenner, Reuven, *Betting on Ideas: Wars, Inventions, Inflation* (Chicago and London, 1985).

Condliffe, J.B., "War and Economics: A Review Article," *Journal of Political Economy*, 51 (April 1943), 157-165.

"The Coston Light," in Bernard C. Nalty, Dennis L. Noble, and Truman R. Strobridge, eds., *Wrecks, Rescues & Investigations: Selected Documents of the U.S. Coast Guard and Its Predecessors* (Wilmington, DE, 1978).

"The Coston Telegraphic Signals," *New Century for Woman*, 1 (13 May 1876), 5.

Coston, Martha J., *Coston's Telegraphic Night Signals. Patented in the United States and Europe, and Adopted by the Government of the United States, France, Italy, Denmark, Holland, Hayti, and the New-York, Brooklyn, and Eastern Yacht Clubs* (New York, 1873).

———, *Signal Success* (Philadelphia, 1886).

Couey, Anna, "The Birth of Spread Spectrum," *Microtimes* (25 June 1997), 106-108, 112, 114, 116, and 134.

Dictionary of American Biography, vol. 9 (New York, 1964).

Dreher, Carl, "Inventions Can Win the War," *Popular Science Monthly*, 141 (October 1942), 64-69, 220, and 222.

"First Aid to Inventors," *Business Week*, 240 (7 April 1934), 24.

"Food Stamps Acquire $75,000 in War Bonds: 1,000 Retailers Adopt the Plan – Hedy Lamarr at Jersey Rally," *New York Times* (6 September 1942).

"Foreign Groups Buy $991,377 War Bonds: Mayor Greets Hedy Lamarr and Honors Carole Lombard," *New York Times* (12 September 1942).

Hacker, Barton C. "Military Institutions, Weapons, and Social Change: Toward a New History of Military Technology," *Technology and Culture*, 35 (October 1994), 768-834.

Hacker, Barton C. and Sally L. Hacker, "Military Institutions and the Labor Process: Noneconomic Sources of Technological Change, Women's Subordination, and the Organization of Work," *Technology and Culture*, 28 (October 1987), 743-775.

Hambrick, Arlene, "Female Scientists and Inventors. An Interdisciplinary Middle School Curriculum Guide: 'What Shall I Tell My Children Who Are Black?'" (Ed.D. Dissertation, School of Education, University of Massachusetts, May 1993).

Harriet Williams Russell Strong Manuscript Collection, The Henry E. Huntington Library, San Marino, California.

Hartmann, Susan M. *American Women in the 1940s: The Home Front and Beyond* (Boston, 1982).

"A Heady Date with a Bond," *New York Times* (20 September 1942).

"Hedy Lamarr a Hit in Newark," *New York Times* (5 September 1942).

Higgs, Robert, "Wartime Prosperity?" A Reassessment of the U.S. Economy in the 1940s," *Journal of Economic History*, 52 (March 1992), 41-60.

Hoke, Donald R., *Ingenious Yankees: The Rise of the American System of Manufactures in the Private Sector* (New York, 1990).

"A Home for Indigent Inventors," *Inventive Age*, 18 (February 1906), 9.

Hounshell, David, *From the American System to Mass Production, 1800-1932: The Development of Manufacturing Technology in the United States* (Baltimore, 1984).

"How to Sell an Invention," *Popular Mechanics Magazine*, 56 (November 1931), 810-815.

Hundley, Norris, Jr., *The Great Thirst: Californians and Water, 1770s -1990s* (Berkeley, 1992).

"Immigration and Invention," *Literary Digest*, 94 (10 September 1927), 24.

Ives, Patricia Carter, *Creativity and Invention: The Genius of Afro-Americans and Women in the United States and Their Patents* (Arlington, VA, 1987).

Ives, Patricia Carter, "Patent and Trademark Innovations of Black Americans and Women," *Journal of the Patent Office Society*, 62 (February 1980), 108-126.

Jenkins, Edward S., "Bridging the Two Cultures: American Black Scientists and Inventors," *Journal of Black Studies*, 21 (March 1991), 313-324.

Jensen, Marilyn, "A Legendary Lady: Harriet Strong," *California Highway Patrolman* (May 1987), 48-50.

Kaempffert, Waldemar, *A Popular History of American Invention*, 2 vols. (New York, 1924).

———, "War and Technology," *American Journal of Sociology*, 46 (January 1941), 431-444.

Khan, B. Zorina, "Married Women's Property Laws and Female Commercial Activity: Evidence from United States Patent Records, 1790-1895," *Journal of Economic History*, 56 (June 1996), 356-388.

Lachman, Christine E., "An Ethnography of Women Inventors in Chicago," (Master's thesis, Loyola University of Chicago, Department of Sociology, 1992).

"Lamarr Autobiography Prompts Plagiarism Suit," *New York Times* (8 February 1967), 18.

Lamarr, Hedy, *Ecstasy and Me: My Life as a Woman* (New York, 1966).

Livesay, Harold C., *American Made: Men Who Shaped the American Economy* (New York, 1979).

Lothrop, Gloria Ricci, "Women and the Western Frontier: The Untold Saga of Three Southern California Heroines," in *Westerners Los Angeles Corral Brandbook*, 15 (Los Angeles, 1978).

Macdonald, Anne L., *Feminine Ingenuity: Women and Invention in America* (New York, 1992).

Marovich, Lisa Anne, "Fueling the Fires of Genius: Women's Inventive Activities in American War Eras," (Ph.D. dissertation, Department of History, University of California at Los Angeles, June 1998).

Mason, Otis T., *Woman's Share in Primitive Culture* (1894; New York and London, 1911).

McGaw, Judith A., "Inventors and Other Great Women: Toward a Feminist History of Technological Luminaries," *Technology and Culture*, 38 (January 1997), 214-231.

McNeill, William H., *The Pursuit of Power: Technology, Armed Forces, and Society Since A.D. 1000* (Chicago, 1982).

Meeks, Fleming, "Science and Technology: Hedy Lamarr: Hollywood Sex Goddess, was also a Brilliant Inventor. She Got Paid for Her Movies, but not for Her Invention," *Forbes*, 145 (14 May 1990), 136-138.

Mendelshon, Everett, Merritt Roe Smith, and Peter Weingart, *Science, Technology, and the Military* (Dorecht and Boston, 1988).

Merritt, Deborah J., "Hypatia in the Patent Office: Women Inventors and the Law, 1865-1900," *American Journal of Legal History*, 35 (1991), 235-306.

Mossinghof, Gerald and Barbara Luxembourg (comps.), *Profile of Female Inventors* (Washington, DC, 1984).

Moussa, Farag, *Women Inventors: Honored by the World Trade Intellectual Property Organization* (Geneva, 1991).

Mozans, H.J., *Woman in Science: With an Introductory Chapter on Woman's Long Struggle for Things of the Mind* (New York and London, 1913).

Mumford, Lewis, *The Myth of the Machine, Vol. 1: Technics and Human Development* (New York, 1967), and *Vol. 2: The Pentagon of Power* (New York, 1970).

National Cyclopedia of American Biography, Volume 17 (New York, 1927).

Nef, John U., *War and Human Progress: An Essay on the Rise of Industrial Civilization* (Cambridge, MA, 1950).

Nelson, Richard and Gavin Wright, "The Rise and Fall of American Technological Leadership: The Postwar Era in Historical Perspective," *Journal of Economic Literature*, 30 (December 1992), 1931-1964.

Paul, Rodman Wilson, "Harriet Williams Russell Strong," *Notable American Women, 1607-1950: A Biographical Dictionary, Volume III* (Cambridge, MA, 1971).

Piper, Edna Mary Alyce, "Beyond the Next Veil: Black Women Inventors," (Master's thesis, University of California at Los Angeles, Department of Afro-American Studies, 1989).

Pursell, Carroll, "The Cover Design: Women Inventors in America," *Technology and Culture*, 22 (July 1981), 545-550.

"The Presidential Election and Invention," *Inventive Age*, 3 (28 June 1892), 4.

Roland, Alex, "Science, Technology, and War," *Technology and Culture*, 36 (April 1995), S83- S99.

———, "Technology and War: The Historiographical Revolution of the 1980s," *Technology and Culture*, 34 (January 1993), 117-134.

Romer, Christina D., "The Prewar Business Cycle Reconsidered: New Estimates of Gross National Product, 1869-1908," *Journal of Political Economy*, 97 (1989), 1-37.

Ropp, Theodore, *War in the Modern World* (New rev. ed.; New York and London, 1962).
Rossman, Joseph, *Industrial Creativity: The Psychology of the Inventor* (New Hyde Park, NY, 1964), originally published as *The Psychology of the Inventor: A Study of the Patentee* (Washington, DC, 1931).
Rossman, Joseph, "War and Invention," *American Journal of Sociology*, 36 (January 1936), 625-633.
Scadron, Arlene, "Letting Go: Bereavement among Selected Southwestern Anglo Widows," in Arlene Scadron, ed., *On Their Own: Widows and Widowhood in the American Southwest, 1848-1939* (Urbana, 1988).
"Selling Patents," *Inventive Age*, 21 (March 1901), 8.
Sifakis, Carl, *American Eccentrics* (New York and Bicester, England, 1984).
Smith, Bertha H., "What are Women Doing in the West," *Sunset* (April, 1911), 407-415.
Smith, Merritt Roe, *Harper's Ferry Armory and the New Technology: The Challenge of Change* (Ithaca, 1977).
Smith, Merritt Roe, ed., *Military Enterprise and Technological Change: Perspectives on the American Experience* (Cambridge, MA and London, 1985).
Sokoloff, Kenneth L., "Inventive Activity in Early Industrial America: Evidence from Patent Records, 1790-1846," *Journal of Economic History*, 48 (December 1988), 813-850.
Stanley, Autumn, *Mothers and Daughters of Invention: Notes for a Revised History of Technology* (Metuchen, NJ, 1993; paper ed., New Brunswick, NJ, 1995).
———, "Once and Future Power: Women as Inventors," *Women's Studies International Forum*, 15 (1992), 193-203.
———, "The Patent Office Clerk as Conjurer: The Vanishing Lady Trick in a Nineteenth-Century Historical Source," in Barbara Drygulski Wright et al., eds., *Women, Work, and Technology: Transformations* (Ann Arbor, 1987).
State of California, City and County of San Francisco, "Articles of Incorporation of the Paso de Bartolo Water Company," filed in the Office of the Secretary of State of California, #2556, (6 August 1898).
Stebbings, Mrs. Sarah Bridges, "Women in Business," *Demorest's Monthly Magazine* (September 1876), 454-456.
Strong, Harriet Williams Russell, "Source Conservation," *Woman Citizen* (July 1914), 21.
"Too Much Secrecy," *Inventive Age*, 18 (January 1906), 8-9.
U.S. Department of Commerce, Patent and Trademark Office, "Buttons to Biotech: U.S. Patenting By Women, 1977 to 1988," (Washington, DC, January 1990).
———, "Buttons to Biotech: U.S. Patenting By Women, June 1993 Update Supplement," (Washington, DC, January 1994).
United States Patent Records.
van Door, Jacques, *The Soldier and Social Change: Comparative Studies in the History and Sociology of the Military* (Beverly Hills, CA and London, 1975).
Vare, Ethlie Ann and Greg Ptacek, *Mothers of Invention, From the Bra to the Bomb: Forgotten Women and Their Unforgettable Ideas* (New York, 1988).
Vare, Ethlie Ann and Greg Ptacek, *Women Inventors & Their Discoveries* (Minneapolis, 1993).
Water Power Hearings Before the Committee on Water Power of the House Representatives, Sixty-fifth Congress, Second Edition. March 18 to May 15, 1918. Parts 1, 2, 3, 4, with contents (Washington, DC, 1918).
Whitesitt, Linda, *The Life and Music of George Antheil, 1900-1959*; Studies in Musicology, No. 70, George Buelow, Series Editor (1981; Ann Arbor, 1983).
Who's Who in the Pacific Southwest: A Compilation of Authentic Biographical Sketches of Citizens of Southern California and Arizona (Los Angeles, 1913).
"Woman as an Inventor and Manufacturer," *Popular Science Monthly*, 47 (May 1895), 92-103.
"The World's Fair as a Stimulus to Invention," *Inventive Age*, 3 (31 May 1892), 4.
"The Work of One Woman," *Southern California Business*, 5 (November 1926), 26, 32.
Young, Christopher, *The Films of Hedy Lamarr* (Secaucus, NJ, 1978).