"New and Untried Hands": Thomas Edison's Electrification of Pennsylvania Towns, 1883–85

THOMAS EDISON WAS DIRECTLY involved with building and running pioneering electric power stations in Pennsylvania from the spring of 1883 until the late summer of 1884.[1] The story of Edison's Pennsylvania ventures, long a justifiable source of local pride, is briefly highlighted by Thomas Hughes as a crucial early step of electrification in the United States and Europe.[2] In Hughes's consideration, Edison's work in Pennsylvania does not rise to the level of a "reverse salient," a term for an unexpected battlefield reversal that Hughes so memorably applied to a sticking point or setback in the development of large technological systems, such as the electrical grid. But Edison, were he inclined to military metaphors, might have expressed his experiences in Pennsylvania in just this way. He was poised in early 1883 to break out of the metropolitan market of Manhattan, where his direct current (DC) system successfully

The authors gratefully acknowledge the abundant research and editorial assistance of present and former colleagues at the Thomas Edison Papers: Scott Bruton, Theresa Collins, Dennis Halpin, Clare Hilliard, Paul Israel, Alexandra Rimer, and Kristopher Shields. Much of this article is adapted from documents and research published in Reese V. Jenkins et al., *The Papers of Thomas A. Edison*, 8 vols. (Baltimore, 1989–), especially vol. 7, *Losses and Loyalties, April 1883–December 1884*, ed. Paul Israel et al. (Baltimore, 2011). Series cited hereafter as *TAEB*. The online edition of the Thomas A. Edison Papers is available at http://edison.rutgers.edu/digital.htm.

[1] The Edison central stations in Pennsylvania completed during this period, with start dates and initial rated capacity [number of ten-candlepower lamps] were: Sunbury (July 1883 [500]); Shamokin (September 1883 [1,600]); Mount Carmel (January 1884 [500]); Bellefonte (February 1884 [800]); and Hazleton (February 1884 [1,000]). Lists of all Edison plants completed and planned during this period are in *TAEB* 7, appendix 2. Edison's extensive correspondence regarding these plants is arranged in several functional groups maintained at the archives of the Thomas Edison National Historical Park in West Orange, NJ (hereafter NjWOE). Incoming correspondence from or specifically about individual central stations is grouped there in a separate archival series arranged by state and town name (including Sunbury, Shamokin, Bellefonte, Mount Carmel, and Williamsport). These place-specific documents and the great majority of others related to central construction may be accessed in several ways on the Thomas Edison Papers website, such as by retrieving individual items (http://edison.rutgers.edu/singldoc.htm) or browsing folders (http://edison.rutgers.edu/sn03.htm#1883).

[2] Thomas P. Hughes, *Networks of Power: Electrification in Western Society, 1880–1930* (Baltimore, 1983), 431–33.

lighted the Wall Street area, and start what he hoped would be a wave of power plants in less dense and more workaday communities across the United States. He opted to start in and around Pennsylvania's anthracite region, first in Sunbury and Shamokin, and soon enough in Mount Carmel, Bellefonte, and Hazleton. Several factors influenced his choice of this area: the relative ease of access from his New York laboratory and offices; local entrepreneurial networks formed semi-independently of mineral wealth; population density; and, ironically, the high cost or unavailability of illuminating coal gas. When he left the region some fifteen months later, Edison had achieved only qualified success at the cost of great aggravation and expense and some damage to his reputation as America's most successful inventor.

The problems Edison encountered in Pennsylvania were not only in the technical design of his system, or at least not exclusively so. He planned the Pennsylvania stations to meet a shortage of financial capital for constructing power plants and distribution networks. What he failed to anticipate fully was a shortage of human capital: the skills needed in each community to operate and oversee the plants. He seriously underestimated, first, the difficulty of transferring his own facility with the system to new hands and, second, the challenges of adapting the system in response to feedback that was often uninformed. Edison and his closest associates had four years of familiarity with the elements of electric lighting: the dynamo for generating electric power, the wiring scheme for transmitting it safely and economically, and the delicate incandescent lamp for converting it into light. Although basic knowledge of electricity was widespread due to the nationwide networks of commercial and railroad telegraphs, there was no analog for electric lighting in telegraphy's batteries, uninsulated iron wires, and sending keys. Much of the skill needed for the power plants would have to be imported or cultivated from the ground up. Edison and his intimates had no more experience doing this than the local plumbers or machinists had with electric lighting; all were untrained hands at their respective tasks. Edison coped by turning to his strength: devising technological solutions, even for problems that were only marginally technical. But despite his past experience as a proprietary capitalist, he could not easily master the administrative tasks of financing and managing the central stations. The plants—and the organizations developed to run them—proved to be fragile and almost ended up justifying the criticism of skeptics. In the end, the tightening financial noose of an unfavorable business

cycle in 1884 helped to force Edison out of the business and nearly undid his work in the state.

This article places those local events in broad technological and organizational contexts and offers an evaluation of their significance to the larger project of electrification in the United States in the late nineteenth century. Edison's work in those fifteen-odd months was crucial to sorting out the technological, economic, and organizational arrangements necessary for his dream of constructing power networks in cities and towns across the country. By unwittingly demonstrating the limitations of his own system in eastern Pennsylvania, Edison kept the door open to a rival who would emerge at the other end of the state. George Westinghouse of Pittsburgh recognized the opportunity and, within just a few years, assembled a cadre of skilled engineers, secured the necessary patents, and devised a feasible business model to promote the more economical alternating current (AC) model of distribution.

Financial and Technical Context: London and New York

The signal event of Edison's presence in the state came on July 4, 1883, when the inventor personally inaugurated central station electric service in Sunbury. It was a festive moment. In addition to its nascent electrification, the town held a boat regatta to celebrate Independence Day and also opened a new rail line. Months of planning and building had gone into the station, and for several weeks Edison himself had intermittently left his New York office and laboratory to supervise the work at first hand.[3]

Edison's route to Pennsylvania went first through London and New York City, where he successfully planned and built generating stations and distribution networks in 1881–82. He was famous around the world as the "Wizard of Menlo Park," the New Jersey village where he had built a laboratory in 1876. The nickname, initially given to him in 1878 as the inventor of the first practical device for recording and playing back sound, carried over to his electric light work.[4] At Menlo Park, he invented not only the famous light bulb but a supporting cast of components all designed to operate together in what was quickly recognized as a coherent system: his dynamos, first and foremost, and also meters, regulators,

[3] Despite the fact that Edison and his associates generated and saved an extraordinarily large amount of documentation during this period, all details of these trips have been lost.

[4] "The Wizard of Menlo Park," *New York Daily Graphic*, Apr. 10, 1878.

fuses, insulated conductors, and a plan for apportioning electric current geographically according to anticipated demand.[5] The "Wizard" nickname stuck even after he left Menlo Park to set up laboratories and offices in New York City in 1881. From Manhattan, he oversaw the installation of a temporary demonstration generating station on London's Holborn Viaduct, a busy commercial corridor. When it opened in early 1882, the plant proved the technical feasibility of his system for the incandescent lighting of shops and offices clustered in a relatively small area—probably fewer than a thousand lamps along about a quarter mile of the viaduct.[6] The dynamos, which Edison had designed as "converters" of mechanical into electrical energy, worked as intended, as did the other parts—all operating to produce a pleasing light at a cost not greatly exceeding that of illuminating gas.

Characteristically confident of success, Edison was already moving in the winter of 1881–82 toward his next step: lighting New York City's financial district on a permanent, for-profit basis. Illuminating the area around Wall Street would be not only a technological achievement but also a possible public relations bonanza. That, in turn, could translate into investment in Edison lighting companies beyond what he already enjoyed from a coterie of financiers affiliated with the banking house of Drexel, Morgan & Company. Edison knew he needed money to put in the necessary electrical plant, of course, but he also wanted to expand his manufacturing capacity for the lamps, dynamos, switches, and meters he expected to use for the widespread electrification of the United States and much of the world.[7] From late 1881 to the next summer, Edison work crews dug trenches and laid down conductors—copper rods insulated inside iron pipes—under the streets of lower Manhattan. The conductors, some fifteen miles of them in a roughly half-mile-square area, were connected to

[5] See, for example, Robert Friedel and Paul Israel with Bernard S. Finn, *Edison's Electric Light* (Baltimore, 2010).

[6] "Electric Lighting (Holborn Viaduct)," *Electrician* 11 (July 21, 1883): 232–33. Regarding the design, construction, operation, and stage-managing of the Holborn installation, see *TAEB* 6.

[7] Edison and several partners provided their own working capital for the manufacturing carried on by the Edison Lamp Company, the Edison Machine Works (dynamos and other heavy electrical equipment), and the Electric Tube Company (underground conductors). Edison was also a partner in the New York firm of Bergmann and Company, which made switches, sockets, lamp fixtures, and other small items. The small and tightly overlapped web of Edison associates supporting and managing the four enterprises makes it possible (for the most part) to consider these entities a unified Edison manufacturing operation before their integration into the Edison General Electric Company in 1889. See "Edison's Manufacturing Operations," *TAEB* 6: Doc. 2343.

six large dynamos in a building on Pearl Street.[8] The Pearl Street station, as it came to be called, started operating in September 1882. Although press notice of the event was muted, the plant did what Edison intended: it illuminated without interruption the influential customers around Wall Street—in particular, banks, printing houses, shops, and a few prestigious residences.[9] The plant and the district it lighted became symbols of a new electrical age. Demand for electricity exceeded Edison's hopes, and the station was enlarged several times.

Although the Holborn and Pearl Street plants met Edison's expectations, they also revealed flaws that would make his design too expensive in areas of lower population density—that is, the great majority of the territory he hoped to electrify. Edison modified his system to meet the needs of these areas and anticipated a wave of construction in small cities and towns throughout the United States.

That wave failed to materialize in the winter of 1882–83, and the impatient inventor saw his "Edison system" of central station electric lighting at a crossroads by the early spring. In addition to London and New York, the system was a reality on a small scale in Roselle, New Jersey, but neither Edison nor the Edison Electric Light Company, to which he had sold his patents, had suitable arrangements—organizational, financial, or technical—for building or operating central stations elsewhere. Edison foresaw a large market in small cities and towns but feared that the prospective business "would go to ruin" in the Edison Electric Light Company's hands.[10] Believing "if the business is to be made a success it must be by our personal efforts and not by depending upon the officials of our Companies," Edison sought new sources of capital.[11] The year 1883 started auspiciously when financier Henry Villard proposed contracting with the light company for "lighting all the cities & towns along the main line & branches of the Northern Pacific" railroad. A conversation with banker George Ballou

[8] See "Pearl Street Central Station," *TAEB* 6: Doc. 2243, for an overview of the Pearl Street plant's design, construction, and operation.

[9] Partial lists of customers as of April and October 1883 are in the Edison Electric Light Company Bulletins 17:3 and 20:30, available through the Thomas A. Edison Papers digital edition (hereafter cited as *TAED*) at http://edison.rutgers.edu/singldoc.htm, document folders CB017 and CB020. A list of first-year customers itemized by type of business is in Payson Jones, *A Power History of the Consolidated Edison System* (New York, 1940), 183–87.

[10] On Roselle see *TAEB* 6: Doc. 2336; Samuel Insull to Edward Johnson, Apr. 3, 1883, Misc. Letterbook 3:120, NjWOE; available online as *TAED* LM003120.

[11] Thomas Edison (TAE) to Edward Johnson, Mar. 5, 1883, Letterbook 13:12, NjWOE (*TAED* LB013012; *TAEB* 6: Doc. 2407).

also lifted Edison's hopes for fresh investment, but neither Villard nor Ballou brought new funds in the short run.[12] Searching for another way to proceed, Edison sketched a partnership arrangement in late March with trusted associates Edward Johnson, Samuel Insull, and Charles Batchelor, but this plan, too, failed to materialize.[13]

Edison would eventually diagnose the apparent lack of entrepreneurship by the Edison Electric Light Company as symptomatic of the innate caution of its president, Sherburne Eaton, a lawyer accustomed to working with established firms like Western Union Telegraph. Whatever the inadequacies of its management, the light company did not stand in the way of efforts to sell the Edison system outside of New York. The firm allowed other companies, formed for the purpose, to build and operate local central stations under license for Edison's patents. This was practically the only option available to the cash-poor New York firm, whose chief assets were those patents. Licensing would preserve the value of the patents and generate income through fees. The company developed a shadowy network of promoters or sales agents, men from other business or professional endeavors who had some allegiance to and financial interest in the company's growth. These relationships were highly individual, and though they would later be somewhat standardized or at least affirmed on something stronger than a handshake, we are largely at a loss to know their terms in 1882 and early 1883.[14]

One of those agents was Phillips B. Shaw, a Williamsport merchant and manufacturer. Shaw must have been forward looking and well connected to the area's mercantile and professional men who had some money to risk. In 1882, he had tried unsuccessfully to broker the commercial use of Edison's patents for electric railroads.[15] He was inquiring about estimates for putting in Edison lighting systems about the middle of that year,

[12] Villard to Sherburne Eaton, Jan. 2, 1883, Letterbook 47:6, box 122, Henry Villard Papers, Baker Library Historical Collections, Harvard Business School; TAE to George Ballou, Mar. 13, 1883, Letterbook 15:465A, NjWOE (*TAED* LB015465A; *TAEB* 6: Doc. 2413).

[13] TAE memorandum for village plants, Mar. 29, 1883, NjWOE (*TAED* HM830172B; *TAEB* 6: Doc. 2417); Samuel Insull to Edward Johnson, Apr. 3, 1883, Misc. Letterbook 3:120, NjWOE (*TAED* LM003120; *TAEB* 7: Doc. 2420); Paul Israel, *Edison: A Life of Invention* (New York, 1998), 219–25.

[14] Licensing also promised to boost the manufacturing businesses, revenue streams for Edison into which the New York company was also trying to tap. For general discussions of licensing and the recruitment of potential licensees, see "Village Plant Construction" and "Thomas Edison Construction Department," *TAEB* 7: Docs. 2424 and 2437.

[15] *TAEB* 7: Doc. 2424 n. 1; "P. B. Shaw," Edison Pioneers biography, NjWOE.

well before Edison had settled on a fixed "village plant" design adapted to such locales, much less built and tested one.

Shaw likely was involved in a nascent Edison illuminating company in Williamsport. Not far geographically from the anthracite fields, Williamsport had little direct economic connection with mining, in part because the Susquehanna River at its doorstep flowed toward the Chesapeake rather than to the coal markets of New York or Philadelphia. Its money came from timber, and the thriving city enjoyed a concentration of personal wealth. The illuminating company there obtained a license from the Edison Electric Light Company of New York, the first such license issued, and it made a public demonstration in mid-March. The demonstration consisted only of one or two small generators and about sixty lights in a handful of stores, but it drew as many as five thousand spectators the first night.[16] Shaw became the Edison Electric Light Company's recognized agent for Pennsylvania about that time.[17]

Shaw had already been busy. Exercising considerable independence from the New York firm, he had in the previous year solicited interest in Edison lighting in Sunbury, a busy county seat of four thousand people down the Susquehanna, and in Shamokin, a larger town and a major railroad junction about a dozen miles to Sunbury's east. Both towns were within about fifty miles of Williamsport, and both were near the active western edge of the anthracite coal region, where fuel for steam power was plentiful and illuminating gas (made from bituminous coal) was expensive.[18] Shamokin's mineral wealth flowed to Philadelphia or New York, but there was enough

[16] Regarding transportation of anthracite coal, see Barbara Freese, *Coal: A Human History* (New York, 2003), 118–24. The Williamsport company was incorporated in May 1882, but construction there did not begin until the end of 1883. Thomas W. Lloyd, *History of Lycoming County, Pennsylvania* (Topeka and Indianapolis, 1929), chaps. 26–30; Edison Electric Light Co. Bulletins 17:19 and 18:36, Apr. 6 and May 31, 1883, NjWOE (*TAED* CB017, CB018); Michael Nash, John Rumm, and Craig Orr, *Pennsylvania Power and Light Company: A Guide to the Records* (Wilmington, DE, 1985), 47; Alfred Tate to William Rich, Dec. 27, 1883, Construction Dept. Letterbook 17:252, NjWOE (*TAED* LBCD4252).

[17] Insull to Johnson, Apr. 11, 1883, Misc. Letterbook 3:135, NjWOE (*TAED* LM003135).

[18] The 1880 federal census listed the population in Sunbury as 4,077 and in Shamokin as 8,184. Gas in Shamokin was about four dollars per thousand cubic feet and, according to one report, ten dollars in Sunbury. For a standard fifteen-candlepower gas jet burning five cubic feet per hour, the latter price meant about five cents per hour per lamp. Thomas Dublin and Walter Licht, *The Face of Decline: The Pennsylvania Anthracite Region in the Twentieth Century* (Ithaca, NY, 2005), 18–19; Francis Jehl, *Menlo Park Reminiscences*, 3 vols. (Dearborn, MI, 1937–41), 3:1096; William Hammer notebook as chief engineer of Edison Electric Light Co., 1885–86, series 1, box 13, folder 1, William J. Hammer Collection, Smithsonian National Museum of American History. On Sunbury see Herbert C. Bell, *History of Northumberland County Pennsylvania* (Chicago, 1891), 480–500. In towns without gas ser-

local interest to form an illuminating company in November 1882.[19] A similar company was organized for Sunbury in April 1883. Despite the Williamsport demonstration and a reported visit by Edison that spring, there was little financial support in Sunbury itself; the firm's capital was eventually raised in Williamsport, where the board met.[20]

Shamokin proved more receptive to Shaw's ideas. A local delegation traveled to New York sometime in the spring, when Edison provided an estimate to put up a plant, poles, and wires for about $25,000. The Shamokin investors agreed and promptly put up money for an initial payment, but they also had their own ideas. Shaw wired Edison from Shamokin on May 3: "Contract for installation of sixteen hundred light plant signed. Boiler

vice, such as nearby Mount Carmel, prospective companies had to apply for a license from the Edison Company for Isolated Lighting, which controlled rights to the Edison system in non-gas territory (see *TAEB* 6: Doc. 2299 n. 4). The Edison Electric Light Company later published some limited retrospective information on the price of gas in fourteen towns and cities, including Bellefonte, Hazleton, York, and West Chester, Pennsylvania. Edison Electric Light Co. circular, p. 24, n.d. [1886?], NjWOE (*TAED* CA001D).

[19] Shaw was among the Shamokin company's directors. Most of the early investors were Shamokin residents; a notable exception was Francis Upton. The company also sold bonds, largely to its stockholders, to help meet its first expenses. Incorporation certificate, Nov. 29, 1882, personal collection of Richard Guth, Georgetown, DE, on loan to the Thomas Edison Papers; Hugh A. Jones, "Edison's Experiment in Northumberland County," *Northumberland County Historical Proceedings and Addresses* ([Sunbury, PA], 1984), 29:69–90; Bell, *Northumberland County*, 627–28; Edison Electric Light Co. Bulletin 18:11, May 31, 1883, NjWOE (*TAED* CB018); Edison Electric Illuminating Co. of Shamokin ledger (1883–99), 1–3, Northumberland County Historical Society.

[20] The close personal and business ties among investors mimicked the tightly interlocking directorates of the New York Edison companies. Among the Sunbury directors were two prominent Williamsport attorneys (Seth T. and Frank McCormick) and a young physician (Thomas Detweiler); another (Charles Story) was from New York. Jones, "Edison's Experiment," 70; Edison Electric Light Co. Bulletin 18:11, May 31, 1883, NjWOE (*TAED* CB018); Emerson Collins and John W. Jordan, *Genealogical and Personal History of Lycoming County, Pennsylvania* (New York, 1906), 293–96; Bill Beck, *PP&L: 75 Years of Powering the Future* (Eden Prairie, MN, 1995), 51; some occupational information derived from 1880 federal census manuscripts for Williamsport (Lycoming County), accessed through Ancestry.com.

In Shamokin, the officers included president William H. Douty (b. 1837), owner of W. H. Douty Dry Goods, who was also a mining operator (and future director of the Shamokin Board of Trade). John Mullen (b. 1838), vice president, owned both John Mullen & Co., which manufactured mining machinery, and the Anthracite Foundry and Machine Works. In a notable but hardly unique overlap of electric and gas lighting interests, Mullen was a director of the Shamokin Gas Light Co. Among other business ties, he was president of both the First National Bank in Shamokin and the Shamokin Coal and Coke Company of May-Beury, West Virginia. The Shamokin treasurer was William Beury, a local gunpowder manufacturer. Beury later became the founding treasurer of the Shamokin Arc Light Company and seems to have become involved with John Mullen in the Shamokin Coal and Coke Company. Andrew Robertson (b. 1831?), a former colliery operator who was active in Shamokin business affairs (including the introduction of water and gas services) had some unspecified role in the firm, perhaps as one of its investors. Bell, *Northumberland County*, 618, 627–28, 892–94, 906–7; "Black Diamonds," *Washington Post*, Aug. 2, 1889, 2; approximate birth years derived from 1880 federal census of Shamokin (Northumberland County), accessed through Ancestry.com.

stock poles building & few miner [*sic*] items cut out of estimate. you better come by penna road to sunbury tonight. I will meet you. answer quick."[21] Edison initially declined to make the trip, but when Shaw insisted, he and Samuel Insull, his secretary and personal business manager, left that night. The next day, they signed a two-page, handwritten contract committing Edison to set up a central station system of 1,600 lamps—ten candlepower each—for $19,209, the price having been reduced by the local company's wish to subcontract for the station building itself.[22] Then Edison and Insull turned around and went back to New York, taking advantage of the geographical proximity that would be so useful during the months of construction to come. At some point around this time, probably soon after this trip, Edison also came to an understanding with the Sunbury company to build a plant there, though the contract has not been found.[23]

Edison praised the Shamokin plan as a "new and successful idea."[24] The contract called for cash payments in three installments, the last to come after the station was in operation for thirty days. It also stipulated that "if from any cause P. B. Shaw fails to furnish the cash payments on the bonds of this company as agreed," Edison would accept bonds at par instead.[25]

Local agents had been drumming up investor interest in several Massachusetts cities as well, but the contracts for Shamokin and Sunbury marked the start of what Edison and Insull expected would be a construction "boom." In April, Insull had remarked that "[Edison] has practically left his Laboratory & now makes my Office his Headquarters & is attending to purely business matters. . . . [T]here are plenty of . . . places which are just crying for these Plants."[26] Upon reflection a few months later, Edison himself came to believe that he "could take hold and push the system better than any one else," remarking, "It is so complicated that I do not feel like trusting it to new and untried hands, because science and dollars are so mixed up in it."[27] On May 3, the day Shaw summoned him to Pennsylvania, Edison gave Insull full power of attorney to act in his stead "to sign contracts for the erection of Edison Electric Light Installations"

[21] Shaw to TAE, May 3, 1883, Document File (hereafter DF), NjWOE (*TAED* D8360B).

[22] TAE agreement with Edison Electric Light Co. of Shamokin, May 4, 1883, Samuel Insull Records, Loyola University (Chicago) Archives (*TAEB* 7: Doc. 2438).

[23] "History of the Edison Electric Illuminating Co. of Sunbury Pennsylvania," typescript on file at the Thomas Edison Papers.

[24] TAE to Joshua Bailey, May 6, 1883, Misc. Letterbook 1:310B, NjWOE (*TAED* LM001310B).

[25] TAE agreement with Shamokin, May 4, 1883, Samuel Insull Records (*TAEB* 7: Doc. 2438).

[26] Insull to Johnson, Apr. 3, 1883, Misc. Letterbook 3:120, NjWOE (*TAED* LM003120; *TAEB* 7: Doc. 2420).

[27] "Promoting the Electric Light," *Electrical World* 1 (Aug. 4, 1883): 489.

and to conduct all other business "appertaining to [his] Central Station Construction Department."[28] That agreement reflected a deepening professional relationship that would influence Edison's work in the region. Insull, a Londoner a dozen years Edison's junior, had taken charge of the inventor's financial books and swelling correspondence in February 1881, just as his boss was relocating from the rural Menlo Park laboratory to the New York metropolis. By force of personality, ceaseless work, zest for power, and devotion to his principal, Insull became, in short order, Edison's de facto business and personnel manager. The power of attorney agreement allowed him to mind the dollars while Edison took care of the science.

Thomas A. Edison Construction Department and the Three-Wire Village Plant System

The Thomas A. Edison Construction Department, as it was officially designated, provided an informal financial and administrative framework in which Edison and Insull could manage a variety of transactions over a wide geographic area. Edison gave no attribution for his notion of a construction department, but the idea was not entirely novel. The organization of specialized construction companies had precedents in capital-intensive projects such as submarine telegraphy and telephone exchanges, and there were by this time numerous examples of independent contractors and suppliers in electric lighting. The tradition of referring to the construction department as a company goes back at least to 1894, but it functioned as a contractual surrogate for Edison himself, who was personally liable for its obligations.[29] The department had no independent legal standing, nor was it a branch of another entity such as the Edison Electric Light Company. It was not necessarily in anyone's interest to specify too closely the relationships among Edison, the Electric Light Company, or the Edison Company for Isolated Lighting, but within the unwritten understandings among the principals, the light company used the construction department's services and exercised some oversight of its operations. Edison's sketchy plan for the new entity created enduring ambiguities over its specific functions and its relations with existing organizations.[30]

[28] TAE power of attorney to Insull, May 3, 1883, NjWOE (*TAED* HM830175).

[29] The formation and operation of the construction department is discussed more fully in the "Thomas A. Edison Construction Department," *TAEB* 7: Doc. 2437.

[30] By prior contract, the Company for Isolated Lighting controlled Edison's patents in areas without municipal gas service (see *TAEB* 6: Doc. 2299 n. 4). Adding to the confusion, the two Edison

Just what was the system that Edison committed to build in Shamokin and Sunbury, and how did it differ from the one working so well in New York? We digress here to explicate a fundamental problem in the design of the conductor network beneath Manhattan's streets, one that Edison began to recognize even before the Pearl Street plant was completed. Edison had arranged the conductors in what he called the "feeder and main system." A few heavy "feeder" lines radiating from the station supplied current at about 110 volts to a grid of smaller "mains" running down each street. The overall pattern looked on paper something like a rectilinear spider web made of expensive, refined copper. It has not proved possible to calculate the overall cost of the Pearl Street plant, but retrospective figures range from several hundred thousand to (more likely) a bit over a half million dollars, both figures being well above the original estimates. Nor is it certain how much went into the conducting rods, but it is clear that copper was a major expense of the Pearl Street district, even as the metal's price was falling. One accounting by the Edison Electric Illuminating Company, which built and owned the plant, put the price of its insulated conductors (not installed) at $114,000, more than 20 percent of the total for the entire project.[31] Faced with an uncertain investment climate, Edison's backers were not eager to put up money for a second New York plant that they had originally imagined would quickly follow in or around the theater district.

From the beginning of his electric light research in 1878, Edison recognized certain tradeoffs between construction costs and the operating efficiency of an electric light system. These compromises were grounded in physical laws that, as it turned out, he understood better than many contemporary practical electricians and even academic physicists. With the aid of Francis Upton, a young, college-educated physicist and mathematician who had trained with the great Hermann von Helmholtz in Berlin, Edison systematically tried to calculate the ideal design parameters of a system years before the first paving stone was lifted in New York. But his calculations were predicated on the distribution of large amounts of current through a relatively small area with a high concentration of paying customers. The physical limitations, and consequently the economic constraints, of less densely populated areas were more severe.

companies had overlapping officers and investors. Sherburne Eaton served both as president and often failed to differentiate these roles in his prolific correspondence.

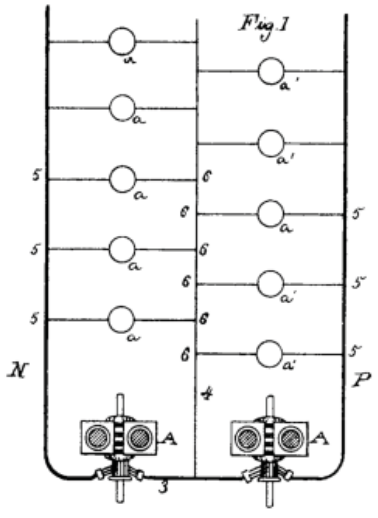
[31] Edison Electric Illuminating Co. of New York memorandum of expenses, Apr. 1, 1883, DF, NjWOE (*TAED* D8326E1).

Two physical principles governed what Edison could do. One was the law articulated in the 1840s by English physicist James Prescott Joule and identified with his name ever since.[32] Joule's Law states that the amount of electrical energy in a circuit converted to heat (wasted, for Edison's purpose) is proportional to the circuit's resistance and also to the *square* of the current, or volume of electricity. That is, tripling the current increases by nine times the energy lost as heat. The other controlling factor was Ohm's Law (voltage = current × resistance), one implication of which is that voltage is inversely proportional to current for a given quantity of electrical energy.[33] This relationship suggested a way to mitigate the harsh implications of Joule's Law if Edison could raise the resistance of the lamps so as to increase the voltage relative to the loss-inducing current. The alternative was to lower the resistance in each circuit by increasing the amount of conductive copper, an unappealing option outside a densely populated city, where there would be fewer revenue-producing lamps per foot of conductor.

Edison naturally wanted to lower the cost of building a plant without compromising its efficiency. He was already designing a new system, one which he later adopted for Pennsylvania. He planned to use higher voltage, meaning that he could transmit the same energy with less current and, therefore, smaller conductors. But this was direct current, which cannot readily be stepped up or down by induction transformers like those now used for AC. He couldn't use much more than 110 volts in his lamps without burning them out. His first attempt was a 330-volt system, with lamps in each house grouped in blocks of three so each would operate at 110 volts. The trouble was that each group could have only one switch; the three lamps turned on or off together. Edison thought this "village plant system" would be economical in towns with fairly low population density. This was the system used in the small demonstration plant that he had persuaded the Edison Electric Light Company to build in Roselle, New Jersey, which worked well.

But Edison had vowed all along that his lamps could each be turned on and off independently, just like a gas lamp, a promise broken in his initial design for the village plant system. He came up with a solution that was ingenious and, it turns out, not unique. At almost exactly the same time, a young mathematician and engineer named John Hopkinson, working

[32] *Complete Dictionary of Scientific Biography* (Detroit, 2008), s.v. "Joule, James Prescott."
[33] *Complete Dictionary of Scientific Biography*, s.v. "Ohm, Georg Simon."



Schematic drawing from Edison's patent on the three-wire system. Lamps (circles) are connected between one leg of the main circuit from the dynamos and the small neutral (or balancing) wire.

for the Edison Electric Light Company, Ltd. in London, independently came up with the same solution, as did the German electrical manufacturer William Siemens.[34] Called the three-wire system by both Edison and Hopkinson, it used two dynamos connected in series, each generating at 110 volts. A third distribution wire ran from a neutral point between the two machines, so that one of the conducting wires was 110 volts above it and the other 110 volts below it. Lamps were placed in pairs, one connected from the positive voltage line to the neutral, the other from the neutral to the negative line. Every lamp therefore experienced 110 volts, and the current flowed through the paired lamps in series from the positive to the negative lines.[35] The result was that electricity was transmitted at 220 volts, permitting the conducting wires to be smaller than in the 110-

[34] Regarding the origins of Edison's three-wire system and its relationship to that of Hopkinson, see *TAEB* 6: Docs. 2308 n.1 and 2407 n. 4; Israel, *Life of Invention,* 219; Samuel Insull to Edward Johnson, Apr.1, 1883, Misc. Letterbook 3:115, NjWOE (*TAED* LM003115).

[35] Edison's US Patent 274,290 also included the idea that, at least in principle, additional compensating wires and proportionally higher voltage could be used, but Edison did not expect to achieve proportional reductions in copper. TAE marginalia on Harry Mather Doubleday to TAE, July 21, 1883, NjWOE (*TAED* D8305J).

volt two-line system. The neutral line could be smaller still, as it would (at least in principle) conduct only a small current to balance the system as lights were turned on or off individually. Edison calculated that there would be a savings of 62.5 percent over a comparable two-wire network.[36] To reduce the cost further, he accepted high electrical losses, resulting in a voltage drop of at least 10 percent along the feeder lines.[37] The three-wire plan was an innovation of great economic benefit, though copper would remain a major part of the construction bill for each station.[38]

Even with the copper-saving three-wire design, cost hemmed in Edison's plans. Of the $19,209 contracted by the Shamokin illuminating company, only $4,802 was to be paid to Edison before the station was ready to go into operation. In the meantime, while he was not responsible for erecting the Shamokin station building itself, he had to finance from his own pocket the purchase, shipment, and installation of everything from steam engines and dynamos to poles and wires. The inventor's pockets were deep, to be sure, lined by regular royalties and commissions on his earlier inventions, an ongoing retainer from the Western Union Telegraph Company, and income from investments in government bonds and from his own manufacturing shops. But the cash flow outlook for construction on the scale that he and Insull envisioned was still a daunting one, which led them to do the work as cheaply as possible.

Although the Shamokin company's quirky insistence on subcontracting the construction work saved Edison some money, it also substantially slowed the work, in effect handing the honor of the first operating Edison three-wire plant to the smaller, less affluent town of Sunbury. Perhaps because out-of-towners ran it, the Sunbury company was content to leave all construction to Edison. The good news was that, unlike in Shamokin, where construction quickly bogged down, Edison's men put up the Sunbury building quickly. The bad news, however, was that *Edison's* men put up the building *quickly*. Edison had no experience with this work.

[36] In an 1884 explanation and overview of the system, a top assistant in the construction department calculated the savings at 69 percent. TAE to William Andrews, Aug. 10, 1883, DF, NjWOE (*TAED* D8316ANI); Henry Guimaraes report, Aug. 29, 1884, Charles Batchelor Collection, NjWOE (*TAED* MB141).

[37] Insull to Johnson, Sept. 25, 1884, Letterbook 18:419, NjWOE (*TAED* LB018419).

[38] Edison was billed, in the aggregate, at least $20,000 for copper conductors up to November 1883 (Insull to Ansonia Brass & Copper Co., Nov. 27, 1883, Letterbook 13:25, NjWOE [*TAED* LB013025]; see also the "Village Plant Construction," *TAEB* 7: Doc. 2424 n. 9). In the illustration, taken from Edison's US Patent 274,290 (issued March 20, 1883), the third (or "compensating") wire runs between the negative (**N**) and positive (**P**) main lines of the direct-current system; dynamos **A** and **A** are at the bottom.

In the middle of May, he designated an assistant, William Rich, as the superintendent of construction. Rich (a former miner) had, as far as is known, no knowledge of construction, but the one-story structure got finished somehow. In June, Edison spent about three weeks, on and off, in Sunbury, boarding at the City Hotel. The local company asked him to move up the operational date of the plant so it would be ready for the "general celebration" planned for Independence Day, which would be "an excellent opportunity to exhibit our light" to the general public and prospective customers.[39] Edison's crews, dispatched from New York, pushed the work hard, but their haste, combined with inexperience, overconfidence, and a penny-wise, pound-foolish approach to expenditure, created lasting problems. For example, the roof soon began to leak, a defect that would appear in a number of Pennsylvania plants.

"Go to school on this job": Edison's Sunbury Experience

As often happens with innovative technological systems, successful completion of the Sunbury plant depended less on executing the newest big idea than on myriad prosaic details. Edison had subcontracted the job of putting up poles and wires to Bergmann & Company, the New York manufacturer of electrical apparatus in which he was a partner. With one month to go, he nagged Bergmann: "poles dont grow right on the exact spot where they will be needed. . . . I would also remind you that the Almighty has'nt yet grown any trees which attain the necessary height and diameter within a week." Only on June 19 did the town issue a permit to erect the poles; workmen then labored against both drenching rains and "the entire change of the plan of running the Pole line" to have them ready by the appointed day.[40]

Edison had been quoted several years earlier stating that "steam engineering forms 75 per cent. of the electric light," and it was that mature technology which came closest to upsetting the July 4 debut.[41] He had been overseeing installation and testing of the dynamo, a model of his own design that the Edison Machine Works built in New York. The machine

[39] Frank McCormick to TAE, June 1, 1883, DF, NjWOE (*TAED* D8361D).

[40] TAE to Bergmann & Co., June 5, 1883, Letterbook 17:68, NjWOE (*TAED* LB017068, *TAEB* 7: Doc. 2457); Frank McCormick to TAE, June 19, 1883; Charles Hanington to TAE, June 29, 1883; both DF, NjWOE (*TAED* D8361U, D8340ZAV).

[41] "The Coming Light," Feb. 12, 1880, unidentified clipping in Menlo Park Scrapbook, Cat. 1014:34a, NjWOE (*TAED* SM014034a).

worked as intended, but in the excitement of July 3, one of his lieutenants forgot to tend the engine lubricators. As a result, the babbitt bearings ran dry and had to be relined in an all-night repair session. Insull, mindful that cost overruns ultimately came from Edison's wallet, made a half-hearted threat to recover the expense from Frank Sprague, a young electrical engineer (who soon left Edison to launch his own brilliant career).[42] Insull also scolded Charles Hanington, who had supervised the wiring, for submitting a bill for eleven days of labor by twelve different men. In his defense, Hanington argued,"Sunbury was very much mixed from the start . . . and I dont think more than ½ of the people that had a hand in it understood it. . . . I was not the only one to go to school on this job."[43]

Edison, too, went to school in Sunbury, though not all of the lessons to be learned were readily apparent. He stayed in town for several days after the plant opened to monitor its performance and to continue training the staff. Before leaving, he wrote out and signed twelve pages of trouble-shooting instructions, including nine possible dynamo problems and their remedies. This primitive manual was the first of several efforts to codify knowledge essential for the reliable and economical operation of central stations far from the resident expertise in New York.[44] Edison left behind in Sunbury one of his principal electricians, William Andrews, but just a few days later, an intense thunderstorm showed how ill-equipped Andrews was to manage on his own. He reported to Edison that lightning had "been snapping most viciously around our light fixtures" in the City Hotel, producing a few cracks "as loud as the firing of a gun cap" and leaving "Some of the folks here . . . quite scared." Edison, with years of experience with uninsulated telegraph lines, instructed Andrews to ground the system through a high resistance during daylight hours and during storms (though doing so would shut down the system) and to "put the omnibus [main conductor] to dead ground when not running storm or no storm."[45] The report from Andrews was the first of many about unexpected contingencies. Some of those contingencies could easily have been avoided,

[42] Samuel Insull to TAE, July 10, 1883, DF, NjWOE (*TAED* D8367Y3; *TAEB* 7: Doc. 2485).

[43] Samuel Insull to Charles Hanington, July 10, 1883; Hanington to Insull, July 10, 1883; both DF, NjWOE (*TAED* D8316AFE, D8340ZBD).

[44] TAE memorandum, July 8, 1883, facsimile reprinted in Jehl, *Menlo Park Reminiscences*, 3:1102–13 (*TAED* X001J3A, X001G2BD; *TAEB* 7: Doc. 2484); see also TAE to William Andrews, Aug. 4, 1883, Construction Dept. Letterbook 14:260, NjWOE (*TAED* LBCD1260, *TAEB* 7: Doc. 2500).

[45] Andrews to TAE, July 11 and 16 (with TAE marginalia), 1883; TAE to Andrews, July 19, 1883; all DF, NjWOE (*TAED* D8361ZAV, D8361ZBE, D8316AIE); Harry L. Keefer and Samuel N. Keefer, "First 3-Wire System in World Installed Here," *Sunbury Daily Item,* Sept. 1, 1927.

particularly those arising from penny pinching during the construction phase. The mere existence on paper of a construction department did not guarantee that the abilities of the nation's most famous technician could be transferred to other crafts or to geographic regions beyond his direct oversight.

Wiring was a particular problem. Left in the supposedly expert hands of Bergmann & Company, the interior wiring worked well enough but was unsightly.[46] Before the plant was even a month old, Frank McCormick, the Sunbury company president, fumed that Bergmann's crew "have caused a great deal of complaint because of the manner in which the work is done and the conduct of the men doing the work." He complained that they had placed unconcealed wires "over the walls and ceilings with no regard whatever for the appearance of things" and had cut private telephone lines lying in their way. They also charged "exhorbitant [*sic*] prices for putting in lamps, in some cases as high as $3.75 per lamp." The stalwart Phillips Shaw, after inspecting the Sunbury system, reported to Edison, "the wiring makes me Sick. I certainly Shall be ashamed to Show this work to people of other towns." He filed similar complaints from Shamokin. The Sunbury directors voted to take the work out of Bergmann's hands and contract for it themselves, further annoying Edison by publicizing their decision.[47] Edison acknowledged the problems but implied that the underlying fault lay not in the workers' competence but in their efforts to economize on costly materials. He vowed that his laboratory assistants in New York were already at work on a cheaper wiring system.[48]

The wiring difficulties were indicative of two general problems that would plague the pioneering Pennsylvania plants to varying degrees. One challenge was to find—or train—a staff to set up and operate what was a fairly esoteric high-tech system. The other was to adapt the technical details of the system in response to feedback from those actually installing and using it. Drawing a bright line between his work as an inventor and his immediate future as a contractor, Edison reportedly boasted to a newspaper while setting up the Sunbury plant that he had "closed [his] laboratory" and gone into business because "there is nothing more

[46] The Sunbury installation was typical of early Edison plants in Pennsylvania and elsewhere in that most of its customers were commercial establishments such as the City Hotel and various shops.

[47] McCormick to TAE, July 25, 1883; Shaw to TAE, July 23 and 31, 1883; TAE to Shaw, Aug. 2, 1883; all NjWOE (*TAED* D8361ZBK, D8361ZBH1, D8340ZBX, D8316ALD).

[48] TAE to Frank McCormick, Aug. 2 and July 26, 1883, both DF, NjWOE (*TAED* D8316ALB D8316AJB; *TAEB* 7: Doc. 2496).

in electric lighting to be invented or required." Soon after, he promised to be "simply a business man for a year. I am now a regular contractor for electric light plants, and I am going to take a long vacation in the matter of inventions."[49] Edison took great personal pride in his ability to adapt an invention or system to unforeseen conditions of actual use through a rapid series of changes—what we now call "innovation." But his experience with innovation had, until this point, been entirely hands-on: he observed a device in operation, identified problems, and devised solutions. In this case, however, the system was in use outside his personal view, meaning he had to rely on reports from others. Some information came from users or investors completely untutored in electricity, whose accounts were of unknown reliability. More coherent and sophisticated information came from his lieutenants in the field, though these men, despite possessing technical vocabularies and skills, also were largely inexperienced with the village plant system. Andrews, Edison's chief electrician, who managed the installation of most of the Pennsylvania plants, fired off dozens of letters and telegrams with critiques and suggestions. Edison, preoccupied in New York with preparing estimates and preliminary layouts for scores of projected new village plant installations, weighed these reports and gruffly advised him by return mail and telegram.

Some of the problems reported from Sunbury, Shamokin, and elsewhere were amenable to technical solutions, and Edison spent part of his planned year as a "business man" working instead in his makeshift laboratory atop the Bergmann & Company factory in New York. The single most serious and persistent difficulty had to do with voltage regulation. The proper voltage was crucial to the system's success: too low and lights would dim, causing customer complaints; too high, even for a moment, and lamps would burn out. (Replacement came at the expense of the company, not the irate customer.) Edison had largely solved this problem in the two-wire Pearl Street district, but the three-wire village plan was a dynamic system in which small changes on one part of the circuit could produce outsized effects on the other. It also raised the possibility of a geographically asymmetrical load in which one leg of the circuit would require more current than the other. Edison devised what he called a "feeder regulator" or "equalizer," essentially a set of resistance coils, to

[49] "Edison," *Chicago Daily Tribune*, June 19, 1883, 8; "The Electric Light," *New York Evening Post*, Aug. 1, 1883, 1.

alleviate the imbalance, and he called for them to be installed at Sunbury and Shamokin. Simple in principle, feeder regulation depended on reliable instrumentation to indicate line conditions to an operator back at the station. Properly interpreting signals from instruments in multiple branches of the network, especially when those devices acted inconsistently, was a difficult art to master.[50]

Vexed by reports of "enormous" lamp breakage, Edison exchanged numerous letters with Andrews on the subject throughout that first summer. They managed to ameliorate the difficulties somewhat, but in early 1884, with seven months of experience behind him, Andrews concluded that the problems were "the almost inevitable consequence of starting up new Stations, and running the same by guesswork."[51]

The larger concern of regulation was simply managing the minute-to-minute changes in load, particularly at dusk, as customers turned on their lights, and again at the end of the evening. If steam power at the station were not adjusted accordingly, the dynamos would generate electricity at a voltage too low or too high for the lamps. In October 1883, after an unrecorded amount of work in his laboratory, Edison prepared to patent a voltage indicator that can be seen in retrospect as one of the first electronic devices. It was based on the phenomenon called the Edison Effect, first noticed at his Menlo Park laboratory in 1880. Edison found then that a wire inserted into the vacuum of a lamp bulb but not electrically connected to the filament acquired an electrical charge when the bulb reached incandescence; moreover, beyond that point, the charge in the extra wire increased out of all proportion to the voltage applied to the lamp.[52] The disproportionate electrical response of the modified bulb, Edison realized, was just the sort of feedback mechanism he needed for a sensitive indicator, and he had the new devices in service at several plants in Pennsylvania (as well as in Massachusetts) before the end of 1883.[53]

[50] For a more complete explanation of the three-wire system and its regulation, see "Distribution System Regulation" and "Voltage Indicators," *TAEB* 7: Doc. 2505 and Doc. 2537 n. 6.

[51] Andrews to TAE, Aug. 12, 1883; Andrews to Edison Construction Dept., Feb. 16, 1884; both DF, NjWOE (*TAED* D8361ZCJ, D8442ZBH).

[52] No one could explain this action without a theory of the electron—still more than a decade in the future—but it was the result of electron transfer from the heated filament wire. This principle is the basis of the vacuum tube. See "Edison Effect and Lamp Life," *TAEB* 5: Doc. 1898.

[53] To Edison's chagrin, he soon found not only that the new indicators were fragile and ill-suited to long railroad journeys from his lamp factory in Harrison (East Newark), New Jersey, but their electrical characteristics changed over time, rendering them quite useless for the job. See "Voltage Indicators," *TAEB* 7: Doc. 2538.

For customers and managers of the Sunbury plant plagued by lamp breakage, the new instruments could not come soon enough. Roughly one hundred lamps failed each month throughout the fall. Frank Marr, an attorney serving as the local company's treasurer and legal representative, reported that eight lamps arced (short-circuited across the filament) in one November evening, destroying the sockets as well as the lamps.[54] Edison blamed the company for deliberately exceeding the capacity of his ten-candlepower lamps. The company reduced the electrical pressure in the 110-volt system, first to 105 volts, then lower, to the point that disgruntled customers took to supplementing their dim electric lights with gas. Edison dispatched one of his most experienced lieutenants to investigate, and fingers were pointed in various directions. The inexperienced Sunbury company operators had little choice but to rely on Edison's recommendations on this and other matters, such as a planned expansion of the service area and the rates to charge customers.[55]

Although Edison was too quick to blame operators for all of the plant's ills, he was correct to suspect a deficit of skill or attention on the part of the operating engineers. Edison had relinquished full control of the plant to the Sunbury company in early August despite misgivings about its high coal consumption and the ability of its fireman. Concerns about the capability of local skilled and semiskilled labor to operate the machinery with only a few weeks of training would haunt his experience not only at Sunbury but in a number of other plants. It is not clear what type of workers the local Edison illuminating companies sought or could hire, but it is likely that they would have looked favorably on stationary steam engineers. In Sunbury, the Pennsylvania Railroad's large car and locomotive shops were probably the major employer of the type of labor the company required. Even so, the electrical instrumentation in the plant would have been outside the experience of almost anyone in the area, and correctly interpreting and responding to the instruments was not a simple matter, as Edison's own experts understood. Long overnight shifts surely aggravated these deficiencies.

[54] Frank Marr to TAE, Nov. 3, 1883, DF, NjWOE (*TAED* D8361ZDN); a capsule biographical summary of Marr and his subsequent involvement with electric lighting in Pennsylvania is in *TAEB* 7: Doc. 2533 n. 3.

[55] TAE to Frank Marr, Nov. 7, 1883, DF, NjWOE (*TAED* D8316BEU; *TAEB* 7: Doc. 2546); Frank McCormick to TAE, Oct. 23 and Nov. 5, 1883; TAE to McCormick, Oct. 26 and Nov. 9, 1883; Thomas Conant to TAE, Nov. 4, 1883; TAE to Marr, Nov. 13, 1883; Marr to TAE, Nov. 3 and 15, 1883; all DF, NjWOE (*TAED* 8361ZDK, 8361ZDO, 8316BCW, 8316BFH, D8360ZCC, D8316BFQ, D8361ZDN, D8361ZDQ).

Supervision of operating engineers was another problem, particularly in Sunbury. The plant's owners and managers were professional men (and out-of-towners, at that) with little or no industrial experience; they entrusted its operation entirely to an engineer and his assistant. In December, Edison received a roundabout report from William Andrews, then working in Lawrence, Massachusetts, that the Sunbury engineer "got drunk the other night and left Station in care of a boy." Frank Marr investigated and, after excoriating Edison again about his choice of subordinates and about interior wiring, reported that the engineer, one William Bateman, was routinely on duty from 3:00 p.m. until 8:00 a.m. and was permitted a few hours' sleep while a young assistant minded the machines. On the night in question, he claimed, the youth had simply failed to wake Bateman before leaving for the evening.[56]

This incident, however, turned out not to be an isolated one, and various complaints continued to reach Edison's office in New York. At the end of January 1884, Alfred Tate, an assistant to Samuel Insull, dispatched construction supervisor William Rich to fix the Sunbury plant's leaky roof and look into other physical problems. Rich's on-site observations provided a broad indictment of the plant's operations. Windows were broken or painted over, a sheet of metal covered a hole in the roof directly over the voltage regulator, there was extensive corrosion, and the interior generally was unkempt. Rich pointed out that the dynamos' original driving belts betrayed little wear, having been replaced because they produced noise that "disturbed the slumbers of the engineer (but still he slept on)." He also related another incident in which Bateman had absented himself, leaving a young assistant in charge. More damning news about Bateman soon came from Andrews, who corroborated Rich's account of the station's "filthy condition" and poor operation. Andrews noted that Bateman was in debt "all over Sunbury" and had "made the station a regular rendevouz for women—I found a couple of doz. empty beer bottles behind boiler." He concluded that Bateman's tenure "shows the evil of leaving a station entirely in charge of an engineer, with no one else in the town that knows anything about Station matters, or has authority to act."[57] Accounts of inebriated engineers also came in from Bellefonte and Hazleton. In February 1884, only a week into the operation of the Hazleton plant, a report reached

[56] William Andrews to Samuel Insull, Dec. 5, 1883, DF, NjWOE (*TAED* D8361ZDY; *TAEB* 7: Doc. 2563); Marr to TAE, Dec. 8, 1883, DF, NjWOE (*TAED* D8361ZEB).

[57] Rich to TAE, Feb. 2, 1884; Andrews to TAE, Feb. 9, 1884; both DF, NjWOE (*TAED* D8458F, D8442ZAV).

Edison that the engineer had "been intoxicated for several days." Edison concluded that in these towns, "in Every Case trouble may be traced to carelessness," and he belatedly drafted a standard contract delineating the responsibilities of the station engineer.[58]

Problems with the System

Problems in Sunbury foreshadowed troubles throughout the region. In addition to staffing and management troubles, the leaky roof in Sunbury was symptomatic of systemic scrimping on generic construction to make the plants more affordable. Edison went to Shamokin in late September to oversee the startup there, but that plant was soon plagued by boiler and engine problems. Elsewhere, he held down costs by ordering engines and boilers too small for the work they had to do. They burned through too much coal and too much of the companies' expected profits.

Edison addressed these manifest problems early in 1884, though not quickly enough to please local investors. In Sunbury, he fired the engineer and put in his own people.[59] He was only able to do so because the undercapitalized company had paid for its plant in stock shares instead of cash, effectively giving him a controlling interest, a pattern that would be repeated by cash-poor and dissatisfied Edison lighting companies throughout the region.[60] He paid particular attention to Hazleton because of the financial involvement there of George Bushar Markle Jr., whose father, now retired, had been a powerful coal operator and leader of efforts to suppress the Molly Maguires. The Markle family was linked through its railroad investments with Drexel, Morgan & Company, whose partners remained deeply involved with the Edison companies in New York. James Hood Wright, a Drexel partner particularly close to Edison, was also connected by the marriage of his stepdaughter into the Markle family. After the Hazleton plant's debut, seemingly rocky even in comparison with the region's other stations, Sherburne Eaton of the Edison Electric Light Company warned in early March 1884 that Edison should quickly

[58] Sherburne Eaton to Samuel Insull, Feb. 18 and 20, 1883; TAE to Insull, Mar. 8, 1884; TAE draft contract, ca. Feb. 5, 1884; all DF, NjWOE (*TAED* D8439U, D8455ZAL, D8439ZAI [*TAEB* 7: Doc. 2625], D8439ZAA1).

[59] TAE to Sherburne Eaton, ca. Feb. 3, 1883, DF, NjWOE (*TAED* D8458E; *TAEB* 7: Doc. 2603).

[60] Regarding payments in stock of the Sunbury company see, for example, TAE to Frank McCormick, Aug. 4, 1884, Letterbook 18:221, NjWOE (*TAED* LB018221; *TAEB* 7: Doc. 2709).

make amends because "Markle means J. Hood Wright," and their collective potential future investment in electric lighting was substantial.[61]

Edison's efforts to improve operations in Hazleton, though swift and effective, proved insufficient to meet the adverse circumstances he faced throughout the region in the first half of 1884. Most of those circumstances were his and Samuel Insull's direct responsibility, to be sure, the culmination of bad planning that led the president of the Sunbury plant to complain, just after its first anniversary, that the whole business "looks very much like a swindle."[62] Some could also be attributed to honest misapprehensions of the risks in a new and untried business. The construction "boom" Insull anticipated came both too fast and too slow: it demanded the rapid outlay of large sums of cash but, after the first wave of expenses, did not generate enough new business to make those debts bearable. It is extremely difficult to reconstruct Edison's financial records, but it can be said that in the first few months of his construction department business he advanced at least $43,000; by the spring of 1884, despite some repayments, he was out of pocket for tens of thousands of dollars and was having trouble collecting the sums due him.[63] Village plant systems were simply too expensive for the sole proprietor business model Edison had adopted for their construction. Despite having modified the network's design to trade some operating efficiency for lower initial costs, he recognized in March 1884 that "the 1st investment is the trouble in pushing our biz."[64] Six weeks later, on April 24, he announced his intention to leave the construction business and negotiate its takeover by the Edison Electric Light Company; a few weeks later, in mid-May, he began releasing members of his engineering staff.[65]

[61] Information on the Markle family from the 1880 federal census for Hazleton (Luzerne County), p. 660; *National Cyclopaedia of American Biography*, 24:138, 18:153, and C:525; and Michael Novak, *The Guns of Lattimer* (East Brunswick, NJ, 1978), 42. Reports of the Hazleton station and quotation from Eaton to Samuel Insull, Feb. 18 and 20, and Mar. 4, 1884; all DF, NjWOE (*TAED* D8439U, D8455ZAL, D8439ZAC [*TAEB* 7: Doc. 2617]).

[62] Frank McCormick to TAE, July 18, 1884, DF, NjWOE (*TAED* D8458ZAE).

[63] Construction Dept. "Trial Balance[s]" show in detail Edison's running expenses as of September 1 and October 1, 1883 (NjWOE [*TAED* HM830186E, HM830186F]). Summaries of expenses for individual central stations are in Edison Construction Dept. Ledger (1883–86), esp. pp. 2–41, NjWOE (*TAED* AB033).

[64] TAE marginalia on letter from William Andrews to Edison Construction Dept., Mar. 2, 1884, DF, NjWOE (*TAED* D8442ZBY; *TAEB* 7: Doc. 2615).

[65] TAE to Sherburne Eaton, Apr. 24 and May 15, 1884, both DF, NjWOE (*TAED* D8427ZAL, D8416BOY; *TAEB* 7: Docs. 2655, 2672).

Edison's action coincided with a circumstance entirely beyond his control: an acute liquidity crisis that brought the nation's banking system, after months of worsening conditions, to the brink of a full-fledged panic in May.[66] These events complicated Edison's efforts to extract himself from the construction business. The Edison Electric Light Company, which he had considered a tepid partner all along, was itself feeling financial strain, exacerbated by having to take stock in the local illuminating companies to which it sold operating licenses, rather than getting the cash it originally expected. The company was also affected by the recent defaults of two of its principals (and Edison backers), financiers Henry Villard and Egisto Fabbri. It had also been trying to gain a toehold in the increasingly lucrative manufacturing operations (especially lamps) that Edison and his partners had financed and controlled themselves. These conflicting interests led to a series of negotiations for the general reorganization of the Edison lighting business in the United States. No agreements were signed until September, but a consensus seems to have been reached by mid-June 1884 by which the Edison Company for Isolated Lighting (a stock company with a directorate interlocked with that of the main Edison firm) would take over the construction business. Among the questions to be settled was how to resolve the standing complaints of the local illuminating companies against Edison and his construction deptartment for defective workmanship.[67]

Denouement

A traumatic and unexpected event—the death of Edison's wife in August—symbolized his separation from the central station electric lighting business. Distracted by grief and the responsibility for three young children, Edison assented to the contracts turning over his construction affairs to the Edison Company for Isolated Lighting. Without any fanfare or public announcement, his stint as a man of business ended, and he soon turned his attention to finding new inventive projects.

Only the matter of money remained. In 1885, as Edison focused his creative energies on other projects, Insull directed his considerable persuasive powers to extracting the cash the local illuminating companies in Pennsylvania, Massachusetts, and Ohio still owed. The debtors

[66] "On the Verge of a Panic," *New York Times*, May 15, 1884, 1.
[67] See *TAEB* 7:481–82, esp. n. 4.

included all five of the Pennsylvania firms: Sunbury, Shamokin, Mount Carmel, Bellefonte, and Hazleton. Insull whittled down the amounts until September 1885, when Edison authorized Phillips Shaw to make settlements with four of the firms. The decision to delegate the power to settle these accounts may have emerged from a special directors' meeting of the Edison Electric Light Company on September 4, called, at least in part, to discuss "a proposition from P. B. Shaw."[68]

Edison provided Shaw with a confidential memorandum outlining the terms he hoped to reach with each organization. Insull had calculated that the various illuminating companies in the Northeast owed Edison $12,960. Of this, the Pennsylvania companies owed the bulk, amounting to some $8,725. Mount Carmel accounted for $2,813, followed by Sunbury ($2,416), Shamokin ($2,238), and Bellefonte ($1,256). The Hazleton firm also owed $762, but Edison left this out of the memorandum. He realized that collecting the payments in cash would be difficult or impossible, in some cases because the company was cash poor and in others because the amount was in dispute or because of dissatisfaction with the construction department's installation.[69]

Edison separately promised to pay Shaw a 5 percent commission on the amount he received in cash from Shamokin, Mount Carmel, and Bellefonte. He did not offer any commission for Sunbury, perhaps because he expected that company to pay in shares of stock. Edison said he would collect the money from Hazleton himself.[70]

Shaw's aid was enlisted only after Insull had run into heavy resistance in his own attempt to collect the debts. In June, Insull had despaired of getting anything out of Shamokin and Bellefonte without threatening to sue. He considered these "the most aggravated cases" of all the outstanding accounts. "We find it absolutely impossible to get any satisfaction from the Shamokin Co.," he complained to Edward Johnson, a friend of Edison and an irrepressible promoter of his inventions, now president of the Edison Electric Light Company. Insull thought there was "no excuse whatever for the Shamokin Co. keeping Mr. Edison out of his money," especially since its directors had agreed the year before to make good its obligation. The Bellefonte enterprise had also acknowledged its debt and sent a check for

[68] Frank Hastings to TAE, Sept. 2, 1885, DF, NjWOE (*TAED* D8526ZAB); TAE to Shaw with enclosure, Sept. 4, 1885, Letterbook 20:467C, NjWOE (*TAED* LB020467C).

[69] Insull to Edward Johnson, June 3, 1885, and TAE to Shaw, Sept. 4, 1885, Letterbook 20:315A, 467C, NjWOE (*TAED* LB020315A, LB020467C).

[70] TAE to Shaw, Sept. 4, 1885, Letterbook 20:467A, NjWOE (*TAED* LB020467A).

$500 in partial payment, but it now claimed to be too strapped to make a full settlement. A skeptical Insull pointed out, "although the Bellefonte Co. cannot find money to pay Mr. Edison a bill which has been standing about for 18 months, they are somehow able to raise money to increase their plant."[71]

Shamokin's refusal to pay stemmed from long-running dissatisfaction with its plant. Construction defects had manifested themselves as early as December 1883, but these difficulties were soon compounded by the poor performance of the dynamos and a high rate of lamp failure. In early 1884, Shamokin president William Douty complained serially that the three 8½ × 10 engines produced by the Providence-based Armington & Sims Engine Company were generating only thirty horsepower and that at least one of them had started "kicking" and would not properly regulate its speed.[72]

Efforts to solve these problems did not satisfy the Shamokin company, which prompted a meeting in New York in June 1884 among Edison, Insull, Francis Upton (manager of the Edison Lamp Company), Sherburne Eaton of the Edison Electric Light Company, and Douty, Andrew Robertson, and John Mullen from the Shamokin firm. Edison later claimed that as a result of the settlement reached that day, Shamokin had been compensated for its difficulties when the Edison Electric Light Company agreed to return its bonds. He noted further that the Shamokin firm, the Edison Electric Light Company, and he had signed a memorandum to this effect at the June meeting, after which the parties had paid him $805.48 and promised to settle the balance as soon as he had replaced a dynamo and two malfunctioning engines and upgraded other equipment.[73]

Immediately after the meeting, Edison personally wrote to Armington & Sims about replacing two of the original engines with one 14½ × 13 engine. He also decided to replace one of the three original sixty-five-horsepower "H" dynamos with two twenty-eight-horsepower "S" dynamos. But in part because Armington & Sims was reluctant to take out its engines, the new equipment was not shipped until the end of September. Even after they were in place in early October, William Brock, the local man-

[71] Insull to Johnson, June 3, 1885, Letterbook 20:315A, NjWOE (*TAED* LB020315A).

[72] Douty to TAE, Dec. 29, 1883, and Jan. 5, 1884; William Brock to Douty, June 20, 1885; Insull to Sherburne Eaton, Feb. 15, 1884; Insull to Douty, Feb. 18, 1884; all DF, NjWOE (*TAED* D8360ZDC, D8457C, D8523ZBE, D8416AOA, D8416AOQ).

[73] Memorandum of conference, June 11, 1884, NjWOE (*TAED* HM840222); TAE to Shaw with enclosure, Sept. 4, 1885, Letterbook 20:467C, NjWOE (*TAED* LB020467C).

ager, complained that the dynamos could not be run because the necessary ancillary equipment had yet to arrive. The new machinery did not prevent problems with lamp breakage, and difficulties persisted with the remaining original steam engine. In July 1885, Douty, replying to a letter from Edward Johnson, noted that because of "the troubles still existing—Caused by the materiel machinery &c furnished by Thos A Edison our Company do not feel disposed in any way to pay Mr Edison one penny more than we have paid him—In law and Justice we do not owe him anything."[74]

Despite such resistance, Shaw evidently achieved some success in collecting monies from the Pennsylvania companies. On September 18, he billed Edison $135.25 on commission for settling the Shamokin and Bellefonte accounts. He also seems to have negotiated an agreement with Sunbury. According to those terms, Edison accepted $1,650 in Sunbury stock, with the understanding that he would subsequently surrender his aggregate interest of 61.51 shares for half as many (at $100 par value) in a reorganized company there. Edison acceded to these terms after Shaw convinced him that the company had only $1,745.78 in total assets. As it turned out, the company had to borrow $400 from Shaw to fulfill its obligation. From Mount Carmel, Edison took 48 shares of stock, later valued at $2,400. From Bellefonte, he agreed to accept just $750, payable in three notes due in two, four, and six months. It is not clear what settlement Edison made with Shamokin. On September 19, Edison sent Shaw signed releases to be given to the Mount Carmel, Bellefonte, and Sunbury companies on the terms stated.[75]

The early experience with the Edison village plant system in Pennsylvania exhibited mixed results at best, which might be expected under the circumstances. After all, electric lighting was a new technology that was evolving rapidly even as it was being implemented. Nonetheless there were,

[74] TAE to Armington & Sims, June 12, 1884, Construction Dept. Letterbook 17:394A, NjWOE (*TAED* LBCD6394A); William Brock to Frank Hastings, Oct. 3, 1884; Brock to TAE, Oct. 10, 1884; Douty to Edward Johnson, July 2, 1887; all DF, NjWOE (*TAED* D8457ZBI, D8457ZBJ, D8523ZBG).

[75] Shaw to Samuel Insull, Sept. 9 1885; Shaw to TAE, Sept. 18, 21, and 25, 1885; William Schwenk to TAE, Oct. 23, 1885; all DF, NjWOE (*TAED* D8523ZBR, D8523ZBT, D8523ZBV, D8523ZBS, D8523ZBW, D8523ZBY); TAE agreement with Edison Electric Illuminating Co. of Sunbury, Sept. 22, 1885; TAE agreement with Edison Electric Illuminating Co. of Bellefonte, Sept. 1885; TAE agreement with Edison Electric Illuminating Co. of Mount Carmel, Oct. 23, 1885; all NjWOE (*TAED* HM850268, HM850269, HM850270); Vouchers (Laboratory) no. 476 (1885) for Sunbury; no. 101 (1886) for Mt. Carmel; both NjWOE; TAE to Shaw, Sept. 19, 1885, Letterbook 20:498A, NjWOE (*TAED* LB020498A).

even in the short run, some notable successes, such as the Edison plant in Harrisburg. The success of the Harrisburg system is perhaps attributable to the strong local executive management of John Irvin Beggs (1847–1925). Beggs, a native of Philadelphia, started his career as a bookkeeper for the Philadelphia & Reading Coal & Iron Company. By 1882, he had become an insurance executive in the state capital. His first experience in the electrical industry came in 1884, when he invested in the Harrisburg Electric Company, which proposed to construct an Edison plant in the city. The company seems to have gotten off to a rocky start. The *Western Electrician* subsequently reported that Beggs "soon realized that unless an aggressive policy was pursued, the enterprise would prove a failure, and he accordingly invested more money in the project and assumed personal supervision over its operations." Beggs served as secretary, treasurer, and general manager of the Harrisburg Electric Company, which started up its plant on May 1, 1885. The plant remained in continuous operation from its inception and was reputed, according to the *Western Electrician*, to be "the most profitable electric light plant in the United States."[76]

Beggs's efforts did not go unnoticed by the Edison interests. The Edison Illuminating Company of New York (which operated the Pearl Street plant) soon recruited him as its vice president and general manager. In this capacity, he oversaw the opening of two new central station plants in the city and significantly increased the number of isolated plants in New York. Under his management, the company's revenue increased from $157,000 in 1887 to $750,000 in 1890, and the customer base grew from 500 to 1,500. After the formation of the Edison General Electric Company in 1889, Beggs was made manager of the Central District of the United States and, from his headquarters in Chicago, supervised the company's electrification efforts in eleven states.[77]

The other Edison Pennsylvania illuminating companies may not have been quite as successful as the Harrisburg Electric Company, but they were by no means failures. Although Edison withdrew from direct personal involvement in constructing new stations and returned to his true calling as an inventor, he had managed to school others in the development and operation of the village plant system. All of the Pennsylvania companies continued to operate and became self-sustaining, demonstrating both the

[76] "John I. Beggs," Edison Pioneers biography, NjWOE; "John I. Beggs, President of the Association of Edison Illuminating Companies," *Western Electrician* 7 (Sept. 20, 1890): 1.

[77] "John I. Beggs," *Western Electrician*, 1.

virtues of central station electric lighting and the deficiencies of Edison's DC system. Later, as electrification matured and became more centralized, the smaller Edison illuminating companies in Pennsylvania and elsewhere were bought up by larger concerns and incorporated into emerging regional systems. The Sunbury, Shamokin, Mount Carmel, Hazleton, and Williamsport companies, for instance, were all eventually subsumed in the Pennsylvania Power and Light Company, while in 1927, Bellefonte became part of the West Penn Power Company.[78]

In spite of the success of the Edison lighting companies in Pennsylvania over the long term, high capital costs would remain a major hurdle in developing the central station model of electric light and power that Edison envisioned. The solutions to the problem required nearly a decade, the formation of industrial giants General Electric and Westinghouse Electric (and the latter's more advantageous system of alternating current), and creative new ideas about financing capital construction (and for rural electrification, government intervention on a large scale in the 1930s).[79] But while the financing and administration of electrification would require a much a higher level of organization and greater economies of scale than Edison anticipated in the early 1880s, it is also true that his efforts to establish village plant systems in Pennsylvania and elsewhere helped not only to solve many sticky technical issues, they also provided practical experience to "untried hands" and extended hands-on technical knowledge of electric lighting outside of New York. This, in turn, helped to create a new skilled workforce capable of handling the next phase of electrification in the United States.

Thomas A. Edison Papers,
Rutgers University

Louis Carlat and
Daniel Weeks

[78] Hughes, *Networks of Power*, 431–33; Sylvester Kirby Stevens, *Pennsylvania: Titan of Industry*, 3 vols. (New York, 1948), 3:848.

[79] Alfred D. Chandler, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, MA, 1990), 214; Christopher Kobrak, *Banking on Global Markets: Deutsche Bank and the United States, 1870 to the Present* (Cambridge, 2007), 52.