

# Competition and Consolidation in the Electrical Manufacturing Industry, 1889–1892

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## Introduction

Competition and consolidation are the yin and yang of American business. On the one hand, we frequently celebrate the competitive aspects of the American economy, claiming that it is the spirit of competition that stirs men and women to devise new technology, marketing plans, and other innovations. And yet while we love to root for the heroic entrepreneur or inventor, citing their successes as a sign of the inherent goodness of American society, we often forget Joseph Schumpeter's point that competition is creative and wasteful. On the other hand, consolidation—the creation of large firms—is equally important to the success of the American economy. As many historians have argued, large complex corporations were essential in order to produce and distribute goods to large numbers of Americans. Without the rise of big business, Americans in the twentieth century would not have come to enjoy their high standard of living, whether it be measured in terms of the low cost of mass-produced goods, the variety of goods available, or the availability of low-cost energy. To be sure, big business has presented many challenges to American culture, in terms of the concentration of power, the standardization of products and experiences, or the exploitation of workers and consumers. Thus, consolidation is every bit as important in the shaping of American business as is competition.<sup>1</sup>

Despite the importance of both competition and consolidation in the American economy, how much do we know about how these two modes influence each other? How does competition give way to consolidation in certain industries at certain times? In particular, during the first three-quarters of the nineteenth century, much of American business was highly competitive, consisting of large numbers of small firms offering one or two products to local or regional markets. Yet between 1875 and

1900, the American economy witnessed the rise of large firms using high-speed, high-volume technology to distribute goods throughout the United States and overseas. How did this remarkable change come about?<sup>2</sup>

Historians have suggested that a wide number of factors contributed to the rise of big business in the United States in the last quarter of the nineteenth century. To be sure, a rapidly growing population meant ready markets and an ample low-cost labor force. Similarly, evolving legal doctrines concerning the corporation and a minimum of government regulation created a favorable environment for creating large firms. Yet the most persuasive argument has centered on technological change and national markets. As Alfred D. Chandler, Jr., has demonstrated in his seminal studies of American business, managers frequently created large complex organizations in order to exploit the economies of speed, scale, and scope inherent in the technologies they were using. In order to use new production processes effectively, businesspeople often had to coordinate several functions or activities within a single firm, thus leading them to create larger and more complex companies. In a similar fashion, as they produced larger quantities of goods, some managers were confronted by problems in distributing goods to the national market, and this led them to create extensive marketing organizations for handling advertising, distribution, and sales.<sup>3</sup>

While I believe that Chandler is correct in pointing to new technology and new national markets as two of the key factors shaping the creation of big business, the case of General Electric suggests that other factors were equally significant. First, I agree with Lance Davis that the undeveloped state of the capital markets in the United States exacerbated competition and favored consolidation in the electrical manufacturing industry.<sup>4</sup> Second, I think that Chandler and economist Williamazonick are correct in suggesting that entrepreneurs and managers often struggle to assemble the right combination of factories, distribution networks, and technological expertise—what they call organizational capability—and consequently they are loathe to let anyone or anything force them to dismantle this capability.<sup>5</sup> And third, I have found it interesting that the key figures in the rise of General Electric—Charles Coffin, Henry L. Higginson, George Westinghouse, and Thomas Edison—possessed differing views about competition and consolidation. Most significantly, Coffin and Higginson came to realize that competition would be undeniably wasteful of their organizational capability, while Edison and Westinghouse fought to the bitter end to maintain competition.

Consequently, in this chapter, I will use the story of General Electric to explore the interplay of competition and consolidation in the American electrical industry in the late nineteenth century. I will begin by sketching the key players in the industry and describing how they competed with one another. Next, I will discuss their needs for capital and how these firms struggled to find long-term financing. With this background in place, I will narrate the various attempts by Henry Villard, Coffin, and the banking interests to overcome competition and the problems of securing capital by consolidating the major firms in the industry. These attempts culminated in the creation of General Electric in 1892. In my conclusion, I will highlight what I think this case reveals about competition and consolidation in the American economy, and what lessons we might draw from it.

## The First Movers

By 1889, three firms had emerged as dominant players in the industry: Thomson-Houston, Edison General Electric, and Westinghouse Electric. Each of these firms promoted central stations, and each had made the investment necessary to implement that strategy; they had developed large-scale production facilities, national and international distribution networks, and expertise in engineering and invention. Armed with such organization capability, each firm was determined to exploit its potential, through either economies of scale (such as utilizing their large factories) or economies of scope (such as expanding into related product areas).<sup>6</sup>

As I have discussed elsewhere, Thomson-Houston clearly had the capability to implement the central-station strategy. Founded in 1882 by a group of shoe manufacturers in Lynn, Massachusetts, this firm initially concentrated on manufacturing and marketing Elihu Thomson's arc-lighting system. Under Charles Coffin's leadership, Thomson-Houston perfected a new marketing strategy of selling lighting equipment to groups of local businesspeople who established central station utility companies. By 1889, Thomson-Houston had a large plant in Lynn producing a diversified product line of arc lighting, incandescent lighting, and street-railway systems. To market and distribute those systems, the firm had a sales and engineering force to help local businesspeople develop utility and traction companies. Likewise, to coordinate production and distribution, Coffin had developed a managerial staff organized along functional lines. And to provide a steady stream of new products and improvements, the firm employed Thomson, Charles Van Depoele, and Hermann Lemp.<sup>7</sup>

Although Edison and his associates had been major players in the electrical industry throughout the 1880s, it was only in April 1889 that their significant resources were brought together as the Edison General Electric Company. Organized by financier Henry Villard, Edison General was a consolidation of Edison's various electrical manufacturing concerns (Fig. 1). Drawing on his connections with major German banks, Villard capitalized the new company at \$12 million. J. P. Morgan and his partners, Edison's bankers, also invested in the new company. Once established, Villard took the title of president, but left day-to-day management to Samuel Insull, Edison's personal secretary. With the help of Edison, Insull created a national sales organization with seven regional districts, all of which reported to a sales vice president. Insull also established an intelligence department at the company's New York headquarters that collected and analyzed sales data. For production, Edison General had the enormous machine works at Schenectady, a lamp factory at Harrison, New Jersey, and a plant in New York City. Although the company continued to focus on dc incandescent lighting systems, it contracted with Edison's new laboratory at West Orange, New Jersey, to develop better lamps, a multipolar dynamo, and a new meter. Insull hoped that Edison would develop an ac lighting system and a street railway, but Edison instead threw his energies into developing his phonograph and ore-milling ventures.<sup>8</sup> Edison General had access to the "wizard" and his laboratory, but it had no guarantee that Edison would put the needs of the company ahead of his own goals. Unlike Thomson-Houston, Edison General had not fully integrated the innovation function into its organization.

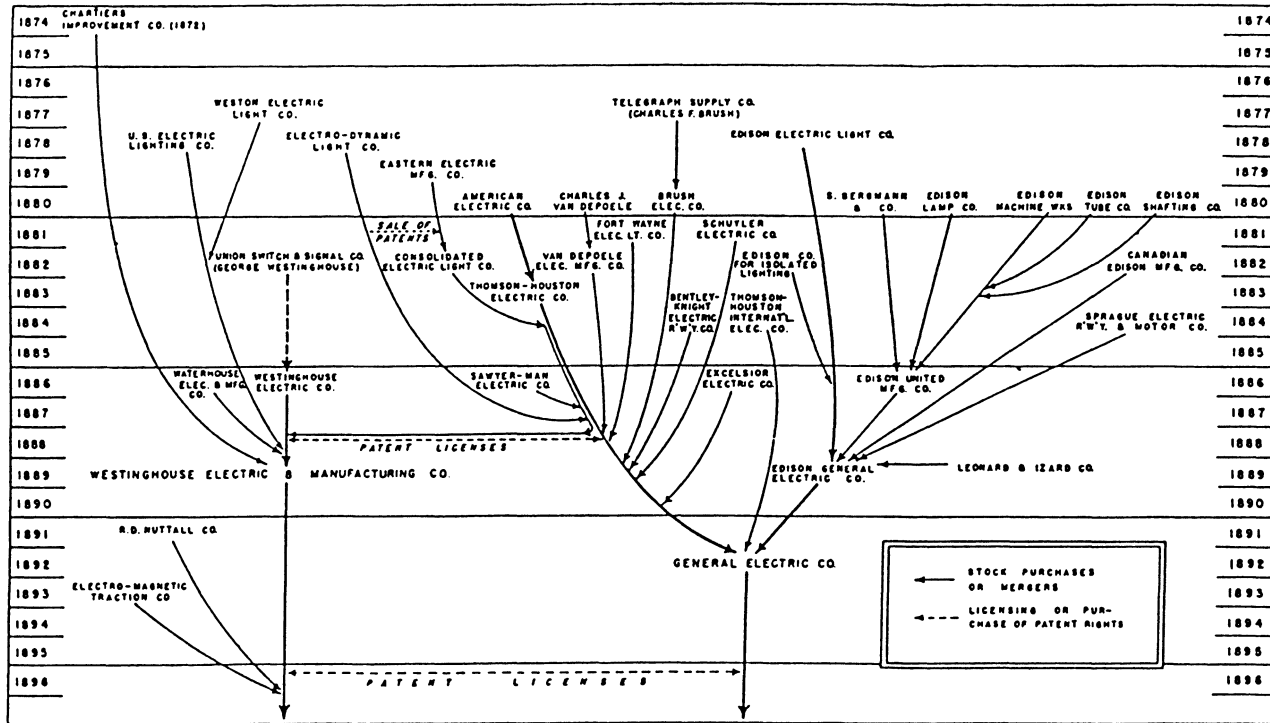


Figure 1. Evolution of General Electric and Westinghouse companies, 1872-96. Reprinted with permission of Macmillan Publishing company from *The Electric Lamp Industry: Technological Change and Economic Development from 1800 to 1947*, by Arthur A. Bright. Copyright 1949 The Macmillan Company; copyright renewed 1975 Evelyn F. Hitchcock.

By 1889 Westinghouse Electric Company had also emerged as a leading firm in the electrical manufacturing industry. Westinghouse had established its reputation by pioneering ac incandescent lighting, but the company had moved quickly into other product areas, including ac industrial motors and street railways. Through a patent-sharing agreement with Thomson-Houston, Westinghouse secured a foothold in the arc-lighting field. To develop its products, Westinghouse employed several inventors, including Nikola Tesla, William Stanley, and Oliver Shallenberger. In terms of production facilities, the company had plants in Pittsburgh (Garrison Alley) and Newark, New Jersey (formerly the United States Electric Lighting Company). For distribution, Westinghouse depended on a small sales force working on commission out of offices in six or seven major cities. Unlike its rivals, Westinghouse lacked a managerial hierarchy; instead, George Westinghouse supervised factory operations, participated in product design, and negotiated many of the major contracts.<sup>9</sup>

For all three firms, it required substantial capital, technical expertise, and entrepreneurial effort to become a major player in the electrical manufacturing industry. Consequently, once they had assembled their factories, sales forces, and inventors, they fought hard to maintain and expand their market shares. Even though the market for electric lighting and power was substantial in the United States, the need to sustain their established capabilities led those firms to keen competition in the early 1890s.

## Competition

Competition among the three firms took several forms. First, they competed vigorously for contracts to supply complete lighting systems and street-railway systems to towns and cities. For example, in 1890, Thomson-Houston, Edison General, and Westinghouse bid \$25,000, \$60,000, and \$70,000, respectively, to provide equipment to electric companies in Ironwood and Bessemer, Michigan.<sup>10</sup> Although Edison General cut prices on individual components, such as incandescent lamps and street-car motors, the other two firms generally did not follow suit.<sup>11</sup> Instead, Thomson-Houston and Westinghouse offered utility companies low prices for complete systems, hoping that the profits would come by way of power plant expansion and sales of replacement equipment. As Coffin explained, "once we have [brought] our system into use [in a town or city], other companies may offer prices twenty-five percent lower, but the users willingly pay our price as they cannot afford to change the system."<sup>12</sup> However, as utility companies sought to lower the unit costs of lighting and power by expanding their service territories, they demanded larger generating plants and distribution networks from the electrical manufacturers. Although the manufacturers could reap handsome profits on a large installation, they also knew that they could lose a great deal if they had to submit an extremely low bid to secure the contract. Consequently, as systems grew in complexity and cost, the risk involved in competitive bidding became a mounting concern for the managers of the leading firms.

In competing for contracts for complete systems, Thomson-Houston and Edison General employed a second tactic of integrating forward into the construction

and operation of central stations. Although Thomson-Houston had a large force of sales agents and field engineers who reported directly to headquarters, it established in 1887 a subsidiary, the Northwest Electric Construction and Supply Company (also known as Northwest Thomson-Houston), which specialized in the promotion and construction of central stations. Headquartered in Saint Paul, Minnesota, Northwest Thomson-Houston sold electrical equipment to the growing cities and towns of the upper Midwest and Pacific Northwest. With its own sales agents and construction engineers, Northwest Thomson-Houston could move into a city, organize a central-station company with local capital and management, market the company's bonds in Boston, sell a full line of equipment, and build a complete plant. In providing these services, Northwest Thomson-Houston took advantage of economies of scope to meet the vigorous competition for contracts. Northwest Thomson-Houston was a logical step in Thomson-Houston's overall strategy of central-station development, and that subsidiary captured a large portion of the market, at least in Wisconsin.<sup>13</sup>

In connection with Edison General, Villard established the North American Company in June 1890 to promote Edison central stations in the Midwest. North American was capitalized at \$50 million, with backing from both the German banks and Morgan. With ample capital in hand, North American took over and enlarged the Edison lighting companies in Cincinnati, Saint Paul, and Minneapolis. In Milwaukee, Villard used North American to consolidate the existing street-railway and lighting companies into a single \$5-million utility company. Unlike Thomson-Houston, which accepted only bonds as partial payment for equipment from utilities, North American accepted as much as four-fifths of the stock of an Edison utility as payment. Villard further insisted that Edison General sell central-station equipment only to North American "at factory prices, free of all royalty or profits, direct or indirect." By controlling large blocks of stock and being the sole source of Edison central-station equipment, Villard hoped to use the North American Company to gain complete control of incandescent lighting in the United States.<sup>14</sup>

Not only did the major firms integrate vertically and create subsidiaries, but as a third tactic they integrated horizontally and took over smaller firms in the field (Fig. 1). Between 1888 and 1891 Thomson-Houston spent \$4 million purchasing control of seven firms in the arc-lighting and street-railway fields. At the same time, Westinghouse bought out the United States Electric Lighting Company and the Consolidated Electric Light Company for their incandescent-lamp patents and the Waterhouse Electric Light Company for its arc-lighting system. In creating Edison General, Villard brought in two non-Edison firms, Leonard & Izard (a small central-station construction firm) and the Sprague Electric Railway & Motor Company. In all cases, the leading firms absorbed minor concerns in order to gain market share and to prevent valuable patents from falling into the hands of the rivals. However, they were also anxious to secure the services of inventors, reminding us again that the knowledge of the new technology was embodied in individuals, not books or theories. Although Thomson-Houston continued to operate the large Brush factory in Cleveland, the smaller factories were closed, and their inventors were transferred to the major plants in Lynn, Schenectady, and Pittsburgh.<sup>15</sup>

As a fourth tactic, electrical manufacturers used patents in a variety of ways. Not only did they purchase smaller rivals to acquire their patents, but they used pat-

ents to shape their relationship with their customers, the central-station utilities. Patents allowed the manufacturer to exert influence over its customers; by requiring them to become licensees, the manufacturer could attempt to force its customers to buy equipment exclusively from it. At the same time, patents were necessary to attract central-station customers because they conveyed to central-station officials the hope of monopoly power. In order to convince local businesspeople to invest heavily in a new utility, frequently each electrical manufacturer would claim that it alone held the key patents for a particular type of system (arc, incandescent, or railway) and that it would prosecute all patent infringers. In making such promises, the manufacturer wanted the local businesspeople to believe that they would face little or no competition in the utility field.<sup>16</sup>

As competition increased in the late 1880s, the three leading firms did not hesitate to use patent litigation to attack each other. In 1887 Thomson-Houston launched a comprehensive attack against all who had infringed the patent for Thomson's dynamo regulator. That campaign helped wear down several of Thomson-Houston's major arc-lighting competitors and facilitated the acquisition of those firms by Thomson-Houston. Similarly, Westinghouse sued Thomson-Houston in 1887 for infringing its Gaulard-Gibbs transformer patent, leading to a patent-sharing agreement with Thomson-Houston.<sup>17</sup>

Of the major firms, the Edison organization was the most energetic in licensing its central-station customers and proclaiming the strength of its patents. As early as 1885 the Edison group began suing both nonlicensed utility companies and competing lamp manufacturers for patent infringement. As competition with Westinghouse and Thomson-Houston increased in the late 1880s, the Edison organization increased the intensity of its legal actions. Edison's lawyers instituted proceedings against a hundred or more infringers, but they devoted most of their energy to trying a single case against the United States Electric Lighting Company, concerned with incandescent-lamp filaments. (Because Westinghouse subsequently purchased U.S. Electric, this case was effectively against Westinghouse.) After a long and involved trial in federal court, in July 1891 Judge William Wallace ruled in favor of Edison, sustaining his claim to have invented the first incandescent lamp with a high-resistance carbon filament in a sealed bulb.<sup>18</sup>

It has been thought that the 1891 patent victory gave Edison General a decisive edge over Westinghouse and Thomson-Houston and permitted Edison General to force Thomson-Houston to submit to the merger that formed General Electric.<sup>19</sup> Yet the court decision had sustained only one claim of the original lamp patent, and both Westinghouse and Thomson-Houston found ways to work around that patent. Westinghouse avoided further infringement by developing a "stopper lamp," which was used in the elaborate incandescent-lighting displays at the 1893 Chicago World's Fair.<sup>20</sup> Thomson-Houston welcomed the decision, because Coffin was confident that he could negotiate a patent agreement with Edison General. As Coffin wrote to Henry L. Higginson:

we believe the decision [sustaining Edison's patent] to be better for our interests than it would be to have the invention thrown open to the public, as we can far better afford to arrange with the Edison Co. than to compete with the fifty or more smaller manufacturers.<sup>21</sup>

Rather than giving one firm a decisive advantage over the others, patent litigation among the major firms served other purposes. It permitted them to weaken and absorb smaller firms, and it allowed one firm to force short-term changes on another. Most important, litigation demanded substantial amounts of time and money; by attacking Thomson-Houston and Westinghouse, the Edison organization hoped to force its competitors to divert resources away from further improvements in their organizational capabilities.

Along with patent litigation, the leading firms mounted publicity campaigns attacking each other. One example of this fifth tactic is how Westinghouse interfered with Thomson-Houston's efforts to secure a revised corporate charter. In late 1888, Thomson-Houston decided to amend its charter in order to enlarge its authorized capitalization and secure the right to manufacture and sell street-railway equipment. Because the company was chartered in Connecticut, Thomson-Houston had to petition the state legislature for a special act. In the course of all that effort, pro-Westinghouse interests vigorously opposed the bill, with the goal of preventing Thomson-Houston from entering the railway field and competing with Westinghouse. During the legislative struggle, Edward H. Johnson of the Edison organization wrote to Coffin, stating that he considered the Westinghouse action unfair and offering to help Thomson-Houston fight Westinghouse on the matter. With this assistance, Thomson-Houston secured its revised charter in 1889.<sup>22</sup> Clearly, this episode reveals the range of tactics that the major firms were willing to employ to prevent competitors from gaining any advantage.

By far the most significant publicity campaign was that mounted by the Edison organization attacking Westinghouse and alternating current.<sup>23</sup> Although Edison and his laboratory staff at West Orange were capable of designing ac lighting and power systems, Edison chose not to do so because he believed that power losses in the available transformers made such a system uneconomical.<sup>24</sup> Instead, Edison concentrated on improving the efficiency of his dc system, in the belief that the Edison organization would attract more customers as the cost of lighting decreased.<sup>25</sup> However, as both Westinghouse and Thomson-Houston began installing high-voltage ac plants, the Edison organization found itself unable to secure contracts in towns and cities with low population densities. (Because of the high cost of copper mains, the Edison system was economical only in populous urban districts where copper costs could be spread across a large customer base.) Edison managers became especially frustrated in the late 1880s when they came to believe that Westinghouse had beaten them on major contracts in Denver and Minneapolis by submitting unrealistically low bids.<sup>26</sup> Feeling that Westinghouse had already acted unethically, Francis S. Hastings, treasurer of the Edison Electric Light Company, launched a publicity campaign depicting ac and the "death current."<sup>27</sup> In doing so, he enlisted several allies who had already begun to question the safety of ac systems. Those allies included Harold P. Brown, a consulting electrical engineer who had already tangled with Westinghouse, and a group of New York City physicians who were investigating electrocution as an alternative form of capital punishment. Working through Brown and the physicians, the Edison organization whipped up public hysteria about the dangers of alternating current and surreptitiously arranged for it to be used in the first electrocution at Sing Sing prison in 1890. The Edison group also tried to convince several state legislatures



to limit the maximum voltage of electrical systems to 300 volts, and they came very close to securing such legislation in Ohio and Virginia.<sup>28</sup>

The “battle of the systems” between Edison and Westinghouse gradually ended as Thomson, Charles Steinmetz, and other engineers improved the safety of ac systems, increased the efficiency of transformers, and introduced rotary converters to link ac and dc systems.<sup>29</sup> In addition, many central-station customers installed ac systems because it allowed them to distribute electricity over greater areas and thus serve more consumers. Yet the battle was significant as another facet of the struggle among leading firms to maintain their organizational capabilities.

Through these five tactics—competing for contracts, integrating forward into central-station development, absorbing minor firms, patent litigation, and publicity attacks—the major players struggled to sustain and improve their positions in the industry. Notably, when considered together, these five tactics suggest differences in the levels of organizational capability of the leading firms. Thomson-Houston and Westinghouse concentrated on improving their organizational capabilities by adding resources (such as buying minor firms or enlarging factories) and by making special efforts to coordinate these resources (such as arranging for in-house inventors to work on key products). Of course, Thomson-Houston went even further than Westinghouse in terms of organization building by developing a national sales network and a managerial hierarchy. In contrast, Edison General appears to have focused its efforts less on building its organizational capability and more on shaping the marketplace. Rather than improve the internal coordination of resources, Edison General chose to engage in price competition, patent litigation, and, ultimately, a major publicity attack on Westinghouse. To some extent, Edison General may have pursued these tactics because they appealed to Edison, but in general, the key decisions in this company were made by Insull, Hastings, and other professional managers. Although it may seem obvious to us that a policy of building organizational capability will lead to long-term growth, we must keep in mind that the Edison managers were among the first to be faced with the challenge of building a large, well-coordinated manufacturing firm, and they did not necessarily see what is obvious to us in hindsight. Instead, they framed a policy that made sense to them, based on their own business experience.<sup>30</sup>

Another important point is that these tactics required substantial amounts of capital, especially for the acquisition of small firms and patent litigation. Yet electrical manufacturing was already a capital-intensive business, requiring enormous amounts of money to develop full product lines, build major factories, and establish national sales networks. As Villard wrote to Drexel, Morgan & Co. in March 1890:

the general business of the Edison General Electric Company is growing at a rate that is equally surprising and gratifying. This growth has rendered the provision for working capital made upon the organization of the Company entirely inadequate. Instead of one million, several millions are imperatively wanted to meet the current demands of the several manufacturing departments.<sup>31</sup>

Already a capital-intensive business, competition made the electrical industry even more unstable financially in the early 1890s.

## The Search for Capital

The major electrical manufacturers found themselves in precarious positions because they had become capital-intensive enterprises prior to the development of capital markets suited to large-scale industrial expansion. Before 1890, individuals tended to invest surplus capital in real estate, and the stock exchanges in New York and other cities dealt only in railroad securities. Most manufacturing enterprises were private partnerships that did not offer stocks or bonds for sale to the general public. The exceptions to this pattern were the New England textile mills, which marketed securities through two Boston brokerage houses (Lee, Higginson & Co. and Kidder, Peabody). As a result, many manufacturers found it difficult to secure capital for expansion. Frequently, their only recourse was to borrow short-term money from commercial banks for long-term investment in plants and repay the loans out of large immediate earnings. Such a strategy was adequate in a period of economic expansion, but it often led to bankruptcy when business conditions worsened. Partly in response to the lack of available capital, firms in other capital-intensive industries (e.g., sugar refining, whiskey distilling, lead smelting) developed "trusts" in the late 1880s as a means of pooling capital and ownership.<sup>32</sup>

Thomson-Houston secured ample capital for expansion and competition by allying itself with the Boston brokerage house of Lee, Higginson & Co. Headed by Henry L. Higginson, this firm had made its fortune through the promotion of the Calumet & Hecla copper mines of northern Michigan. Building on that experience, Higginson specialized in the development of industrial securities. Higginson probably became associated with Thomson-Houston when the firm introduced its "trust series" for reselling central-station bonds. In 1889, Higginson helped Thomson-Houston offer one of the first industrial issues of preferred stock. (Preferred stock issues were popular with conservative investors, because dividends were paid on preferred shares before common shares.) By the early 1890s Higginson was assisting Thomson-Houston in raising money for takeovers, selling large blocks of Northwest Thomson-Houston stock, and financing street-railway companies. To facilitate these financial efforts, Coffin corresponded regularly with Higginson, sharing market data and consulting about strategy.<sup>33</sup>

Neither Edison General nor Westinghouse had a similar alliance with a powerful investment house that provided a steady flow of capital. In building up the Schenectady works for Edison General, Insull doubled the value of the plant from \$750,000 to \$1.5 million, but only by juggling numerous short-term loans and operating with a cash holding of less than \$10,000. Drexel, Morgan & Co. did lend money to Edison General, but the Morgan partners were more interested in investing in Edison central stations in New York and Boston than in improving the factories.<sup>34</sup> Insull and Villard probably intended to expand operations by plowing back profits, but that proved difficult because Edison General accepted so much utility stock as payment for central-station equipment. In the fall of 1890, with the passage of the Sherman Silver Purchase Act and the failure of the London brokerage house of Baring Brothers, the German bankers lost confidence in Villard and recalled their loans to Edison General. These developments weakened Edison General and completely crippled the North American Company. In response, Villard ordered Insull to sell

equipment only for cash or short-term credit, and in January 1891 he decided to raise \$3 million through a new stock issue.<sup>35</sup>

Westinghouse also faced the problem of earning enough to pay off its short-term loans, and this problem nearly bankrupted the company. Thanks to the company's innovative ac equipment, Westinghouse annual sales jumped from \$800,000 in 1887 to \$4 million in 1890. As sales boomed, though, Westinghouse had to develop an engineering staff and enlarge its factories. At the same time, Westinghouse joined the other major firms in buying out smaller companies and engaging in vigorous patent litigation. Amazed by his rival's bold and rapid growth, Edison commented in 1889 that

[George Westinghouse's] methods of doing business lately are such that it cannot be accounted for on any other grounds than the man has gone crazy over the sudden accession of wealth, or something unknown to me, and is flying a kite that will land him sooner or later in the mud.<sup>36</sup>

Westinghouse partly financed this expansion by advancing the company \$1.2 million of his own money, but he also borrowed heavily. By mid-1890, the firm was carrying \$3 million in short-term liabilities, when its total assets were \$11 million and its current assets \$2.5 million. As with Edison General, disaster struck in November 1890 with the failure of Baring Brothers, and Westinghouse's creditors called in their loans. In response, Westinghouse proposed to reorganize the company and double its capital stock, but investors failed to take up the new issue. Westinghouse next asked Pittsburgh bankers for an immediate loan of \$500,000; however, they insisted that Westinghouse relinquish control of the company, and Westinghouse refused. In desperation, Westinghouse turned to the New York brokerage house of August Belmont. With the help of Higginson, Belmont set up a committee of powerful investors who reorganized the firm. Viewing Westinghouse as "a bright & fertile mechanic" who lacked both tact and an understanding of high finance, the committee initially tried to circumscribe his power. However, drawing on his friendship with committee member Charles Francis Adams, Jr., Westinghouse persuaded the committee to let him to continue as president.<sup>37</sup>

### Cooperation and Consolidation

Concerned about their continuing problems in raising capital, the top management of the electrical companies concluded that relentless competition might well be fatal for all of their firms. Consequently, Villard early on investigated the possibility of cooperation among the three firms. Perhaps drawing on his extensive experience in Wall Street maneuvers, Villard shrewdly established relationships with both Westinghouse and Coffin. At first, Villard simply exchanged information on production, sales, and earnings with each man, but soon he was attempting to negotiate a patent agreement with Westinghouse and fix contract bids with Coffin. For instance, in February 1889, Villard and Coffin agreed that Sprague would not bid on a street-railway contract in Washington, D.C., provided that Thomson-Houston not compete

for a railway contract in Richmond, Virginia. Similarly, in 1891, Villard sent an Edison General manager to meet with Coffin to negotiate the bids that Edison General and Thomson-Houston would submit for four street-railway contracts. Charles Fairchild, a Higginson partner, estimated that those negotiations saved the two companies \$1.5 million, leading him to conclude that “the Co[mpanie]s in harmony get that much more than they would in Competition.”<sup>38</sup> Although Villard had little success in cultivating a relationship with Westinghouse, such behind-the-scenes negotiations appealed to Coffin and helped establish rapport between Edison General and Thomson-Houston.

As Villard pursued a policy of cooperation, Coffin boldly proposed consolidation. In March 1889, just as Edison General was being organized, Coffin outlined a possible merger, arguing that continued competition and patent litigation would ruin both Edison General and Thomson-Houston. Coffin may have suggested that a larger consolidated company could work with Higginson to secure ample capital. Although Villard politely declined the proposal on the grounds it would be difficult to convert Edison General’s stock to match that of Thomson-Houston, he let Edison demolish Coffin’s plan. Enraged by the audacity that Thomson-Houston would even think of taking over his company, Edison attacked Thomson-Houston as “amateurs” who had “boldly appropriated and infringed every patent we use.” As far as Edison was personally concerned, a merger would mean that “my usefulness as an inventor is gone. My services wouldn’t be worth a penny. I can only invent under powerful incentive. No competition means no invention.” Instead, Edison believed that the best policy for Edison General would be to reduce the cost of electric lighting through more efficient products and better manufacturing techniques.<sup>39</sup>

Although Edison still believed in competition, Higginson and the other investors came to agree with the managers that consolidation offered the only means of protecting their substantial investment in the electrical companies. J. P. Morgan was especially concerned with how much capital was required by the electrical manufacturers, but at the same time he was uncertain as to how Edison General and Thomson-Houston might be joined. As he observed to Higginson in February 1891:

regarding Thomson-Houston, I do not think it worth while to run two establishments. The Edison system affords us all the use of time and capital that I think desirable to use in one channel. If, as would seem to be the case, you have the control of the Thomson-Houston, we will see which will make the best result. I do not see myself how the two things can be brought together, certainly not on any such basis as was talked about a year or more ago.<sup>40</sup>

Just as railroad leaders and financiers had concluded a few years earlier that competition and cooperation had to give way to consolidation, so the electrical manufacturers and their financiers were coming to realize that the competitive tactics of takeovers, patent litigation, and the creation of central-station subsidiaries were proving costly and ineffective. It seemed obvious to both the managers and bankers that their only way to manufacture and market electrical equipment profitably was to concentrate the necessary resources in a single firm. “What we all want,” wrote Charles Fairchild, a Higginson partner, in July 1891, “is the union of the large Elec-

trical Companies.” Accordingly, during the reorganization of Westinghouse, Belmont and Fairchild attempted to arrange for Thomson-Houston to take control of the troubled Pittsburgh firm. That merger attempt failed not only because Westinghouse persuaded the committee that he should remain as president but also because Coffin antagonized the reorganization committee by letting it be known that he preferred to see Westinghouse fail.<sup>41</sup>

### **The Creation of General Electric**

Unable to bring Thomson-Houston and Westinghouse together, Higginson and Fairchild encouraged Coffin and Villard to investigate combining their two companies. Villard and Coffin continued to exchange information on street-railway contracts and technology, and in February 1891 Villard visited the Thomson-Houston factory in Lynn. During the next eight months, little progress was made toward consolidation, perhaps because Villard may have felt more confident after winning a favorable decision in the litigation over the lamp patent in June. In the meantime, though, Thomson-Houston was beating Edison General in the marketplace, or, as Coffin boasted, “he is knocking the stuffing out of them all along the line.” For 1891, Thomson-Houston had total sales of \$10 million, and \$2.7 million in profits, whereas Edison General had sales of \$11 million and profits of only \$1.4 million.<sup>42</sup>

Such marketplace performance may finally have brought Edison General to the bargaining table. Perhaps the major stockholders realized that although Edison General possessed substantial resources—large factories, a national sales network, and access to Edison’s laboratory—Insull and the firm’s top managers had not succeeded in creating an effective organization. Consequently, in early 1892, Coffin and Fish began negotiating a merger with Hamilton McKay Twombly, a Morgan associate who represented Edison General. The negotiations focused on the issue that Villard had raised in 1889, namely, the exchange of Edison and Thomson-Houston shares. Even though Thomson-Houston had earned 50 percent more per share than Edison General in 1891, Fairchild recommended that Coffin offer to assign a higher value to the Edison shares because “for the sake of union T-H can afford to give them a good trade.” Coffin proposed that three common shares of Thomson-Houston be converted to five shares of the new company, with Edison General shares being converted one-to-one. That offer was accepted in February 1892, and a committee consisting of Twombly, J. P. Morgan, D. O. Mills, Frederick L. Ames, T. Jefferson Coolidge, and Higginson was organized to handle the exchange of stock and the creation of the new company. That committee met in March, and at Coffin’s suggestion it secured a charter from the state of New York creating the General Electric Company (GE) on April 15, 1892<sup>43</sup> (Fig. 1).

General Electric was capitalized at \$50 million; after U.S. Leather, it was the second largest merger prior to the financial panic of 1893. GE’s board of directors consisted of six bankers, two Thomson-Houston men, and two Edison men, with Twombly as the chairman. The bankers included Morgan and his associates Charles H. Coster and Mills, and Higginson was joined by Boston financiers Coolidge and Ames. Representing Thomson-Houston were Coffin and Eugene Griffin, and they

were balanced by Edison and Hastings. Thomson was also offered a directorship, but he declined it because he believed that it would keep him from his work as an inventor. Coffin was named president of the new company, and he selected most of his top managers from Thomson-Houston. The only Edison man to receive a major post was Insull, who was offered the position of second vice president; however, he chose to move to the presidency of Commonwealth Edison in Chicago.<sup>44</sup>

There were several reasons why GE was dominated by Coffin and Thomson-Houston men, not by Edison and his associates. First, at the time of the merger, Thomson-Houston was the more successful firm; in 1891, Thomson-Houston earned a return on capital of 26 percent, while Edison General earned only 11 percent. Anxious to see such profits continue, Higginson decided that Coffin and his associates should run the new company. Second, the other likely candidate for the presidency of GE, Villard, was not acceptable to the bankers. Involved in several business ventures (including the presidency of the Northern Pacific Railroad), Villard had had little to do with the management of Edison General. Moreover, his credibility had been severely damaged by the collapse of North American in the fall of 1890. Preoccupied with troubles on the Northern Pacific and campaigning for repeal of the Sherman Silver Purchase Act, Villard resigned as president of Edison General in February 1892. Thus, contrary to the claims of other historians, Villard played no part in the GE merger.<sup>45</sup> And finally, it had been Coffin, Higginson, and Fairchild—not Villard or Morgan—who had pushed through the merger. They had been seeking such a consolidation since 1889, and they took the lead in the negotiations. Consequently, Coffin and the Boston investors reaped the rewards of consolidation.

One might well ask why Westinghouse was not included in the merger of Edison General and Thomson-Houston. Higginson and Fairchild had participated in the reorganization of Westinghouse in 1891 and had hoped at that time to combine all three firms. It appears that such a merger was not possible because of the personal characteristics of George Westinghouse. Although the Boston bankers admired him as an engineer and entrepreneur, they questioned his understanding of finance and his ability to negotiate. As Fairchild explained:

whatever power Westinghouse has, and I grant that it is great, is mechanical. His forte is the arrangement & control of a factory & in dealing with the practical problems. He is not a financier & he is not a negotiator. . . . What we all want is the union of the large Electrical Companies, and to bring this about will require skill & tact in the management of competing business as well as able negotiations when the time comes to trade. The final step will be to build up a disposition to trade—a willingness—Westinghouse cannot possibly do this. He irritates his rivals beyond endurance.<sup>46</sup>

Westinghouse particularly irritated his rival Coffin. Like the Edison managers, Coffin did not like the Westinghouse Company's "attitude of bitter and hostile competition"—an attitude reflected in the Pittsburgh firm's low bids on equipment contracts. Further, during the 1880s, when Thomson-Houston and Westinghouse shared the Sawyer-Man patents through the Consolidated Electric Light Company, Coffin felt that Westinghouse had been obstinate and difficult. At the same time, Westinghouse had little love for Coffin. Anecdotal evidence reveals that Westinghouse saw

Coffin as an aggressive wheeler-dealer who “will make a man about ten different propositions in ten minutes.” Westinghouse had built up his business on the basis of engineering and manufacturing, and he had little respect for Coffin’s understanding of marketing, finance, and organization building. Consequently, Westinghouse made it quite clear that he would not work with any electrical combination headed by Coffin.<sup>47</sup> Knowing of the animosity that had arisen between the two men, Higginson and Morgan probably decided that it was best not to attempt to include Westinghouse in the GE merger.

From another perspective, the Westinghouse Company may have been left out because it lacked a managerial hierarchy. Both the Edison and Thomson-Houston organizations had managerial and engineering staffs whose members could talk to each other. Ostensibly in competition, these staffs had been known to cooperate at times. As we have seen, Edison managers helped Thomson-Houston fight off Westinghouse and secure a revised corporate charter in 1888–1889. Under Villard’s encouragement, Edison General and Thomson-Houston managers and salespeople had exchanged information about street-railway contracts. Although communications between the staffs of the two companies certainly did not cause the merger, such communications may have signaled to Higginson and Twombly that the combination of Edison General and Thomson-Houston would be feasible. In contrast, because George Westinghouse made most of the key decisions, the Westinghouse Company lacked a similar cadre of managers and engineers who might have interacted with their peers at Edison General or Thomson-Houston. Thus, there was no communications or managerial momentum to encourage the inclusion of Westinghouse in the merger.<sup>48</sup>

## Conclusion

In his study of the electrical industry, Harold C. Passer argued that the formation of GE could be attributed to the patent situation and the desire of Thomson-Houston and Edison General to diversify their product lines.<sup>49</sup> As the foregoing narrative reveals, neither factor was as significant as Passer suggested. Although the ongoing patent litigation was costly, it had not created an impasse that could be resolved only by consolidation. Even though the court had found in favor of Edison in the incandescent-lamp case, both Westinghouse and Thomson-Houston had found ways to work around the Edison patent. Likewise, product diversification was not a major issue. To be sure, Edison General had focused on dc incandescent lights and motors, whereas Thomson-Houston had specialized in arc lighting and ac systems. However, through takeovers, patent agreements, and in-house research, both firms had taken steps to diversify their full product lines prior to the merger. Although it is not generally known, Edison’s associates at West Orange experimented extensively with alternating current, high-voltage dc transmission, and rotary converters, all for the purpose of developing an alternative to their competitor’s ac systems. Thus, neither patents nor incomplete product lines determined the creation of GE.

Instead, GE was the result of three other factors: the desire to eliminate competition, the problem of raising sufficient capital for a capital-intensive industry, and

the efforts of managers and investors to maintain organizational capability. As we have seen, Thomson-Houston, Edison General, and Westinghouse competed fiercely between 1889 and 1892. Using a variety of tactics—new products, integrating forward into central-station construction and management, publicity campaigns, and patent litigation—each firm tried to expand its share of the market and increase its profits. However, whereas Edison and George Westinghouse firmly believed that such competition would lead to the survival of the fittest, Coffin, Villard, and their financial supporters soon realized that over the long run, competition was a poor use of resources and would lead to diminishing returns. Although the three firms could have continued to attack each other in the marketplace, the courts, and the technical and popular press, such attacks would have consumed capital and resources that could be better spent developing new products and improving manufacturing techniques. Well aware of the problems of competition, Coffin and Higginson chose to minimize it by merging with their chief rival, Edison General.<sup>50</sup>

The problem of competition in the electrical industry was compounded by the difficulties of raising capital for industrial enterprises in the late 1880s and early 1890s. The electrical manufacturing industry was created just as investors and bankers were developing the mechanisms for providing large amounts of risk capital for industry. Indeed, both Edison General and Westinghouse were caught in the trap of trying to build organizations appropriate for the scale and scope of electrical technology while employing the existing financial practice of borrowing short-term money. In my opinion, Higginson and Coffin saw this difficulty, solved it for Thomson-Houston, and then decided that the long-term solution was to create an even larger company. A large firm would be more profitable because it could take advantage of economies of scale (such as larger factories) and economies of scope (by manufacturing several closely related products). By exploiting such economies, the large firm should have a higher rate of return than several smaller firms and hence be more attractive to investors. Thus, the creation of GE was a response to the problems of raising sufficient capital in a capital-intensive industry.

Closely related to the problem of raising capital was the third factor of maintaining organizational capability. As the industry's pioneers, Coffin, Villard, and Westinghouse had struggled to build large factories, organize sales forces, develop full product lines, and create managerial hierarchies to coordinate production and distribution; in short, they had brought together the resources necessary to compete effectively. Once they had assembled their resources, those managers were loathe to let anyone or anything harm their organizational capability; indeed, they were anxious to utilize and expand their resources in pursuit of greater profits and market share. To build organizational capability, however, managers had to borrow heavily, and thus financiers such as Higginson and Morgan came to have a significant stake in those companies. Consequently, whereas the three firms competed and tried informal cooperation, eventually it became clear to both the managers and their bankers that the most promising way to sustain organizational capability was through consolidation.

The creation of General Electric in 1892 offers several lessons which we can use for thinking about competition, consolidation, and the American economy in the 1990s. First, while it is tempting to assume that impersonal market forces shape



the course of competition and consolidation, the GE episode reveals that individuals and their personalities influence the level of competition and the timing of mergers. Clearly, both Westinghouse and Edison believed in fierce competition, and they actively encouraged their respective organizations to challenge each other in terms of price, product, and publicity. Likewise, Westinghouse's personality was a factor in the consolidation process, leading Coffin and Higginson to choose to leave his company out of the GE merger. In the contemporary setting, we still see individuals playing prominent roles in shaping events, whether it be Bill Gates at Microsoft or Frank Lorenzo at Texas Air. Hence any economic or social analysis of competition and consolidation must take the personalities of the entrepreneurs into account.

Second, not only do firms compete in terms of price and product, they also struggle to find sources of capital. As I have suggested in the preceding, Coffin and Thomson-Houston were victorious in the battle with Edison General and Westinghouse because they were able to raise more capital. Through their alliance with Higginson, Thomson-Houston was able to secure the capital needed to enlarge their factories, buy out their smaller competitors, set up a construction subsidiary, and extend credit to its customers. In contrast, Edison General and Westinghouse never secured the support of bankers who were able to supply them with the capital needed to undertake all of these activities. Looking at the history of electronics, we see that the need for capital continues to define the dual processes of competition and consolidation. In its early years, the challenge for the semiconductor industry was to find the capital needed to build high-volume production facilities, and the successful firms were those who could attract the necessary investment. Likewise, it has been suggested that the rapid development of high-tech firms on Route 128 outside Boston was as much the result of New England bankers willing to invest in electronics and computer firms as it was in the ready supply of engineers and scientists in the region. Hence, while it is obvious that the availability of capital shapes the level of competition in an industry, we seem to pay scant attention to this factor in both our historical and policy musings.<sup>51</sup>

Third, the case of GE also provides insight into what makes a firm a successful competitor. Of the three firms discussed here, Thomson-Houston was clearly the most effective, and I would argue that its strength came from doing two things well. First, this company worked to match its product line to the needs of its customers. Not only did Thomson-Houston offer a full range of lighting and streetcar systems to its customers but it also provided the necessary services of installation and credit. Second, in order to design, manufacture, and market these systems, the company developed the necessary organizational arrangements that allowed for the coordination of these functions. By creating a team of managers and engineers that could perform all of the tasks related to the production and marketing of central-station systems, Thomson-Houston was able to compete and surpass both Edison General and Westinghouse. For today, I think the lesson of Thomson-Houston's organizational strength should be quite clear; although we tend to think of the ideal competitor as a firm with a good product, low prices, or low production costs, we should pay more attention to those firms that have the right organizational structure for the tasks that need to be done.

In the final analysis, I would argue that any discussion of technology and competitiveness must consider the dual processes of competition and consolidation. Yes, at times, it is desirable for American industries to have numerous firms, competing in terms of product, process, and price. However, at other times, the success of American business is that competition gives way to firms capable of mass production and mass distribution, firms whose hallmark is the ability to achieve substantial economies of scale and scope. For both the historian and businessperson, the challenge is to understand how competition and consolidation are part of the heritage of American business and how both will continue to shape our future.

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### Notes

1. For an indication of the significance of consolidation for the American economy in the 1990s, see “The age of consolidation,” *Bus. Week*, October 14, 1991, pp. 86–94. This article was the cover story during the week of the IEEE Conference on Competitiveness.
2. For a concise overview of nineteenth-century American business, consult Louis Galambos and Joseph Pratt, *The Rise of the Corporate Commonwealth: United States Business and Public Policy in the 20th Century* (New York: Basic Books, 1988), pp. 17–37.
3. Alfred D. Chandler, Jr., *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, Mass.: Harvard Univ. Press, 1977) and *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, Mass.: Harvard Univ. Press, 1990).
4. Lance Davis, “The capital markets and industrial concentration: The U.S. and U.K., a comparative study,” *Econ. Hist. Rev.*, Vol. 19, 1966, pp. 255–272.
5. Chandler, *Scale and Scope*, op. cit., pp. 24–34, and William Lazonick, “Organizational capability and technological change in comparative perspective,” paper presented to the Business History Seminar, Harvard Business School, Boston, March 1987.
6. My thinking about the key characteristics of the three leading firms has been influenced by Chandler’s discussion of a first-mover firm in *Scale and Scope*, p. 34–35.
7. W. Bernard Carlson, *Innovation as a Social Process: Elihu Thomson and the Rise of General Electric, 1870–1900* (New York: Cambridge Univ. Press, 1991), pp. 203–270.
8. On the formation of Edison General Electric, see Forrest McDonald, *Insull* (Univ. of Chicago Press, 1962), pp. 39–42; Dietrich G. Buss, *Henry Villard: A Study of Transatlantic Investment and Interests 1870–1895* (New York: Arno, 1978), pp. 207–210; and Harold C. Passer, “Development of large-scale organization: Electrical manufacturing around 1900,” *J. Econ. Hist.* Vol. 12, Fall 1952, pp. 378–395, especially pp. 380–381. Edison’s role in organizing the management of Edison General is suggested by an undated list of

men, titles, and assignments in 1886 electric lighting, Edison United Manufacturing Co. folder, Edison National Historic Site, West Orange, N.J. (hereafter cited as ENHS). During the late 1880s, Edison raised the efficiency of his dc system by developing a new multipolar dynamo, a five-wire distribution network, high-voltage dc distribution using a rotary converter, a new meter, and a 200-volt incandescent lamp for street lighting. See Edison General Electric Company, "Central station lighting," February 1892, Trade Catalog Collection, Archives and Library, Henry Ford Museum, Dearborn, Mich.; Edison, [notes on multiwire systems], October 5, 1889, notebook N870902, ENHS; A. E. Kennelly, "Calculation for the dimensions of a commutating continuous transformer of 100 light capacity," notebook N880828, ENHS; Edison, "Induction-converter," U.S. Patent No. 534,28 (filed May 21, 1888, granted February 12, 1895); and "The new Edison municipal lamp," *Electr. World*, Vol. 11, February 18, 1888, p. 74. On Edison's plans for a street railway, see J. C. Henderson to Villard, June 27, 1890, box 63, folder 473, Henry Villard Papers, Baker Library, Harvard University Graduate School of Business Administration, Boston.

9. Passer, "Development of large-scale organization," op. cit., pp. 389–392.
10. These bids came from a telegraph message Villard sent to Coffin. In that message, Villard accused Coffin of submitting an "unreasonably low" bid and proposed that if Thomson-Houston withdrew its bid, then Edison General would give it one-third of the contract's net profits. See Villard to Clark, Dodge & Co., May 21, 1890, box 127, Letterbook 167, p. 235, Villard Papers.
11. Edison was quite adamant that his manufacturing companies cut component prices in order to gain market share; see "Mr. Edison's reply to Thomson-Houston memoranda of March 23d, 1889," box 673, folder 472, Villard Papers. As examples, the Edison organization reduced the price of incandescent lamps from \$1 in 1886 to \$0.44 in 1891, and it sold streetcar motors for under \$1500 when manufacturing costs would have dictated a price over \$1600. See McDonald, *Insull*, op. cit., p. 42; and Arthur Pound and Samuel Taylor Moore, eds., *More They Told Barron: Conversations and Revelations of an American Peeps in Wall Street* (New York: Harper, 1931), p. 38.
12. Coffin's quotation is from Pound and Moore, *More They Told Barron*, p. 37. For an informed discussion of the economics of network technologies, see Paul A. David, "The hero and the herd in technological history: Reflections of Thomas Edison and the 'Battle of the Systems'," publication No. 100, July 1987, Center for Economic Policy Research, Stanford University, especially pp. 9–13.
13. Forrest McDonald, *Let There Be Light: The Electric Utility Industry in Wisconsin, 1881–1955* (Madison, Wis.: American History Research Center, 1957), pp. 21–22; T. Commerford Martin and Stephen Leidy Coles, *The Story of Electricity* (New York: Story of Electricity Company, 1919), p. 137.
14. On the formation of the North American Company, see Buss, *Villard*, pp. 215–217. The quotation is from McDonald, *Insull*, p. 42. For a description of its operations in Milwaukee, see McDonald, *Let There Be Light*, pp. 51–55.
15. Elihu Thomson to Charles A. Coffin, December 20, 1892, Letterbook 1/1/92–3/29/93, pp. 775–759, Thomson Papers; Harold C. Passer, *The Electrical Manufacturers: A Study in Competition, Entrepreneurship, Technical Change, and Economic Growth* (Cambridge, Mass.: Harvard Univ. Press, 1953), pp. 52–57, 103, 147; Arthur A. Bright, Jr., *The Electric-Lamp Industry: Technological Change and Economic Development from 1800 to 1947* (New York: Macmillan, 1949), pp. 80–83.
16. To the best of my knowledge, no historian has analyzed the role of patents in the relationship between electrical manufacturers and utility companies. In narrating the

- problems GE encountered in the early 1890s with former Edison licensees, George Wise suggested that the licensees expected that the patents would convey monopoly power to them; see his "History of General Electric" (unpublished ms.), chap. 3, "Shoemakers," pp. 104–107. Additional information about the relationship between the Edison organization and its licensees can be found in A. Michal McMahon, *Reflections: A Centennial Essay on the Association of Edison Illuminating Companies* (New York: Association of Edison Illuminating Companies, 1985), pp. 13–17.
17. Bright, *The Electric-Lamp Industry*, op. cit., pp. 86–87; Passer, *The Electrical Manufacturers*, op. cit., p. 144.
  18. Bright, *The Electric-Lamp Industry*, op. cit., pp. 87–88; John Winthrop Hammond, *Men and Volts: The Story of General Electric* (Philadelphia: Lippincott, 1941), pp. 180–187.
  19. For examples of how historians have interpreted the lamp decision as giving Edison General the decisive edge, see McDonald, *Insull*, p. 48; and Hammond, *Men and Volts*, p. 192.
  20. On the Westinghouse stopper lamp, see Passer, *The Electrical Manufacturers*, pp. 142–143. According to Thomson, although those lamps avoided conflict with the Edison patent, they worked very poorly, and Westinghouse used as few of them as possible in the lighting displays at the Chicago fair; see Elihu Thomson to Charles A. Coffin, June 19, 1893, Letterbook 3/93–4/95, pp. 132–133, Thomson Papers.
  21. Charles A. Coffin to Henry L. Higginson, July 15, 1891, Henry L. Higginson Papers, Baker Library, Harvard University Graduate School of Business Administration, Boston, box XII-3, folder 1891, Charles A. Coffin.
  22. Untitled lecture on the history of Thomson-Houston and General Electric, Hammond File, 6290–6392, especially 6350–1.
  23. Among the more useful accounts of the "battle of the systems" are the following: Passer, *The Electrical Manufacturers*, op. cit., pp. 164–175; Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore, Md.: Johns Hopkins Univ. Press, 1983), pp. 106–139; Paul A. David and Julie Ann Bunn, "The economics of gateway technologies and network evolution: Lessons from electricity supply history," *Inform. Econ. Policy*, Vol. 3, 1988, pp. 165–202; W. Bernard Carlson and A. J. Millard, "Defining risk within a business context: Thomas A. Edison, Elihu Thomson, and the AC-DC controversy, 1885–1900," in eds. V. Covello and B. B. Johnson, *The Social and Cultural Construction of Risk* (Boston: Reidel, 1987), pp. 275–293.
  24. Despite the claims of various Edison biographers, Edison's notebooks and caveats reveal that he did understand alternating current and that he sketched a number of ac generators, transformers, and distribution networks. See Edison, "New idea—The whole system as a transformer" (sketch), November 22, 1887, notebook N87115, ENHS; and caveat No. 117, November 2, 1889 (Cat. 1141), ENHS. Edison also encouraged Arthur E. Kennelly and his other experimenters to test ac machinery at West Orange; see Kennelly Notebooks, Vol. 1, ENHS. On the basis of that research, Edison filed for several patents for ac systems, see "System of electrical distribution," U.S. Patent No. 438,308 (filed December 6, 1886, granted October 14, 1890); "System of electrical distribution," U.S. Patent No. 524,378 (filed December 6, 1886, granted August 14, 1894); "Alternating current generator," U.S. Patent No. 470,928 (filed August 25, 1891, granted March 15, 1892).

However, as Edison studied alternating current, he grew suspicious. He was troubled by power losses in transformers, which he found to be at minimum 7 to 12 percent.

- “Evidently this results in a great diminution of the profits of the business,” he observed in “System of electrical distribution,” U.S. Patent No. 382,415 (filed December 27, 1887, granted May 8, 1888). See also Edison to Villard, February 8, 1890, box 63, folder 473, Villard Papers. Furthermore, Edison was concerned about the costs of building ac generating stations. Westinghouse claimed that a major advantage of ac was that one could erect a large plant that could generate cheap power on the outskirts of a city. Familiar with the difficulties of raising capital to build his own dc stations, Edison believed that large ac plants would cost too much money to construct and that the interest charges on the investment would eliminate any operating profits. See Edison to H. Villard, December 11, 1888, Letterbook 881112, p. 354, ENHS. Finally, Edison was distressed by the problem of properly insulating ac wires. He and his men were having enough difficulty finding good insulation for their low-voltage system, and he doubted that he could find insulation for a 1000-volt line and its transformers. See Edison, “Reasons against an alternating converter system,” notebook N860428, pp. 261–265, ENHS. For all those reasons, Edison concluded that “the use of the alternating current is unworthy of practical men.” See Edison to H. Villard, February 24, 1891, box 63, folder 475, Villard Papers.
25. Edison summed up his competitive philosophy when he advised a central-station manager: “Try everything you can towards economy. No one is safe in the cold commercial world that can’t produce as low as his greatest competitor. No matter how much money you are making never for an instant let up on economizing.” From Edison note, May 10, 1895, Meadowcroft Papers, box 84, ENHS.
  26. For information suggesting that the Edison organization lost contracts in Denver and Minneapolis to Westinghouse, see “A Warning from the Edison Electric Light Company,” circa 1888, Electricity, box E-5, Warshaw Collection of Business Americana, National Museum of American History, Washington, D.C. This is the famous red-covered pamphlet in which the Edison organization attacked the safety of ac systems. For a description of the technical and financial troubles of the Westinghouse plant in Denver, see W. P. Hancock, “Report on Westinghouse plant of Colorado Electric Company,” 1888 Electric Light-Westinghouse folder, ENHS.
  27. Documents in the Edison archives strongly suggest that it was Francis S. Hastings, not Edison himself, who mounted the attack on Westinghouse and ac systems; see Hasting’s letters to A. E. Kennelly, August 6, 1888, November 20, 1888, and November 26, 1888, in 1888 Edison Electric Light Co., July–December, folder, and 1888 Electrocutation folder, as well as Hastings to Edison, January 21, 1889, in 1889 Electricity-Use folder, ENHS.
  28. On Harold P. Brown, see Thomas P. Hughes, “Harold P. Brown and the executioner’s current: An incident in the AC-DC controversy,” *Bus. Hist. Rev.*, Vol. 32, 1958, 143–165. On the role of the New York physicians in promoting ac electrocution as an alternative to hanging as capital punishment, see Roger Neustadter, “The murderer and the dynamo: Social response to the first legal electrocution in America,” paper presented to the Popular Culture Association, Toronto, Ontario, April 1984.
  29. Hughes, *Networks of Power*, op. cit., pp. 121–129.
  30. Louis Galambos makes a similar point in his essay “The American economy and the re-organization of the sources of knowledge,” in eds. A. Oleson and J. Voss, *The Organization of Knowledge in America, 1860–1920* (Baltimore, Md.: Johns Hopkins Univ. Press, 1979), pp. 269–284, especially p. 275.
  31. Villard to Drexel, Morgan & Co., March 13, 1890, syndicate book 2, pp. 159–60, Archives of The Pierpont Morgan Library, New York.

32. Thomas R. Navin and Marian V. Sears, "The rise of a market for industrial securities, 1887–1902," *Bus. His. Rev.*, Vol. 29, June 1955, pp. 105–138, especially pp. 106–116, 125.
33. On the history of Lee, Higginson, see Navin and Sears, "The market for industrial securities," pp. 116, 125. The relationship between that brokerage house and Thomson-Houston is revealed in various letters in the Higginson Papers. In particular, see the following letters from Charles A. Coffin to Henry L. Higginson: April 18, and September 24, 1890, box XII-2, folder 1890 General; July 13, and October 5, 1891, box XII-3, folder 1891 Charles A. Coffin; February 25, 1892, box XII-3, folder 1892 Charles A. Coffin. See also the following letters between Charles Fairchild and Higginson: January 23, 1890, box XII-2, folder 1890 Fairchild; April 14, and December 28, 1891, box XII-3, folder 1891 Fairchild.
34. On Insull's efforts to juggle short-term loans, see McDonald, *Insull*, p. 38. In September 1891, Drexel, Morgan & Co. loaned Edison General \$1 million by selling Edison General's six-month notes to a syndicate of a dozen banks and investors. See J. P. Morgan to H. Villard, September 9, 1891, and J. P. Morgan to Unger, Smithers & Co., September 11, 1891, Letterbook 1887–1893, pp. 600–602, the Pierpont Morgan Library, New York. See also Vincent P. Carosso, *The Morgans: Private International Bankers, 1854–1913* (Cambridge, Mass.: Harvard Univ. Press, 1987), no. 166, p. 775. Morgan's role in promoting Edison central stations is discussed in "Personal recollections. Edward H. Johnson. Mr. Morgan's contribution to the modern electrical era," November 1914, Herbert Satterlee Papers, box 3, folder A10, The Pierpont Morgan Library, New York.
35. On Villard's fall in 1890, see Henry Villard, *Memoirs of Henry Villard, Journalist and Financier, 1835–1900*, 2 vols. (Westminster: Archibald Constable, 1904), Vol. 2, pp. 342–343, 357–358; and Buss, *Villard*, p. 217. On the Baring crisis, see Charles P. Kindleberger, *Manias, Panics, and Crashes: A History of Financial Crises* (New York: Basic Books, 1978), pp. 153–156. On Villard's new policies for Edison General, see McDonald, *Insull*, p. 49. In response to the failure of North American, Fairchild recommended that Thomson-Houston "disregard the Edison Competition so far as to decline to give special credits in any shape or to take bonds & stocks of local [companies];" see Fairchild to Higginson, November 11, 1890, box XII-2, folder 1890 Fairchild, Higginson Papers.
36. Passer, *The Electrical Manufacturers*, p. 279. Quotation is from Edison note on Edward D. Adams to Edison, February 2, 1889, box 63, folder 472, Villard Papers.
37. For an overview of the financial difficulties encountered by Westinghouse, see Passer, *The Electrical Manufacturers*, p. 279; and Francis E. Leupp, *George Westinghouse: His Life and Achievements* (Boston: Little, Brown, 1918), pp. 157–161. The negotiations between Westinghouse and Belmont are described in letters sent by Charles Fairchild to Higginson; in particular, see letters dated December 30, 1890, February 4, 1891, and undated items in box XII-2, folder 1890 Fairchild, and box XII-3, folder 1891 Fairchild, Higginson Papers. Quotation is from Fairchild to Higginson, May 6, 1891, box XII-3, folder 1891 Charles A. Coffin, Higginson Papers. On the relationship between Charles Francis Adams, Jr., and Westinghouse, see Fairchild to Higginson, July 19, 24, and 26, 1891, box XII-3, folder 1891 Charles A. Coffin, Higginson Papers; and Edward C. Kirkland, *Charles Francis Adams, Jr., 1835–1915: The Patrician at Bay* (Cambridge, Mass.: Harvard Univ. Press, 1965), pp. 175–176.
38. Villard's efforts to cooperate with Coffin and Westinghouse are described in the following letters from Villard: to Westinghouse, December 16, 1889, box 126, Letterbook 64, p. 500; to Westinghouse, February 20, 1890; to Charles A. Coffin, March 5, 1890; to Westinghouse, March 10, 1890; and to Charles A. Coffin, March 25 and 28, 1890; all in

- box 127, Letterbook 66, pp. 74, 111, 144, 299, and 341, respectively, Villard Papers. See also John Muir to Villard, March 31, 1890, box 12, Letterbook 66, pp. 360–362, Villard Papers; and Charles Fairchild to Higginson, n.d., box XII-3, folder 1891 Charles A. Coffin, Higginson Papers. On the Washington and Richmond deal, see Villard to Charles A. Coffin, February 18, 1889, box 126, Letterbook 61, p. 161, Villard Papers. In that deal, Villard got the better contract, because Thomson-Houston was unable to secure permission from the authorities in Washington to use overhead trolley wires and was forced to use expensive storage-battery cars; see Charles A. Coffin to Higginson, June 29, 1891, box XII-3, folder 1891 Charles A. Coffin, Higginson Papers. Quotation is from Charles Fairchild to Higginson, n.d., box XII-3, folder 1891 Charles A. Coffin, Higginson Papers.
39. I have not been able to find Coffin's 1889 merger proposal; consequently, the terms of his proposal must be inferred from "Mr. Edison's reply to Thomson-Houston memoranda of March 23d, 1889," April 1, 1889, box 63, folder 472, Villard Papers. See also Villard to Charles A. Coffin, March 15, 1889, Letterbook 76, p. 381, box 130; and Villard to Charles A. Coffin, April 3, 1889, Letterbook 62, pp. 3–4, box 12, Villard Papers.
  40. Quotation is from J. P. Morgan to Higginson, February 3, 1891, Letterbook 1887–1893, pp. 532–533, the Pierpont Morgan Library, New York, I am grateful to Jean Strouse for calling this letter to my attention.
  41. Alfred D. Chandler, Jr., provided an overview of the consolidation of American railroads in *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, Mass.: Harvard Univ. Press, 1977), pp. 145–171. Quotation is from Fairchild to Higginson, July 24, 1891, box XII-3, folder 1891 Charles A. Coffin, Higginson Papers. On Coffin's antagonistic attitude toward Westinghouse, see Fairchild to Higginson, May 5, 1891; and Charles A. Coffin to Higginson, n.d.; both in box XII-3, folder 1891 Charles A. Coffin, Higginson Papers.
  42. Fairchild to Villard, February 23 and 25, 1890, box 63, folder 473, Villard Papers; Passer, *The Electrical Manufacturers*, p. 322; McDonald, *Insull*, pp. 48–49. Quotation is from Fairchild to Higginson, December 29, 1891, box XII-3, folder 1891 Fairchild, Higginson Papers; profits and sales figures are from "Committee on stock list. New York Stock Exchange. General Electric Co. 31 May 1892," syndicate book 3, 1890–1892, p. 127, The Pierpont Morgan Library, New York.
  43. Thomson recalled that Twombly was initially asked by the Morgan interests to reorganize Edison General and that in doing so he decided that Edison General and Thomson-Houston should be merged; see ET to John W. Howell, January 7, 1930, Woodbury's notes, Collected Letters, Elihu Thomson Papers, Library of the American Philosophical Society, Philadelphia. The course of the negotiations can be gleaned from letters from Charles A. Coffin to Higginson, February 1 and 7, 1892, and two undated notes, box XII-3, folder 1892 Charles A. Coffin, Higginson Papers. Quotation is from Fairchild to Higginson, January 29, 1892, box XII-3, folder 1892 Fairchild. J. P. Morgan does not appear to have played a significant direct role in the negotiations; his principal contribution was in securing the support of a majority of Edison General stockholders. See his letter to Higginson, March 1, 1892, box XII-3, folder 1892 General, H-Q, Higginson Papers. The terms of the stock trade and the organization committee are from "Stockholders' Agreement Appointing Committee," February 8, 1892, syndicate book 3, 1890–2, The Pierpont Morgan Library, New York. The March meeting of the organization committee is mentioned in J. P. Morgan to Higginson, March 1, 1892, folder 1892 General, H-Q; and C. H. Coster to Higginson, March 22, 1892, folder 1892 Coster; both in box XII-3, Higginson Papers. The charter is discussed in Charles A. Coffin to Higginson, March 2, 1892, box XII-3, folder 1892 Charles A. Coffin, Higginson Papers.

44. GE's board of directors and top management: Navin and Sears, "The market for industrial securities," p. 188; Passer, *The Electrical Manufacturers*, p. 322; David O. Woodbury, *Beloved Scientist: Elihu Thomson, A Guiding Spirit of the Electrical Age* (New York: Whittlesey House, 1944; reprinted Cambridge, Mass.: Harvard Univ. Press, 1960), p. 205; McDonald, *Insull*, pp. 51–54.
45. Perhaps impressed with how Villard had organized Edison General, several historians have assumed that he played a part in the creation of GE, only to be squeezed out at the last moment by Coffin and Morgan; see Matthew Josephson, *Edison: A Biography* (New York: McGraw-Hill, 1959), pp. 362–363; and McDonald, *Insull*, pp. 49–51. As evidence that Coffin and Morgan conspired to eliminate Villard, these scholars cited an unpublished Edison biography, "The Old Man," by Hugh Russell Fraser, in the Edison archives that described the Edison General and Thomson-Houston negotiations and a meeting between Coffin and Morgan. I have examined the relevant portion of this manuscript (pp. 362–372) and found that it does not mention the famous Coffin–Morgan meeting and that Fraser attributed a quotation to a Thomson-Houston executive (C. W. Dean) whom I have never seen mentioned anywhere else. A careful reading of letters in the Villard, Higginson, and Morgan papers reveals nothing to suggest that Villard was involved in the negotiations. In fact, according to the memoirs prepared by Villard's son, Villard advised his German banking friends to sell off their Edison General holdings in early 1892, and he strongly disapproved of the GE merger; see Villard, *Memoirs*, Vol. 2, p. 326. Both Morgan and Higginson were quite aware that Villard could be a stumbling block to creating a consolidated company; as Morgan wrote to fellow banker T. Jefferson Coolidge on March 24, 1892, "I entirely agree with you that it is desirable to bring about closer management between the two companies. Mr. Villard's resignation will take effect on the 1st [of] April, and I think the best way would be for Mr. Coffin to be then elected President of the Edison General Co." See Letterbook 87–93, p. 676, The Pierpont Morgan Library, New York. Villard's resignation can be found in his letter to the board of trustees of Edison General Electric, February 18, 1892, Letterbook 76, p. 318, box 130, Villard Papers. For a discussion of his activities in 1891–1892, see Villard, *Memoirs*, Vol. 2, pp. 358–363; and Buss, *Villard*, pp. 224–243.
46. Quotation is from Fairchild to Higginson, July 24, 1891, box XII-3, folder 1891 Charles A. Coffin, Higginson Papers.
47. First quotation is from Charles A. Coffin to Higginson, May 7, 1891, box XII-3, folder 1891 Charles A. Coffin, Higginson Papers. Second quotation is from Pound and Moor, *More They Told Barron*, p. 38.
48. I am grateful to Alfred D. Chandler, Jr., for suggesting this point about managerial hierarchies. He briefly discussed this problem for Westinghouse in *Scale and Scope*, pp. 215–216.
49. Passer, *The Electrical Manufacturers*, pp. 324–326.
50. In his study of the electrical industry, Passer is cautious about claiming that the desire to eliminate competition was a factor in the formation of GE. In his view, one could only draw this conclusion if the merger had included Westinghouse and thus completely eliminated competition. See *The Electrical Manufacturers*, pp. 326–327. However, as the many letters from Coffin, Higginson, and Fairchild reveal, these men believed that competition was problematic and that it should be minimized or eliminated. Furthermore, they had tried to merge all three firms during the Westinghouse reorganization, only to find it difficult to deal with Westinghouse personally. Consequently, given the



severity of the competition and the views expressed by the leading actors in their correspondence, I would conclude that the desire to eliminate competition contributed to the GE merger.

51. In fact, I would argue that historians and economists have failed to move beyond the conclusions made by Lance Davis twenty-five years ago; see Davis, "The capital markets and industrial concentration," *op. cit.*