The Old GE

1886-1986

George Wise

2024

To Bonnie Mary Annis Wise

1947- 1996

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Chapter 1. Introduction: Two GEs

In Schenectady, New York, 1986 was not a very good year. It seemed fitting that, on November 22, while marching in the pre-Christmas Parade at a local Shopping Mall, Santa Claus suddenly keeled over, felled by a fatal heart attack.[1]

Just a couple of miles away, the works of Schenectady's biggest local employer, known sarcastically as Generous Electric, was in the midst of its own corporate coronary. In January, the top GE area executive had warned that job reductions would number "at least" 1500. That "at least" sounded ominous, even in a city where jobs had been leaking away by the hundreds for decades. It soon became apparent that the number would be a lot larger. On November 17, some 800 members of Local 301 of the International Union of Electrical Workers (IUE) marched on Schenectady's city hall to protest the 3000 most recent layoffs that were reducing the initial 13,000 work force by 23%.[2]

The workers chanted such slogans as, "Here lies motors, here lies gas. GE kiss my ass". The references were to the Large Motor and Generator Business, the Schenectady Works' initial and oldest business, which was to be shut down, and to Gas Turbine, the Works' youngest and most promising business, which was completing a move to South Carolina. Schenectady 's mayor, who had herself married a scientist at General Electric's nearby Research Lab, met with the marchers, sympathized, but could do nothing. Next to the entrance to that Schenectady City Hall stood a recently installed stone slab celebrating "General Electric 's 100 years in Schenectady" . An observer noted that the slab was looking more and more like a tombstone.

Those worst of times in Schenectady and at its General Electric Works were, however, the best of times at GE's Fairfield, CT corporate headquarters. The opening lines of the company's 1986 annual report proclaimed that

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[1] **Woodruff, Kathy. 1986. Mall Santa Claus Dies, Stricken During Parade. Schenectady Gazette 24 Nov 1986. p.27**

[2] **Walerius, Randolph. 1986. " GE Workers Mach on City Hall." Schenectady Gazette. 18 Nov 1986 p. 23. See also Albany Knickerbocker News, 18 Nov 1986**

> By any measure 1986 was a strong year for your Company-- record sales, record earnings, several successful acquisitions and excellent positioning for the future.

That report went on to describe two of those 1986 acquisitions, each among the largest in the company's history. They brought in RCA, including its NBC television network, and an old and well known investment house, Kidder Peabody. None of that old electric stuff here! What was here was less clear. The most frequent label applied in 1986 by outsiders to General Electric was "conglomerate". The company's management disliked that description. It preferred "the New GE." At the conclusion of that 1986 Annual Report , that New GE was described in a summary most notable for the absence of that now unnecessary word "electric".

> In summary, GE is a unique set of different businesses, run by a unique group of people with different talents-- united by the company's shared values and strengthened by its human, technical, and financial resources. Whether it is Financial Services' ability to adapt to its market environment, or Medical Systems' technology leadership, or Aircraft Engines' and Plastics' use of creative alliances.

The New GE could have said, echoing the fictional movie star Norma Desmond, "I'm still big. It's electricity that got small "

Leading the New GE in 1986 was a small man who had got very big. Jack Welch had been educated as a Ph.D. Chemical Engineer. On joining GE, however, he quickly expanded beyond technology, training himself in management, manufacturing, finance and sales. He did so not by reading the company's management instructional "Blue Books" or attending its business school in Crotonville NY . He learned how to manage by leading one of GE's major business successes, its plastics business. He was now, in 1986, the scourge of the Old GE. His layoffs earned him the nickname Neutron Jack (like the Neutron Bomb, kills the people but spares the buildings.) This was inaccurate. In Schenectady at least, he was destroying the buildings too.

This is a story of how the Old GE got from its prehistoric origins in 1886 to its renewal in 1986, from its progenitor Thomas Edison to its renewer Jack Welch. Telling this story has two purposes. One is to answer some specific questions about the Old GE. Why was it born? Why did it thrive for a span not terribly different from the length of a human life? Why did it end suddenly, replaced by a New GE?

Beyond those specific questions, there is a general historical issue that the story of the Old GE illuminates. That issue is the role played in the U.S. economy by Giant Corporations. Identifying those Giant Corporations begins with a question. What is a corporation? A corporation is a business collectively owned by stockholders. It is chartered by a government (in the U.S., by one of the 50 states). It possesses special rights granted through that charter, such as limited liability of those stockholders for the debts of the corporation. Also through that charter, a corporation can exercise many, though not all, of the legal rights of a person. Instead of further explaining those features, this book focuses on an old folk-definition. A corporation is a giant immortal artificial person without an ass to kick or a soul to save.

If a corporation is already a giant, what is a Giant Corporation? Here that term identifies a U.S. corporation that consistently throughout the 20th century appeared in one of the top 25 spots on the Fortune 500 list of largest U.S industrial companies or similar retrospectively compiled rankings covering the pre-Fortune years. Examples of those 20th Century Giants include AT&T, DuPont, Exxon, Ford, General Motors, Proctor and Gamble, U.S. Steel and General Electric.[3]

Those Giant Corporations were typically ten times as big (measured, for example, by annual sales) as the Very Big Corporations occupying the next 100 or so places on such a top 500 list. The Giants were 30 times or more as big as the Merely Big Corporations occupying the remaining few hundred places.

In the the 20th century those Giant Corporations typically grew much faster than the U.S. GDP. Measured in current dollars, GE, for example , a company with approximate sales (measured in current dollars) of $13 million in the year of its founding 1892 grew by the year 1986, the year the Old GE gave way to the New, to sales of $36 billion (also in current dollars), This is a multiple of about 2800. Over that same time span, the U.S. Gross Domestic Product , GDP, (also measured in current dollar terms) grew from about $17 billion to about $4,6 trillion, a multiple of only 270. In that year of 1986 the dollar value GE delivered to the U.S. economy was nearly one half a percent of the U.S. GDP. In other words, just 200

[3] **Louca, Francisco and Mendona , Sandro. 2000. Steady Change: the 200 largest Manufacturing Corporations throughout the 20th Century. Industrial and Corporate Change. 11. 817-845.**

companies the size of GE could have produced the entire U.S. GDP. (Details of GE's numerical performance are in Appendix 1 , The Old GE by the Numbers).

What ought one to think about the Old GE and its fellow Giants? Even after more than a century of arguing, Americans are not sure. One 21st century book on Giant U.S. Corporations, by law professor Tim Wu, condemns The Curse of Bigness. Another, by two professors of public policy, Michael Lind and Robert D. Atkinson, proclaims that Big is Beautiful**.** [4]

What have historians said about the emergence and historical significance of Giant Corporations? One historian in particular has dominated the answering of that question. Alfred DuPont Chandler presented an extremely influential interpretation of the rise of Giant Corporations in three major books: Strategy and Structure (1962), The Visible Hand (1967) and Scale and Scope (1990). With those books, Chandler achieved a market dominance in the field of business history that the corporate giants he studied might well have envied.

Chandler's interpretation viewed those 20th Century Giant Corporations as neither curses nor things of beauty. Instead, he implicitly viewed them as generally beneficial, and explicitly declared them inevitable. That inevitability, he said, flowed from the previous 19th century arrival of such technologies as the steam engine, mass produced steel and chemicals, machine tools, fossil fuel extraction, railroads, and the telegraph. These enabled the assembly of raw materials, energy, and information on a vastly greater scale than had ever before been possible. These bigger companies ran bigger machines in bigger factories producing high volumes of products This larger scale paid off only in a minority of industries. It was, however, an important minority. Examples were telephony, chemicals, oil, automobiles, soap, steel, and electricity. In those industries grew Giant Corporations including AT&T, Exxon, Ford,General Motors, Proctor and Gamble, U.S. Steel and General Electric.

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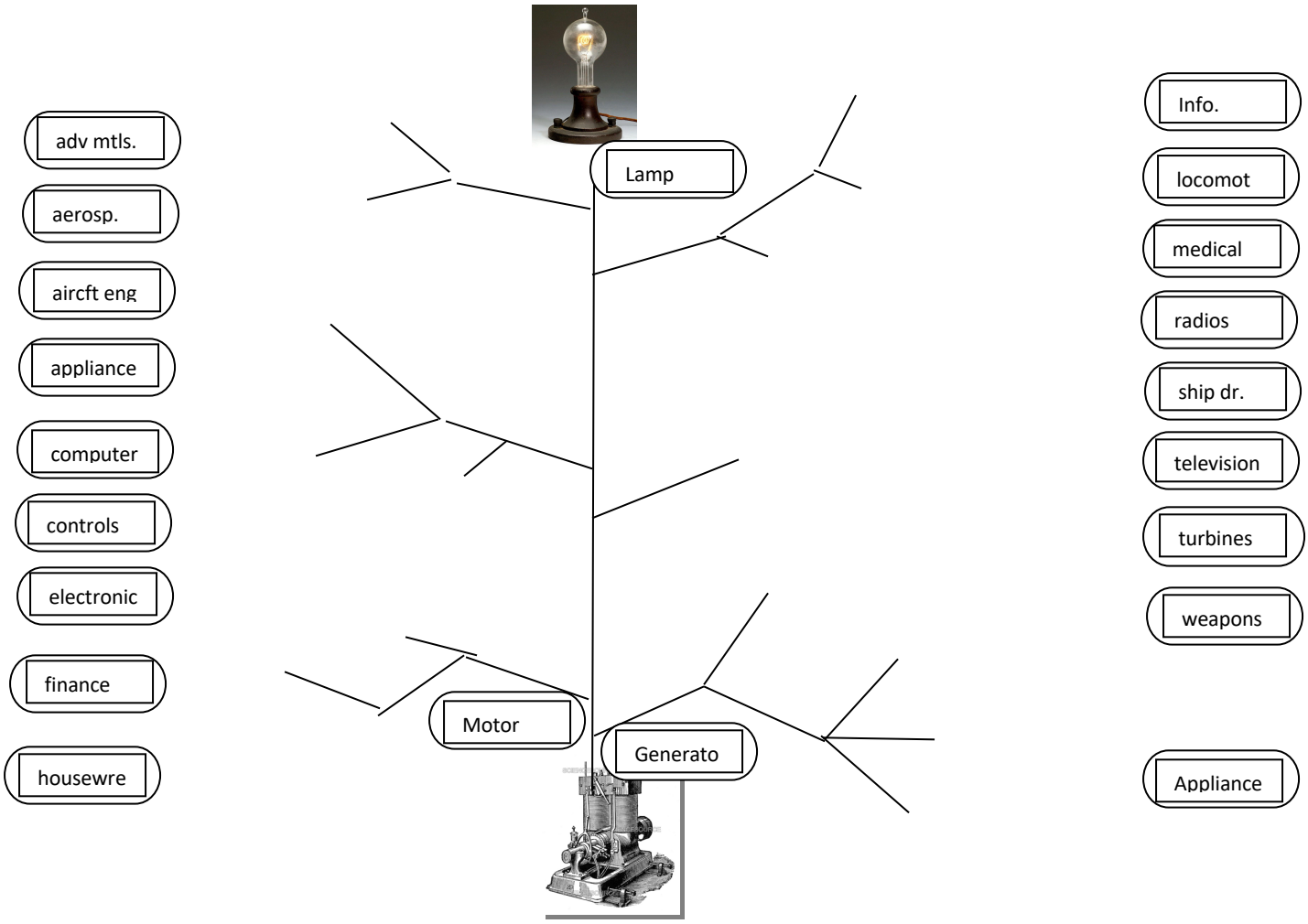
[4] **Wu, Tim. 2018. The Curse of Bigness. Columbia Global Reports. Atkinson, Robert and Lind , Michael. 2018. Big is Beautiful. MIT.**

As scale increased, it became increasingly costly for those Giant Corporations to let a significant portion of their expensive productive capacity lie idle. A solution was to broaden scope; that is, to diversify into new product lines that used existing productive capacity and human skills. For the Old GE, for example, the following 20 examples illustrate the breadth of that scope expansion . They are, in alphabetical order, advanced materials, aerospace equipment, aircraft engines, appliances, computers,controls, electronics, finance, generators, housewares, information services, lamps, locomotives, medical diagnostic equipment, motors, nuclear reactors, radios, ship drives, televisions, turbines, and weapons. The natural growth of these diversifications is here depicted in a visual metaphor called the Edison Elm.



The elm is depicted schematically, from its root in the electrical dynamo, to its crown the light bult. Its trunk is the electrical equipment need to connect

those two original elements. Some branches are nearer the root, some nearer the crown, some in the middle. The places of three of the earliest product "leaves", lamps, motors and generators, are indicated. The reader is invited to play a game of pin the leaf on the elm, and place the leaves for the other 17 diverse products where they branch off the tree. The answer is on page 411 .

Another key element of Chandler's interpretation addressed control over that scale and scope. In the 19th century, production quantities and prices were mainly determined by the market. For the vastly greater scale and scope of the new Giant Corporations, market signals no longer sufficed . Control had to be exerted from inside the corporation, by its management. Chandler expressed this change by updating an earlier metaphor coined by Adam Smith. Around the turn of the 20th century, Chandler said, Smith's Invisible Hand of the market was replaced by the Visible Hand of professional managers.

The above is a very condensed summary of the Chandler interpretation. Since its introduction a half century ago, it has been amended and improved by other historians.

For example, economic historian Naomi Lamoreaux noted that Chandler went too far in attributing the emergence of the giants to the rational, technocratic strategizing of that new breed of professional managers. Some giants, such as U.S. Steel and GE, were instead the product of mergers executed by the old breed of financiers on Wall Street.[5]

Another limitation was pointed out by historian Stephen Maher. He argued that Chandler understated the role of the U.S. Federal Government in promoting corporate giantism. Government is often depicted as the corporation's enemy through its antitrust laws and other regulations. Arguing

[5] **Lamoreux, Naomi. 1988. The Great Merger Movement. Cambridge., esp. pp. 153-155. Other Chandler revisionists include Roy, William G. 1997. Subsidizing Capital. Princeton. Edwards, Richard. 1974. Contested Terrain.Basic Books. Lazonick, William. 2022. Innovative Economies or Sweatshop Economics. INET WP #25.**

to the contrary, Maher depicts the Federal government and giant corporations as capitalist co-conspirators. [6]

Incorporating and extending these improvements and revisions was economist Richard Langlois in his 2023 book The Corporation and the 20th Century**.** In that book, he accepted Chandler's Visible Hand view of the ca. 1900 emergence of those U.S. 20th Century Giant Corporations. He disagreed, however, about what happened next.

To Chandler, the arrival of the Visible Hand assured the dominance of GE and its U.S. Giant Corporation peers well into the foreseeable future. **"**These giant enterprises," he wrote in 1973, "undoubtedly will continue to play as decisive a role in the American economy during the remainder of the century as they have during the years of the century that have already become history." He stuck with that prediction. "To Alfred Chandler, " an admiring journalist wrote approvingly in 2000, "the giant corporation is still king. "[7]

It was not just Chandler and his followers who thought that the U.S. Giant Corporations had discovered the elixir of eternal life. Eminent labor historian David Montgomery was no friend of the Giants. Looking back from near the end of his career, however, in 2014, he wrote:

> One thinks of U.S. Steel, Westinghouse, General Electric, International Harvester, Armour, and Standard Oil (all soon to be joined by General Motors) whose eternal life we older folk took for granted.[8]

With the benefit of another decade of hindsight, Langlois pointed out that in fact, the dominance of these 20th century giants had begun to decline by 1970. He then went further. The Visible Hand, he argued, had never been the ultimate in industrial organization. It was instead a "second best" solution

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[6] **Maher, Stephen. 2022. Corporate Capital and the Integral State. General Electric and a Century of American Power. Springer. See also Jacobs, David C.D. 1999. Business Leaders and the Power Structure in America. Quorum.**

[7] **Chandler, Alfred D. 1969. The Structure of American History in the 20th Century. Business History Review.43: 255-298 p. 281. Gabor, Andrea. 2000. The Capitalist Philosophers. Times. P. 285.**

[8] **Quoted in Fink, Leon, Ed. 2014. Workers in Hard Times. Illinois, p. 53**

made necessary by the weakness of ca. 1900 markets. That temporary Visible Hand advantage was then unnaturally extended by the turmoil of the 20th century, with its world wars, cold war, and Great Depression.

After about 1970, says Langlois, the Invisible Hand struck back. In a now global, electronically empowered, and fully entrepreneurial world economy, the 20th Century Giants were exposed as clumsy Goliaths. The new Giants of the 21st Century-- Amazon, Alphabet, Meta, Microsoft-- grew up as two-handed Davids, blending Invisible Hand market responsiveness with Visible Hand managerial decisiveness.

The Chandler interpretation, as amended by Lamoreaux, Maher, Langlois and others, provides one view of Giant Corporations. It is, however, a monochromatically management centered view. "I have not, " wrote Chandler, " tried to describe the work done by the labor force or the aspirations of the workers. Nor do I attempt to assess the impact of modern business enterprise on existing political and social arrangements. "[9]

Other historians have shown an interest in the workers, customers, communities and citizens that Chandler ignored. For example, in the 2023 book The Big Myth historians Natalie Oreskes and Erik Conway address those topics by presenting what they call " the true history of a false idea." That false idea is "the magic of the marketplace." A principal purveyor of that false idea, they assert, was GE. They present the Old GE as "once a forward looking company" that turned "deeply problematic" . The forward looking part included running factories efficiently, paying many workers well, creating innovative products, doing Nobel Prize winning research and employing a socialist chief consulting engineer and a progressive president. That forward looking part is dispensed with in a single paragraph.

By contrast, many pages are devoted to the problematic part of the GE story. In roughly chronological order it includes the following. GE collaborated with the electric utility industry to delay the electrification of the U.S.. GE repeatedly broke the law by conspiring with competitors to fix prices. GE "built its business on government electricity contracts while rigging electricity markets" . As the "leading architect of anti union policies" GE abused workers and broke labor laws. It used its eponymous TV program,

[9] **Chandler, Alfred. 1977. The Visible Hand. Harbard/Belknap. P.6**

the General Electric Theatre not to sell turbines, refrigerators and light bulbs, but to sell capitalism, smaller government and lower taxes. It provided the host of that show such a thorough political and economic re-education that "much like the Soft White light bulb or the washing machine, the Ronald Reagan who burst on the public scene in the 1960s was one of the company's products". Finally, GE ended up in the 1980s in the hands of a CEO who was "famous (or infamous) for insisting that corporations existed to produce only one thing: value for stockholders. "[10]

Which historical interpretation is more helpful? Was the Old GE more like Chandler's inevitable, and generally beneficial consequence of increasing scale, widening scope, and the strategizing of professional managers? Or was the Old GE more like Oreskes and Conway's once good company gone bad, lured over to the dark side by the Big Myth of market infallibility?

The chapters that follow present, in narrative form, evidence bearing on that issue . This evidence ranges from episodes of technology development and organizational change to snippets from the lives of a wide range of GE individuals. No claim is made that the episodes are the only important ones, or that the individuals are typical. Instead, those events and lives are put in focus to suggest the wide range of ways the history of the Old GE played out, not just in the executive suite but on the more ordinary human level.

On that human level, workers, customers, communities, and the public defy simple and definite characterization. Workers, for example, ranged from managers and skilled professionals to unskilled operatives and laborers. Even within those categories, attitudes differed. Among U.S industrial workers , Montgomery has pointed out, some consistently sought " a common commitment to democratic direction of the nation's economic and political life" while others "made their peace with a most undemocratic America". For GE's workers at its most important location Schenectady, historian Catherine Haag has written that "radical was mainstream in Schenectady, at least in certain moments in Schenectady labor history." One purpose of this history of the Old GE is to trace the ever changing balance

[10] **Oreskes, Natalie and Conway, Erik. 1923. The Big Myth. Bloomsbury. Pp. 17-69, 230-236.**

between GE workers' moments of mainstream radicalism and moments of making peace with the undemocratic side of America[11].

Customers also do not fit neatly into a single characterization. The purchaser of a 60 watt light bulb was not likely to have the same motives and economic status as the purchaser of a 600 megawatt steam turbine generator. The communities housing GE's major production facilities also could house many views. They might, for example, see the the Old GE as the benevolent giant source of their city's prosperity. Conversely, they might see the Old GE as a giant bully suppressing local development and self determination.They might swing between the views, or even hold both at the same time. On a national scale, citizens also could have a mixed view of a Giant Corporation such as the Old GE. They mght see it, for example, as a technological powerhouse that made progress its most important product, or as a threat to democracy.

The conclusions in the final chapter regarding the impact of this prototypical Giant Corporation on workers, customers, communities and citizens will address those many dimensions. Here in this introduction, those conclusions will only be hinted at. The hints are three old aphorisms. From 18th century dictionary pioneer Samuel Johnson, "men are rarely so harmlessly employed as when they are making money." From 17th century writer Francois de La Rochefoucauld "hypocrisy is the tribute vice pays to virtue". From 20th century economist Joan Robinson. " The only thing worse than being exploited by the capitalists is not being exploited by the capitalists."

The story leading to those conclusions begins in an old fashioned way. Once upon a time, there was a Wizard...

[11] **Montgomery, David. 1987. The Fall of the House of Labor. Cambridge. p. 8. Haag, Catharine. 2023. Mainstream Radicalism. Ph.D Thesis. U. Albany. p. 1**

Chapter 2. Wizard 1847- 1892

Though he never worked for GE, no story of GE would be complete without its Wizard, Thomas Alva Edison. The Old GE embraced that ancestral Wizard. The New GE downplayed him. Neither, however showed much interest in his actual connection to their company. This first chapter explores that question. What was the real connection between that Wizard, Thomas Alva Edison, and General Electric?

Thomas Edison was born in 1847 to a middle class family in an Ohio town on the shore of Lake Erie. He grew up active, curious, ornery, and ambitious. He was expelled from grade school as unteachable, then capably home schooled by his mother. As a young boy, he sold newspapers on a train and set up his chemistry lab in a boxcar. He learned telegraphy from a railroad employee whose young son Edison had saved by pulling him off the tracks just before a train's passage. Edison then mastered electricity while traveling the country as a telegrapher.

It is sometimes said that Edison was uneducated. Another way to look at it, however, is that he got his bachelor's degree from Western Union and His Ph. D. from Michael Faraday. Working on Western Union's telegraph system he got a better education in electricity than he could have gotten at any U.S. college. Taking Western Union equipment back to boarding houses in cities where he worked, he repeated the experiments described in Michael Faraday's book Experimental Researches in Electricity. [12]

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[12] **By far the best biography of Edison is Israel, Paul. 1998. Edison. John Wiley. Also useful are Josephson, Matthew. 1955. Edison. McGraw Hill. Conot, Robert. 1979. A Streak of Luck. Seaview, which describes Edison's repeating Faraday's experiments on p. 50, and Dyer, Frank and Martin, T.C. 1929. Edison, His Life and Inventions. Harper. 2 vol. The Edison Papers Project at Rutgers University has put a large share of Edison's papers on line.**

General Electric rarely acknowledges how completely its electrical century of 1886- 1986 rests on work done by Michael Faraday and a handful of other scientists in the decade 1821- 1831. They worked separately, connected by an emerging practice of scientific publication. They were propelled by curiosity and funded frugally by non-profit institutions or their own resources. They gave little or no thought to the impact of their research on their own financial future, or on creating new industries. Faraday, like Edison, was self educated and a visual rather than a mathematical thinker. In 1831, he made one of the greatest discoveries in history when he discovered how to use magnetism to generate electricity.

That observation, now called electromagnetic induction, revolutionized science. It also initiated a rarely occurring socio-economic mechanism called the innovation assembly line. The analogy is to a factory assembly line. In this mechanism, the processes of discovery, invention, engineering, manufacturing, marketing and use occur sequentially in that given order like the linearly arranged operations of a factory . Most of history's innovations did not happen by that mechanism. "New technology, ", historians of technology Donald MacKenzie and Judy Wacjman wrote

> typically emerged not by flashes of disembodied inspiration but from existing technology by a process of gradual change or new combinations of that existing technology.[13]

Gradual change would, however, have been extremely unlikely to develop Faraday's wholly new way of converting mechanical to electrical energy. The electric power industry is one of the few industries that emerged directly, if with century-long slowness, from a sudden, curiosity powered, giant conceptual scientific leap. Joining Faraday in taking that leap was a small group of mainly European scientists such as Hans Christian Oersted of Denmark, Andre Marie Ampere of France, and perhaps the only significant U.S. participant, Joseph Henry of Albany NY.

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[13] **McKenzie, Donald and Wajeman, Judy. 1985. The Social Shaping of Technology. Open University Press. See pp.3-7.**

Faraday made the key discovery in 1831. He showed that it was not magnetism alone, but a change in magnetism, that caused an electric current to flow. Push a magnet through a loop of wire and there follows a brief burst of electric current in the wire. Without that observation, no electromagnetic induction, no electric power industry, and no GE.

Over the following decades, that discovery sparked inventions, most notably the electricity generator. Other sources of electric current, such as the battery, had earlier been invented. So had primitive versions of the electric light and the electric motor. The battery would, by the 1840s, prove useful in such applications as telegraphy and electroplating. The electric light and motor, however, remained through the first half of the 19th century only potentially useful. Running them with batteries proved far too expensive.

The electric generator, based on Faraday's discovery, required a human generation of improvement to become useful. That improvement was mainly engineering, which has been defined as doing for one dollar what any damn fool can do for two. One might add being able to do at the hundred kilowatt scale what any damn fool could do at the hundred watt scale, then doing reliably in actual application what any damn fool could do erratically in a demonstration.

By 1870, a lot of the engineering of electrical generators had been done, mainly in Europe.The results were diffusing to the U.S., a nation just getting started at financing capital intensive industries. So when Thomas Edison moved from corporate telegrapher to independent inventor in the early 1870s, and then moved to New York City, he was in the right place at the right time.

By repeating and analyzing Faraday's experiments, Edison had gained a scientific, understanding of electricity. He then preceded to put that understanding to work. His big break in inventing happened on Wall Street when he first fixed, and then manufactured, the electric stock tickers the financiers needed to follow the market. It was then, as a still boyish looking Harry Potter of invention, that he got that nickname the Wizard.

In 1876 he decided to devote full time to invention. He and a dozen or so skilled associates set up in Menlo Park, New Jersey perhaps the world 's first, and perhaps the world's all time most productive, invention factory. Edison almost immediately made his most creative invention, the phonograph. He

would go on to get more than 1000 patents. He did not, however, invent the one thing most people think he did. That is, he did not invent the light bulb.

Instead, he was in part inspired to work on the light bulb in 1878 after visiting an electric light factory. The factory was in Connecticut where William Wallace, the innovative son of a brass maker, and Moses Farmer, an independent inventor, were improving an earlier invention called the arc lamp. It was sort of a long-lived lightning bolt. It was already in 1878 in commercial use for lighting city streets. It was, however, too bright for use inside houses.

Another form of electric light had also long since been invented. It had a lesser brightness that made it suitable for household use. It was simply a wire in a glass bulb, heated by a current of electricity to glow, or, to use a fancier word, to incandesce. Unfortunately, unlike the arc lamp, this incandescent lamp had too short a life to be useful. The same electric current that caused the wire to incandesce soon caused it to melt or burn out.

Edison proclaimed that he could develop a practical electric lighting system based on a longer lived incandescent lamp. In 1878, before he actually knew how to accomplish this feat, his conviction was embodied in the Edison Electric Light Company. It was backed by an unusually large capitalization for an 1870s start-up, a par value of $300,000. An initial $50,000 was put up by an unusually eminent group of backers such as William Vanderbilt, President of the New York Central Railroad, Norvin Green, President of Western Union, and Egisto Fabbri, a partner of J.P. Morgan in the nation's pre-eminent bank, Drexel, Morgan & Co.[14]

At Edison's side stood his legal adviser. Grovesnor Lowry. He had been Edison's patent attorney. He had convinced Edison to drop an early effort to manufacture stock tickers and concentrate full time on invention. Now he was helping Edison make that focus pay off.[15]

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[14] **Edison to Lowry, Oct. 3, 1878, Edison Letterbook 003:390, Thomas A. Edison Papers, Edison National Historic Site, Orange, N.J.,quoted in Friedel and Israel."Contract between Thomas A. Edison and the Edison Electric Light C., Nov. 15, 1878, General Electric Co., Secretary's File.MiSci.**

[15] **Taylor, Jocelyn. 1980. Grosvenor Porter Lowry. Privately Printed. EDison to Lowrey, Oct. 3, 1878, Edison Letterbook 003:390, Thomas A. Edison Papers, Edison National Historic Site, Orange, N.J.,quoted in Friedel and Israel.**

In just one year, in 1879, Edison achieved what he had promised. He demonstrated the essentials of the modern incandescent lighting system. Every part of that system had been invented earlier. The dynamo that generated the electricity, the copper wires that sent it to and from the lamp, the carbon wire that heated up and glowed, and the glass bulb enclosing that wire in a near-vacuum all were previous inventions.[16]

What Edison added started with economics. He first computed what incandescent lighting had to cost to compete with the present best lighting method, gas lighting. Then he determined the specifications of the system and its parts needed to achieve that cost. Those specifications were, across each light bulb a voltage of about 100 Volts and through each bulb's filament an electric current of about 1 Ampere. This required a filament resistance of about 100 Ohms. Then he developed the system meeting those specification, and chose the circuit type needed, parallel rather than series.

In a word, he did innovation. He turned a bunch of components that had already been invented but were only potentially useful into an indoor electric lighting system that could be, and soon actually would be, used. In November, 1879, Menlo Park shone with the glow of prototypes of the kind of indoor electric lights that would be used throughout the world through the twentieth century.

How could the people who put up the money cash in on this innovation? Those with the least patience could watch as publicity drove up the stock price of the Edison Electric Light Company and sell out. Those somewhat more patient could finance the first successful Edison product: “isolated systems”, complete electrical supply and lighting systems for a rich person’s home (J.P. Morgan’s was the first), or for such sites as a factory or commercial establishment. Fewer were willing to follow Edison on the quest to light and power the world. “When I asked them to furnish capital for manufacturing shops” Edison would later recall

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[16] **Friedel, Robert, and Israel, Paul. 1986. Edison’s Electric Light. Rutgers. homas A. Edison, "The Beginning of the Incandescent Lamp and Lighting System," (Dearborn Mich, Edison Institute, 1976 (draft dated 1926)**

> They were sorry {Wall Street sorry) that they could not see their way clear, as it was an untried business, etc. I pawned my future , and with a few associates funded the necessary shops.[17]

In those necessary shops, Edison's expanding work force built the systems that put his lighting system to work. In the fall of 1882 Edison lit up a square mile of New York City with electricity produced in a single building, the Pearl Street station. It was the ancestor of the electric utility industry of today. In that year he made his last major contribution to electric power technology, his three wire system. Turning on the first commercial three wire system at Sudbury PA on July 4, 1883, to the accompaniment of the roar of cannon and the bursting of fireworks, celebrated the ending of the peak years of Edison's electrical innovation.

In 1884-1885 his time of triumph became a time of troubles. They began as business troubles, as Edison fell out with his financial backers, and even with his adviser Lowry. They became personal troubles, as his wife became ill, both physically and mentally, and died of a brain tumor in the spring of 1884. The Wizard himself was changing from a youthful Harry Potter to a greying Gandalf. He put on weight, and suffered increasingly from a bad stomach, the taste of too many cigars,and then, in 1885 persistent illness.

Recovering his health, Edison began the year 1886 by remarrying. His second wife Mina came from an upper middle class family. She encouraged him to start enjoying the social amenities that his achievements had earned. The couple took a long honeymoon. They bought two mansions, one in New Jersey and one in Florida. When the Wizard got back to work, in mid year, he had a new goal. That was to build, in West Orange, New Jersey, the greatest laboratory in the world. This laboratory embodied a sharp turn he planned to take in his inventive career. As he would put it in an 1887 letter, he was building that laboratory to produce "new and useful inventions " not "big cumbersome things like a system of electric lighting. " He added that

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[17] **Thomas A. Edison, "The Beginning of the Incandescent Lamp and Lighting System," (Dearborn Mich, Edison Institute, 1976 (draft dated 1926)**

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"My ambition is to build up gradually and surely a great industrial works in the Orange Valley[of New Jersey]. "[18]

He also added in that same letter that "I do not manage shops myself as I am incompetent for that class of work but I do know how to select the right kind of men to do it for me." These right kind of men mainly included long time inventive associates, such a Princeton trained physicist Francis Upton and skilled craftsmen Charles Batchelor, and John Kruesi.

The most recent addition to Edison's inner circle was different. Samuel Insull was young, only 26 in 1886. He grew up in London in a lower middle class family. He initially worked as a clerk-stenographer. He moved upwards rapidly, ultimately to a post in the Edison companies' British office. He moved on to the U.S. in 1881 to take up the post of Edison's private Secretary. He quickly made himself indispensable. [19]

In the summer of 1886, those managers of the Edison empire had a new problem: a union. The problem was most acute at the company run by Charles Batchelor, the Edison Machine Works, successor to the machine shop at Menlo Park. The machine works was an independent company. Thomas Edison owned the majority of shares. It was housed in a former iron works on Goerck Street in New York City, in an area an Edison associate described as "an 'east side' region of decayed tenements and tumble down buildings. "[20]

There some 300 workers, many of them skilled machinists, made parts for and assembled Edison's dynamos. By 1886 It was already apparent that the Goerck St. works would be too small to meet the growing demand for electrical machines. Bachelor had, in the spring of 1886, taken an option on a property in Brooklyn.

In the summer of 1886, workers across the nation rose up in strikes, rallies, and demonstrations. Those addressed agendas that included the eight hour day and recognition of a rapidly growing new national union, the Knights of Labor. Around these realities swirled vastly exaggerated rumors of anarchist

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[18] **TAE to William Lloyd Garrison Jr. 13 Aug. 1887. Edison Papers.**

[19] **McDonald, Forrest.1962. Insull. U. of Chicago.**

[20] **Bryan, George S. 1920. Edison, the Man and His Work. Garden City, NY. p. 188.**

and communist conspiracies. In May of 1886, in Chicago's Haymarket Square, the throwing of a dynamite bomb into a line of policemen, with fatal results, seemed to verify those conspiracy theories.

The May, 1986, activities of the Knights of Labor at the Edison Machine Works in New York City were peaceful. They brought a list of demands regarding wages, hours, and other workplace issues to works manager Charles Bachelor. He was willing to compromise on wages and hours (reducing the work day from 10 to 9 hours with no reduction in pay), but not on recognizing any union, or any other compromise of management prerogatives. The workers went on strike. After two weeks Bachelor met with the strike committee and made a further concession on wages, after which the strikers returned to work. The Edison management seems to have taken a lesson from the incident. Perhaps moving the Machine Works to Brooklyn was not far enough.

Aware of this situation were two machinery salesmen and Edison associates, George Place and his brother-in-law Harry Livor. Their territory as salesmen included a small machinery industry center, Schenectady NY.[21]

It is located 180 miles north of New York City, near the state capital of Albany. It is on the south bank of the eastward flowing Mohawk River, just west of where a waterfall blocks river travel to the Mohawk's junction with the southward flowing Hudson River. This had marked Schenectady as a transportation break for the region's indigenous inhabitants. Under the Dutch, then the British, and then the Americans, its role as a transportation hub widened to include the Mohawk River west of the city,That prosperity was interrupted when the Erie Canal replaced the river. Then prosperity was revived by Schenectady's choice as terminus for some of the earliest U.S. railroads, and then for the building of locomotives.

In 1882 the Schenectady Locomotive Works was a significant competitor to the industry leader, Baldwin of Philadelphia. In that year, the recently demoted long time chief locomotive designer of Schenectady Locomotive joined forces with Schenectady County's richest man to launch a second Schenectady locomotive making company. Two modern factory buildings

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[21] **Details of the story that follows, the move of the Edison Machine Works to Schenectady NY are taken from Wise, George. 2014. Edison's Decision, on file at Schenectady County Historical Society, Schenectady NY, and accessible on the web.**

were built on the Schenectady flats beside the Mohawk River. Then the new company ran into the 1884 business depression, It never built a locomotive, and went out of business.

Place and Livor, in May, 1886, put together their knowledge of the Edison Machine Works' need with this Schenectady opportunity. In a few weeks, they had not only brought their idea of buying these abandoned buildings to Charles Batchelor, but had made an offer for the buildings on behalf of the Edison Machine Works. By June , Edison had set aside $42,500 for the purchase.This was a great bargain. Ever cash short, however, the Edison team did not close the deal without a money saving twist. They put out the word that the sellers were demanding $42,500 while the the Wizard would pay no more than $35,000.

Schenectady's city fathers panicked at the thought of losing this lucrative and prestigious new industry. One of them, merchant Robert Furman, organized a fund raising rescue. Dozens of Schenectadians pitched in, at a few hundred dollars each from the wealthy to ten or twenty dollars each from owners of small stores. Even Charles Ellis, president of the local Locomotive Works, made a contribution, despite the likelihood that the new works would poach his skilled machinists. Nor did it bother the Schenectadians that they were getting nothing concrete for their contribution: no stock in the new business, or even a promise that it would stay.[22]

Once the $7500 was raised and given to them, the Edisonians wasted no time. In June, 1886, the deal closed and the move was announced. The purpose of the move, Edison told reporters, " was to get away from the embarrassment of the strikes and communists to a place where our men are settled in their own homes. "[23]

That summer and fall of 1886 saw a stream of men and equipment flow up from New York City to Schenectady. Edison aimed to get a full 300 man work force up and running by the end of October. The most notable arrival

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[22] **The negotiations for the McQueen Locomotive Works are described in Charles Batchelor Diary, pp. 37-87, Edison Papers. Rutgers. See also Schenectady Evening Star 31 May 1886 p. 4., 4 June 1886 p.4. A list of Schenectady contributors is in the City Hall History Center, Schenectady NY.**

[23] **Edison Machine Shops Going. New York Tribune 24 June 1886, p. 1.**

happened on August 19. Checking into Schenectady's Givens Hotel was the 39 year old Wizard himself.[24]

A reporter descibed him as "a jolly looking gentleman of medium height, good build, with a round, smoothly shaven face and a thick head of hair only slightly tinged with gray. " After pausing to light a cigar, Edison noted he had stopped in to see his new works, and found it "just what he wanted in every particular."At the new Works, he said, " they will make dynamos, torpedoes, shafting, pulleys, wire covering, electric cables, underground tubing, electric motors, and rock drills. "

He talked most about the most surprising item on that list, the Sims-Edison Elecric Torpedo. It was developed by AmerIcan inventor Winfield Scott Sims, with funding from the U.S. government. Edison's rare second billing reflects the fact that he contributed little beyond his name and the efforts of his Edison Machine Works associates to make the electric motors. As a weapon for defense of the U.S. coasts, this underwater metal fish would be driven by an electric motor that was fed through a long extension cord. It would carry 750 pounds of dynamite. It would, Edison said "blow up a.$2 million ironclad so there won't be enough left to make a row boat."

The actual torpedo, indeed built in Schenectady, would, after some promising early tests, prove impractical. Widespread torpedo use would await a portable power source. Edison's message, however, was accurate in its implications. The Edison Machine Works would not merely be a dynamo factory. It would also be a major development center for extending the electrical idea. It, and its successor General Electric, would join the already emerging Military-Industrial Complex. Soon the Edison empire was selling less futuristic but more useful apparatus to the military, such as a dynamo and light bulbs to illuminate the cruiser Yorktown.

Edison also told the reporter that he would not be moving to Schenectady. Nor would the president of the Edison Machine Works, Charles Batchelor. Those who would move included Samuel Insull, soon promoted from Edison's Secretary to Secretary and Treasurer of the Edison Machine Works. He would run the business side of the new works while continuing to provide Edison with a high level of personal assistance. Running

[24] **Schenectady Evening Star 20 Aug 1886, p.4.**

manufacturing at the works would be John Kruesi, assisted by skilled machinist and millwright William "Pop" Turner.

For Insull it was an opportunity to shine in an area where he believed he surpassed his mentor. As he put it many years later (and not altogether accurately) "we never made a dollar until we got the factory 180 miles away from Mr. Edison." Insull's first efforts, however, involved not making money but raising it. He immediately, In August, 1886, sought a mortgage on the property and buildings.[25]

Raising cash was the Works' chronic issue. The Edison Machine Works Co. was under financed, indeed hardly financed at all. Three fourths of the stock was owned by Edison, whose contribution had mainly been his inventions, not cash. "We have had to work," Insull complained to Edison in 1887, "with a capital which is decidedly inadequate for the amount of business."[26]

Instead of putting capital into the Schenectady Works, Edison instead sucked cash out it. He required an annual payment to his laboratory from the works. That was the fee for Edison's West Orange Laboratory to serve as the Schenectady Works' research and development arm. The Works was to concentrate on manufacturing existing products and making money. In its first full year, 1887 It recorded $2 million in sales. Insull claimed a profit rate of 18%, almost all of which he plowed back into the Works. In that first year's report Insull anticipated a conclusion later reached by historian Chandler. A major reason for corporate bigness was economies of scale in manufacturing. As Insull put it, " our general expenses do not increase in anything like the same proportion that our work has increased. " [27]

Insull's bet on economies of scale paid off. Profits stayed high while sales climbed to $10 million by 1891. Most of the Works' profitability came from being part of the Edison empire. The Edison electric utility businesses

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[25] **McDonald, Forrest. 1962. Insull. U. of Chicago. P.28. Samuell Insull to. NY Life Insurance Co. 6 Aug 1886, LB 022309. Edison Papers.**

[26] **Minutes, EMW Annual Meeting, Oct. 29, 1888. Edison Papers. Insull to Edison, 3 Aug 1887, D8736ADC.. Edison Papers.**

[27] **Report from Edison Machine Works, Samuel Insult to Thomas Edison, Jan 26, 1888. Edison Papers.**

agreed to a contract that named the Edison Machine Works as the exclusive supplier of its dynamos and other equipment, at a 20% profit rate.[28]

Future payoffs were, however, less certain. What the Works lacked, and its two largest competitors, the Thomson-Houston Works at Lynn, MA, and the Westinghouse Works at Pittsburgh, PA possessed, was the capability for innovation.This lack largely stemmed from founding circumstances. Recall that Edison had combined the move of his Machine Works to Schenectady with creation of his new laboratory. That West Orange NJ lab was intended to be big enough both to serve as the research and development arm of the existing Edison empire, and the launching pad for new Edison enterprises. In the rapidly evolving ca. 1890 electrical industry, this arrangement was insufficient. Edison put inadequate effort after 1886 into advancing electrical technology. At the same time he both charged Insull for lab services, and discouraged Insull from funding research and development at the Schenectady Works.

A main promising area for R&D was alternating current (AC). This technology enabled longer distance transmission from central stations than did Edison's direct current (DC): tens of miles and perhaps much more for AC, versus less than five for DC. This was true for an economic reason. The cost of electricity transmission depended largely on the amount of copper needed to carry the electrical energy. It turned out that the higher the voltage (a sort of electrical pressure) the thinner the wires could be, so the less copper you needed. AC electricity could, using a device with no moving parts called a transformer, raise or lower the voltage much more easily than could DC, thereby enabling this copper saving.

At this time, Europe was far ahead of the U.S. at inventing AC. Teams in Great Britain and Austria-Hungary had invented practical transformers. The U.S. innovator earliest to follow the Europeans was George Westinghouse. He had spent his youth in Schenectady, fought in the Civil War, dropped out of Schenectady's Union College after one semester, then started making inventions while working as a machinist at his father's agricultural equipment works. In a typical late nineteenth century career move, Westinghouse then climbed the urban ladder to Pittsburgh, where he found

[28] **Agreement EMW and Edison Electric Co. Sept. 1, 1884, Edison Papers.**

both better metals for his early railroad inventions, and more capital to fund them.[29]

In 1886, when he challenged Edison in electricity, Westinghouse was already rich and famous from feats such as perfecting the railroad air brake. He started out his electrical efforts by imitating Edison's DC. system. In the same month, May, 1886, that Schenectady newspapers carried the first stories about the Edison Machine Works' interest in its two abandoned factory buildings, a bigger story in the same paper announced that Schenectady was getting its first incandescent electric lights, via the Schenectady Westinghouse Illuminating Company, using DC and managed by George's brother John.

At the same time, however, George Westingouse had hired researcher William Stanley to explore AC. Stanley added significant improvements to the AC systems invented in Europe that Westinhouse had licensed. In that month of May, 1886, Stanley was lighting Great Barrington MA with an experimental AC system. By 1887, Westinghouse AC systems were competing vigorously with the Wizard's DC systems.[30]

Edison continued to focus on his laboratory. The managers of the Edison empire responded to Westinghouse not with research, but with rhetoric. Potential new electric utility creators in the late 1880s would receive from the Edison companies a booklet with a blood-red cover entitled "A Warning ".[31]

Part of the warning was legal. The Edison system was protected by more than 200 patents, on everything from the generator to the system configuration to the light bulb . Going with Westinghouse meant fighting, and probably losing, an expensive legal battle. Another part of the warning was economic. The copper cost savings of 90% touted by Westinghouse

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[29] **Leupp Francis. 1918. George Westinghouse His Life and Achievements. Little Brown. Prout, Henry. 1921. A Huber, William. 2022. George Westinghouse. MacFarland & Co. Usselman, S.W. 1992.From Novelty to Utility; George Westinghouse and the Busineess of Invention. Business History Review. 66. 251-304**

[30] **Furfari, F.A.and Owen, E.L. 2003. Rediscovering William Stanley. IEEE Industry Applications. 9.8-12 and 10. 10-13. Wise, George. 1984. William Stanley's Search for Immortality. American Heritage's Invention and Technology. 4 (now online)**

[31] **A Warning. 1887. Edison Electric Light Company.**

were actually more like 50%. When you added in the cost and energy losses contributed by those new and untried components the transformers, you ended up with a system more expensive and less reliable than Edison's. Yet another part of the warning was technological. DC could drive powerful and efficient electric motors. AC could not. It was true that there were in 1887 a total of only 450 kW of motors in New York City, and 150 kW in Boston.The electric motor was, however, coming into its own, and only DC could power it.

The big warning of the booklet, however, and the reason for its blood red cover, was another issue-- safety. Sending electricity around cities at the thousands of volts of the Westinghouse AC system, compared to the hundreds of volts of the Edison DC system, would kill people. This had already been proven by high voltage arc lamp street lighting systems. Examples in the booklet described the grisly deaths of men and horses who came in contact with those killer high voltages.

From this start, the safety issue veered in 1887-1890 into black comedy. DC advocates challenged Westinghouse to a duel to be fought by grasping electrically charged cables. They electrocuted dogs during public lectures. In their greatest coup, they convinced the New York State Legislature to change the state's method of capital punishment to electrocution-- using, of course AC. In 1890, at the Auburn, NY state prison, convicted murderer William Kemmler was wired up to a Westinghouse AC generator and died a prolonged and painful death.[32]

Edison was not the worst offender in this publicity war of the currents. He did, however, participate in it strongly enough to stain his reputation as a man of science. In opposing AC from the economic and technological standpoints, by contrast, the Wizard was on more solid scientific ground. He was not, as sometimes alleged, either ignorant or suffering from a severe non- invented- here complex. In fact, the contest between Edison's improved DC system, and Westinghouse 's original AC system would be, in the 1880s, essentially a draw. Edison's DC, improved by his last major electrical invention, the three wire system, had the advantage in large densely

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[32] **Hughes, Thomas. 1958. Harold P. Brown and the Executioner's Current. Business History Review. 32. 143-165. Reynolds, Terry and Bernstein, Theodore. 1976. The Damnable Alternating Current. Proceedings of the IEEE. 64. 1339-1343. Edison, Thomas. 1889. The Dangers of Electric Lighting. North American Review. 149. 625-634**

populated cities. Westinghouse's original version of AC had the advantage in smaller sparsely populated cities and towns. In addition, Edison's DC could drive electric motors far more effectively than could Westinghouse's original version of AC. [33]

What AC did have was greater potential for further advances. DC, by contrast, was reaching a temporary dead end. It would later be revived by 20th Century power electronics. Today the two types are essentially equal and interchangeable. For very long distance transmission, DC is now superior.

Back in 1886-1889, Edison's financial backers urged him to explore AC. An Edison company did purchase an option on a European patent on the key AC component, the transformer, but did not exercise the option. Edison hired a man who would become one of the top U.S. AC experts, Arthur Kenneally. Edison, however, used him more to expose AC's dangers than to explore its possibilities. In a rare episode of disagreeing with his mentor, Insull objected to Edison's policy of doing all research on AC at the West Orange Laboratory . "Our experimental expenses are very small, but you cannot possible [sic] wipe out our experimental account here", he argued. "There are lots of little things which it would be absurd for us to send to Orange to be tried". This came to include an 1888 effort at the Schenectady Works to develop a transformer. This effort, however, proved too little and too late to have any discernible effect.[34]

Insull seemed generally, despite his objections, to have accepted this geographic division of labor between manufacturing and R&D.. When in 1887 he had received a recommendation to hire a man who was touted as a "mechanical genius" Insull replied:

> It does not strike me that a 'marvel of mechanical genius' is the class of lad to enter a machine shop. I should think that he would be better suited for employment in the Edison Laboratory. We don't want marvels of genius in a manufacturing establishment. All we want are young men who have the ability to do as they are told.

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[33] **David, Paul and Bunn, J.A. 1988. Economics of Gateway Technologies. Information Economics and Policy 3.165-202.**

> 'Marvels of mechnical genius' in such a position are usually troublesome and chafe under discipline.[35]

Competitors' efforts at exploring AC's potential were far more extensive and productive. The technical and commercial consequences of this next step in AC will be detailed in a subsequent chapter. Suffice it here to say that the science and technology of that next step were sufficiently complicated to stall development for some six years.

A strong competitor to both Westinghous and Edison, producing both AC and DC systems, was the Thomson Houston Company. The company's founder was a prolific inventor, Elihu Thomson. Though he acquired many patents, some useful, the company's main tactic was fast following. That is, Thomson kept company President Charles Coffin informed about the best technology available in small rival companies. Coffin then bought the rivals and hired their top technologists. They were put to work in the well-organized engineering and manufacturing works run by Thomson's former student Edwin Wilbur Rice, Jr.

Edison's Schenectady Works was saved from an early eclipse at the hands of such effective competitors by luck. This had two parts.First, the luster of AC temporarily dimmed in 1888-1890 when it proved harder than expected to develop an improved system. In 1890, Westinghouse, facing severe financial pressures, put further AC advances on hold. Westinghouse's caution at this point showed up in his 1889 recommendation to the Niagara Falls Commission on how to transmit power from the falls over the 22 miles to Buffalo NY: do not use electricity, but use compressed air! [36]

Meanwhile, in those years 1886-1891, another electrical technology leaped to the fore. In contrast to the future possibilities of AC, it emerged as an immediate money maker.This was electric transportation, the replacement of the horses that pulled trolley cars through the streets of U.S. cities by DC electric motors. It had many pioneers before 1886, including Thomas Edison himself. These early movers, however, produced only token systems of only a few cars running on only a few miles, of track.

All this was changed by a bolder pioneer named Frank Sprague. He was a graduate of the Naval Academy and former Edison employee. Sprague

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[35] **Letter, Samuel Insull to E.O. Tate. 4 June 1887.D892 4AO9 Edison Papers**.

[36] **Adams, Edward. 1932. Niagara Power. Bartlett. Vol. 1, p.227.**

contracted in 1886 to run 40 cars over 12 miles of track in Richmond VA. By early 1888, after a succession of failures, a stream of burnt out motors, a massive cost overrun, and four months past the deadline, he succeeded. Electric street railways vaulted from impractical novelty to the most promising way to make money from electricity. [37]

Sprague contracted to build his motors, both for street railways and stationary uses, at the Edison Machine Works in Schenectady. This alone assured that despite its lack of innovation, the Works would remain profitable in the 1890s.[38]

It would do so under a new corporate identity. The more initially successful and soundly financed big fish of the electrical industry were now gobbling up the little fish. A new player had entered the game, a German immigrant named Henry Villard. He had begun his U.S. career as a newspaper reporter during the Civil War and moved on to railroad financing. He had gone bankrupt, and returned to Germany to refresh his fortunes. He returned to the U.S. In 1888 with a new interest in the electrical manufacturing business.

A longtime admirer of Edison, Villard soon established strong ties also with Insull. The two were soon hard at work in late 1888 putting together an new electrical combination. "The proposition is," Insull reported to Edison, " that a Trust should be created which would purchase a controlling interest in all the shops, the Light Co., and the Sprague Co. " [39]

Crucial to the deal was the approval of the Edison Companies' banker and major stockholder, J.P. Morgan . On December 27, 1888, Insull reported to Edison that Villard had gotten "absolute agreement" from the bank Drexel,

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[37] **Passer, Harold . 1952. Frank Julian Sprague. In Miller, William, ed. 1952. Men in Business. Cambridge. Srague, Frank J. 1887-88. The Solution of Municipal Rapid Transit. Trans. AIEE. 5. Sprague, Frank J. 1904. The History and Development of Electric Railroads. Hammond File H -315. MiSci. Passer, Harold. 1953. The Electrical Manufacturers. Harvard. pp.235- 245.**

[38] **Edison Machine Works Weekly Report. 28 May 1889. Electric Light-EMW- 1889. Edison Papers. Letter from Frank Julian Sprague to.Edward Hubbard Johnson. 27 April 1889. X120CAR. Edison Papers.**

[39] **Samuel Insull to TAE, 18 Aug 1888 D8832 DAE. Edison Papers.**

Morgan & Co. Villard had also brought in new money: "Villard's German friends, $1,500,000- $2,000,000" .[40]

The new company was incorporated in April, 1889. In its first full year it would report sales of $10 million and 4576 employees, 2420 of them in Schenectady. Villard's German friends, especially the Deutsche Bank, ended up investing more than $2 million in the new company, and secured its presidency for Villard. In deference to the Wizard, it would be called Edison General Electric. Edison himself, however, would not be an employee. He would be a board member and a well paid consultant, offering the services of his new laboratory. The contract he signed with Insull in 1890 ran to 30 pages. It called for Edison to devote half the time of his laboratory to the needs of Edison General Electric in exchange for a payment of $62,500 a year. Meanwhile, the Wizard himself was to receive a personal payment in cash and stock of over a million dollars, rendering him at last financially independent.[41]

The efforts of Edison's lab were, however, still proving insufficient to provide technical leadership. The resulting technical weaknesses of Edison General Electric were showing up in its products. An engineer installing Edison General Electric streetcar motors in Pittsburgh and Cleveland found those motors so defective that they had to be rebuilt with new insulation systems. In power systems in Chicago, Edison General Electric junction boxes were blowing up. The Edison Lamp Works failed to investigate new combinations of materials and heat treatments that competitors were using to increase lamp life and efficiency.[42]

The technological battle among Schenectady, Lynn, and Pittsburgh was accompanied by a financial battle in New York City and Boston. It matched Villard and his German backers against the Drexel, Morgan bank of New York City with its senior partner J.P. Morgan, and the principal backers of

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[40] **Letter from Samuel Insull to TAE, 27 Dec. 1888. D88 32 ADL. Edison Papers. McDonald, Forrest. Insull 1962. U.of Chicago, p. 39.**

[41] **Hammond File D- 56, MiSci .Yearly stockholders meeting of EGE, as reported in New York Evening Post, 19 Jan 1891.**

[42] **Insull to Edison, und. "1889 Electric Light- EMW. Men and Volts, p. 186. Emmet, W.L.R. 1931. Autobiography of an Engineer. Ft. Orange. Pp. 75; 86-89. Henry Villard to J.C. Henderson. 16 Oct 1889, Box 186, Book 64. pp. 197-198. Villard Papers. Baker Library. Cambridge MA.**

the Thomson Houston, the Boston financial house Lee, Higginson and Company.

Villard's opening salvo was to create secret cartels with competitors. In street railways he offered, in a letter to the President of Thomson Houston in 1889 , that "Sprague will withdraw from Washington for a consideration of $250 per car provided you withdraw from Richmond". He made similar deals with incandescent lamp competitors. These deals soon, however, collapsed due to each of the participants cheating on its quota. His next step, in early 1890, was to meet with a Lee, Higginson partner and the President of Thomson Houston. "I am trying," Villard wrote in a letter, "to acquire a controlling interest in the Thomson Houston Company." He launched a similar exploration with Westinghouse.By early 1891, these efforts had come to nothing. "We have considered long ago all possibilities of connection with Westinghouse and Thomson Houston, " he wrote early in 1891. " and reached the final decision to let them take their chances as we do ours." [43]

By then, Villard had returned to his main interest, railroads, and stumbled into another round of financial difficulties. To raise money, he had to sell Edison General Electric stock to Morgan . That banker had originally put less cash into the new company than had the Germans. However, the stock Morgan held in the original Edison companies had been exchanged for Edison General Electric Stock on such favorable terms that when Villard stumbled, Morgan took financial control, forcing Villard's retirement.

Morgan's controlling role was exercised in New York City by the "Morgan Men". On the Edison General Electric Board of Directors sat Morgan's closest associate, Charles Coster. At Schenectady a more recent Morgan protege, Joseph P. Ord, served as Edison GE's comptroller. He was not previously a Morgan employee, but had impressed the great financier by his work for a Morgan-related railroad. One of Ord's co-workers described him

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[43] **Villard's negotiations with Thomson Houston regarding cartels and.consolidation are in Villard Papers, Harvard Business School, Villard to Charles Coffin 15 Mar 1889. Box 126 Book 61 p. 381. 24 May 1890, Box 127, Book 64, p. 325. Villard to S. Eaton 26 May 1890. Box 127 Book 67. p. 302. The Edison Papers contain a.Memorandum of Agreement between Thomson Houston and the.Sprague Railway Co. . NY Times 13 Feb 1890; Daily Union 12 Nov 1890. Carosso, Vincent. 1967. The Morgans. Harvard.pp. 270-273.**

as "practical to the point of ruthlessness". His favorite phrases were "what's his market value?" and "fire the kickers. " [44]

At Schenectady, Ord and Insull began the process of turning Edison's federation.of independent companies into a Chandlerian Visible Hand style corporation. The Edison General Electric Company now was made up of three functional departments: manufacturing, accounting, and engineering; five product departments: light and power, lamps, railway equipment, wire, and lamp fixtures; two main Works, a Machine Works in Schenectady NY, and a Lamp Works in Harrison NJ, some smaller factories, and six sales offices, spanning the nation from New York to San Francisco. The product departments specified a product line, produced a catalog, and promoted products nationwide. The district offices handled actual sales, and placed orders with the Works. The Works then built the apparatus, based on the engineers' designs.[45]

This structure was designed, implemented and operated by Ord, Insull, and another rising star, Samuel Dana Greene, jr. He was the son of a Civil War naval hero and later Admiral, and was himself a Naval Academy graduate. He had joined fellow Annapolis alumnus Sprague's electric traction venture, and was a key contributor to the Richmond success. At Edison General Electric he proved to possess a rare combination of technical knowledge, aggressive salesmanship and organizational skill. Greene seems to be the one who finally got a serious effort started at Edison General Electric on AC. In 1890 he wrote to the Edison Lab asking what progress been made on a proposed multipolar AC dynamo. By August, 1891, Greene and Kruesi at Schenectady and Kenneally at Edison's lab were leading a collaborative AC development effort.[46]

So by 1891, three companies of roughly equal size contested for leadership in the new electrical manufacturing industry. All were now exploring

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[44] **Biography of Joseph P. Ord. ethw.org; New York Herald 21 Mar 1901 p. 14. Broderick, John. 1929. Forty Years With General Electric. Ft. Orange. p. 57.**

[45] **HF H- 290- 295. Recollections of S.L. Whitestone, 3/10/25.. Organization of Edison General Electric, 1 Aug 1890, Secretary's File. MiSci.**

[46] **Letters from Samuel Dana Greene Jr. to TAE 10 Oct 1890, A.E. Kennelly to Samuel Insull, 25 Aug 1891, LM115201.Edison Papers. Kennelly to Kreusi, 4 Nov. 1891 Edison Papers.**

opportunities in both AC and DC. Each had competitive strengths, embodied in key personnel and protected by key patents. Thomson Houston led in arc lamps, Edison General Electric in motors, and Westinghouse in exploring, though not yet quite mastering, the next advance in AC.

The companies also contrasted in control. With the departure of Villard, Edison General Electric was firmly under the control of J.P. Morgan. Westinghouse was still a technology driven company, controlled by its founder, though he now has to supplement the capital he raised in Pittsburgh with finance from New York City's August Belmont. Control of Thomson Houston was divided between its sales oriented president, Charles Coffin, and its Boston financial backers.

Where did the Wizard fit in? In 1891, he was on the outside looking in. Though promising to put a significant part of his laboratory's services to work on electrical matters, he was actually concentrating on such technologies as sound recording and iron mining. As for the electrical industry, he was contemptuous of the financiers who now dominated it. He saw them as seeking to suppress technological competition in order to keep prices high and increase profits. Edison had nothing against profits. He wanted to earn them, however, in a different way than did the financiers. He wanted to do it by inventing superior technology, protecting it with invulnerable patents, and then offering products to the public at the low, though still profitable, prices that would maximize sales. He would get high profits, in other words, by high volume, not by high margins. He also objected to any further mergers. " On no solid business ground, " he concluded in 1889 “is there a shadow of reason for any justification for any coalition with the Thomson Houston Company or any other company. " [47]

So what was the real connection between that Wizard, Thomas Alva Edison, and General Electric? Was he its founder, or one of its most vocal critics? The answer was both, but each at a different time. In 1878 he was the founder of the first of the companies that in 1892 would become GE. By that year 1892, however, he had become the man who did not want to see GE happen.

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[47] **Edison to Villard. 23 Mar 1889.Box 63, item 472, Villard Papers. Baker Library.**

This was not, however, a decision for the Wizard to make. Since 1886 an increasingly grey and weary Gandalf, the Wizard had lost touch with the industry he had created. By 1892, he was still a significant stockholder in Edison General Electric, but not an employee, much less an executive. Though a member of the Board of Directors, he was not a decision maker. As the Wizard, now a spectator, awaited the financiers' next move, consider the changes that the move of his Machine Works to Schenectady had already wrought.

Chapter 3. Machine Works 1886-1892

Also in 1892 awaiting the next move by the financiers were the 15,000 people of the city of Schenectady. What had been the impact of a big, by 1890s standards, Machine Works on this little, even by 1890s standards, city? That is the question this chapter will address. That question will be examined first from inside the Works, then from inside the city.

The Edison Machine Works in Schenectady originated, as noted, in two buildings abandoned by an unsuccessful venture into locomotive making. That Works immediately outgrew those two original buildings. It quickly expanded into a Works exceptional in size and scope for the 1880s. Few production sites of any kind employed its wide range of technologies. Of the many products soon emerging from the Works, two were most important. One was dynamos (a term then used to encompass both electricity generators and electric motors). These were high precision carefully machined, intricately wired devices used to turn mechanical energy into electromagnetic energy, or vice versa. Dynamos were at the leading edge of 1880s technology, and earned the Works' highest profit rate

The second largest business, was by contrast hot, dirty dangerous,relatively low tech, low in profitability but essential to fulfilling an Edison commitment. The Wizard had promised not to send his electricity through dangerous overhead wires, but safely underground. To satisfy this commitment another New York City company had been formed, the Edison Tube Company.

It was managed by John Kreusi. In a process developed by Kreusi himself the "tubes", 25 foot long sections of iron pipe, were threaded with copper wire, and then force filled with a molten asphalt-based insulating material. The tubes could then be lowered into ditches in New York Streets and connected up. Filling in the ditches left all transmission wires safely underground, fulfilling Edison's promise.

The Edison Tube Company also moved to Schenectady in the fall of 1886, providing the works with its hottest, most exhausting and most inflammable factory. In 1892 it would ignite in the greatest fire in the entire history (so far) of the Schenectady Works. The fire briefly threatened to go out of control and consume the entire works. It was, however, put out with contained damage and, miraculously, no fatalities. Evidence that at least

some women worked in the extremely unpleasant conditions of the Tube Shop is contained in a resulting headline: " Edison Works Fire. Tube Shop Destroyed. Girls are saved. " [48]

Between those two extremes, the works took on the whole range of tasks aimed at getting electricity to users, and enabling them to use it in new ways. In addition to dynamos and tubes, the product list included, condensers, wire and cable, junction boxes, switches, and those Sims-Edison torpedoes, as well as non-electrical products such as pulleys, shafting and castings. [49]

One major Edison product was not made at the Works which 20th Century Schenectady boosters would label "the city that lights and hauls the world". The Works never manufactured any incandescent light bulbs.These were mad at Harrison, NJ. The end products that were made in Schenectady Ranged from over all the rest of the system that brought electcicity to those light bulbs, and powered electric trolley cars. In addition, those electrical products were only the tip of an industrial iceberg. Behind them were intricate machines for using copper wire to direct electricity in just the right amounts to the places where it was wanted. Meanwhile, other machines or hand processes applied insulating materials to keep the electricity from going where it was not wanted. All this required not a single big factory building, but a whole industrial village . [50]

For example, in a building, reminiscent of a cotton mill, whirring machinery applied insulation to wires, while young women scurried around fixing breaks and keeping things running. In another building, the mica shop, human dexterity chopped mica into thin layers needed to insulate a key component of DC electric generators and motors called a commutator. The human dexterity with mica was also mainly supplied by women. This owed less to particular female skills than to the fact that women were paid on the average half the daily wage of men.

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[48] **Schenectady Daily Union 25 July 1892.**

[49] **Insull to TAE 3 Aug 1887 D 8736 ADC. Edison Papers.**

[50] **Descriptions in this and the following paragraphs adapted from Martin, Thomas Commerford. 1888. A day with Edison at Schenectady, Electrical World, 25 May 1888**

Coil winding occupied another shop. It operated at a medium level of mechanization. It also has and a gendered work distribution. Women wound the smaller more intricate coils for half the pay of the men who wound the larger, heavier ones.

Not all the work was shop labor. By 1890 the sales and bookkeeping forces occupied a main office building that would, an observer noted, have graced a small town. The drafting department was housed in a building described by that visitor as spacious and elegant as a billiard hall. There was a small brass foundry, and a large iron foundry which, when not fully occupied with Works needs sold its services to the local economy. To complete the industrial village analogy the works had its own transportation department, police force, and 200 man volunteer fire department. For the firemen. management purchased a steam powered La France fire engine superior to anything possessed by the then still all volunteer Schenectady Fire Department.

The Works labor force grew from 300 at the end of 1886 to 2500 in 1891. These new arrivals fit right into the community. In April, 1887, for example the Edison Machine Works Baseball Team defeated a "picked side from this city". The Edisonians also provided new customers to local businesses. This likely included Ranch 10, a "disorderly house" located near the Works. It was raided by the police in that same month of April, 1887.[51]

The new work force that had these impacts was diverse in origins and occupations. Late 19th century industrialization is often characterized as replacing skilled craft workers with unskilled operatives. This was not the whole story in Schenectady. Before the arrival of the Edison Machine Works, Schenectady's distinctive employment category had been machinists. A machinist is basically a person who uses a machine to cut metal into parts that will be used to make other machines. Machinists were employed, pre-Edison, at Schenectady's Locomotive Works, as well as at smaller Schenectady firms building such products as agricultural machinery, steam power for ships, and, two decades earlier, the turret mechanism for the Civil War ironclad Monitor.

The Edison Works did not replace this machining skill with unskilled machine tenders. Instead, the demands of the electrical industry required more and better machinists, as well as a range of other skilled crafts such as

[51] **Schenectady Daily Union, 3 and 6 April 1887**

moulders, tool and die makers, blacksmiths, patternmakers, and model builders. The Edison Works did employ more operatives and laborers than had ever been assembled at one Schenectady location before, about 1000 in all. There were also, however, more than 1000 skilled craftsmen, mainly machinists, also an unprecedented number for a single Schenectady location.

The remaining few hundred employees might be labeled white collar workers and managers. They ranged from the sole Works gatekeeper up through bookeepers, clerks, draftsmen, engineers foremen, and a handful of top managers led by Samuel Insull. Consider these all these layers of employment, one layer at a time.Start with the operatives and laborers. An employee log of operatives and laborers in the Armature Winding Department Edison Machine Works for 1890- 1893 survives. It includes a tabular listing of over 1000 employees, giving the date they started, their names, addresses, specific occupation, pay rate, previous occupation and date of termination, often with the reason .[52]

About one third of the operatives were women. Both women and men were mainly in the age range 15-30 years. About one in seven, however, was listed at the lowest listed age, 14 years. A bill recently passed by the New York State Assembly had put 14 as the minimum age for work in factories. A comparison of the employee log with census records by Catherine Haag showed that some 60 of the workers were actually under that age limit of 14, in violation of the law.

Only about 1 in 10 of the workers were over 30. The oldest was 52. Among the women, only about 1 in 10 was married. The average wage was about a dollar a day, typical for what laborers earned throughout the later 19th century. However, that average was within a doubly peaked distribution. The women and 14 and 15 year old boys essentially all made $.50-$.70 a day. The men almost all made $1.00 to $1.35 a day. The work day was 10 hours Monday through Friday and 9 hours on Saturday.

About half the operatives and laborers had previously been Schenectady residents. The most common previous occupation was "home work", followed by farming and school. These are trailed by a long list of other

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[52] **In her 2023 Ph.D. dissertation, Mainstream Radicalism. U of Albany, pp. 170-180Catherine Haag gives a thorough and illuminating analysis of ths employee log that the account here draws on and superficially skims.**

previous occupations: broom maker, knitting mill operative, printer, plumber, blacksmith, grocery clerk, barber and many more.

The ethnic origins of the workers are not listed, but can be inferred from their names. Like Schenectady as a whole, the majority were "Yorkers": people whose names indicated family residence in New York State or its neighbors for at least two generations. The Van surname, indicating descent from original Dutch settlers of the region, was underrepresented compared to the Schenectady population. The Mc and O' surnames, indicating Irish, and the Sch surnames, indicating German, were overrepresented. The surnames with a Di or Ko prefix, or a final vowel, indicating Eastern European or Italian origin , were present, but only in very small numbers. A larger presence of these later immigrants would be a 20th century phenomenon.

A biographical sample from this listing turns up no dramatic subsequent rags-to-riches stories. The closest is that of Andrew Geisemer, a 14 year old mica paster. His grandfather was a German born saloon keeper on Albany Hill, and his father worked at the Locomotive Works. After just two years at the Edison Machine Works, Andrew left his operative job to become a carpenter, and went on to a successful career as a building contractor. At the other extreme Mrs. Frances Tiffany had gone from wife and homemaker to a widow taking in boarders. Now, at age 52, she was earning $.50 a day as a coil winder.

Most of the known stories are somewhere in between those examples of Andrew Geisemer's upward mobility and Frances Tiffany's downward slide. Many of the children and single women were second earners, often children of other Edison workers. For example, 20 year old mica splitter Laura Dey was not only the daughter of an Edison Works employee, but also a cousin of a fellow mica splitter, 19 year old Celia Mereness.

Finally, more than half of the workers were listed as departing employment by 1893. So many are in this category to raise the suspicion that this might be a selective list. It is more likely, however, that it simply expresses two known facts about industrial operative employment in the US at the time: first, high turnover, sometimes exceeding 100% per year even in good times, and second, the frequency of depressions, such as the one that began in 1893.

Most of the departures are listed as "quit". A smaller number indicate a transfer to another job at the machine works. A similar small number

indicate firing for such deficiencies as "incompetence" or "absenteeism." Only a few are listed as "laid off."

A step above the operatives and laborers were the semi skilled workers. On an August day in 1892 some thirty Metal Polishers of Edison Machine Works Building 25 posed for a group picture. A caption later applied to that picture allowed some of those metal polishers' life stories to be sketched.

Metal polishing was a semi skilled job, and a hazardous one. Giving the rough castings that emerged from the foundry a smooth finish began with filing off those castings. The process filled the air with tiny metal particles . The workers had no protective equipment to prevent them from breathing in those particles. Another step, dipping and plating, involved polishing metal surfaces with liquids that released into the air harmful vapors, from which the workers were also unprotected.

Two men in that 1893 picture were sons of John Clune, an Irish immigrant to New York City . They had followed the Edison Machine works to Schenectady . John Jr. was a shop worker and James was foreman of the dipping and plating room. They would soon be joined by brother Martin, after he completed a six year enlistment in the U.S. Marines, and later by a fourth brother, Harry.[53]

As the Clune brothers exemplify, it was often the presence of family ties that enabled some workers to stay permanently in Schenectady and sometimes even prosper. Martin Clune, for example, would by 1900 be a property owner and Republican Party Committeeman in Schenectady's Second Ward. He was also a member of the Schenectady Trades Council, a pioneering effort to organize labor unions in Schenectady. In their roles at the intersection of occupation, labor relations, and politics, the Clune brothers will be heard from again.

The next layer up were the 1000 or so skilled workers. About 300 came up to Schenectady from the Goerck Street works. A contemporary states that many soon quit and returned to New York City. This led at Schenectady to a persisting shortage of machinists. The response was recruiting, and poaching, near and far. Recruits ranged from Schenectady locomotive

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[53] **The Clune Family story was traced using that original picture and later capton in the Schenectady Works News, census and occupational directory records, and the Schenectady County Historical Society Family Files.**

machinists to tool and die makers at the Singer Sewing Machine Company in New York City, to machinists at the large nearby New York Central Shops at West Albany to skilled immigrants getting off the boat at New York City, to recent journeyman from the Midwest taking the machinist 's traditional post-apprenticeship wandering year.

Immigrant groups that had become numerous in Schenectady before the arrival of the Edison Works welcomed this new employment opportunity. For example, machinists Henry and Frederick Schwenker had arrived together in Schenectady from Prussia in 1861 to work at the Locomotive Works. By 1891 five Schwenkers were working either at the Locomotive or Edison Machine Works.[54]

Atop the skilled worker hierarchy were the tool and die makers. Their critical role was to design and make tools, dies, guides, and and other attachments. These enabled less skilled workers to carry out relatively simple and repeated operations, yet produce some of the precise and complex parts previously made by highly skilled craft specialists. These demanding tool and die maker posts proved hard to fill by recruiting. One resort for the foreman was to train his own.

Jacob Weller, for example, was a farm boy in a family that had resided for decades in the then rural Schenectady suburb of Scotia. In July, 1887, he crossed the Mohawk to Schenectady and walked down to the river flats to try his luck at the new machine works. A city directory lists his first occupation as laborer. In that role, however, he caught the eye of Peter Weber, foreman of the Tool and Die Department. Weber took Weller under his wing as part of what was then an informal, highly personalized system of apprenticeship. [55]

Jake Weller earned a permanent place among the 30 Tool and Die makers. He further proved his mettle on the day of the great fire of 1892. He was one of 20 men who grabbed the pump handles of a 50 year old hand pumper to douse the blaze. In the course of it, he got trapped between railroad cars, breaking his arm. He suffered other, more permanent disabilities, but his arms and hands recovered. The job of tool and die maker mainly reqired

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[54] **Warrensburg NY News Thurs Nov 29 1956; Schwenker Family File, Schenectady County Historical Society. Gazette, 10 May 2013.**

[55] **Works News 22 June 1945**

dexterity, not mobility. So despite lasting physical problems he was able to serve out a 44 year career as a GE tool and die maker. In the course of it, he fathered what would become a dynasty of skilled craftpersons.[56]

The next level above the most skilled worker was testing electrical equipment. That was best done by people who understood the principles of electricity. That mainly meant college men.They initially showed up on the payroll as students hired for the summer, paid at the same 50¢ per day that boys and women got. They got their hands dirty in the shops, working alongside laborers, operatives, machinists, and skilled mentors. This enriched with experience their previously only theoretical electrical knowledge .

By the end of 1891 this student category was formalized into the "Test Program". From its beginning the Test was international, with one of the first members being Kunihiko Iwadare from Japan, who would go on to become a founder of the Japanese electrical-electronics giant corporation NEC. For the next 60 years the Test would serve as the main way of initiating new engineers into General Electric.[57]

About half of the graduates of the Test would stay with the Company. The other half would often take jobs at electric utilities and other potential Works customers. For example, J. Edward Schwenker, Union College and Test Program trained scion of that aforementioned Schenectady Schwenker family, became one of the leading contractors in New York State, and likely a good customer for General Electric.

Moving up to the hierarcy, consider the 60 or so foremen. Like feudal land owners in earlier days, they had absolute rule over their local domains. They made all hiring and firing decisions within their own team , and were often accused of favoritism, and of requiring personal perks, such as free Sunday work on the foreman's home. What limited their dictatorial possibilities was their own background as workers. They knew from experience that

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[56] **Works News 4 Dec 1925; 22 June 1951. Weller Family History, MiSci.**

[57] **Wise, George.1979. On Test. IEEE Transactions on Education. E-22. 171-177 Letter from T. Hashegawa to TAE, 11 July 1888. D880 5AEJ, Edison Papers.HF E-193A. Albany Times Union 13 Feb 2025.**

disaffected craftsmen had ways of getting back at abusive foremen-- ways that often negatively affected the department's productivity.

Illustrating the balance between decisiveness and fair tratment was foreman Billy Madigan. He was the son of Irish immigrants living in Albany NY. In 1884, at age 15, he went to work at the West Albany shops of the NY Central. There a machinist named Soles, whom Madigan later described as "a fine old man with his beard down to his chest and always wearing a hat" took charge of him, providing a personal apprenticeship similar to that of Weller's. .After five years, Madigan was told by Soles " to go out and hit the country." This wandering year was typical for machinists graduating from apprentice to journeyman status. Madigan spent his at various railroad shops around the Northeast, growing in confidence as he developed skills as a problem solver as well as a craftsman. After he returned to Albany, Soles sent him off again, in May 1891, with a letter of recommendation to William "Pop" Turner , shop Superintendant at the Edison Machine Works. Turner soon promoted Madigan to foreman. "Pop Turner liked men who were snappy and full of pep, not afraid to get into the job themselves," said Madigan.

Billy himself was not so sure about this added responsibility as a permanent career. "I never took my overalls off in my first job as foreman," he said. Pop Turner helped him make up his mind. " I was coming along one day with a handful of tools when Turner stopped me and said." "Lad I want you to take charge of 10 tomorrow [Building 10 was one of the two original Machine Works buildings, and in the 1890s the most important machine shop].Added Turner, "take your overalls off. "[58]

Works Superintendant Turner, though just a step above the foreman level, was one of the two top shop officials. These two lords of manufacturing performed a sort of good cop - bad cop routine. John Kruesi, manager of manufacturing, was the good cop. His nickname was Honest John. He was universally respected for his combination of competence and calm. He was

[58] **The above is based on item L 3068, Hammond File, MiSci, and an interview with Madigan in the WN 4 July 1924 p. 12-13**

reputed to be the only manufacturing manager or foreman not to use profanity.[59]

Kreusi managed manufacturing by collective consensus. As Tube Shop foreman Christian Rach recalled, "whenever a large order was received, Kruesi would call together in a conference all the heads of the manufacturing departments to lay out the work. " [60]

Turner was the bad cop. He was seen, a contemporary said, rarely in a coat and never a collar. He earned , in equal measure, respect for his competence and fear of his temper. Said a subordinate "he ruled with might and and was usually right" . Turner acted impulsively, once firing a foreman whom family matters kept from attending a Sunday foremen's picnic. Kreusi had sometimes to act as a court of appeal against Pop's excesses.[61]

At the top of the management structure stood Samuel Insull. He owed his authority as much to his special relation with Edison as to any assigned job description. He was an energetic combination of money raiser, salesman, final authority on Works matters, and active investor in local companies and real estate. Insull sometimes had to work through Turner to impose his will on long time Edisonian Kreusi. For example, when Insull wanted to introduce piecework as the way of paying the skilled employees, he instructed Turner to make that suggestion to Kreusi, to avoid a possible clash with that longer time Edisonian.[62]

Beyond rule by foremen, the Works had no formal labor relations policy. The original labor relations goal, escaping unions, had largely been achieved. In the Works' early years it experienced only a few small local strikes. Despite the workers' lack of formal rights, however, at times the scarcity of particular skills gave a few skilled workers a surprising degree of negotiating power. For example, the pattern makers were sort of sculptors in wood,

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[59] **John Kruesi papers, in possession of Evelyn Kruesi Joyce, Schenectady, N.Y. Recollections of H. F. T. Erben, E184' Hammond File, MiSci. National Cyclopedia, p. 100.**

[60] **Edison Tube Co, Christian Rach. Poulon Archive, Book 20. Schenectady County Historical Society.**

[61] **Recollections of F.F. Schwentker; Recollections of H.F.T. Erben. Poulin Archive, Book 20. Havens, Morton. 1927 Recollections. PTM Magazine. 2.4.**

[62] **Insull to TAE 31 Aug 1887. D 8736 ADR. Edison Papers.**

making the patterns that, packed in sand, provided the molds for cast iron parts.Their particular skill, more artistry than science, was very hard to replace. So when they walked out briefly in 1893 seeking a slightly shorter work week, the management quickly and quietly met their demands. The pattern makers secured unofficial but lasting recognition as the first GE union with whom management would bargain. Their special status would survive until the 1960s. Where skills were more replaceable, GE did not negotiate with unions. In 1890, Insull was accused of firing three union organizers. He denied the charge, attributing the firings to insubordination. "We do not object to our employees belonging to labor organizations," he said, " so long as they permit is to run out business." [63]

The Machine Works had brought one employees organization up from New York City. The Edison Mutual Benefit Association continued in Schenectady its practice of collecting dues from voluntary employee participants, and making small payments for specified emergencies such as injury or funeral costs. It played no role in workplace policy

As for safety, the Schenectady Works was not an exceptionally dangerous workplace by contemporary standards , but neither was it exceptionally safe. Pop Turner claimed in an 1890 newspaper interview that the works had only "a single serious accident" in its first four years. This claim is supported by the New York State Factory Inspector's 1888 Report. It lists several workplace accidents at other Schenectady manufacturers, but none at the Edison Machine Works. That safety record was, however, not kept up. The Factory Inspector 's Report for 1892 lists more than 40 accidents at the Works.[64]

A few such accidents highlight one possible contributing hazard: the shortage of skilled hands, and a resulting insertion of inexperienced newcomers into skilled positions. For example, John McGinnis, who presented himself as a steamfitter, was sent on his first assignment into a works basement to repair a leak. He instead released a blast of steam,

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[63] **On the pattern makers strike, See Schenectady Daily Union 9 June 1893. Insull's quote is in Schenectady Daily Union 22 Sept 1890.**

[64] **Rochester NY Democrat & Chronicle 26 July 1890. Annual Report of the Factory inspector of the State of New York for the Year Ending Dec. 16, 1888. Troy Press. Eighth Annual Report of the Factory inspector of the State of New York. publ. 1894 Lyon,Albany, covering years 1892- 1893. pp. 682-712.**

receiving a fatal scalding.[65]

In another episode, a skilled operator of a die casting machine was found smuggling a pail of beer into the shop. Ordered to dispose of it, he instead quit. He was replaced by a newly arrived German immigrant, Carl Sillman. On his first day on the machine Sillman reached in to remove a casting and had both arms caught in the mechanism , with "frightful" results. Never losing consciousness he walked down to the infirmary where both his arms were amputated at the elbow.[66]

Alongside its workplace hazards, improvised and informal management structure, and many opportunities for abuse by foremen and management, the Machine Works achieved the profitable financial results its owners hoped for. "They are doing a large and increasing business," the credit rating firm Bradstreet Co. concluded in 1888. "The business is said to be carefully and capably managed, and payments satisfactorily met." [67]

Turn now to the city perspective. How did the Works impact Schenectady? The answer began with a surprise. It turned out that the Edison Machine Works was not located in the City of Schenectady at all. In a quirk of boundary setting early in the 1800s, those flats by the river, frequently flooded and fertile, seemed destined for an agricultural rather than an industrial future. So despite being closer to the city center than most of the proposed city boundary, those flats were designated as outside that boundary, and instead part of the neighboring country village, Rotterdam.

This meant that the Works would not just avoid paying the high taxes of its original home, New York City. It also would avoid paying the lower but still significant taxes of the City of Schenectady. Rotterdam residents were soon complaining that the Edison Works was paying less than its fair share of even those lower county and local taxes.As one Rotterdam official put it "the Works of the Edison General Electric Company were assessed at a very low figure." By 1895, an Albany newspaper was claiming that " The personal property of the Edison General Electric Works was originally

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[65] **Schenectady Evening Star, 18 May 1891.**

[66] **SchenectadyEvening Star 10 Dec 1891, 14 Dec 1891.**

[67] **Report from Bradstreet Co. , Edison Machine Works, Oct. 1, 1888. Edison Papers.**

assessed at $15,000,000 but that was afterward reduced to $600,000. " As the Works got these rural bargains, Schenectady city taxes went up as the city welcomed thousands of new workers. They needed to be housed, which in turn generated the need for paved streets, new sewer lines and water mains, more policemen, the establishment of a professional fire department, and new schools for the soon to arrive children of those incoming young workers.[68]

So Edison General Electric started with a big unfair advantage. It could house its workers in a conveniently nearby and modernizing city without having to pay a full share of the costs of that modernization. This did not, however, mean that Edison General Electric turned a totally blind eye to city development. Instead, almost immediately, key members of Schenectady's political and economic leadership and the very top level of Works leadership formed an informal and unofficial city improvement liaison committee.

On the civic side were two successful businessmen. Henry DeForest's biography traced Schenectady's economic evolution. He was born on the floor above the county jail, where his father served as sheriff. He studied business and became a clerk, and soon the, owner of a broom making shop. Then he was a farmer growing broom corn and sugar beets on an island in the Mohawk River. Then, twice in the 1880s , he served Mayor of Schenectady. After the arrival of the Edison Works De Forest abandoned politics in favor of real estate, leading the development of new neighborhoods.[69]

Two of those De Forest developments were in the city, just outside the Works boundary. They featured new avenues named after Edison and Kreusi. Their selling point was the short walk to and from work. De Forest's aim, he said, was to "give each of the mechanics employed at the Rotterdam shops an opportunity to enjoy 365 warm dinners."

Following De Forest's lead, local realtors changed the names of once out of the way locales from the merely descriptive, such as Engine Hill or Cotton Factory Hollow to the more inviting, such as Mount Pleasant, Pleasant

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[68] **Legal Testimony, EMW, Samuel Insull, 1888. Edison Papers Schenectady Evening Star 2 9 Dec 1892. Albany Morning Express, 24 Apr 1895.**

[69] **Schenectady Daily Union 30 Sept 1889, 14 Nov 188922 Aug 1890. " Sketch of Henry Dr Forest.. " Family, File, SCHS.**

Valley and Bellevue. Neighborhoods in the sometimes damp or flooded flatlands were now advertised as within a short walk to the Works. Those that were significantly uphill were advertised as high and dry -- and soon to be on a trolley line.

A second key player in the Works-city alliance, Willis T. Hanson was a descendant of New England Yankees and a second generation Schenectadian. He was druggist in the 1880s when he purchased the American rights to a patent medicine called Dr. Williams' Pink Pills for Pale People. This iron supplement was touted, without evidence, as cure for such ailments as arthritis and cholera. It proved popular, and made Hanson rich. When the Machine Works arrived, Hanson was in the process of improving his local image by becoming president of a new bank and helping found the Schenectady Board of Trade. Part of this civic activism was active cooperation with Edison General Electric and its successor. He will be seen, for example, leading the city 's effort to purchase and donate to General Electric some crucial property, and later receiving a reward in the form of an insider trading opportunity brought to him by General Electric's president. Hanson also partnered with Pop Turner in buying up hundreds of lots in the soon to be developed suburb of Bellevue.[70]

The reaching out to the corporation by these civic leaders was met by similar outreach to the city on the part of Edison General Electric leaders Insull, Kruesi, and Turner. When the Edison Works arrived, Schenectady was just opening its first trolley line. It consisted of horses pulling a car over a mile or so of tracks on the city's main thoroughfare, State Street.After Sprague's Richmond success, a new management promised to electrify and expand the system. After they lagged in this effort Schenectadians learned in 1890 that this local effort had been bought out by a company whose principals were Sam Insull, John Kruesi, and Pop Turner. " The road, " Insull told reporters "will be a model one in every respect in order to show the new motors to the best advantage. "

They emphasized that were not acting on behalf of Edison General Electric, but were their own company. They would, however install Edison General Electric's newest equipment, and give Schenectady a world class system. Said Insull, " we are willing to run the road through every street in town of it will pay is to do so. " Nor did the trio stop there. Soon a second Insull-

[70] **Willis T. Hanson jr. Papers, SCHS. Schenectady Evening Star 18 Sept 1894.**

Kreusi-Turner company underbid the previous street lighting company and got the contract to light the city with electric arc lamps. "Arc lighting is something new for the Edison company, " said Turner. "We intend to make this a model plant." The three went on in 1891 to buy the Schenectady Gas Company, and then the Schenectady Westinghouse Electric Lighting Company. This last purchase removed the embarrassment of a competitor supplying the city with Edison's signature product. When Henry De Forest proposed a new Edison Hotel, Insull, Kruesi and Turner were investors. This "first class" establishment held a bar, billiard rooms, a barber shop, and 30 rooms, one of them permanently reserved for the Wizard.[71]

Another Machine Works official took a more direct route into city affairs. William Gilmore came to Schenectady as Insull's secretary, but was soon promoted to assistant works manager. He moved into the elite downtown Stockade section. There, in 1890 he ran as a Republican for the post of city alderman. Despite a Democrat near sweep of the rest of the city, he won. At his very first City Council meeting, Gilmore led a coalition of the Republican minority and some Democrat dissidents against the previous Democrat majority. His local reach went further in 1889, when he married the granddaughter of the most prominent politician in that town of Rotterdam. Gilmore then saw his grandfather in law elected in 1892 to the U.S. Congress.[72]

On the City Council, Gilmore quickly involved himself in the the city's main public health issue. Schenectady's trademark disease was typhoid. This waterborne infectious disease was especially severe where crowded together housing placed homes' privies too close to home water wells. In response, a private investor built, and the city later purchased, a water supply system serving city needs with piped water .Unfortunately, that system's water intake was in the Mohawk River, just downstream from an open sewer

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[71] **Schenectady Daily Union 3 and 11 June 1890; 17 June 1890. Albany Morning Express. Oct. 7, 1890. Schenectady Daily Union 17 and 29 Oct 1890, 8 and 12 Nov 1890. Albany Morning Express. For July 31, 1891. Schenectady Evening Star 30 July 1891. Schenectady Daily Union 10 July 1891; 29 Jan 1892.Schenectady Daily Union 30 May 1887; 12 July 1889**

[72] **Schenectady Daily Union, 7 May 1890. Schenectady Daily Union 28 Mar 1890, 2 April 1890. Schermerhorn Genealogy and Family Chronicles. Schenectady Digital History Archives. SCHS**

called Cowhorn Creek. The Edison Machine Works now added its wastes, also entering the river just upstream of that water supply intake.

In 1891, an Albany Medical College researcher published an article identifying Schenectady as the "fountain head" of the region's recent typhoid epidemic. He singled out "the sewage of the Edison Company in Schenectady," and included case studies of typhoid contracted by Edison Machine Works employees.[73]

In response to this danger, the city's commissioners had a plan. Drill wells on the banks of the Mohawk River to reach an underground aquifer. Filtering the water through a a thick layer of sand left the aquifer untainted with contaminants. [74]

Then politics intervened. Labeling that aquifer plan as too expensive and inadequate in quantity, a coalition of economy minded politicians from both parties rejected it. They installed a new Water Commission which concluded in 1893 that the place for the new water intake was, after all, in the Mohawk River. Here Gilmore came out for quantity over quality. In the interim, the Edison General Electric Works had been connected into the city water supply. It had done so with questionable legality. Being outside the city limits, that hookup was, the city attorney stated, "directly in violation of the city charter." Legal or not, the Edison Works needed the large quantity of water that the river could supply. At this point in the debate, Gilmore gave what a reporter described as "an eloquent speech." His key message: " unless the Edison Works had a larger supply of water than at present they would be forced to shut down and this would throw 3500 people out of employment. " It was an already familiar and soon to be repeated tactic of corporate bullying. Either do what we demand or we will not come here at all (1886) or shut down (1893) or move out (1895). Gilmore ignored a recent finding by Union College biologists that the proposed new input, though now located upstream from the Works outlet, had a dangerous level of bacteria per cubic centimeter due to the discharges of the dozen other

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[73] **Schenectady Evening Star 12 May 1891, summarizing an article by Dr. Craig in the public health journal Sanitarian. The full paper is Craig, Joseph. 1891. Intestinal Diseases in Albany and Vicinity. 1891.Sanitarian, July 1891.#260, pp. 212-234.**

[74] **SchenectadyEvening Star, 5 and 12. April 1893.**

industrializing cities and towns further up the Mohawk. Gilmore and his allies won the vote that approved that polluted intake. Only a courageous Mayor, Joseph Clute, saved Schenectady. He vetoed the bill that specified the Mohawk intake, saying, "the city wants pure water". He then led a turnaround that ultimately approved the aquifer plan. It took 4 years to install the new system. When it was ready, however, it proved a resounding success, providing clean, safe water in astonishingly abundant quantities. Aquifer water has met the needs of the city and the Works ever since, and remains sufficient and clean in the 21st century.[75]

If the officials of the Edison Works acted with less than perfect corporate citizenship in regard to the water crisis, they did a little better in response to another source of urban danger. The increasing scale of the Works magnified the already serious problem of dangerous transportation hazards.This danger was the flip side of the transportation access that attracted industry. The Erie Canal, still useful for carrying heavy products, passed through the center of the city. Its shallow stagnant ditch spread germs, and occasionally held the drowned body of an untended small child or intoxicated adult. Much more serious by the 1880s was the toll taken by the hundreds of daily trains passing at street level on four parallel tracks across the main downtown streets.

Commenting on this, a local newspaper editorialized that "Every working day several hundreds of the employees of the Edison Works travel up and down the railroad tracks to and from their work. It is a source of wonder that accidents are not of more frequent occurence. " Two months later Alderman William Gilmore moved that a tunnel be dug to carry the trains under that crossing. This led to passage of a bill In the State Legislature and, in 1894, construction of the tunnel. This relieved the problem, at least for the crossing directly in front of the Works. The toll of railroad accidents at ground level crossings elsewhere, however, continued. The Edison General Electric Company, as a corporate resident of the adjoining village of

[75] **SchenectadyEvening Star 11 Jan 1893. SchenectadyEvening Star 20 July 1891.p.4. SchenectadyEvening Star 26 April 1893, 9 Aug 1892, 26 April 1893; 4 May 1893. 10 May 1893, 16 May 1893. The full story of the Schenectady search for safe water is in Wise, George. 2014. Edison's Decision. Schenectady County Historical Society**

Rotterdam, saw fit to ignore this bigger city of Schenectady portion of hazard that its presence had amplified.[76]

So to sum up, what was be the impact of this big, by 1886 standards, Machine Works on this little, even by 1886 standards, city? In the main, it was just one example of a wave of 1880-1900 industrial relocation that created one of the world's greatest industrial belts. Big corporations moved into little cities in the late 19th Century for some of the same reasons they would eventually move out of those cities in the late 20th Century. They sought abundant and cheap land on good transportation, a lower wage rate, and an escape from political interference, taxes and labor unions.

As the Edison General Electric Company scaled up its Works just outside the little city of Schenectady, it completed the process of turning a transportation break into an industrial city, a process the Locomotive Works had begun. Schenectady went from a population mainly concentrated within half a mile of the original city center to a downtown surrounded by a ring of densely populated multi-family home neighborhoods. As it thus reshaped Schenectady, the Edison Machine Works would stand outside the city's boundaries, paying the city no taxes. As it did so, it subjected Schenectady to the costs of growth, such as the flow of more pollution into its unfortunately placed water supply intake. If city leaders protested, the company would bully them with threats of departure.

All this added one more nicknamed little city --the Electric City-- to the list stretching from the Shoe City of Lynn MA to the Collar City of Troy NY to the Rubber City of Akron OH to the Glass City of Toledo OH to the Plow City of Moline IL. These repurposed little cities filled a parallelogram bounded by Boston, Baltimore, St Louis and Minneapolis that was fast becoming one of the world's greatest industrial belts.

At Schenectady, the managers of the Edison Machine Works, Insull, Kruesi and Turner, were big frogs in a small pond. At the same time, their managerial fates, as well as the fates of their Schenectady work force, were being determined by the much bigger frogs in the nation's biggest pond.

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[76] **Schenectady Daily Union 6 Feb 1890 p. 3 claims 250 trains passed through Schenectady per day . See Schenectady Daily Union 31 Dec 1889 for list of railroadaccidents. Schenectady Evening Star 22 Nov 1892. Schenectady Evening Star 11 Jan 189, 16 Feb 1893.**

Down in New York City, a small group of financiers were busy creating the giant corporation that the Wizard had wanted not to happen.

Ch 4. Shoemakers 1892- 1900

To anyone who had been following the electrical industry, the news that broke at the beginning of April, 1892, was no surprise. Even to those insiders, however, the details were surprising. That surprise was felt especially strongly in Schenectady.

The unsurprising news was a merger of two of the three largest electrical manufacturing companies, Edison General Electric and Thomson Houston. The third of those companies , Westinghouse Electric, remained independent. Some sort of merger among some of these three had been rumored at least since 1889.

The surprise was in the detailed description of the new company. Especially surprising to Schenectadians was the absence of Edison and Edisonians. The Wizard's name was conspicuously absent from the new company's name, General Electric. The management of this new company did not consist of the former leaders of Edison General Electric . In their place, in six of the

seven top spots, was a Thomson-Houston team that Schenectadians derisively nicknamed "the shoemakers".The questions this chapter addressess are; Why did this not-quite-monopoly, the General Electric Company, appear at this particular historical moment? Why was it run by those shoemakers?

Though not literally shoemakers, the organizers of the Thomson Houston Company had indeed started out in the shoe business. They had, however, sensed in the 1880s that their home city of Lynn MA had passed its peak as the nation's Shoe City. Seeking a rising opportunity, they had found one in 1883 in New Britain, Connecticut. There a young company called American Electric, a maker of dynamos and arc lamps, was struggling to survive.

The Lynn group bought the company. They brought it back to Lynn, and changed its name to that of its founders , electrical experts Elihu Thomson and Edwin Houston. Then they named as President not an electrical expert but one of their own: a successful shoe merchant named Charles A. Coffin.

When Coffin took over, Thomson Houston was a small startup concentrating on arc lighting systems. It was one of a number of rivals to Edison that lagged far behind the Wizard in technical accomplishment, public recognition, and financial support. Coffin quickly accelerated Thomson Houston's efforts. He got support from some leading Boston financiers. He followed Edison into the incandescent lighting business and then, largely by acquiring other pioneering companies, expanded into transportation and alternating current systems. He accompanied this technical diversification with strong manufacturing and marketing.

In those activities, Thomson Houston was sometimes described as a mere imitator, the "cowbird of the electrical industry". (A cowbird is a kind of blackbird that lays its eggs in nests made by others). Actually, under the more respectable name "fast follower" this legitimate and logical strategy would succeed not only at Thomson Houston but also throughout the entire history of GE.[77]

Coffin's technology champion was Elihu Thomson. He had been a science teacher at an elite high school in Philadelphia when he found his knack for invention. This led to near misses at inventing the induction motor and radio,

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[77] **Carlson, W. Bernard. 1995. A Case Study of the Thomson Houston Company. In Naomi Lamoreaux et. al. eds. Coordination and Information. Chicago. Pp. 56-65**

but also to commercially valuable follow up inventions in arc lighting and alternating current. He was scholarly, systematic, ethical and gentlemanly, no Wizard, but rather a man fitting his nickname "the Professor". [78]

Along with Thomson came his former student, now a self trained engineer and manager of manufacturing, Edwin Wilbur Rice jr. (known as E.W. or Wilbur to avoid confusion with his nationally known father, a prominent Sunday school organizer and author or editor of religious texts). Coffin then added, by acquisition, the efforts of such leaders as electric railway pioneers Charles Van De Poele and Walter H. Knight, and arc light pioneers Charles Brush and James J. Wood. This team continued to work on electricity after 1885, while Edison was moving on to other fields. By 1890, Thomson Houston, Edison General Electric, and Westinghouse stood more or less evenly matched as the biggest U.S. electrical manufacturers.

Electrical manufacturing companies had been merging since the 1870s. Henry Villard, as shown in the previous chapter, had accelerated this merger trend by creating Edison General Electric in 1889, and trying, but failing, to take merging to another level.[79]

Soon however, others picked up the idea. They included backers of Thomson Houston, such as the Boston financial house of Lee, Higginson & Co., and the main backer of Edison General Electric, the New York financial house of Drexel, Morgan & Co. Taking the lead in this round of negotiations was a financier with a foot in both camps, and homes in both cities. Financier Hamilton McKay Twombly was a fellow Harvard alumnus of Boston banker Henry Lee Higginson, as well as a business associate and friend of J.P. Morgan. It was Twombly who succeeded where Villard and

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[78] **Carlson, W. Bernard. 2003. Innovation as a Social Process. Elihu Thomson and the rise of General Electric. Johns Hopkins.**

[79] **Villard' negotiations with Thomson Houston regarding cartels and.consolidation are in Villard Papers, Harvard Business School, Villard to Charles Coffin 15 Mar 1889. Box 126 Book 61 p. 381. 24 May 1890, Box 127, Book 64, p. 325. Villard to S. Eaton 26 May 1890. Box 127 Book 67. p. 302. The Edison Papers contain a Memorandum of Agreement bet,ween Thomson Houston and the.Sprague Railway Co.**

others had failed. In the deal Twombly negotiated, the two original companies, each valued at about $15 million, would exchange their stock for shares in a new company, to be increased in value by new stock and bond issues to $47 million. That new company, shorn impartially of the names Thomson, Houston and Edison, would be called simply General Electric.

The merger was met with skepticism in the press. A term quickly applied to it by its opponents was "Electrical Trust". The magazine Electricity condemned the "immense capitalization' as "reckless financing" that was "foredoomed to failure. " [80]

Two New York State Assembly representatives objected to the process of incorporation.The state had a general incorporation law. Its provisions, however, were not as generous regarding such matters as size of capitalization and right to own stock in other corporations as that of neighboring New Jersey. The lawyers handling the General Electric incorporation told New York State officials that unless given a special incorporation law containing the especially favorable treatment offered by New Jersey , the new company would incorporate in that neighboring state. New York not only complied, but even threw in a sweetener, reducing its tax on capital from the usual one-eighth of a percent of capitalization down to one-twentieth percent.

So even before formally existing, General Electric used what would become a familiar tactic, telling a government body that if it was not given the special treatment it wanted, General Electric would go elsewhere. "The bill has created a great franchise without proper compensation to the state," complained New York State Assemblymen Sony and Deyo, to no avail. [81]

As for those accusations of reckless financing, proponents of the merger argued that the $47 million valuation was a reasonable one for such a strong

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[80] **Electricity 6 and 20 Mar 1893 HF L 3183.**

[81] **Schenectady Evening Star 8 April 1892. An Act to Incorporate General Electric Company. Laws of NY Vol.I. Passed at 115th Session of Legislature. Albany. Banks & Brothers. 1892. Supreme Court of U.S. 288 U.S. 517 (1933). Leggett vs. Lee #301, p. 562. Grandy, Christopher. 1989. New Jersey Corporate Charter Mongering. Jour. Economic History. 49. 677-682.**

company in the booming field of electricity. That company was not a trust, a financial form distinct from the chosen form of merger. Nor was it a monopoly, since Westinghouse was still in the field. If it was not a trust or monopoly, then why was it created? That issue of "why General Electric?" remains a historical puzzle. Chandler's answer of economies of scale does not work here. The previous size of each of the three equal-sized companies, Edison General Electric, Thomson Houston, and Westinghouse was big enough to exploit fully the scale opportunities.

General Electric's own later official answer to the reason for its existence was complementarity. Edison General Electric brought to the party mastery of incandescent lamps and DC. Thomson Houston brought mastery of arc lamps and AC. Both brought strength in electric railways and motors. General Electric, concluded the company's historian John Winthrop Hammond. "combined the wisdom, tradition and vitality of two vigorous rivals." He went on to add that "the incandescent lamp and the alternating current transformer belonged together...The two were complements of each other."[82]

For Hammond and others, another key cause was patents. Previously, each company could use its key patents, such as Edison's on incandescent lamps and Thomson's on transformer improvements, to block the other. Concluded General Electric patent lawyer and key participant in the merger negotiation Frederick Fish: "The patent situation was the real reason behind the consolidation...No customer could buy either a lighting or a railway unit without running the risk of infringing some patent." [83]

The historian of the early electrical industry, Harold Passer, did not settle the argument. His main effort was in arguing that the merger was never intended as a monopoly. On what it was intended to be he was less clear, though giving weight to both the complementarity and patent motives.

Neither of those answers fully works. As for complementarity, Edison General Electric was by 1891 entering arc lamps and AC. Thomson Houston had already entered incandescent lamps and DC. Both companies were on their way to offering a full line of electrical products. Complementarity was

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[82] **Hammond, John W. 1941. Men and Volts. Lippincott. .pp.192-193**

[83] **Comments and reflections of Frederick F. Fish. HF L . 2922.**

already achieved within each company. If the financiers who created General Electric had really aimed at offering full electrical capabilities to the public they could have achieved that better by leaving those big-enough competitors alone. Benefits to society in the formative days of the electrical industry arose more often from competition than from consolidation.

As for patents, merger was not necessary to remove patent roadblocks. A simpler way was through a patent pool. This is an agreement by competitors allowing each to use the other's patented technologies. This was done successfully in the 1850s by the major competitors in the sewing machine industry. It was done in the 1880s by Thomson Houston and Westinghouse in AC. It would soon be done, in 1895, by General Electric and Westinghouse. Modern examples include Intel and AMD in microprocessors, Apple and Microsoft in software, and Google and Samsung in Android smartphones. Such agreements support the scale economies of sufficient bigness, but preserve the spur of competition.[84]

Another, and better, answer to that question "why General Electric?" was suggested by J.P Morgan's best biographer Vincent Carosso. The General Electric merger was, he wrote: "intended to stabilize production and prices in what were then highly competitive industries. Such an intention, Carosso added "appealed strongly to Morgan's instinct for industrial order, cooperation, and opposition to price wars, and his preference for combination over destructive competition." [85]

The best historian of Thomson Houston agrees. W. Bernard Carlson put "the desire to eliminate competition " at the head of his list of causes of the merger. So did an expert on the economics of the electrical industry, Ralph Sultan, who wrote that the merger of Edison General Electric and Thomson Houston occurred "for the purpose of joining forces to prevent price competition". [86]

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[84] **In the Edison Papers there is a " Draft of Arbitration of Patent Differences between Edison GE and Thomson Houston, June 1890. Electric Light- 1890.**

[85] **Carosso, Vincent. 1967. The Morgans. Harvard. pp.390-391.**

[86] **Carlson, W. Bernard. 2003. Invention as a Social Process. John's Hopkins.p.299. Sultan, Ralph. 1974. Pricing In the Electrical Oligopoly. Harvard. Vol I, p. 4. See also Lamoreaux, Natalie; Raff, Daniel and Temin , Peter. 2003. Beyond Markets and Hierarchies. U . of Pennsylvania Management Paprrs. 4-1-2003. P. 36.**

In short, GE was created to suppress competition. Hot competition among three equal sized competitors was likely to destabilize prices. And indeed by 1890 the prices of electrical equipment, such as generators and street railway motors were fluctuating wildly and often heading in a dangerously downward direction. Reviewing results for 1891, Edison GE's Annual Report reported that "the year's profits were diminished somewhat by a considerable decline in prices for the product owing to increased competition, etc." With the merger, Morgan was firmly in control of General Electric and able to exert his preference for competition suppression and price stabilization

The merger appeared to the financiers to offer this price stability even with Westinghouse on the outside. In two of the technologies likely to pay off rapidly, arc lamps and electric railways, Westinghouse had little presence in 1892. As for the third, incandescent lamps, an 1891 judicial victory of a key Edison patent looked likely to shut Westinghouse out. [87]

Meanwhile the eventual Westinghouse advantage, technological and patent superiority in AC, had, as earlier mentioned, hit heavy going in 1888-1891. Its future viability and profitability were uncertain. Evidence that AC was beyond the financiers' 1892 vision is provided by the first General Electric Annual Report, issued in January, 1893. That report would begin by extolling company strength in electric lighting and transportation. "While your Company has about 6000 customers" and many businesses, the Report said: "The interesting and important development is in the direction of local lighting and railway enterprises." By contrast, that report would not even contain the acronym. "AC" or the word "alternating."

In sum, why General Electric? It was created by financiers for whom price stability, not progress, was General Electric's most important product.

While getting mixed reviews on Wall Street, the merger generated no enthusiasm in Schenectady. The main problem its Works already faced, separation from its research and development arm, the Edison Laboratory, was made worse. Now not only R&D, but also engineering and design, were in the hands of recent rivals in Lynn MA. That Lynn team was, in 1892, going head to head with Westinghouse in a revitalized effort to catch up with the European leaders who had finally made practical an advanced AC system. At stake were some major future opportunities, such as tapping the enormous power of Niagara Falls.

This new electricity challenge will be discussed in detail in the next chapter. In 1892, its main immediate impact on the Schenectady Works was to carry off to Lynn the nascent Edison General Electric AC effort and its dynamic leader Dana Greene.

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[87] **Schenectady Evening Star. 15 July 1892.**

Another Schenectady leader, Samuel Insull had originally been offered one of those top seven GE positions. He turned it down in favor of a new start, as president of a then small and struggling electric utility, the Edison Electric Company of Chicago. What had led to passing over the other Edisonians in favor of the shoemakers? Credit for that belonged too the chief shoemaker, Thomson Houston's president, Charles A. Coffin.

Few CEOs of giant corporations ever kept as low a public profile as Charles Coffin. He almost never gave a speech, and seldom an interview. Fewer photographs survive of him over his full lifetime than of Thomas Edison on a single day's visit to the Schenectady Works. Most of those photos show Coffin in his later years, as white haired and grandfatherly. Little evidence remains of the stocky bull-necked, walrus-mustached captain of industry of the 1880s, veering, in the words of associates from a "cold and obdurate" manner to "kindliness, patience and princely charm." Only an occasional tug on that mustache or tapping of his foot might reveal his energetic impatienc. He might occasioinally show some interest in electrical technology. One aide recalls him once holding up a negotiation to personally take apart a ten-cent lamp socket. Much more often, however, his questiom would not be "how does it work?" but "who is the man?"[88]

A child of Maine Quakers, he spoke, dressed and lived simply. In an age of grandly named executive mansions, he lived in an unpretentious house nicknamed "the bungalow". Though he had a car and chauffeur, he was known to walk alone and unannounced from the General Electric office in Manhattan to a customer's office when a key contract hung in the balance. The greatest such selling job in Coffin's career was the one he did in late 1891. He convinced J.P. Morgan that Thomson Houston was the better managed of the two companies, and therefore should get the upper hand. In retrospect, his claims of better management do not seem entirely correct.

Thomson Houston had achieved apparent higher return on invested capital by risky financial practices. As will be seen, when the next depression hit, those practices nearly sunk General Electric. By contrast, Edison General Electric's more conservative financial practices had led to slightly lower

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[88] **J.R. McKee, "Methods of CA Coffin" 20 April 1927 J757-758. Hammopnd File. Reccollections of M.P. Clough. Oct. 1925. J 722 Hammond File Hammond, John. 1941. Men and Volts. Lippincott. Pp 90-92. Broderick, John. 1929. Forty Years With.General Electric. Ft. Orange. p. 32**

short term profits, but would, in 1893, help save the company. In the calmer economic seas of 1891-1892, however, Coffin's argument about the shoemakers' better management convinced Morgan.

As CEO, Coffin showed many strengths. His personal simplicity did not prevent him from appreciating complicated technologies. That appreciation had however, a practical purpose. His assistant recalls Coffin saying "in our zeal to test Ohm's Law, or any other law, we must not forget that our stockholders are yearning for dividends."[89]

To serve that yearning, Coffin was willing to pay top dollar for key patents. He consistently supported and rewarded top company technologists. When Thomson Houston bought out rivals, Coffin had much success in persuading those companies' top brains to stay on board. He did not impose his own product preferences. He cared as little if customers preferred AC or DC than if his previous customers had preferred black or brown shoes.

He was also good at delegating. He simplified his executive responsibilities by leaving things he was not much interested in to his subordinates. The conspicuous example here was the fate of General Electric workers. An associate described Coffin's labor policy this way. " Employees were considered simply part of the necessary means of conducting business and were to be acquired as cheaply as they could be obtained." As for his immediate subordinates, he referred to them as "my associates" Notable among them were First Vice President Eugene Griffin, a West Point graduate who brought organization and discipline, and Technical Director Wilbur Rice, who brought a calm, competent, consensus oriented approach.[90]

Despite the turnover in executive leadership, nothing much changed at the Schenectady Works in the first General Electric year of April 1892- April, 1893. That honeymoon, however, came to a sudden end on July 21, 1893, when it suddenly looked like General Electric's first year might be its last.

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[89] **Broderick John. 1929./Forty Years with General Electric. Ft. Orange. p.14**

[90] **Recollections of M.P. Clough. HF J 722 and Jesse Lovejoy. HF L 3043.**

On that day, Schenectadians opened their newspapers to read that "a rumor was in circulation on the streets this morning that the General Electric Company has failed." Company officials immediately "emphatically denied" the rumors. The rumors however, though indeed false , were uncomfortably close to the truth. [91]

The threat of failure traced to the Coffin financial legerdemain that had so impressed J.P. Morgan. In the 1880s all companies supplying equipment to electric utility customers faced a problem. Those customers typically could not pay fully in cash. So the sellers agreed to accept customers' stocks or bonds in partial payment. Coffin preferred bonds, and found a way to convert them into the immediate cash that Thomson Houston needed to fund its own capital intensive growth. He created a subsidiary in which Thomson Houston cosigned the utility bonds (that is agreed to make the bond payments if the utilities could not do so). It then sold the bonds to private investors at a discount. So Thomson Houston got the instant cash it needed, while, because of the discount, the more patient buyers earned an impressive profit. In modern terms, Coffin put Thomson Houston into the junk bond business.[92]

All this worked fine in good times, such as the years 1885- 1892. Then, however, early in 1893, a steep depression began. The utilities could not make their bond payments. General Electric, which had inherited Thomson Houston's obligations, now not only saw its sales collapse, but also saw the obligation arise to make those bond payments. As a result, General Electric could not meet its financial obligations. In 1893 it had about $10 million in debts, and only $1.3 million in cash. Nor could it escape by selling the utility bonds it still held, since their value had plummeted. By August of 1893, GE's stock price had fallen from the post merger 120 dollars a share to 31-1/4 .[93]

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[91] **Evening Star 21 July 1893.**

[92] **Recollection of M.P. Clough. HF J 722.. H.F. Westover, Statement 8 Nov 1825. HF L 80-82.**

[93] **John T. Broderick An asset salvaged. HF L3201 . O'Sullivan, Mary. 2006. Living with the U.S. Financial System. Business History Review. 80. 621-655. P. 630. "The Fall in the Value of General Electric Stock. Scientific American 5 Aug 1893 p. 82.**

In contrast to Thomson Houston , Edison General Electric had accepted utility stocks, not bonds, in payment, and had done so in a more conservative manner. So it did not have to make ruinous payments at the same time as its sales fell. As a Thomson Houston executive admitted "it proved to be the securities of local companies which had been accumulated by the Edison company in payment of license fees which saved General Electric in the panic of 1893." [94]

A small company in such a situation would have indeed have gone bankrupt. For giant General Electric, other options were available. These options were considered by a reorganized Executive Committee, appointed by the Board of Directors. It consisted of just four men. Charles Coster, J.P. Morgan's right hand man , headed the list. Next came the two Boston financiers, Henry Lee Higginson and Thomas Jefferson Coolidge. Coffin, the fourth name on the list, kept his post as President. It was the financiers, however, who were in actual control.

Those financiers now ordered Coffin to do another selling job. That was to convince the money lender of last resort that General Electric was too big to fail. That lender of last resort in 1893 was not the Federal Government, which would bail out GE when it faced a similar situation in 2008. The lender of last resort in 1893 was J.P. Morgan himself. Coffin sought for General Electric a multi million dollar loan. He would later describe those days in the summer of 1893, as he awaited for an answer to come from Morgan, who was vacationing in Maine,as the "days of scalding centuries."[95]

Those days ended with a yes. Morgan would put together a syndicate that would, in three installments over the next eight months, give General Electric enough money to stave off its creditors. In return, General Electric would give the syndicate electric utility bonds currently unsaleable, but destined, when good times returned, to be worth three times the amount advanced to General Electric. So the syndicate members, who could afford to be patient, would get huge profits. General Electric would get survival.

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[94] **Comments and Recollections of Frederick F. Fish. HF L 2922.**

[95] **Hammond, John. 1941. Men and Volts. Lippincott. pp.221-224.**

Back in Schenectady, no one bailed out General Electric's workers. Two thirds of them, some 2000, were laid off, leaving only 1000 people on the payroll in the depths of the depression in late 1893. General Electric was not Schenectady's worst casualty. Its Works did kept running. Many other Schenectady manufacturers, including the Locomotive Works, suspended production entirely. Some would never restart. One such casualty was Pop Turner. On January 1, 1893, he had officially resigned from General Electric and had gone into business for himself. The Turner Machine Works was intended to produce shafts and pulleys. Instead, in 1893 it went bankrupt and disappeared.

More seriously hit were the city's laborers and operatives, who had barely scraped by even In the good times. Hardest hit of all was the wave of new immigrants just beginning to respond to the Schenectady opportunity. By the fall of 1893 Father Dercezewski, pastor of the Catholic Church serving Schenectady's community of recently arrived Polish immigrants, reported that in his congregation alone some 50 families and 30 single men and women were destitute**.**The people of Schenectady did step up. Several of the city's leading citizens and religious congregations formed in November 1893 a new Associated Charities organization. It promised "prompt relief in cases of real destitution" conditioned on "the supply whenever possible of employment as the basis of relief." That employment included laying the mains for a new water system. [96]

By late 1894, Schenectady's recovery had begun. For General Electric as a company, however, the after effects of that 1893 depression would linger for the rest of the decade. New competition from Westinghouse on such major products as street railway motors kept prices low. A depressed economy reduced orders from the struggling young electric utility industry. The company's total sales for the rest of the 1890s remained stuck at about $12 million per year, barely above the level that the Edison General Electric Company alone had recorded in its last full year of 1891. Management admitted in 1894, with a candor rarely seen in corporate annual reports, to "grave mistakes in the estimates of value of accounts securities and inventories of merchandise. " It further confessed that these mistakes had to "a greater extent" been made by the Thomson Houston Company, and only "to a lesser extent" by Edison General Electric. In 1899, the company, over

[96] **Schenectady Evening Star 25 Sept 1893 6 Oct and 4 Nov 1893. 11 April 1894.**

the strong objections of some of its stockholders , including J.P. Morgan, , reduced its capital valuation by 40%.[97]

In its January, 1894, Annual Report, however, the company had good news for Schenectady. Indeed, it would set the course for that city and its Works for the rest of its electric century. That news read:

> So far as is practicable your manufacturing business has been and will be concentrated at Schenectady; and the operation of its other factories are now directed from there.

The company would henceforth manufacture "the heavy and intricate machinery" at Schenectady . Lynn would produce only "stock material and other goods of the ordinary type." Light bulb manufacture, still the company's biggest money maker, would stay in Harrison. NJ. To support this division of labor, the engineering staff, as well as administrative departments such as accounting and sales, would move to Schenectady. The reasons for this reorganization were space and money. Despite the 1893 setbacks, General Electric's management still planned to make the company bigger, and have it build bigger things. That required more and bigger buildings on more land. Yet, under financial pressure, the company had to keep spending low. That required land that was both plentiful and cheap. Schenectady offered such land . Lynn did not. An 1894, newspaper story reported Coffin as saying that:

> The Works in this city [Schenectady] were far superior to those at Lynn and would accommodate 6000 people without being crowded in the least. He [Coffin] also said that land at the Schenectady Works could be purchased by the acre here for the price of a square foot of land in Lynn. [98]

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[97] **Certificate of Reduction of Capital Stock of General Electric Company. July 14, 1899. MiSci, Schenectady Daily Union 10 Aug 1898. Schenectady Evening Star, 11 and 17 Aug 1898**

[98] **Schenectady Evening Star 14 April 1894.**

So in the last week of January, 1894, 60 engineers from Lynn arrived at Schenectady to stay. Some arrivals seemed significant enough to be listed by name in the daily newspaper. These included Walter H. Knight, Henry G. Reist, Frederick Fish, and James.B Cahoon, all momentary celebrities in Schenectady but all soon forgotten by the general public. [99]

Missing.from the newspaper list was the one new arrival whose name would be remembered nation wide deep into the 20th century. In 21st century Schenectady it is remembered still. That name was Charles Proteus Steinmetz.

Perhaps his omission from that 1894 newspaper list was because his 1894 occupational title was not "engineer" but the humbler "calculator". Perhaps it was his lack of a college degree. Perhaps it was his appearance, described by a friend as " a small misshapen young man... the size of a twelve year old boy. " His condition, retrospectively diagnosed today as congenital scoliosis, was often labeled in his lifetime with the cruel and derogatory term "hunchback." [100]

Just six years earlier, the then-named Karl August Steinmetz, son of a railroad company lithographer, had been well on the way to a doctorate at the University of Breslau, Germany (now Wroclau, Poland). He was also a member of a Socialist Club, though one that was idealistic and utopian rather than revolutionary and Marxist. Nevertheless, his activities were, in Bismarck's Germany, highly suspect. In what follows, it is difficult to separate fact from a legend. The legend features a flight across the border a step ahead of the police. The facts feature a stop off in Switzerland to polish electrical and engineering credentials (but still no degree) and an ocean voyage ending in New York City. There, perhaps legend again, he was allegedly almost turned back due to his unhealthy looking appearance.He did, however, successfully embark onto the land of opportunity. Helped by a letter of introduction, he soon got a job that suited his combined mathematical and electrical skills. It was at the Yonkers NY factory of an earlier politically motivated 1848 German emigre, Rudolf Eickmeyer.

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[99] **Schenectady Evening Star 22 Jan 1894.**

[100] **Kline, Ronald . 1992. Steinmetz. John's Hopkins. p.5. This book's description of Steinmetz is largely taken from Kline's book, by far the best of the several Steinmetz biographies.**

Celebrating his new start Karl August changed his first two names to Charles Proteus.The image behind that name was to become an enormous General Electric asset . In its public appeal, it resembled a later equivalent, the British physicist Steven Hawking, and for much the same reason: the public perception of a brilliant mind in a challenged body.

Back in the early 1890s, Steinmetz was soon swept up in the hurricane of consolidation. His first employer's company was bought by Thomson Houston. This was not, as legend has it, to acquire Steinmetz. Actually Eickmeyer, an inventive hat maker turned Civil War gun maker turned electrical manufacturer, had invented promising electric motors, some with Steinmetz's help. GE acquired Steinmetz as an extra benefit, sending him first to Lynn and, in 1894, on to Schenectady. There he lived the last 30 years of his life. He became the subject of numerous anecdotes regarding everything from his cigar smoking to his absentmindedness to his poker playing to his collection of misshapen life forms such as cacti and lizards. After two decades, he would rediscover his socialism, and become the soul of a city.

The 1894 arrival of Steinmetz at the Works was followed that October by a more mixed signal. A statement, by an unnamed "spokesman for the Works", contained both optimism and a warning. The optimism was the goal of increasing employment at the Schenectady Works over the next 18 months to 6000 workers. The warning was a reminder to Schenectady not to entertain illusions of indispensability. The company was aware of the dangers, as well as the advantages , of putting all its eggs in one basket. "We will have branches elsewhere," the spokesman said, " in order to protect ourselves in case of fire or labor disturbances. "[101]

Few labor disturbances emerged at the Works as its work force quickly recovered in 1894- 1895 to that pre- Depression level of 3000 workers. The jobs were, at first, mainly those of the previous Edison Machine Works. Most numerous were the numbingly repetitive ones, such as winding coils, or hot, dirty and dangerous ones, such as that Tube Factory. Only in the event of an exceptional occurrence do a few of those operatives or laborers emerge for a moment from obscurity. For 38 year old metal polisher Andrew Galko, described as a "Polander", that moment was the bursting of an emery

[101] **Schenectady Evening Star 16 October 1894.**

wheel that, in April 1894, cost him his life. He left behind, in the part of Russia today known as Poland , a widow and four children.[102]

For workers at all skill levels, the work day began at 7 AM. It included a half hour lunch break, 12:00 - 12:30. In the absence of a cafeteria during most of the 1890s, workers typically rushed to the front gate to receive food delivered by a family member or boarding house owner. Work began again at 12:30 and ended at 5:30 PM Monday through Friday and 4;30 PM on Saturday. Pay increased over the 1890s to a typical $2 per day, less for women and more for the most skilled crafts such as making tools, dies or patterns . [103]

Organization was still feudal. The foremen were still in control. Yet each department had its own story, and not all were bleak stories of oppression. Consider, for example, the Porcelain Department. It saw one of the first major inflows of workers from Eastern and Southern Europe. The use of porcelain to insulate electrical wires preceded Edison. Among those bringing porcelain making to Schenectady was a immigrant from Bohemia (now the Czech republic) named Vaclaw Cermak.[104]

He and his family " had come from Europe because they hated the church's corruption and its hold," said a granddaughter many years later. "My grandfather became an American the day he landed. He never would go back." He had become a skilled pottery maker in Bohemia, and had married the daughter of a bookbinder. In New York, he went to work for a ceramist who had figured out how to mix the right clay for electrical insulators, and how to stamp the smaller of those insulators out with a press, or mold bigger insulators by hand on a potter's wheel.

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[102] **Schenectady Evening Star 21 April 1894.**

[103] **Rules of the Edison General Electric Company. Albert Rohrer Papers No 1 Folder 1. MiSci.**

[104] **For the details of the Cermak family story that follows I am indebted to Dr. Ethel Cermak, who spent 3 June 1984 telling me the story and sharing some family papers**

Vaclav Cermak became a foreman at this independent company, which in 1889 was bought by Edison General Electric. In 1894 he was sent to Schenectady. He was now William Cermak, foreman of the Porcelain Department, a short, cheerful man with a receding hairline and handlebar mustache. He bought a house in the suburb of Mount Pleasant, and brought two of his sons in to work in the Department.The real force in the family was William's wife Anna, "a bossy, dictatorial woman", her granddaughter recalls, who "would squeeze a nickel until the buffalo roared." When a new plant beyond the GE Works went broke, she bought up some of its property, and sold it on to incoming workers at a large profit.

She needed that determination and those financial reserves. Later in the 1890s, William developed what may have been Alzheimer's disease, losing his memory. His oldest son Frank was just over 20, and not long out of apprenticeship. Anna told Frank to claim full command of his father's craft and move right into the foreman slot. The Works management was already beginning to replace craftsmen with college trained experts. Porcelain was still, however, more art than science. Frank got his chance.

He had a rocky start. At one point the works manager told him that if quality did not improve, another keeper of the craft secrets would be found. Frank did improve that quality. By trial and error he learned such clues as the particular touch of a stamped out and drying insulator that indicated it was ready for firing. .

He looked stern and commanding, but he could laugh readily with his workers, to whom his door was always open. His shop grew from some 25 men, mostly Bohemian and Italian immigrants in 1895 to a diverse force of 80 men and women by 1905. Frank married the daughter of a Bohemian peasant. Her main memory of the old country was walking barefoot and hungry past bright windows through which she could see the parties of the rich. Her main memory of the Church was being compelled to kiss the filthy hem of the priest's gown. In Schenectady, a new U,S, patriotism was paired with old country tradition, via the Sokol, the Bohemian social and gymnastic club .

Frank was now a department head for Porcelain, and his brother Charlie a foreman. Frank bought GE stock and never sold a share. He became a Republican Alderman, moved from the working class suburbs to elite downtown Union Street, and drove a Cadillac. His mother Anna remained

the real boss. "She had masterminded the whole thing" said her grandaughter, " and she knew it. ".

The Cermaks' story is not a typical one. In the history of the foreman ruled departments that made up the 1890s Works, it is the success stories that survive. Of the other cases, we get only hints.For example, when John S. Winne, a carpenter at the Works, was fatally struck down by a travelling crane, an unnamed company spokesman was quick to blame the incident on Winne's own carelessness. A coroner's jury, however, found differently. It blamed foreman David Waller for stationing Winne in the wrong place at the wrong time.

Most experiences with foreman fell somewhere between these examples of Frank Cermak's happy teamwork and Waller's fatal mismangement. Most foremen could draw on previous experience as workers, as well as authority bestowed by management. They recognized that earning trust could be as important as discipline in making workers productive.

A new level of management, emerging just above the foreman level, was the superintendents. There were about a dozen of them, each ruling over a particular building, such as the Power House or Foundry, or over a particular specialty such as electrical or mechanical matters. Most superintendents had worked their way up from the bench. In the 1890s, however, their ranks were being salted with a few college graduates.Electrical Superintendent Albert L. Rohrer, for example, was an Ohio farm boy who graduated in engineering from Ohio State. At Thomson Houston he had distinguished himself by his improvements to the carbon brushes used in railway motors.[105]

At Schenectady, as a Superintendent, he observed the difficulty of recruiting enough skilled workers. For example after a large machine shop was added to the Works in 1901, many of its machines sat expensively idle due to shortage of machinists. The established methods of recruiting, such as trolling among the railroad shops or making offers to arriving immigrants, proved insufficient. "Machinists, " said Rohrer at the time, "don't seem to

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[105] **Biographical information on Rohrer is taken the Albert Rohrer Papers, MiSci, especially Box 1, Folder 1. Albany Times.Union 4 September 1950, p.4, Schenectady Gazette 4 October 1941 p. 13. 7 April 1914., 17 July 1919 1 May 1911 p. 3, Works News 25 June 1920. P.2.**

like our city." He then proposed a solution. General Electric should train its own skilled labor by modernizing the process of apprenticeship. Looking into the matter, he learned that such a new type of apprenticeship had been pioneered by the Hoe Printing Press Company in New York City in the 1850s.That model had already been adopted by about a dozen other companies. Rohrer put it in place at General Electric's Schenectady Works in 1901.[106]

As a result, when toolmaker Jacob Weller's son went to work at the Works just after 1900, he did not have to rely, as his farm boy father had, on the luck of being noticed by a personal mentor. Instead, he and and a couple dozen other local applicants won admission into this new program.It combined classroom work and hands on experience. It both recognized craft skill and tapped the advanced numeracy and literacy emerging from increasing high school completion. A young man, aged 16- 18, who joined the.program signed an indenture, a legal document committing himself to four years of 52 hour work weeks, divided between classroom work and rotation through various shops. The pay of less than 10 cents an hour in 1901 was less than that of an operative or laborer, and less than half that of a skilled craftsman. .The reward for completion was a bonus payment of $50, journeyman status in a specialty, and the guarantee of a job.

Rohrer's new style apprentice program went into effect at the Schenectady Works in 1901, with 20 participants. It grew into hundreds per year, in a half dozen different specialties, from drafting to machining to tool and die work. Of the 1700 or so graduates in the first quarter century of the Apprentice Program, about 60% stayed with General Electric. Many became foremen, some engineers or managers. They made up a small minority of the Works' skilled workers, as a sort of worker aristocracy.

Rohrer became an advocate for technical training and a skeptic about the superiority of a white collar. Speaking to the Schenectady Board of.Trade in 1911, he said that "too many men are entering the counting house instead of the work shop." Young skilled shop workers , Rohrer claimed, had shorter hours, better pay, and a better chance of keeping their jobs or quickly finding

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[106] **Interview with Frank Lange 6 Jan 1977. Recollections of Joseph Dancer. Hammnd File E 178. 40th Anniversary Celebration, Apprentice Alumni Association, Schenectady Works. 1941. Albert Rohrer Papers Box 2 Folder 7. MiSci .**

new ones than their counterparts in the office. At the root of this employment problem , Rohrer concluded, were "parents with false standards of what makes a gentleman." [107]

For him personally that Apprentice Program was the beginning of a self-invented role. Though officially promoted to Assistant Works Manager, a better title might have been called Superintendent of Education, Works Amenities, and Community Relations For in addition to creating the Apprentice Program, he also reorganized the Test Program, the program for recruiting and breaking in college trained engineers. He is said to have interviewed all 4000 college engineers who joined the company during his time with the Company. He was a driving force behind such additions to the Works as a cafeteria and an emergency hospital.

His community service dovetailed with his role at the Works. Recognizing that getting capable local apprentices depended on a strong local school system, he became a member of the Schenectady School Board, and eventually its President. His other community roles ranged from membership in the Schenectady Board of Trade and on the Board of Directors of Willis T. Hanson's Union National Bank, to leadership in the creation of the city's free library. In addition, he served as a committeeman of the local Republican Party. In 1898 he was offered, but turned down, nomination as that party's candidate for Mayor of Schenectady.

Only occasionally do we glimpse Rohrer at the intersection of his corporate and political roles. One such occasion was the November, 1900, election night. During the election night festivities, James Clune, that earlier mentioned metal polisher, was arrested for the stabbing of Thomas P. Davies of Resselaer. Clune said he had been drinking, remembered nothing, and was "very penitent for this act." Even before he came to trial he was, despite this repentence, allegedly discharged from his GE metal polishing job.

A newspaper story would note, however, that James' brother Martin Clune was the "lieutenant and right-hand man," of John N. Parker, the Republican boss of Schenectady County. "When (James) Clune was discharged" , the newspaper pointed out, "Johnnie Parker went to A.L. Rohrer and demanded that he be reinstated, and that demand was acceded to. "

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[107] **Schenectady Gazette 25 Feb 1911 p.1.**

James Clune indeed kept his job, Rohrer, however denied the details of the story. "Clune was not discharged,"he said, “but if he had been neither Mr. Parker nor any other politician would be permitted to dictate to or to influence the of the officials of the company.” [108]

Turn now now to the highest level of executive positions at the Works. These had expanded from the Edison days, but still numbered only about a dozen. The two top men, Manager of Engineering and Manufacturing Wilbur Rice, and Works Manager George Emmons, were both Thomson Houstonians. At Schenectady they had roles more or less corresponding to those previously played by John Kreusi and Pop Turner. Like those predecessors, neither Rice nor Emmons was a college graduate. Unlike those predecessors, however, their combined persona was not good cop - bad cop, but two good cops.

Rice grew up in Philadelphia, the son of a self made rural New York farm boy who had graduated from Schenectady's Union College and gone on to become nationally known as a Sunday School organizer and writer or editor of religious literature. At the elite Philadelphia high school attended by Wilbur, his science teacher and inspiring mentor was Elihu Thomson. When Thomson moved from teaching to entrepreneurship, Rice followed.Though he would earn 100 patents, Rice’s particular skill proved not to be invention, but managing engineers and directing manufacturing. In the 1894 move to Schenectady he first worked alongside John Kreusi, a natural fit. Kreusi was soon kicked upstairs, and Rice replaced him.[109]

If Rice resembled Kreusi, Works Manager George Emmons was the opposite of his predecessor, Pop Turner. Emmons was compact, neatly dressed, and congenial. He came from a middle class Connecticut family, left school after the 8th grade to work in a grocery store, went to Indiana in

[108] **Albany Argus.10 Nov 1900 .**

[109] **Historian Julia Blackwelder kindly shared with me information from her forthcoming biography of Wilbur Rice and his family.**

1880 to start his own store, failed there, and came back east to become bookkeeper with Thomson Houston.

He worked his way up to auditor. Along the way he demonstrated that his organizational skills surpassed even his excellent bookkeeping. Tried out as Schenectady Works manager, he developed a pragmatic personal approach toward workers, many of whom he got to know by name. The nickname the workers gave him, "the little man" was not a taunt, but a compliment. It recognized that he did not rule by might, but managed by skill, patience, and constructive consensus. Union leaders would find fiendish his way of anticipating worker demands and making the minimal concessions that would defuse worker action, leaving management uncompromisingly in control. [110]

Rice and Emmons exemplified a way that management of the Schenectady Works in the shoemaker era departed from the Chandler pattern of management by hierarchical pyramid. At the Works there was no dominant CEO sending orders downward. Indeed, General Electric's President Charles Coffin did not transfer himself from Lynn to Schenectady. Instead, he took an office in Boston, and later moved to New York City . After narrowly surviving the 1893 crisis, he focused on stabilizing the company, and regaining control of it from the financiers.

Coffin accepted the financiers' goal of stabilizing competition. To that he added three elements of his own: the fast follower strategy so successfully employed by Thomson Houston, stockpiling cash to escape the Wall Street shackles , and helping electric utility customers raise capital.

In stabilizing competition, Coffin focused on General Electric's most profitable business, selling light bulbs. In keeping it profitable, he explored the limits of legality. His main bout with the 1890 Sherman Anti Trust Act will be described in the next chapter. In stockpiling cash, Coffin's goal was to avoid the need, when the next depression came along, to again go begging to J.P. Morgan. To carry out this goal, new capital was mainly raised from retained earnings or the sale of new stock, rather than by selling bonds. The company also set aside more money for depreciation (that is, future

[110] **Hammond, John. 1941. Men and Volts. Lippincott. pp.35, 244-246.**

equipment replacement) than was typical for companies its size. For most of the 1890s it also paid no dividends, keeping the money as a cash reserve.

In carrying out this plan, Coffin benefited from a steady, if initially slow, recovery from the 1893 crash, followed by a boom from 1899- 1906. When the next depression came, in 1907, General Electric was soundly ballasted with financial reserves. It safely rode out the storm, while it was rival Westinghouse that was forced into receivership. By making recourse to the likes of Morgan unnecessary, Coffin achieved by 1907 a 20th Century style independence of management from financier or stockholder control. Edison had succumbed to financial control in 1889. Westinghouse would in 1907. The shoemakers would not.[111]

Coffin was willing to take some financial risks. He resumed, though in a more careful way, the financial practice that had got General Electric in trouble in 1893. As the economy recovered Coffin found that selling generators and other apparatus to electric utility customers still required helping those customers raise the money needed to pay for those products.

By 1905, Coffin, with the aid of another of GE's Naval Academy grads, Sidney Z. Mitchell, had worked out a plan for providing this service. Through a new subsidiary called Electric Bond and Share, GE would purchase stock in utility companies, providing those companies with needed cash. GE would then repackage those stocks into packages of diversified and therefore less risky Electric Bond and Share securities. These were then sold to the public. The process was similar to what banks in the late 20th century did with home mortgages. In addition, GE would provide those utilities with consulting services in both finance and engineering.This concept, called a utility holding company, proved profitable not only for GE but for others who adopted it in the early 20th century, such as Samuel Insull and the Stone and Webster Company.

For GE, there was a legal wrinkle. With one part of GE financing and advising the utilities, and another part selling them turbine- generators and other equipment, there was the potential for the kind of undue influence that violated the antitrust laws. Sensitive to that issue, GE included in the Electric Bond and Share by-laws the provision that GE was not to make a

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[111] **Carpenter, Niles. 1916. The Westinghouse Electric Company, the General Electric Company and the Panic of 1907. Jour. Political Economy. 24. 230-253, 382-389.**

sale to an Electric Bond and Share utility unless the GE offer was as good or better than the offers of competiting companies. Despite this provision, GE would, as will be seen later, clearly gain by the 1920s an unfair advantage in sales. That advantage would become a target for GE critics. [112]

While concentrating on financial issues,such as Electric Bond and Share, and occasionally acting as a salesman when major opportunities arose, Coffin left most management decisions to subordinates Their decision making was done by committees. These included a Sales Committee, a Manufacturing Committee, and an Engineering Committee. Though each was chaired by one top company officer, they worked by consensus. Above them stood an Executive Committee, a portion of the Board of Directors. It had the power to overrule the decisions of those lower ranking committees, but rarely did so. From 1895 until about 1950, General Electric would remain largely a company of committees. These committees sometimes clashed in defining their responsibilities. They also had only very uncertain and approximate estimates of the actual costs of doing business. This was brought out in an exchange between Coffin and Rice in 1903. In it Rice admits that the cost estimates in GE manufacturing contained so much guesswork as to be almost useless. [113]

So to sum up the internal management of GE in the Coffin era, it was far from the orderly hierarchy of professional managers depicted by Chandler. Instead, Coffin's GE was managed by a combination of committees, consensus, and confusion.

By contrast, GE's dealings with the cities that held its major works, involved less consensus and more bullying. In Schenectady, that was best illustrated by an 1895 story of a street.

Kreusi Avenue was a new street created by mayor turned realtor Henry De Forest. It ran right beside the Works, enabling De Forest to advertise it as an avenue of family homes and family values to which a worker could return

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[112] **Hughes, Thomas. 1991. The Electrification of America: the Systems Builders. In Reynolds, Terrry ed. The Engineer in America. Chicago. Pp. 191-228**

[113] **Rice to Coffin 3 Feb 1903. Commercial File. MiSci.**

in time to get a hot supper. As the Works grew, GE buildings came to surround Kreusi Avenue.

On that avenue, the original vision of workers homes and hot meals turned out not to be the whole story. "On Kreusi Avenue, " one reporter wrote, "saloons are at present as thick and close togethers bones on a shad." Other stories noted the presence of "disorderly houses" on what had been nicknamed Crazy Avenue, and described as "a mecca for frail women and disreputable men."[114]

The 1893 depression hastened that new specialization. Consider the case of Annie Brown. In 1893 she had been an assistant foreman at the Sanford Mills in nearby Amsterdam. When she lost her job due to the depression, she went to Schenectady to find new work. Though assuring her family that she was respectably employed as a domestic, she was actually "an inmate of disreputable places in the city. " She ended up at the Robins' Nest, a "disorderly house" just outside the General Electric Works, and then in Municipal Court. There she was released to the custody of her mother. Her disorderly house co worker, Sarah Chapin, was not so lucky, getting a six month jail sentence.[115]

For General Electric, vice was a minor part of the Kreusi Avenue problem. The major part was location. Kreusi Avenue lay right against the back end of some major works buildings. The Company wanted to lengthen those buildings so large castings for the new big electrical machines could be brought in at one end, the entire assembly process completed along the building's length, with the finished product being loaded onto a rail car at the other end.To achieve this, Kreusi Avenue would have to go. That meant local government would have to close off the avenue, and someone would have to buy up the houses and saloons located on it.

Logically it might seem that the someone should be General Electric. That was not, however, the message that the company's Second Vice President Joseph Ord brought to the Schenectady Board of Trade in April, 1895. Instead, he brought an ultimatum. If the people of Schenectady did not buy

[114] **Schenectady Evening Star 2 April 1894**

[115] **Schenectady Evening Star 2 4 May 1894**

up those properties and give them to the company, General Electric was prepared to move elsewhere.[116]

Skeptical Schenectadians might well have felt that they heard heard this story before. The first time.had been that $7500 needed to bring to Schenectady the Edison Machine Works. Subsequently, rumors would depict the Works about to move to such locations as Albany or Cohoes, NY, or Orange, NJ. This version, however, was different. This emerged when Ord took the witness stand, under oath, at a County Court hearing convened to hear a General Electric motion to close Kreusi Avenue. There he told a remarkable story.

This proposed move of the Works was no mere rumor. General Electric had received two very tempting offers of new locations. The best offered 50 initial acres with plenty of room for expansion, plus an amount of money somewhere.between $100,000 and a million dollars.This proposal had gone before that Board of Directors Executive Committee. All but one of the members not only approved the move, but offered to forego parts of their salaries to help pay for it. The one Executive Committee holdout was Joseph Ord. He asked the other committee members to suspend action and give Schenectady one more chance. They agreed, and here he was, testifying in public in Schenectady County Court.

Was this story plausible? Ord told it under oath. Willis.T. Hanson, president.of the Board of Trade, noted that "many residents" of the city had been " disposed hitherto to dispute the sincerity of the announcements that the General Electric Company proposed to go elsewhere. " Now however, said Hanson, "such objections have been swept away" by Ord's testimony. Ord had not named the rival site. Soon however, a nearby newspaper, the Albany Argus, did. The name proposed, Depew, New York, added plausibility to the story, though a General Electric spokesman asked about the Depew destination refused to confirm or deny it.[117]

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[116] **The Kreusi Avenue story that follows can be found in the Schenectady Evening Star 17 April 1895, 15,22 and 24 July 1895; 2, 7,9 17, 22 August 1895, as well as a summary in the Willis Hanson jr. Collection, Box 1, SCHS.**

[117] **Albany Argus 30 July 1895 p.1.**

Depew NY, a new suburb of Buffalo, was located at the junction of major east coast and Midwestern railroad lines. It had convenient access both to the cheap and abundant electric power that was soon to be transmitted from Niagara, and cheap coal via rail from nearby Pennsylvania. The promoter of the Depew Development Company, Walter Webb, assembled a blue ribbon group of investors. They included Hamilton McKown Twombley, who had engineered the General Electric merger and served as the Company's first board chairman; John Jacob Astor III, heir to one of the greatest U.S. fortunes; and Chauncey Depew, not only a millionaire and a past president of the New York Central Railroad, but also a national leader of the Republican Party. Building on the latter's name recognition, Depew Development Company was incorporated in March, 1895, just two months before the Kreusi Avenue issue went public.

All this makes Ord 's sworn testimony more plausible. A new little city under total control of such financial power might be an ideal place to develop the next generation of electrical machinery. Ord's testimony convinced the Schenectady Board of Trade to accept the GE ultimatum. The Board of Trade passed the hat among local businesses and individuals. More.than 100 donors chipped in. Contributions ranged from $1500 from the city's leading department store, the H.S. Barney Co. to $1 each from several H.S. Barney employees.

That fund raising effort initially soared to $30,000, the original estimate of the properties' total value. Then, however, it was determined by a court appointed panel that payment to the Kreusi Avenue property owners would total $50,000. The Board of Trade went back into action to raise the other $20,000-- and failed to get it. Would General Electric indeed, as Ord warned, pull the plug on Schenectady?

The answer came back quickly. Ord appears to have been bluffing after all. For he now pronounced himself satisfied with the community effort. General Electric would put up the other $20,000. Within a year, the Kreusi Avenue property owners were paid off and the land was turned over to the company. In 1896, the buildings were extended, and, production of bigger machines in those bigger spaces began.

In seeking the land, General Electric had originally offered nothing in exchange. The Board of Trade leaders insisted, however, on some benefit to the city. Finally, they got.these words written into the final agreement.

> Said property purchased therewith to be transferred to said company only upon condition that the principal officers and works of said company remain in Schenectady.

Taken literally, that would have entitled Schenectady, when General Electric did later move its "principal officers" out of Schenectady, to take back that land. However, by that time, the Kruesi Avenue story was long forgotten. As for Depew NY, it never did attract a major company. The Depew Development Company went bankrupt within a decade.[118]

At Schenectady, GE , despite its shaky financial status, began immediately the lengthening of those buildimgs. Even before the Kruesi Avenue issue had been settled, in November 1894, from one of those later to be lengthened factory buildings emerged a behemoth.This was the first of three 90 ton, 3000 kW electric locomotives to be used by the B&O Railroad to haul cars through a tunnel at Baltimore. This was not only an impressive achievement in its own right, but also a step into an envisioned future.[119]

That future was electrifying all railroads, not just urban trolleys. Just as electric motors were already replacing horses on city streets, General Electric hoped that more powerful electric motors would replace steam engines on all forms of rail transport. This was initially to happen in special uses, such as that Baltimore tunnel, on the elevated railroads of Chicago and New York City, and then in the tunnels beneath New York's proposed Grand Central Terminal. Eventually, however, General Electric officials foresaw electric railroads expanding to main line use and transcontinental scale.[120]

The maneuvering that led the lengthening of Works buildings to accommodate manufacture of those giant locomotives had exhibited General Electric using bullying and as bluffing to get its way with the city. On other occasions however, GE could exhibit bursts of good corporate citizenship. An example was that old problem of deadly railroad crossings. Proposals to elevate the railroad tracks above street level to eliminate level crossings within the city limits had been repeatedly raised in the city’s

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[118] **Kreusi Avenue Fund. Willis T. Hanson jr. Collection. Box 1, Folders HC2- H13; HC28-HC41.Schenectady County Historical Society.**

[119] **Schenectady Evening Star 19 November 1894**

[120] **Schenectady Gazette 11 March 1902.**

Common Council. Lacking the money to carry out this expensive infrastructure project, the Common Council repeatedly postponed action[121]

Death and injury, however, had not been postponed. It was the General Electric workers among the victims that got the company's attention. Fatalities included shop workers Wincentz Fydowski, Lawrence Maloney, and Joseph Brander, and Clytie Curtis, a tracer in the General Electric Drafting Department. She was on her way to work by bicycle when, crossing the tracks at State Street, she was struck and killed by a fast mail train.[122]

On this topic, the City's Common Council Meeting of March 27, 1900 had an unusual visitor. He was GE's Vice President for Engineering and Manufacturing Wilbur Rice. In most accounts of GE history Rice gets little respect. He was unimpressive in appearance, with a receding hairline, toothbrush mustache and goatee. His lack of consequence seemed confirmed during his later, 1911- 1921, presidential administration, which was dominated by Charles Coffin, who held on to the post of Chairman of the Board and the real power.

Yet it was Rice who was present at, and quietly and patiently in charge of, many of the decisions and actions that formed GE and assured its 20th century prosperity. He had been the top manager of both engineering and manufacturing for both Thomson Houston and GE. He had championed Steinmetz. In 1900 just as he was appearing before the Common Council, he was at the center of two momentous GE decisions. One was to develop its own version of a crucial technology, the steam turbine. Another was the pioneering U.S. adoption of the German idea of industrial research. More generally, his quiet, calm problem solving mentality and organization skills helped establish the committee and consensus based approach to technological development that served GE so well for so many years.

At that March, 1900, evening meeting of the Common Council meeting, Rice took the floor. He began by noting that a year earlier, when a bill was

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[121] **SchenectadyDaily Union 12_Jan 1895. Schenectady Evening Star 14 November 1895.**

[122] **Schenectady Evening Star 5 March and 22 October 1895, 5 Mar 1896. Schenectady Gazette July 30 1901, 6 Mar 1902..**

proposed in the state legislature annexing the suburb of Mt. Pleasant and the General Electric Works into Schenectady, "the Company was not ready for such a move, taxation being the main point." Now, however, things had changed. If Schenectady would now adopt that long debated plan for elevating the railroad grade crossings above street level, the company "is now willing to be incorporated within the bounds of the city and will willingly aid in shouldering the increased burden [of taxes]. "[123]

By 1906 construction of the elevated tracks was underway. By then, Mt. Pleasant and nearby Bellevue had been annexed, and the General Electric Works was a tax paying corporate citizen of the city of Schenectady. Wilbur Rice rarely repeated that Common Council appearance. He would, however, become the only GE President in its history to live and work in Schenectady.

In another, more equivocal, display of corporate citizenship, General Electric had also taken over, in an indirect and shadowy manner, the local energy monopoly that Insull, Turner and Kreusi had created circa 1890. This is best evidenced by the presence in leading positions on the boards or in top executive ranks of those local companies of the names of Works Manager George Emmons, and a rising star in General Electric executive ranks. chief lawyer and then vice president of the legal department, Hinsdill Parsons.[124]

To further model the power of electricity, General Electric turned its own Schenectady Works into what was in the late 1890s perhaps the.nation's most electrified major industrial operation. By 1893, in the two original Edison buildings , giant electric cranes swooped overhead carrying heavy metal parts between workstations. Outdoors, an electric railroad carried components and products between buildings. At 43 locations within the works, electric motors provided power, transmitted by belts and pulleys to groups of perhaps a dozen nearby machines. This "group system" was a transitional step toward modern factory practice. The modern "unit drive"

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[123] **Schenectady Gazette 28 and 29 March 1900, 30 July 1901, 6 Mar 1902. The story of the Mount Pleasant annexation issue is in the Schenectady Evening Star 27 March 1895, 3 November 1895, 13 December 1895, 3 February 1896, 18 February 1896, 11 Mar 1896.**

[124] **Schenectady Evening Star 15 Feb 1893.. 4 Mar 1893.**

idea of each machine being run by its own electric motor was then still only a futuristic vision.[125]

Do not exaggerate the.extent of this electrification. One 1899 observer noted that a "first impression of a visitor to these Works may be one of disappointment on account of the comparatively minor part which electricity seems to play." Energy distribution still depended mainly on belts , pulleys, and shafts. Much of the Works lighting was still natural. Much of the power for lifting, hauling and carrying still came from horses and humans.

One final touch in General Electric's makeover of the city of Schenectady was finalized in 1900. It began with financial difficulties experienced by another major local institution, Union College.To keep the college in Schenectady and pay its bills, Union College put 75 acres of valuable land just east of its campus on the market.That opportunity met a recently recognized aim of General Electric. That was to provide an elite residential neighborhood for its growing roster of Schenectady notables. In 1900 the General Electric Realty Company was organized. It purchased that Union College land for about $60,000. The Realty Company initially declared that "Sale [of lots] for the present is confined exclusively to employees of the General Electric Company. " To make sure these were the right kind of employees-- managers and eminent engineers-- the Realty Company required each house to cost $4000 or more, twice the city mean of $2000. The houses would be individually deigned by prominent architects. This “GE Plot” would have " no stores, saloons or apartment buildings", opting instead for a self-designated label " an enclave of elegance". [126]

One executive did not move to the GE Plot. Charles Coffin’s residence remained that modest bungalow on Long Island. His office remained in Manhattan. His tactics remained stabilizing competition, piling up cash reserves to escape Wall Street financier domination, protecting the highly profitable light bulb business by means fair or foul, fast following into new businesses, and assisting utility customers raise the capital they needed to buy equipment. Beyond these, Coffin allowed almost all issues of technology and manufacturing to be settled by committees. He took personal charge only of the closing of a very few exceptionally important

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[125] **Schenectady Evening Star 11 Apr 1893.**

[126] **Schenectady Gazette 8 September 1900**

sales, such as equipment for electrifying the Manhattan Elevated Railroad. He did not impose his own technology preferences.

Few detailed records of Coffin in action survive . One that does provides a rare detailed look at this reclusive corporate pioneer. Late in 1901, Coffin received an urgent request from the president of a French ally Compagnie Francaise Thomson-Houston (CFTH). It had gained an opportunity to provide street railways to several cities in France and Algeria. It however needed funding to do so, and French finance was "very depressed." Could General Electric help provide the funds? Coffin took this request to his board of Directors. They agreed on the condition that J.P. Morgan provide backing. Morgan, however, refused, finding the risk too high.

This did not stop Coffin. He found a way for General Electric to put together the loan without Morgan, and with a timing that got this risky venture off the books before the company's annual financial reporting would have exposed it. He then added an extra twist.. "I have a Schenectady associate who has been of great service to the company who I want to include in the loan", he wrote. That associate was Willis,T. Hanson, who had played such a crucial role in the Kreusi Avenue purchase. He would get an insider opportunity to profit from this investment opportunity.

By January, 1902, Coffin could report to his CFTH counterpart that the deal was sealed. "It would be gratifying to me personally, he added, "if you could see your way clear to give us some fair orders." This episode provides a glimpse of Coffin, as a spider at the center of a web of power linking U.S. manufacturing, French and Algerian transportation, international finance, sales of transportation equipment made by General Electric, and a reward to a helpful peddler of pink pills for pale people in Schenectady, New York. [127]

To conclude this chapter, return to its original questions. Why did this not-quite-monopoly, the General Electric Company, appear at the particular historical moment 1892? Why was it run by those shoemakers?

Here Chandler's invocation of inevitability is only partly convincing. Scale and its economies did make Giant corporate size, if not inevitable, at least highly likely. Evidence for this is the simultaneous circa 1900 emergence of

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[127] **The story of this trnsaction is in the File "French Loan" in Secretary's File, GE Collection, MiSci.**

Giant Corporations under the very different political systems of the U.S., Germany, Great Britain, and France.

Chandler's interpretation, however, explains only part of the story. Electrical manufacturing was a very capital intensive industry with technologies that had strong economies of scale. This favored concentration into a few big companies. There was no technological reason, however, why the biggest electrical manufacturing company had to be twice as big as the second biggest. Each of three roughly equal sized companies would still have each been big enough to capture all economies of scale.

It was the financiers' quest for price stability that led to that extra step of bigness. Those financiers would likely have preferred a single monopoly, like the U.S. Steel Co. that J.P. Morgan later helped create in 1900. In 1892, however, George Westinghouse was still in control of his companies, despite his alliance with financier August Belmont. Westinghouse insisted on independence. By the time the financiers gained full control of Westinghouse, in 1907, the Federal Government was taking the Sherman Anti Trust Law too seriously to make a final monopoly-creating merger possible.

Why were those shoemakers put in charge? Because Charles Coffin had, in a decade of relative economic stability, taken financial chances that had made Thomson Houston look like the more successful company at that merger moment of 1892. A year later, those earlier Coffin financial moves nearly sank GE. Why did the giant company that was thus created move its headquarters from the Shoemakers' Lynn to Edisonian Schenectady? Because in 1893 a cash strapped, financially imperiled, company had a need for big buildings in which to create not just big products but big systems. To design, build, sell, and ship those systems, it helped to put all the key players in the same place. This in turn required bigger buildings, built adjacent to railroad and canal transportation, preferably in abundant and cheap land. Schenectady offered cheap land and low taxes. Lynn did not. By the time other attractive locations, such as Depew NY, emerged, manufacturing was already too deeply rooted at Schenectady to pull up without disruption.

All this left one question still unanswered. Could GE, and its now dominant Schenectady Works, not only manufacture, but also innovate? To that question this book now turns.

Chapter 5 . Proteus: 1892-1912

The newspapers headlined it "An Electric Triumph." On June 30, 1895, electric power was transmitted from a new power station at Niagara Falls, received at a nearby factory, and put to work. The destination was the Pittsburgh Reduction Company, a company located less than a mile from the Falls. Honored guests at the triumph included, the newspapers reported, "Mr. Stillwell of the Westinghouse Company, and Mr. Greene, Professor Thomson and Mr. Steinmetz of the General Electric Company. "[128]

The news clipping raises immediate questions. If it was the Pittsburgh Reduction Company, what was it doing at Niagara Falls? What was it reducing ? What does all this have to with the history of the Old GE? The answers are hinted at in a single word near the end of the excerpt: Proteus. That word not only identified one major participant. It also suggests the particular emerging role of that new technology of electricity.

Proteus, Charles Steinmetz's self chosen middle name, began as a nickname given to him by university classmates at Breslau for the breadth and accessibility of his knowledge. Proteus was a Greek God able to take on many forms. Here that ability is used in its adjective form, protean. In the mid 19th century, scientists introduced a new concept called energy. It united many familiar phenomena, such as heat, light, motion and chemical change in one protean concept. Later in that century, electricity would emerge as the best way to exploit these protean possibilities of energy. It was those protean possibilities that put the General in General Electric. That generality came to mean equipment to convert other forms of energy to electromagnetic energy, to get that electromagnetic energy to a place where energy was needed, and then to convert that electromagnetic energy into the particular form of energy needed at that particular place.

As earlier mentioned, the financiers who created General Electric in 1892 had no such grand purpose in mind. They had the more specific goal of stabilizing prices for light bulbs and street railway motors by suppressing competition. The company then passed from the hands of the financiers to those of Charles Coffin and his shoemakers. As it did, a question arose. Would GE remain that narrowly defined competition -stabilizing

[128] **Schenectady Daily Union 1 July 1895.**

Specifically Electric company that the financiers initially intended? Or would it become a more vaguely defined protean-possibility-exploring Generally Electric that the financiers more expansive name choice suggested?

As Specifically Electric, the Old GE prevented excess competition that would result in too rapidly falling prices. It did this through exploring the limits of the law. The exploration focused on two areas of the law, antitrust and patents. Some might describe that exploration in less benign terms. For example, it might be called breaking the law, or using the letter of the law to violate its spirit.

In contrast, as Generally Electric, the Old GE participated strongly in electrical innovation. It did so by assembling strong teams of various kinds of professional technologists and skilled workers at works, factories, and laboratories under the direction of a leaders with access to lots of money. The result was rarely invention and discovery by GE . It was rather innovation and improvement carried out with many other actors in a process that mixed competition and cooperation.

Which was more characteristic of the Old GE. Was it the innovating and improving Generally Electric? Or was it the limits-of-the -law exploring, competition suppressing Specifically Electric? That is the question this chapter addresses.This issue will be illustrated by two campaigns of innovation and improvement. In one, developing the Universal System of electricity GE played a supporting role. In the other, improving the light bulb, GE played a leading role. In both, success depended on electricity's superiority over all other energy transmission and distribution methods at exploiting energy's protean possibilities.

Consider first the search for a Universal System of electricity use. The 1880s had seen a stalemate between two ways of delivering electricity, direct current (DC) and alternating current (AC). The conceptually simpler, less costly, DC prevailed in densely populated cities. AC was more complicated and required additional equipment. It could, however, transmit electricity economically over much longer distances . This made it superior where customer locations were less densely packed.

By 1890, AC transmission distances were still increasing, widening its advantage. On the other hand, electric trolleys that ran on DC were dominating urban transportation. Stationary DC electric motors were finding increasing use in industries such as mining. The brand new field of

electrochemistry also demanded DC. Was there a system that enabled the use of both AC and DC? Was there, in other words, a Universal System?

The emergence of the Universal System would be a transatlantic mixture of competition and cooperation among a large roster of individuals, companies, colleges, universities, and countries. It was far from mainly a U.S. story, much less mainly a GE story. Developing the Universal System required a command of science and engineering much closer to the leading edge of knowledge than had the first generation DC and AC systems. That knowledge mainly resided in Europe. The most important contributor had been a Scottish physicist, James Clerk Maxwell. He had In the 1860s turned Michael Faraday's electromagnetic intuitions into a mathematical theory. By the 1880s that theory was widely being taught at European universities, but was only beginning to enter those of the U.S. So in this more theoretically based round of electrical innovation the U.S. started at a disadvantage compared to Europe. GE, in turn, started at a disadvantage compared to its remaining large U.S. competitor Westinghouse. In 1888, George Westinghouse had widened that advantage by buying a key patent from an independent inventor trained in European academia and industry.

That inventor was a Serbian immigrant named Nikola Tesla. He been earlier employed and brought to the U.S. by Edison. In 1886-87, having gone out on his own, he (and, simultaneously and independently an Italian physics professor, Giulio Ferraris) had invented the first potentially generally useful AC electric motor, the AC induction motor, and the system required to run it, the polyphase AC system.[129]

The AC induction motor eliminates the most problematic part of the DC motor, the commutator. That commutator reverses one magnetic field within the motor, enabling it to chase a second magnetic field in a circle, giving the motor its rotary motion. The commutator can wear out or get out of alignment, reducing motor reliability.

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[129] **Carlson, W. Bernard. 2013. Tesla. Princeton. Recognizing Teslas's major contributions, while providing an essential correction to accounts giving Tesla exclusive credit for the entire Universal System is Kline, Ronald. 1987. Science and Engineering Theory in the Development of th eIndustion Motor. Technology and Culture. 28. 283-313.**

In the AC induction motor, the magnet chasing is produced not by contacts opened and closed by that commutator, but by electromagnetic induction, that contactless phenomenon discovered by Michael Faraday. No physical contact or frequent making and breaking of an electical circuit is required. This leads to far greater reliability, making, for example the modern form of household refrigerator practical (not to mention the motor driving a 21st century electic automobile named after that Serbian-American inventor).

For electric power systems to use the AC induction motor, a wholly new system of circuitry, from generator to motor, was required, This new system, polyphase AC, sends electricity through not just one electrical AC circuit, but through two or three of them arranged side by side. The timing of the peaks and troughs of the AC wave carried by each circuit (the phase) leads or lags the other peaks and troughs by a small fraction of a second. These multiple phases play a role analogous to multiple cylinders in an automobile engine. They power rotary motion more evenly and with more torque than a single phase in an electric motor, or a single cylinder in a gasoline engine.

Polyphase AC would eventually, despite its added complexity, become universally useful. At first however, in 1888-1890, it was only potentially useful. Even with the consulting aid of Tesla, George Westinghouse and his engineering team initially failed to turn it into an innovation. In 1890, under financial pressure, Westinghouse temporarily suspended the effort.

By then the technologically superior European companies had raced into the lead. The German Company AEG and the Swiss Company Oerlikon built by 1890 the first really useful AC induction motors. All of a sudden, that AC induction motor, previously confined to low power and low torque, could compete with and often surpass DC motors.

Then, in 1891, those two European companies demonstrated the beginnings of a Universal System . At a time when most electricity transmission was less than five miles, Oerlikon and AEG used polyphase AC to electrify the electrical world. They generated electricity in three phases at a water power site on the Nekar River at Lauffen, Germany. They then transmitted it 111 miles to Frankfurt Germany. There, in an exhibition, it drove AC induction motors more powerful than any previously demonstrated.[130]

[130] **Hughes, Thomas. 1983. Networks of Power. Johns Hopkins, pp. 130-135.**

That got the attention of Thomson Houston Vice President of Engineering, Wilbur Rice, who visited that Frankfurt Exhibition. His company then hired a Swedish electrical engineer, Ernst Danielson, to bring to Thomson Houston the successful European advances in induction motors and polyphase. This help enabled the company to recommission a DC transmission line it was attempting unsuccessfully to build for the Hartford CT Electric Co. It became first Thomson Houston's, and then GE's, first development project using polyphase AC. Even with Danielson's help, however, GE lagged far behind Oerlikon and AEG.

The major initial U.S. contribution to the Universal System was not from GE or Westinghouse. Indeed, it did not involve technology leadership at all. It was leadership in finance, and possession of a unique natural resource. That resource was Niagara Falls. In 1890 it offered the world's most promising combination of massive concentrated water power and accessibility. Why not tap some 20 MW of the power of that falls, and send it 22 miles to the booming industrial city of Buffalo NY? A new company, the Cataract Construction Co. set out to do this. It attracted in 1890 an investment of $2 million from many of the top names in U.S. finance including J.P Morgan. The company's president, banker Edward Adams, secured expert advice that proposed an innovative way to tap that power. Bypass the falls with a water tunnel, put a central power station in the tunnel, and then transmit energy to customers.[131]

Suggested methods of energy transmission ranged from electricity to wire cables to hydraulics to compressed air. To choose among then Adams in 1890 staged a competition with monetary awards (first prize £2000, about $10,000). Fifteen plans were submitted, almost all from Europe. Notably missing from the competition was Edison General Electric. It was focused on electric lighting and transportation, was entering the application of DC motors to industry, and was just beginning research on AC. It was not ready for a project on such a large scale as Niagara. Thomson Houston and Westinghouse were ready. Both had developed both DC and AC systems, and both were achieving power transmission distances greater than five miles. Their absence from the competition was not because they lacked capability. George Westinghouse remarked that the Cataract Construction

[131] **Adams, Edward Dean. 1932. Niagara Power. Bartlett. 2 Vol. Belfield, Robert. 1976 The Niagara System. Proceedings of the IEEE. 64. 1344-1350**

Company was offering to pay $10,000 for information he estimated as worth $100,000. His contribution was, as mentioned earlier, to recommend not electricity at all, but compressed air.

None of the entries won that £2000 first prize. The competition did have, however, a positive result. One competitor, British electrical engineer George Forbes was appointed in 1892 as the Cataract Corporation's chief consultant. He championed polyphase AC as the energy transmission method. Official announcement of that choice by the Cataract Corporation on May 6, 1893 marked the beginning of the creation of the Universal System. [132]

It was logical for Cataract Construction to commission a European company , the world leaders in polyphase AC, to lead the project. Adams tried to do just that. First he invited electrical engineer Charles Eugene Launcelot Brown, the Swiss born son of a British engineer and a principal figure in the Lauffen-Frankfort demonstration, to come to Niagara and set up a new electrical manufacturing company. Brown chose instead to create his own company in Switzerland. In the 21st century it would merge with a major Swedish competitor. That company, now ASEA Brown Boveri, is still a world leader in electrical manufacturing. Adams next invited Oerlikon and AEG to submit bids for a polyphase system for Niagara. However, after adding in the cost of the 40% U.S. tariff and the 10% transportation cost, Adams decided that the European companies were too expensive.

Only then, in 1893, did Adams and Forbes turn to the American companies. For Westinghouse, the Lauffen- Frankfurt demonstration had been a signal to resume induction motor and Polyphase AC efforts. In 1892 it had developed a full two phase system, which it would display at Chicago's 1893 Columbian Exposition. So in 1893 it was able to meet, and even improve on, the Cataract Construction Company's requirements.

For General Electric it was a game of catch up. Dana Greene was brought from Schenectady to Lynn to lead the effort. Though Ernst Danielson had returned to Europe in 1893, a capable team, including engineers Henry Reist and Henry Parshall, physicist Louis Bell and calculator Charles Steinmetz, remained at Lynn to provide the advanced knowledge needed for the effort. In 1893 the GE team installed the first commercial polyphase system in the U.S. at Redlands CA. This was, however, proposed and led not by GE itself,

[132] **Adams Edward. 1927. Niagara Power, vol. 2. Privately printed. p.182**

but by the consulting engineer of the Redlands Light and Power Company, Almarin Decker. He had insisted on, specified, and provided the initial design for the polyphase AC system used at Redlands.[133]

Perhaps indicating the fast follower urgency of that General Electric effort was an 1893 incident. There was found in an office at the General Electric Lynn Works some copies of blueprints for equipment being built by Westinghouse. A Westinghouse spokesman claimed they had been stolen from a Pittsburgh drafting room. This led to an indictment, and a trial that ended in a hung jury.[134]

Whether or not it had been assisted by industrial espionage, General Electric did succeed in demonstrating a polyphase system in 1893 at that year's Chicago Exposition . It used the three phases pioneered by that European 1891 Lauffen-Frankfurt demonstration and by Almarin Decker , That three phase idea would ultimately prove superior to Tesla and Westinghouse's two phases.

In 1893 the Cataract Construction Company requested bids from both Westinghouse and GE for generators based on the Forbes design. The competition resulted, deservedly, in a win for Westinghouse. Though smaller and less wealthy than its major competitor, Westinghouse had bet its future in polyphase AC, and won the bet. Its generators would, in April, 1895, send, from Niagara Power House Number One the first polyphase AC electricity generated from Niagara Falls.

General Electric found that loss to a smaller competitor perhaps embarrassing, but not damaging. The Cataract Construction Company wanted to maintain two competing suppliers. So it quickly offered other contracts to General Electric. For example, General Electric got the contract to build the 22 mile long, 10,000 volt transmission line from Niagara Falls to Buffalo.

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[133] **Burgess, Ronald. 2007. Redlands Powers the World. Fortnightly Club of Redlands CA (on line)**

[134] **Kline, Ronald. 1992. Steinmetz. Johns Hopkins. Pp. 86-87. Schenectady Daily Union 10 May 1893**

In 1894, the General Electric polyphase AC effort moved from Lynn to Schenectady. At that time, a problem with the Universal System remained. Polyphase AC would indeed prove to be the best way to transmit electric power, and the induction motor would prove to be an excellent way to turn electrical energy into mechanical energy.There persisted, however, important places where DC power was needed. One was in electric railways. AC railway motors were possible, but would remain for some time inferior to DC. Another exclusively DC need involved chemistry.

It was this kind of chemical need that led to the "Electric Triumph" featured in that 1895 headline that began this chapter. The very first polyphase AC transmission of electric power from Niagara Falls went not over the 22 miles to Buffalo, but to the Pittsburgh Reduction Company, located less than a mile from the Falls. There electricity would be used to help turn aluminum oxide, a common mineral found in clay, into the then rare metal aluminum . Previously made at Pittsburgh with coal powered electricity, aluminum had been an expensive specialty metal. Now, made with inexpensive electricity from Niagara, aluminum would become an inexpensive commodity metal. Ultimately its uses would range from automobile parts to kitchen foil. The Pittsburgh Reduction Company would change its name to Alcoa.

In the early 20th century, more of Niagara's power would be used in such electrochemical applications than would be used at Buffalo. Those electrochemical applications required DC power. So did the main application at Buffalo, electric street railways. So to make a truly Universal System required DC. This in turn re uired a way of converting polyphase AC into DC. Fortunately, that conversion method already existed.

It began with an obvious and well known idea. One way to convert AC to DC was to use an AC induction motor to drive a DC generator. In 1887, an independent inventor named Charles Bradley was the first to take an only slightly less obvious step and combine motor and generator in a single machine. He asked his attorney to apply for a patent on the device. That attorney, Charles Curtis, was himself a significant inventor. He told Bradley that the device was insufficiently novel, non-obvious and useful to qualify as an invention. Fortunately for Bradley, Curtis' law partner was less fastidious.

He applied for got a patent for Bradley on this device, soon named the rotary converter[135].

This turned also to be fortunate for General Electric. For Bradley's first stretch as an independent inventor and manufacturer was a brief one. He and his patents were In 1890 acquired by Thomson Houston. Though he returned to independent invention, his patent became, with the 1892 merger, the property of General Electric. So when Benjamin Lamme, the leading electrical equipment designer at Westinghouse, developed improved versions of this seemingly obvious conversion method, he was in for an unpleasant surprise. He and his company learned that this important piece of the Universal System was protected by a rival company's patent.

So that choice of honored guests, presented at the beginning of this chapter, was appropriate. Lewis Stillwell was the head of the Niagara Falls project of Westinghouse, the company that was both the U.S. pioneer of polyphase AC and builder of those first Niagara generators. Elihu Thomson had much earlier led the initial entry of Thomson Houston into AC and came close to anticipating the invention of the induction motor. Dana Greene led Edison General Electric's belated entry into AC, and then General Electric's rise to polyphase AC parity. Finally, the contributions of Charles Proteus Steinmetz were so varied and significant as to deserve a more detailed description.

Steinmetz indeed suggested design improvements to the transformers and rotary converter used in the Pittsburgh Reduction Company project. His contribution to the GE polyphase AC efforts, however, went much deeper. His ascent through the U.S.engineering profession had begun in 1890 By careful observation and simple mathematics, he had solved a puzzle about unexpected energy losses in electric motors and generators.

The explanation was labeled "Steinmetz's law of hysteresis". The word hysteresis , Greek for memory, indicated that in electric motors, a transitory applied magnetic field left a persisting magnetic effect, a sort of magnetic memory. Steinmetz 's discovery was not actually a law of science. It was an experimentally determined empirical correlation. By any name, however, it was both extremely helpful to designers of electric motors, and suggestive to later physicists who did develop theories of magnetic effects.

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[135] **Recollections of Charles S. Bradley. Hammond File L 2939. MiSci.**

Then, in 1891, while still with his first U.S. employer, Rudolf Eickmeyer, a fortunate circumstance enabled Steinmetz to shift his focus from experiment to theory. Eickmeyer's company, with its innovative electric motors, had become a bidding target among the three electrical manufacturing leaders, Edison General Electric, Thomson Houston,and Westinghouse. (At this time, Steinmetz preferred Westinghouse). While the bidding went on, the Eickmeyer company's business slowed down.As Steinmetz wrote to a German friend in 1893:

> While negotiations were in progress the Eickemeyer Co. performed no experiments. The regular business was done by the other electrical engineers so I had nothing to do and carried on scientific investigations or wrote mathematical treatises.[136]

He chose to combine science and mathematics and explore ways to simplify the application of Maxwell's laws of electromagnetism. This would prove to be the most important display of his electrical genius. Of what did that electrical genius actually consist ? An engineering (and socialist) colleague, Vladimir Karpetoff of Cornell, put it best: Steinmetz generated electricity from the square root of minus one.

That is, while a student of mathematics at Breslau, Steinmetz had learned about a concept called imaginary numbers, of which that square root of minus one is the canonical example. Meanwhile, other European geniuses, such as Britain's James Clerk Maxwell and Oliver Heaviside, were developing a mathematical version of the laws of electromagnetism. Unfortunately, to even understand their original versions, you had to be a genius yourself.

Steinmetz, at the beginning of the 1890s, became a leader among a small group of engineers who recognized that the concept of imaginary numbers enabled the translation of those previously genius-level laws into a sort of algebra that an ordinary engineer could not only understand but also apply. Steinmetz did not invent this idea of an imaginary number based algebra of electromagnetic theory. It was his hearing the use of the idea in an 1892 lecture by an American electrical engineer, Arthur Keneally, that prompted

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[136] **Steinmetz to Hinz. 25 Oct 1893. In Turner, Justin G. 1963. Steinmetz. Manuscripts (an archivists' journal). Fall 1963.**

Steinmetz to explore this idea. His intensive study during that free time at the Eickmeyer company enabled Steinmetz to make a comprehensive follow up. He presented that comprehensive version in his own 1893 lecture to the American Institute of Electrical Engineers. That presentation became the first generally useful and influential expression of electromagnetic theory as imaginary number algebra. It was the peak achievement of Steinmetz's life.[137]

Using that algebra, he introduced systematic methods for the design of induction motors, transformers, generators and other electrical equipment. Ascending far above his initial title as calculator, by 1900 he would earn the formal title of Chief Consulting Engineer of General Elecfric, and the nickname "the Supreme Court."

As such he participated in the competition with Westinghouse. Competition was, however, only part of the story, and perhaps the smaller part. While the company teams competed the individual technologists collaborated. They formed technical societies, set standards, and expanded engineering education. Steinmetz, for example, while keeping his GE job, joined the faculty at Schenectady's Union College and created its Electrical Engineering program. In 1923 Union supplied 20 entrants to the Schenectady Works Test Program, more than any other college or university.[138]

As Steinmetz participated in these efforts, he and his Westinghouse counterpart Benjamin Garver Lamme were much more than merely competitors. They worked together on setting those electrical standards, mentoring young engineers, organizing a professional society for electrical experts, the American Institute of Electrical Engineers (AIEE, now IEEE). They even shared lists of their favorite science fiction books and exchanged thoughts on world politics.

Steinmetz, though deserving the attention he drew, was far from the whole story of General Electric's contribution to the universal system. Other more practical engineers, such as GE's Sidney Paine, sold this new way of using

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[137] **Kline, Ronald. 1992. Steinmetz. Johns Hopkins. Pp. 159-173**

[138] **Works News 19 Jan 1923 p. 7**

energy to old industries. An example was one of America's oldest industries, cotton spinning. [139]

The movement in the late 19th century of that industry from New England to the South had not been driven by energy considerations. The driver was lower labor costs by the exploitation of poor whites and child labor. Energy could be supplied sufficiently cheaply by direct application of water power.

So it was an impressive feat of salesmanship in 1892 for Paine to sell the new and costly idea of polyphase AC to the owner and the technical consultant of a new cotton mill at Columbia SC. He was aided by topography. The best location for the new cotton mill was atop a hill. This ruled out direct water power from the nearby Columbia River. Electric power could most cheaply be provided by DC. Two competitors had offered this solution at half the price of Paine's polyphase AC proposal. Paine countered by explaining that GE had tried DC at a cotton mill in Connecticut. The DC motors could not provide the constant rotation speed needed by cotton mill spindles. An AC induction motor, by contrast, had an inherently constant rotation speed.

This argument won him the order. It came at a bad time, as GE's 1892-1893 financial troubles were beginning to surface. Indeed, the GE Executive Committee intially declared, in August, 1892, that "the proposed contract with the Columbia Mills Company was discussed" and "this committee witholds its appproval for this contract." Fortunately for GE, when recovery began a year later the opportunity was still open.[140]

The subsequent success of that GE powered Columbia Mills plant became the model for a slow but steady increase of the use of polyphase AC to drive Southern cotton mills. That increase did not happen overnight. The many further innovations and improvements needed to adapt the induction motor to the needs of cotton spinning and many other industries have been detailed by historian Ulrich Wengeroth. "Before electrification could succeed,"he

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[139] **Paine, Sidney B. 1895. Electrical Driving of Textile Establishments. Boston MA. Paine, Sidney B. 1900. Development of the Electric Drive. GE Publication 9080. 2 Ju;y 1900. Havens, F.S. The Columbia Mills. Hammond File L 571.**

[140] **GE Corporate Administrative Collection Box 1. Series 1. Minutes Executive Committee 16 Aug 1892. MiSci.**

wrote, “what was really needed was that the new motors accommodate the way industrial production was organized.” This required significant improvements in such technologies as gears and speed control.[141]

That effort took decades. By 1920, however, the versatle, reliable polyphase AC induction motor, in ratings from 10 to 7200 horsepower, was doing everything, said a GE publicist,"from running an ice cream freezer to turning the propellor shaft of a battleship. "[142]

At Schenectady by 1920, some 2500 GE employees, 508 of them women, were annually producing 25,000 induction Motors. The rapidity of this induction motor and polyphase conversion should not be exaggerated. In 1900, only 5% of U.S. industry's mechanical power was delivered by electricity, the rest coming directly from water power or steam engines. Most of that electricity was still DC. It would not be until the 1920s that more than half of U.S. industry's mechanical power was delivered electrically, by then mainly via polyphase AC. [143]

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[141] **Wengeroth, Ulrich. 1993. How they Won the Market. Electric Motors in Competition With Steam Engines, 1890 - 1925. In IEEE History Center, ed. 1993. Technolgical Competitiveness. Contemporary and Historical Perspectives on Electrical, Electroic and Computer Industries. IEEE Press**

[142] **For a more general treatment of the entry of electricity into manufacturing, see. Devine, Warren D. 1982. From Shafts to Wires. Journal of Economic History. 43. 347-372 andd DuBoff, Richard. 1967. The Introduction of Electric Power in American Manufacturing. Edonomic History Review.20. 509-518.**

[143] **GE Reporter. 1917. 1. 5. Works News. #1 . Jan 1920 p.12**

Still, it was in the 1890s that the vision emerged. It provided a new way to jump start General Electric's stagnant sales and profits. The writer of the company's 1896 Annual Report had gloomily pointed out the devastating effect of the recent depression, and of more recent Westinghouse competition, on sales and profits of established products. Turning to the future, however, he waxed Whitmanesque. He heard America singing the music of polyphase, via "the operation of milk tramways, cranes, elevator pump hoists, coal cutters, drills, picks, blowers, air compressors, draw bridges, printing presses, powder mills, the operation of turrets and the training of guns, and machines of all sizes, large and small."

Even, however , with polyphase AC, big hydroelectric generators, transmission at tens of thousands of volts over tens of miles , the AC induction motor, the rotary converter, and installations ranging from Southern cotton mills to Western waterfalls, the Universal System was not quite complete. Water power was electrifying the far west, and the Niagara region of Western New York. Most places east of the Mississippi, however. were not within convenient transmission distance of Niagara or a comparable water power. What was needed was a sort of Land Niagara-- a means of using coal at any location to produce electricity that would approach the cost reduction offered by Niagara. The conventional method for driving electrical generators, the steam engine, could not do this. It was too low in capacity and efficiency.

Pressure for this next key piece of the Universal System came not from inventors but from customers. They will be exemplified here by a man who was last seen in 1892, leaving Schenectady and the new General Electric Company to take a significant pay cut to become President of the Chicago Edison Company, then just one of many small and unprofitable electric companies in the Chicago vicinity. This was Samuel Insull. In the 1890s he began his shaping of the U.S. electric utility industry. He applied to Chicago Edison a profit-increasing technique he had used successfully at the Edison Machine Works. This was exploiting economies of scale. More powerful electricity generators might produce energy for fewer cents per kilowatt hour than smaller generators. Those big machines could be concentrated in a few big power stations instead of being dispersed among many small ones. So construction costs could also be cut. The older small power stations could be converted to substations to distribute power locally. Those substations could hold rotary converters to serve applications needing DC. To make it work, however, a piece was still missing: that Land Niagara.

It came, as polyphase AC had, from Europe. As a frequent visitor there, Insull was aware by the late 1890s that Europeans had invented a promising step in that Land Niagara direction. It was called the steam turbine. It was conceptually simple. A series of metal pinwheels spun around inside a metal cylinder. The pinwheels were driven round and round by a blast of steam. The steam entered fast, hot and at high pressure at one end. It left slow, cool and at low pressure at the other.

That idea had been around for centuries. Hundreds of attempts had failed to produce a practical machine. Only with the 19th century advances in thermodynamics and stronger metals did the idea become an invention. By 1880 two inventors had solved the steam turbine problem independently and nearly simultaneously, though in different ways . Gustaf de Laval of Sweden had invented a very high speed small steam turbine initially used for driving cream separators. Charles Parsons of Great Britain, the younger son of a duke and a trained engineer, developed a slower speed bigger steam turbine initially for ship propulsion. Both inventors were, by the 1890s, applying their inventions to electric power generation.

By the 1890s it was becoming clear that 5 MW, the power of the largest steam engine then in use, was about as powerful as a steam engine was ever going to get. Those reciprocating dinosaurs were too bulky and slow for future use in the power stations of the Universal System. Recognizing this, U.S. electrical manufacturers went to Europe to explore patent rights on the turbine inventions of Parsons and de Laval. General Electric was, in 1897, offered a license on the Parsons turbine. Vice President of Manufacturing and Engineering Wilbur Rice called on Steinmetz for advice.

Steinmetz replied that General Electric would indeed need to build steam turbines if it hoped to be a leader in electrical manufacturing. The Parsons turbine, however, was the not the one to build. It required too many parts and too tight tolerances. General Electric should seek a better approach.Rice did turn down the Parsons license, which was taken up by Westinghouse. At Schenectady a team under John Kreusi designed and built its own small experimental steam turbine. A witness to the first startup recalled it emitting a horrible squeal, then shutting down for good. It was then carried off to a remote part of the Works and unceremoniously buried.

At this point, in 1897, an independent inventor came to General Electric. He brought his own turbine idea, and a proposal for a joint venture. The

inventor was Charles Curtis. He was encountered earlier as the patent attorney who turned down Charles Bradley's proposed rotary converter patent. Like Bradley's rotary converter (and, indeed, like most technology advances) the Curtis Turbine was a combination of previous ideas. In this case those were the inventions of De Laval and Parsons. That Curtis' design became covered by a strong U.S. Patent may have owed as much to the legal skills of Curtis the patent attorney as to the originality of Curtis the inventor.

Rice recommended purchase of both the rights to use the Curtis turbine patents, and the services of Curtis as a consultant at Schenectady. Royalty fees would be determined later should the project succeed. [144]

In 1897- 1898, Schenectady's first experimental Curtis turbines were built under Curtis' supervision. They failed to show superiority over steam engines . There was some question about continuing the development effort. Before giving up, Rice asked for one more opinion. This was from engineer William Le Roy Emmet. He was fresh off successfully contributing to the Niagara effort. There he had become familiar with the powerful hydro turbines driving the 5 MW generators. This familiarity would play a significant part in the steam turbine story.

Emmet's favorable arguments helped save the project. There was, however, another reason to continue. Westinghouse had not only licensed that more complex Parsons turbine, but was claiming to be succeeding with it, even to the point of taking orders. (Actually, Westinghouse was encountering difficulties similar in seriousness, though different in kind, to General Electric's). Emmet was chosen to lead a redoubled GE development effort. [145]

William Le Roy Emmet's path from the Naval Academy to engineering leadership was more rocky than those of his fellow Annapolis graduates

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[144]**The above account of GE steam turbine origins relies on E.W. Rice Papers, Box 5. Development of the Curtis Steam Turbine. MiSci. Other sources for the turbine story that follows include Hammond File HF 725. Recollections of W.L.R. Emmet, L 272 Recollectons - O. Junggren L 773 Recollections Henry Geisenhoner, L 775 and Recollections of Billy Madigan. All at MiSci.**

[145] **Emmet, W.L.R. 1903. The Curtis Steam Turbine. Proc. Amer. Philosophical Society. 42. 68-84**

Frank Sprague and Dana Greene. They had used top of the class academic performance to earn special assignments as naval electrical experts. This eased their transition to electric railway entrepreurship. Emmet finished near the bottom of his class. After a round the world cruise, he had been honorably discarged from the Navy in a year of budget austerity. He descended to the role of a common laborer. It was, he said, a dismal fate for a man who had recently commanded deck watches on a man of war. Emmet also, however, studied up on electricity, and got a job with Sprague.Within a decade, he was respected enough to be offered the job of chief engineer of the Niagara Power Plant. Turning it down, he took up design responsibilities at Schenectady.[146]

As an engineer and manager of engineers, he was an iconoclast and individualist, blending contradictory qualities. He could be irascible, but also inspire teamwork and loyalty. He could be well organized, but also be absent minded enough, or at least so he claimed in his memoirs, to be seen on the first tee of Schenectady's Mohawk Golf Course without his trousers.

Under his leadership, General Electric's first successful experimental turbine was built. By 1899, a 500 kW Curtis Turbine was running in the Schenectady Works power house. A 1500 kW turbine would be delivered to the Port Huron Michigan Electric Co in 1901. This was fast progress. Soon, however, it was judged not fast enough.The judge was Samuel Insull. He was pursuing his scale up plans. He saw the steam turbine as essential, and his industry leadership as being challenged by the Hartford Electric Company. Hartford Electric was already beginning installation of a 1.5 MW Westinghouse Parsons turbine. Insull came directly to Charles,Coffin, seeking to leapfrog his Hartford rival. Coffin offered a 2 MW Curtis turbine. No, Insull replied, he wanted a 5 MW turbine.After consulting Rice and Steinmetz, Coffin agreed. A measure of the high level level of risk involved can be seen both in architecture and in an unusual clause in the contract. Insull's Fisk St. Power House was built tall enough to hold the much bigger 5 MW steam engines, if their use as replacements for failed turbines became necessary. The two companies also agreed in advance to share the high costs that might result from the not unlikely event that the GE turbine proved

[146] **Emmet, W.L.R. 1930. Autobiography of an Engineer. Ft. Orange**

a failure.This contrasted to the usual way of waiting until after failure to point fingers and perhaps initiate legal action.[147]

The effort did not fail. Two aspects of the success will be emphasized here because they illustrate general features of fast follower engineering . They are the mobilization of manufacturing skills, and what will be called here the conquest of dislocations of scale. A steam turbine generator has been described as a 200 ton watch. The manufacturing challenge combines gargantuan size with thousandth of an inch precision. Choice of the Curtis turbine over the Parsons turbine, resulted in fewer parts and less demanding tolerances. It made manufacturing less difficult but far from easy. An advantage of a big company is the capability to put together quickly skills addressing both the large scale and the high precision. The company can quickly reassign workers already on hand.

To lead that manufacturing effort, Schenectady Works Manager Emmons picked Billy Madigan. As chief foreman of newest “big shop” of the Works, Building 60, he already managed 1500 men. He he had also already presided over the machining of some of the most demanding parts for that Chicago turbine when he was called on to be foreman of the entire turbine effort . Madigan was not colorful like Steinmetz, or eccentric like Emmet. “ A pleasant -spoken quick moving master mechanic," is the way the GE Works News reporter described him. "He is all over the floor space, and as it covers about 11 acres of floor space one has to hunt for him."[148]

Under Madigan the lagging manufacturing program leading to that first 5 MW turbine was brought onto schedule. As it did, another feature of innovation emerged. Here it is called dislocation of scale.It refers to a new problem that often emerges when a so far successful innovation is scaled up in size or power. For example, when a steam turbine was increased in power output by a factor of three, new and unanticipated problems of balance, vibration, or control emerged. In scaling up GE’s steam turbine from the previous 1.5 MW size to 5 MW, the dislocation of scale was in balancing. Steam turbines contain a series of disks spinning on a horizontal axis. Trying to raise the power output meant lengthening that axis. That

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[147] **Jesse R. Lovejoy Reminiscences, ca. 1925 Hammond File L3440 MiSci**

[148] **Works News 4 July 1924 p. 12-13**.

tended to put the turbine out of balance. The resulting friction could unacceptably reduce efficiency.

Here Emmet drew on his experience at Niagara. The 5 MW hydro turbine generators there had a vertical axis. This made balancing easier. Why not try this with a steam.turbine? Why not tip it on its end and spin it like a top?[149i]

Emmet first tried this out on a 500 kW vertical turbine built for and shipped to a utility customer at Newport RI. It worked fine in the Schenectady shop. When reassembled and turned on at Newport however, there soon arose loud discordant noises, indicating unacceptable vibration.

Fortunately, Emmet had accompanied the turbine to Newport. In a day of intense effort, he was able to devise and install a fix. He brought the fix back to Schenectady, and applied it to the 5 MW Chicago turbine. Without that Newport prototype, test, warning, and quick fix, this dislocation of scale might have caused unacceptable delays in the Chicago project. Instead, in March 1903, the first 5 MW General Electric Curtis turbine was delivered on time to Insull's Fisk St. Chicago power station , and started up on schedule.[150]

As usually told, the story ends on that triumphant note. Actually, more dislocations of scale followed. The turbine ran erratically, and failed to meet its efficiency guarantees.With some demanding customers this could have caused trouble. Insull, however, was undisturbed. He had confidence that the Works he once ran would fix the problems. The turbine had already promised to generate future construction savings by requiring only a small power house due to the machine's compact size.

Emmet left his assistant, Oscar Junggren, to solve the initial difficulties. "When the turbine ran the General Electric stock price went up", Junggren said . "When it did not run, the price went down". The first turbine did eventually run smoothly. It never did meet that efficiency guarantee. In later GE turbine installations at Fisk Street, however, that efficiency guarantee was not only met but significantly exceeded. Junggren would later succeed

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[149] **Glenn B. Warren. Speech to 1954 Meeting of Managers of Installation and Field Service. Turbine Dept. 24 Oct 1954. Glenn Warren Papers.**

[150] **GE Large Steam Turbine Department. 1976. A Legacy of Leadership.**

Emmet as General Electric's chief turbine engineer. Under his leadership, in 1910, much more efficient 10 MW General Electric Curtis turbines, using a horizontal axis again to solve further dislocations of scale, replaced those 5 MW vertical pioneers. The first 5 MW model was brought back to Schenectady Works and became outdoor statuary. Labeled "a monument to courage ", it can still be seen there today.[151]

GE would sell more than 1200 Curtis turbines by 1912. By 1920, when the steam turbine generator had become the dominant way of supplying electricity in the U.S, GE had supplied 70% of those turbine generators. The business at that time had a profit rate of 18% of sales, about three times as great as the average for the company as a whole [152]

Building turbines soon became the most important business of General Electric's Schenectady Works. It also confirmed an already established GE pattern of innovation. Generally, for GE innovations, the inventors were independent outsiders, as De Laval and Parsons were. Often those inventors, such as Curtis, brought their ideas to GE, and served as consultants. A knowledgeable customer with a powerful vision, such as Insull, was often the human engine behind the effort. So even though a corporation's name may be on the final product, that corporation should be modest about its role. It was just one player in an improvisational innovation repertory company.

That said, a giant corporation and its giant Works did bring special assets. Exposure to earlier large projects sparked applicable ideas. This was the case for Emmet's vertical turbine idea, sparked to the hydro turbines he saw at Niagara. GE also became resilient regarding dislocations of scale. By participating all the way through to installation at a customer's site, such as Emmett did at Newport and Junggren at Chicago, project leaders could both troubleshoot the problems , and bring back ideas for solution. Finally, giant Works could rapidly assemble a diverse collection of workers with varied essential skills .

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[151] **Junggren, Oscar. Recollections. Ca. 1925. Hammond File L 772. MiSci.ASME. 1975, The 5000 KW Vertical Curtis Steam Turbine- Generator. Printed in occasion of its dedication as a National Historic Mechanical Engineering Landmark.**

[152] **E.S. Gilbert to G. Swope, 29 April 1925. Swope Papers MiSci.**

GE also had some less fair advantages. The Edison-descended early 20th century U.S. utility companies were already predisposed to buy from GE. Other utilities were under the financial sway of Electric Bond and Share, the GE subsidiary that bought utility stocks, packaged them and sold them as less risky bonds. This influenced those companies' turbine purchases. Said a Junggren successor as chief GE steam turbine engineer, Glenn Warren, "I think we established preeminence [in steam turbines] because the Edison Companies were affiliated with Edison General Electric originally, and also we had financial arrangements with Electric Bond and Share."[153]

The steam turbine completed the Universal System as it developd circa 1900. The major addition in the 20th century would be electronics. That would make the rotary converter obsolete, would make electric motors more flexible , blur the distinction between AC and DC, and ultimately revive DC transmission. Otherwise, the main elements of the early 20th century universal system-- generation by hydropower and "land Niagara" scale steam turbines, transmission and distribution by polyphase AC, the dominance of the polyphase induction motor, and persistence of DC in uses ranging from recharging batteries to electrochemistry -- survived into the 21st century.

In becoming a producer of virtually every element of the Universal System, GE also reshaped itself and its policies. For example, in producing complete Universal Systems, GE and Westinghouse were at an impasse over patents. It was Westinghouse's Tesla Patents on AC induction motors versus General Electric's Bradley Patents on rotary converters.In 1896, after four years of patent warfare, the two companies made peace. They did so by an earlier mentioned method, the patent pool. The two agreed to mutual use of some 300 patents. A compensation clause in the agreement specified that unbalanced benefits for one company required a compensation payment to the other . Balanced benefits were considered to be roughly two thirds of annual sales for the twice-as-big General Electric, one third for the smaller Westinghouse.

One motivation of this agreement was to enable both companies to produce full versions of the Universal System. Another use was less benign. The two companies created a Board of Patent Control to enforce their pooled patents

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[153] **Warren, Glenn B. Speech to 1954 Meeting of Managers of Installation and Field Service. Turbine Dept. Schenectady. 24 Oct 1924. Glenn Warren Papers. MiSci**

against other competitors. For example, when the Walker Electrical Manufacturing Company competed for powering the New York City Elevated Railroads it was sued for patent infringement by the Patent Control Board . Though Walker won a contract for the Brooklyn Elevated, it soon, under that legal pressure, gave up its independence and merged with Westinghouse.[154]

Similarly, a new company formed by AC pioneer William Stanley proved competitive for power transmission projects by offering higher voltages than either of the Patent Board companies. They responded with patent infringement suits that drove Stanley to merge with General Electric. In 1903 Stanley described how the "industrial trusts" regularly employ "bureaus known as boards of patent control to operate "an offensive patent campaign" against a smaller competitor to "annul his usefulness, discourage his endeavors, disgust him with surrounding conditions, and finally drive him into line." Other victims driven into line by the GE Westinghouse Board of Patent Control included electric lighting inventor Peter Cooper Hewitt and street railway controller inventor Stephen Van Choate[155].

Assessing the effects of this GE and Westinghouse market power in a 2023 book, economist Mordecai Kurz has described such efforts as " full monopoly power of GE and Westinghouse over the market for electrical supplies and eqipment". He asserts that the GE-Westinghouse monopoly not only earned profits far above those of a competitive economy, but in the process delayed the electrification of the U.S. He estimates that because of that monopoly control, getting electricity of 75% of US homes, a task that took the 30 years, from 1899 to 1929, could, in the absence of monopoly, have been done in only 19 years. He reaches this conclusion using a mathematical model difficult for the mathematically uninitiated to assess, (For more about this important book, see Appendix 2).

Kurz's conclusions contrast with those of other energy experts, economic historians and historians of technology. They generally view the 30 year electrification of the U.S. as typical or even rapid for a society-wide change.

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[154] **Schenectady Evening Star 26 Jan and 10 Feb 1898 1898. Schenectady Daily Union 19 and 28 Sept 1898**

[155] **William Stanley. The Inventor and the Trust. Electrical World and Engineer. 28 May 1903 p. 514. Bright, Arthur Aaron. 1949. The Electric-Lamp Industry. MacMillan. Pp. 221-225**

Furthermore, it was paced not mainly by equipment costs, but also by by a complex of economic and political issues. For example, economist Arthur G. Woolf concluded by describing the electrificatnion of the U.S. as “rapid”, and paced by such economic variables as “high income levels and industrialization”, rather than by the price of electrical equipment. Further evaluation of Kurz’s new and revisionist conclusion awaits scholarly reviews by his economically and mathematically literate peers.[156]

The aggressive use of pooled patents by that General Electric and Westinghouse virtual monopoly was attacked on anti trust grounds. They would discontinue the Board of Patent Control in 1911. Before they did, a curious and still mysterious episode suggests GE and Westinghouse may have considered an even closer partnership, perhaps even a merger.The minutes of the GE Board of Directors note that on 1 Mar 1900 “in response to a letter from Mr. George Westinghouse” the GE Board approved “a conference between individuals, members of the Boards of Directors of the two companies to consider “the general business relations of the two companies.” Unfortunately, neither the Westinghouse letter, nor a previous one written in the preceding November, are includend in the minutes. Negotiations, in which GE President Coffin also participated,continued through June, 1900. At that point the GE negotiating committee made its final report to the Board, reporting that no agreement had been reached regarding Westinghouse’s proposal. No further actions on the subject were recorded. In the absence of the Westinghouse letters or a GE summary of their contents, the subject of these high level negotiations remains a mysterious episode of the Universal Systems story.[157]

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[156] **Kurz, Mordecai. 2023. The Market Power of Technology. Columbia U. pp. 246-256. For previous views, see Hughes, Thomas. 1983. Networks of Power. Johns Hopkins, Woolf, Arthur. 1987. The Residential Adoption of Electricity in Early Twentieth Century America. Energy Journal. 8. 19-30, and Smill Vaclav. 2003. Energy at the Crossroads. MIT. Pp. 32 38.**

[157] **Minutes 82nd GE Board of Directors Meeting. 1 Mar 1900-9 June 1900. GE Corporate Administrative Collection. Box 1. Series 1. MiSci.**

To sum up that Universal System story, it was an international, multi-institutional, multi-disciplinary combination of competition and cooperation. GE can be proud of its contribution. It should also, however, be modest. In the billing its name should appear below, such names as Maxwell, Tesla, Westinghouse, the Cataract Construction Company, Bradley, De Laval, Parsons, and Insull. That GE role included the major positive contributions of such leaders as Steinmetz, Emmett, Madigan, and Junggren. It also, however, included less admirable exploration of limits and loopholes of the antitrust and patents laws. These included the unfair marketing advantage of Electric Bond and Share, and the anti-competitive aggressions of the GE-Westinghouse Board of Patent Control.

Turn now to another example , improving the light bulb. Here GE deserves a higher billing. It played the starring role in changing electric lighting from a luxury to a necessity.

At the end of the 19th century, only about 1% of U.S. homes were wired for electricity. A light bulb was a luxury-- and, for General Electric, by far its most profitable product. Unlike most other GE products, it was small, standardized, and produced on a low-tech assembly line by cheap labor. The labor cost per dollar of light bulb sales ca. 1900 was not GE's typical 40¢ per dollar of sales , but only 10¢. The 30¢ difference went mainly to profits, which reached as high 40 cents per dollar of sales. For other electrical products, the profit per sales dollar was typically a dime or less. [158]

Light bulb makers had In the 1890s standardized production around some 35 processes. Only a few, such as glass blowing to make the bulbs, required skilled craftsmen. Simple machines amplified the labor of operatives. Some 80-90% of those operatives were women. They were typically immigrants under the age of 25. To earn her dollar a day, each one typically repeated a simple but physically wearing operation hundreds or even thousands of

[158] **The light bulb story that follows draws heavily on Bright, Arthur Aaron. 1949. The Electric-Lamp Industry. MacMillan, an excellent industry history. Also highly useful are the works of Leonard Reich, including Reich, Leonard. 1985, The Making of American Industrial Research. Cambridge, and 1992. Lighting the Path to Profit. Business History Review. 66. 305-344/The author of this book here also gratefully acknowledges the historical assistance and encouragement Leonard Reich personally provided nearly half a century ago.**

times each ten hour workday. Workplace hazards ranged from eyestrain to electric shocks to noxious vapors[159].

GE's initial high profits proved precarious. Making light bulbs initially offered few economies of scale. Small rivals could jump in, undercut a giant company's price and profit margin, and still make money. If this free entry were to be carried far enough, nobody would end up making much money. The financier-founders of GE had initially thought they had this danger covered. In 1891, just as the merger was being negotiated, a legal decision confirmed the validity of Edison's most important light bulb patent. This appeared to suppress those pesky competitors for 17 more years. A legal technicality, however, knocked out that patent in just four years. GE's light bulb market share, after briefly rising above 80%, fell to about 40% by 1900. Much of the remaining 60% was produced in small factories across Western Pennsylvania and Northern Ohio.

GE's response initially took two forms. One was creating the economies of scale that are a giant's main competitive advantage. At GE's own light bulb factory in Harrison NJ, engineers such as John Howell and William Burrows developed lamp making machinery more complicated and expensive than any then in use, but offering more than compensating cost-cutting. In addition, GE encouraged Corning Glass to develop automatic bulb making machinery, with GE getting advantageous access due to its size. Meanwhile, GE spent about a million dollars (in those days big money) between 1895 and 1905 buying up light bulb related patents, mainly in Europe. Enforcing its purchased patents, it formed an organization called the Incandescent Lamp Makers Association. By 1901 Westinghouse and 14 other lamp makers had joined, lamp prices had stabilized, and 90% of light bulb sales were done by association members.[160]

All, however, was not yet secure. The high reward for patents encouraged independent inventors to redouble their efforts. Some ca. 1895 inventions even threatened to make the incandescent lamp obsolete. For example, a

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[159] **A detailed description of the difficult working conditions in light bulb factories, drawn from government reports, is Montgomery, David. 1987. Fall of the House of Labor. Cambridge.Pp. 112-114**

[160] **Bright, Arthur Aaron. 1949. The Electric-Lamp Industry. MacMillan, pp. 104, 144**

ceramic lamp that did not need to be enclosed in a vaccum was invented by a prominent German chemist and later Nobel laureate, Walther Nernst. Two Americans, D. McFarland Moore and Peter Cooper Hewitt, invented precursors of the fluorescent lamp.

Meanwhile two salesmen with experience in the electrical industries had their own idea for reviving light bulb competition. Franklin Terry and Burton Tremaine in 1900 proposed combining the flexibility and fast response of those small lamp factories scattered from Pittsburgh to Chicago with the machinery-developing and inventive clout of a central jointly owned laboratory. Their National Electric Lamp Association would be a federation of those small companies, supported by centralized engineering and research facilities. This required capital. Terry and Tremaine got that capital from a surprising source. In 1900 they invited GE to become the leading stockholder in that National Electric Light Association (NELA). Charles Coffin agreed. Secretly, GE bought up 75% of NELA's stock.

This secret combination in restraint of trade violated Section 1 of the 1890 Sherman Anti Trust Act, which read:

> Every contract, combination in the form of trust or otherwise, or conspiracy, in restraint of trade or commerce among the several States, or with foreign nations, is hereby declared to be illegal.[161]

An ongoing dispute over that Sherman Law's application to manufacturing delayed prosecution of this clear violation. Did GE's president Coffin think the combination was legal? The Department of Justice was later to answer that question with another question. If GE thought the deal was legal, why keep it secret?

For the next decade GE and National pretended to compete, each getting about 40% of the total lamp business. This enabled prices to fall more slowly, and profits to stay higher, than would have been the case if the two companies had been actually competing. The federal government would ignore this arrangement for a decade. In 1911, however, President William Howard Taft included GE among the trusts against whom anti trust prosecutions were launched.The main targets of this campaign were two companies that directly impacted the ordinary consumer, American Tobacco

[161] **Sherman Antitrust Act of 1890. 26 Stat. 209, 15 U.S.C. §§ 1–7**

and Standard Oil. They were strongly prosecuted and broken up. For most of the other targets of Taft's campaign, including American Thread, Burroughs, and Otis Elevator, the government settled for consent decrees.

GE, at a time when light bulbs illuminated less than 10% of U.S. households, fell into that less urgent group of antitrust targets. Though the light bulb cartel clearly violated the Sherman Law, it got lower priority prosecution and the more lenient treatment. The GE-National cartel was dissolved by a 1911 consent decree. Far from reducing General Electric control of that industry, that decree allowed GE to buy the rest of NELA and tighten its dominance of the light bulb business. [162]

GE had by 1911 added another tactic for limiting light bulb competition . In its 1901 Annual Report, the company made public its creation of a research laboratory at its Schenectady Works. Engineering Vice President Wilbur Rice It described the lab's purpose this way:

> Although our engineers have always been liberally supplied with every facility for the development of new and original designs and improvement of existing standards, it has been deemed wise during the past year to establish a laboratory to be devoted exclusively to original research. It is hoped by this means that many profitable fields may be discovered. [163]

This was a bit misleading. The actual main purpose was not "original research" but protective patents. The idea of a scientific laboratory had been proposed by Steinmetz. He was no doubt familiar with industrial research laboratories in the chemical industry of his native Germany. He described his proposed General Electric Lab as an "electrochemical laboratory". The purpose of that electrochemistry was creating better light bulb filaments. Europeans, some using electrochemistry, were by 1900 making metal filaments that could far outperform and outlast the GE carbon filament.

The new GE Laboratory's first manager was Willis Whitney. After graduating from MIT, he had gone to Germany to earn a Ph.D. in chemistry

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[162] **Langlois, Richard. 2023. The Corporation and the 20th Century. Princeton. P. 83**

[163] **Report of Vice President of Engineering and Manufacturing E.W. Rice, jr., GE Annual Report, 1901.**

at the University of Leipzig. He returned to MIT to teach chemistry, as well as to carry out industrial consulting with that activity's pioneer, Arthur D. Little. At GE, he proved both an efficient manager and an inspiring mentor. He was likely to enter a researcher's lab asking "are you having fun today?" His door, always open, bore the sign "come in rain or shine." He would subsequently literally remove the doors from researchers' labs to encourage communication and discourage internal secrecy.

He was unbending, however, in his insistence that researchers pursue patents, all of which would become company property. As he put it, the General Electric Research Lab was not established as a charitable institution for indigent scientists, and must not become one, even accidentally. He also, however, established a university-like research seminar, held Saturday afternoon after the work week was over. He encouraged scientific publication as long as it revealed no proprietary information and was carried out in addition to, rather than instead of, invention. This new form of industrial research allowed sufficiently industrious scientists to become not only corporate inventors and innovators, but also professional scientific researchers. [164]

The laboratory was located in the middle of GE's Schenectady Works to emphasize the practical side of its responsibilities. In the years 1900- 1905, however, few such practical results emerged. The one significant lighting innovation, achieved by Whitney himself, was a carbon filament made more efficient by applying a hard coating, a process called "metallizing ". It would however quickly be made obsolete by European-invented filaments made of actual metals.

What brought the lab back to the forefront of the light bulb game was Whitney’s almost accidental hiring of two young, talented, but so far unknown, scientists. Both had earned Ph.D.s from German universities. Neither had immediately turned that credential into either financial reward or research opportunity.

Physicist William Coolidge held in 1905 a temporary post-doc position at an MIT lab. A colleague at that lab bench, still jointly holding an MIT post while easing into industry, was Willis Whitney. Direct observation of Coolidge's exceptional experimental skills, a product as much of Coolidge's

[164] **Wise, George, 1986. Willis R. Whitney. Columbia U.**

youth on a Massachusetts farm as his German training, led to a succession of GE job offers from Whitney, all refused. What earned Coolidge's ultimate acceptance was a 1905 promise by Whitney that Coolidge could spend half his time in pure research of his own choosing. Coolidge never exercised that option. Instead, on arrival in Schenectady, he was mysteriously overcome by a desire to improve the light bulb.

Irving Langmuir was a chemistry professor at Stevens Tech in 1908 . A heavy teaching load, and the lack of technician support or apparatus funding led to a slow start in research and publication. Applying for a summer job at the GE Research Lab, he lost out to an applicant from Harvard. Then, however, the Harvard man cancelled. Langmuir was called to Schenectady. Whitney was sufficiently impressed by Langmuir's summer efforts to hire him full time.

Joining GE unsurprisingly increased Coolidge's and Langmuir's incomes. More surprisingly, it also increased their opportunities to exercise fully their talents, and to ascend to the highest levels of both science and invention.

The GE lab team, stung by its failure to anticipate European patents on metal light bulb filaments, had after 1905 focused on leapfrogging those European leaders. Tungsten and similarly high atomic weight metals were being tried out as light bulb filaments, one metal per researcher.The most valuable, and costly, of GE's purchased European patents covered the invention made in 1904 by two young Austrian physicists, Alexander Just and Fritz Hanaman, of the tungsten filament. GE would downplay this patent in later publicity, and exaggerate GE's own contributions. It was, however, the upholding of that Just and Hanaman patent in U.S. court in 1916 that laid the foundation for GE's subsequent light bulb dominance.

Just and Hanaman had taken a powdered form of normally brittle tungsten and mixed it with other materials to make a sort of paste. The filaments were then squirted out one at the time. The materials other than tungsten were then driven off by heat, leaving a sufficiently strong, all-tungsten filament. [165]

What if pure tungsten, without the additives, could be continually processed into a wire, then chopped up into filament lengths? This might result in far

[165] **Bright, Arthur Aaron. 1949. The Electric-Lamp Industry. MacMillan p. 239**

more economical production of better filaments. The GE team pursued this idea, on that one metal per researcher basis. Working on the metal molybdenum, team member Colin Fink got the first hint. He showed, by drawing through a die a clump of the metal molybdenum and making a wire, that this approach might be possible.

Coolidge, taking on tungsten in 1906 , took the hint. He combined his skills as an experimenter with craft techniques he mastered visiting the wire mills of the Schenectady Works and the copper and brass factories of Connecticut. He spent five years putting conventional methods, such as heating, hammering, swaging (hitting repeatedly with small mechanical hammers), rolling and pulling through diamond dies, into the right order under the right conditions. By 1908 he could start with a block of brittle tungsten, and, using a precisely ordered and timed sequence of those processes, produce a continuous thin flexible tungsten wire. It took two more years to turn his method into a manufacturing process. In 1910, the first GE "drawn tungsten" lamps went on the market. Within a decade they would make lamps with other filament types obsolete.[166]

It was a manufacturing tour de force, the kind of unglamorous but highly productive process improvement that goes a long way toward justifying the existence of Giant Corporations. Whether it was, in legal terms, an invention that entitled GE to monopolize tungsten filament light bulbs was, however, more questionable. For one thing, later testimony suggests that the process was more a collective effort than a purely individual inspiration. For example, lab scientist Truman Fuller recalled later that Coolidge was sent on a trip to Europe before the project was completed. Colin Fink, the chemist who had provided the initial hint, took over and adopted Coolidge's method. It was Fink who made the first samples of tungsten wire. GE knew that that the U.S. patent office frowned on rewarding collective industrial effort. So it downplayed the contributions of Fink and others, and emphasized Coolidge's role. Unhappy that his name did not appear on a patent, Fink left GE for a distinguished career as inventor and Columbia University chemistry professor.

A more serious issue concerned whether Coolidge’s effort had resulted in an invention, defined by the patent office as something new, unobvious and

[166] **Brief for Plaintiff. The Wrought Tungsten Case. GE Company vs. Independent Lamp and Wire on Coolidge Patent #1,082,332. 30 Dec 1913C.A. Hollenbeck.**

useful, or merely a better way of manufactuiring the tungsten filament invention of Just and Hanaman.[167]

Could GE depict this process improvement as an invention, and one achieved by Coolidge alone? GE's patent attorneys proved up to the challenge. They proclaimed that it was no mere process improvement. Coolidge had met the patent system definition of invention by creating something not only potentially useful, but also non-obvious and new. Tungsten, the GE lawyers said, was inherently brittle. Coolidge, they declared, had invented "an entirely new product known in this Record as 'Coolidge Metal.' "[168]

This scientifically dubious distinction succeeded in convincing a judge that Coolidge 's patent was valid, and could be enforced against competitors. It was enforced, until 1925. Then, in another patent case, the same judge had second thoughts. He declared, sensibly, that drawing tungsten wire did not create a new metal. By then, however, the Coolidge patent had done its competition- suppressing work.[169]

Irving Langmuir had more theoretical interests than did gifted experimenter Coolidge. So Research Director Whitney managed him differently. Rather than assigning Langmuir to a particular metal, Whitney gave him a freer hand to explore general light bulb issues of his own choice. Whitney also supplied Langmuir with a pair of experimentally capable hands, those of Karl Sweetser, a veteran technician and equipment builder. Sweetser built Langmuir an apparatus for studying specific light bulb problems, such as why they turn black with use. With it, Langmuir explored not only light bulb

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[167] **Truman S. Fuller, interview, HoH, 33 Mar 1978.**

[168] **Brief for Plaintiff. The Wrought Tungsten Case. GE Company vs. Independent Lamp and Wire on Coolidge Patent #1,082,332. 30 Dec 1913C.A. Hollenbeck., P. 3**

[169] **The overturning of the new metal claim of the Coolidge patent is G.E. Company vs. Dr Forest Radio Company. 17 Fed. 2d. District . Delaware. 1927. A detailed description of the judge's decision reversal can be found in Liebhafsky, Herman. 1974. William David Coolidge. Pp. 70-73. Dr. Liebhafsky was an eminent chemist (and also a colleague and friend of the author of this book). Though a fervent GE loyalist, he recognized the legal correctness of the judge's second decision.**

problems, but also. the physics and chemistry of atoms, molecules and ions. In 1910 this was unconventional. Many scientists, including most chemists, did not then believe in the physical reality of distinct and observable atoms, molecules and ions.

By a combination of theoretical modeling and experiment, Langmuir reached a counterintuitive and remarkably useful conclusion. The way to further improve those tungsten filament light bulbs was not, as expected, to create an ever more perfect vacuum inside the bulb. It was to fill the bulb with an inert gas at atmospheric pressure. While reaching this conclusion, Langmuir simultaneously pioneered new ways to study the chemistry of those individual atoms, molecules and ions. He would build on those efforts and win the 1932 Nobel Prize for chemistry.

If the scientific value of his work was unquestioned, the patentable aspects were less clear. Predecessors had already invented gas filled incandescent lamps. Those early inventions were indeed novel, non- obvious, and potentially useful. They did not, however, become actually useful. Before Langmuir, gas filling was guesswork, not science. Langmuir's work, by contrast, provided an accurate theoretical model of the atomic-level chemistry and physics that was going on inside those light bulbs. Using that model, he was able to identify and quantify the various bad and good effects of gas filling, such as its carrying of heat away from the filament by convection (bad) and the suppressing of evaporation of those blackening agents from the filament (good). He then applied that model to devise modifications to lamp components (such as not merely coiling the filament, but then coiling again that first coiled filament) that accentuated the good effects while suppressing the bad ones. Details are here left to the reader with an appetite for a remarkable scientific detective story.

For GE, the result was another challenge to patent attorneys. They had to convince the U.S. Patent Office, and later the courts, that this remarkable addition to knowledge constituted an invention. This despite the facts that knowledge is not patentable, and gas filled incandescent lamps had already been patented. The GE attorneys, defying these facts, succeeded in getting the patent.

Coolidge's patent on ductile tungsten and Langmuir's on the gas filled lamp proved two of the most valuable patents in GE's history. After the breaking up of the GE-NELA light bulb cartel in 1911, they became the main means by which GE suppressed competition and locked in a 20%- plus ratio of

profits to sales for decades to come. In 1920, for example, GE sold $57 million worth of incandescent lamps, about 20% of the company's total sales. It made from light bulbs a profit of $13 million, about 40% of its total profit. George Morrison, Vice President of GE Lighting, was not yet satisfied. In 1921 he told Coffin how he was using patent law to further increase GE Lighting's dominance. The Langmuir and Coolidge patents would enable GE to buy out, at bargain prices, several competitors. "It is not our intention" said Morrison, "to take over these assets at a figure that would result in a profit [for the competitors] or even let these companies out flat". GE intended to pay no more than 75% of value for those companies.

The next step was global. In 1924, the patents served as a basis for a cartel, an arrangement then legal in Europe, to control the light bulb industry there. Meanwhile, back in the U.S. GE extended its control of light bulb prices by such methods as an "agency method" of price control that enabled GE to dictate the price all the way to the consumer. All this led to persistent complaints, such as those of the Lockwood Committee of New York State Legislature in 1922. There witnesses testified to GE "legal harassment" and "exorbitant profits." In response to such accusations, in 1924, GE in asked U.S. Department of Justice to investigate its light bulb business. This led to an indictment of GE for antitrust violations. The case went all the way to the U.S. Supreme Court. There GE was totally vindicated. In the 1926 legal decision sustaining that GE policy the U.S. Supreme Court declared that it was the ownership of those Coolidge and Lagmuir patents that entitled it to use of that competition suppressing agency method. [170]

So, to sum up the two examples described in this chapter the Universal System and the better light bulb,what conclusion might one reach from those examples about the early 20th century GE. Was it the innovating and improving Generally Electric? Or was it the limits-of-the -law exploring, competition suppressing Specifically Electric?

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[170] **Bright, Arthur Aaron. 1949. The Electric-Lamp Industry. MacMillan. P. 253 George Morrison to Charles A. Coffin, 5 Feb 1921. Edwin W. Rice Jr. Papers. Schenectady Archives of Science and Technology. Union College. Schenectady NY.; United States v. General Electric Co., 272 U.S. 476 (1926). United States v. General Electric Company. No. 113. Argued October 13, 1926; Krajewski, Marcus. 2014. The Great Lightbulb Conspiracy IEEE Spectrum 24 SEP 2014 (on line)**

It was both. In its more constructive “Generally Electric” identity GE was a strong supporting actor in the development of the Universal System. It pioneered major applications, such as powering cotton mills. It helped turn Maxwell's theory of electromagnetism into a useful tool for designing electrical equipment. It played a major role in turning the steam turbine inventions of De Laval, Parsons, and Curtis into a steam turbine generator industry. In light bulbs, in that constructive Generally Electric identity, GE developed machinery to make light bulbs faster, more uniformly and at lower cost. It developed the best process for making the tungsten filaments that would go on to emit most of the twentieth century's electric light. It took an earlier but useless invention, the gas filled lamp, and provided the scientific knowledge and engineering design to turn it into a practical light bulb that both improved efficiency and lengthened life.

In its other identity, however,as “ Specifically Electric”, GE focused on stabilizing prices and limiting competition. This led GE to explore, and sometimes cross, the boundaries of the law -- particularly the Sherman Anti-Trust Law, and the laws governing the U.S. Patent System. GE used its 1890s Patent Pool with Westinghouse to set up a Patent Board that harassed competitors into selling out to the giants. Later, GE used the dominant role of its financial arm Electric Bond and Share, to influence utility companies to buy GE equipment, likely in violation of anti trust law. In the case of light bulbs, GE's secret cartel with National Electric light was a violation of the Sherman Act. Regarding patents, GE followed the letter of patent law, but not its spirit. The spirit of patent law depended on a particular definition of invention. That definition combined the properties of novelty, non-obviousness, and utility. The efforts of GE's ingenious patent attorneys helped a giant company crush smaller competitors using patents that sometimes only dubiously met that definition of invention.

The light bulb industry was exceptional in GE for the use of patents for competitive advantage. Though GE employees got several thousand patents in other areas than light bulbs in the first half of the twentieth century, most of those others had much less impact. As GE president Charles E. Wilson put it in a 1949 congressional hearing:

> In only one area of the industry have patents have been of major importance: lamps. But In other sectors their importance has been small.[171]

That GE effort in electric lighting much later got another evaluation, by a more neutral observer than GE President Wilson. Electric lighting technology, despite its monopolization and competition suppression, was chosen by economist William Nordhaus, later a Nobel Prize winner, to exemplify the way returns to society from new technology far outweigh the returns to the Giant Corporations that dominate the industry. He calculated the number of hours an ordinary 20th century worker needed to labor to be able to afford the light emitted by a typical 20th century 100 watt light bulb for one hour. He found that, in the Old GE century of 1886 to 1986, that labor cost of light fell by a factor of more than a thousand. More generally, he concluded that most of the social benefits of new 20th century electrical technologies far surpassed the private benefits.[172]

So, in conclusion, on one side, arrogant and sometimes illegal efforts to suppress competition. On the other, a lead role in improving the light bulb to the status of not a luxury but a necessity, and a key supporting role in the Universal system, the key to the 1890- 1920 takeoff of the electrification of the world. Which was more important? Readers are invited to weigh constructive Generally Electric against destructive Specifically Electric, and reach their own conclusions. As you do, this book turns from GE technology to GE labor relations and politics.

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[171] **Testimony of Charles E. Wilson to the Hearings on the Study of Monopoly Power. House Committee on the Judiciary. 81st Congress. 1st Session. Washington DC 30 Nov 1949 p.107**

[172] **Nordhaus, William D. 1988. Do Real Output and Real Wage Measurements Capture Reality? The History of Lighting Suggests Not. Cowles Foundation Paper No. 957. Nordhaus, William D. 2004. Schumpeterian Profits in the American Economy. NBER Working Paper No. 10433.**

Chapter 6 Pragmatists 1911- 1920

In 1911, Schenectady became the second largest U.S. city, behind only Milwaukee WI to vote Socialists into control of its city government. Initiating that Socialist political movement was a group of labor leaders who had also brought labor unions to General Electric's Schenectady Works. Their political allies were Schenectady's two most prominent Socialists. George Lunn would become the first (and , so far, only) Socialist to be Mayor of Schenectady. Charles Proteus Steinmetz was the first (and only) Socialist to be the Chief Consulting Engineer of the General Electric Company. [173]

There was much less to Schenectady Socialism, however, than the term suggests. Far from fomenting revolution, Schenectady's politically successful socialists were not radicals but pragmatists. Their capitalist bosses at GE were not union busting reactionaries, but also pragmatists. The Lunn-Steinmetz politically successful pragmatic variety of Socialism was condemned by more doctrinaire Socialists as mere "Sewer socialism." The mild and even sometimes approving response of GE managers to the Socialist takeover of Schenectady's city government and rise of unions was also a disappointment to established Schenectady politicians and more militantly anti-union corporate leaders.

The particular history of unions and socialists in 1910- 1915 Schenectady casts light on a more general question. What might the experience with socialism and unions of GE and the the city of Schenectady suggest about the course of the nation's contentious politics and labor relations of the first two decades of the 20th century? That is the question this chapter answers.

The years 1900- 1916 saw both a surge of labor union organization at the General Electric's Schenectady Works and a surge in Socialist politics in the city. Behind the leadership of the unions and Socialist Party stood, albeit only briefly, more than 6000 Schenectady residents who at least once voted

[173] **Buell, William.2019. George Lunn. Troy Book Makers**

Socialist, and more than 6000 Schenectady GE workers who, at least once, went on strike behind union leadership.Knowledge about this rank and file will here rest mainly, perhaps excessively and precariously, on censuses and organization directories, a voter registration book for the year 1912, and a transcript of the U.S. War Labor Board hearings held at Schenectady in 1918. One would, however, like also to encounter workers as they were living their daily lives --to see, for example, one of them rising from bed on a cold dark winter morning.

> He threw a dressing gown over his shoulders and went to the window which the frost had rimmed with white fur. He thawed a spot with his breath, gave it a rub and peered out. Opposite was the yard of the gas works, and under the arc-lamp above the gate figures as rigid as icicles and with coat collars turned up moved past in hurrying silhouettes, then vanished into darkness like spectres. The carbon sputtered and threw capricious gleams and shadows upon the discolored snow. It was an hour before dawn , and Veeder Street was stirring to a realization of coffee and fried bacon and impending duty.

The description is taken from a 1929 novel entitled Steel Chips. Its author, Idwal Jones was born in Wales, the son of an engineer-geologist who came to the U.S. to work in the mining industry. Idwal worked as an apprentice machinist at General Electric's Schenectady Works not long after 1900, then as a machinist there briefly, before lighting out for California and a career at a writer. It is asserted here that though the plot and characters of Steel Chips are fictional, the descriptive passages are recollections-- as indeed, in actual early 20th century Schenectady, Veeder Avenue (not Street) wound downhill on its arc lamp lit way from an area of workers' boarding houses to large Works of General Electric.[174]

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[174] **Jones, Idwal. 1929.Steel Chips, Knopf. P.3. Idwal Jones biography, Online Archive of California. Schenectady Gazette, 2 May 1926, p.6. Albany Times Union. 18 June 1929 p. 1 Alfred NY Sun July 1936 p.2. The New York Times review of Steel Chips is 14 July 1929. It concludes that "Steel Chips is an objective picture, often an objective study, of life among the machines."**

That works had, in 1886, moved from New York City to Schenectady to escape unions . By the 1890s, however, the unions were beginning to follow. Those unions of the 1890s differed from the one that the Edison Machine Works had left behind . That 1886 union, the Knights of Labor, had been, in modern terms, an industrial union. That is, all workers in a particular factory or works joined the same local of the one big union. The unions that reached Schenectady in the 1890s, in contrast, were craft unions. Members of each craft, such as machinists, carpenters, or blacksmiths, joined a separate local craft union.

Two national organizations on the craft union model had been created just as the Edison Machine Works was starting up in Schenectady . The American Federation of Labor (AFL), founded in 1886, was a national federation of craft unions. It was moderate in its policies, seeking to avoid strikes, gain the acceptance of politicians in the major national parties rather than start its own labor party, and negotiate labor agreements with the more progressive capitalists.The International Association of Machinists (IAM) was founded in 1888. It was part of the AFL and, in principle, endorsed the AFLs moderation. In practice, however, the IAM's activism earned it the nickname of the AFL's attack dog.

General Electric's labor policy permitted any worker who chose to do so to join a union. This provided an opening for AFL union organizers. What narrowed that opening was the company's refusal to give any official recognition to any kind of union.

Seizing on this narrow opening in 1895 was Henry V. Jackson. He was born in nearby Coeymans NY and was employed in Schenectady in the 1880s as an engineer and co- owner of a machine shop. In the 1890s, as a Republican,he served a term as a Schenectady Alderman Also in the 1890s, though nowhere listed as either machinist or a General Electric employee, he led the organization at the General Electric Schenectady Works of Local 204 of the IAM, known as the Dorpian Lodge ("Dorp", Dutch for village, is one of Schenectady's nicknames).Though destined to become the Works' leading

union, the Dorpian Lodge got off to the slow start. Jackson later admitted that in the 1890s he sometimes put up dues money out of his own pocket to keep the paying membership numerous enough to retain official IAM recognition.[175]

A few other crafts, though less numerous than machinists at the Works, got organized sooner. The union organized by the patternmakers , sculptors of the precisely dimensioned full scale wooden models around which were formed the sand molds into which molten metal was poured, has already been described. GE kept quiet about this surprising, and not soon repeated, concession. After 1900, union membership, although still a minority of the now 10,000 employees of the Works, began to grow at an increasing rate. This was not merely due to the increasing persuasiveness of Jackson and other leaders. Rather, it benefited from the arrival at the Works of a new generation already converted to unionism, and in many cases also to socialism.

For example, Frank Dujay came to Schenectady from Melrose, Canada in 1900, already a member of the Brass Workers' Union. At Schenectady he became "one of the best known labor men in the city." British born Patternmaker Patrick McEwen landed in America in 1903 as already a union man, and joined the Patternmakers League of North America on his first day in the New World. William Turnbull had been trained as a machinist in the shipbuilding industry of Britain's Tyne River. He had already served as Secretary Treasurer of the Cranemen's Union at Schenectady's Locomotive Plant before he came to the GE Turbine Department in 1907. Scots- born John Bellingham arrived in Schenectady in 1905 and at Switchboard Department of the GE Works in 1908. He quickly established himself as both a leading Socialist and machinist union organizer.

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[175] **Jackson, a previously forgotten GE union pioneer, was rediscovered by Catherine Haag. He is the leading character in her 2022 U. Albany Ph.D. Thesis, Mainstream Radicalism, the principal source of information about him used in this book. Glimpses of Jackson's career can also be fournd in Albany Argus, 19 July 1900, 3 Oct 1904, Albany Times Union 3 Dec 1903.**

Other new leaders were American born, Machinist Harvey Simmons, for example, had become a union leader while witnessing the exploitation of child labor in New England textile mills. Schenectadian Charles Noonan, a metal polisher, seemed to have a chip on his shoulder from the moment he emerged in Schenectady labor and politics just after 1900 until his last campaign on a Socialist ticket in 1934. By contrast soft spoken, scholarly Herbert Merrill, a New Hampshire born armature winder turned labor organizer, was more likely to be found in Schenectday's new public library than in any of its 200 saloons.[176]

Many of the newly arrived union leaders were also already socialists. Socialism will here be defined as a political ideology advocating ownership of the means of production by the entire community, rather than as private property. Within that definition, socialist sects differed widely on how immediately that public ownership should happen, and on the means of achieving it. Those proposed means ranged from the political process to revolution.Schenectady socialism gained a convert in Henry V. Jackson. No longer a Republican, he ran in 1902, unsuccessfuly, as a candidate for Schenectady local office on the Democratic Socialist Party ticket .[177]

By then Jackson's Dorpian Lodge of Machinists was the most prominent of Schenectady's unions. The new union with the most workers, however, represented the semiskilled. This was the International Brotherhood of Electrical Workers (IBEW), for which Herbert Merrill was an early organizer and later bargaining agent . Its members mainly made parts for and assembled motors and generators. By 1903 the IBEW claimed a

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[176] **Dujay is discussed in Schenectady Gazette 23 July 1914. Turnbull's obituary is in Schenectady Gazette 10 April 1962.McEwen tells his life story in "Official Record of Proceedings before National Labor Relations Board. Case 11-R-1786, Oct 1940. U.S.National ArchivesRG-25 Items 250, 4385. A brief biography of Turnbull is in the Citizen 12 Nov 1911, p. 4. Bellingham's obituary is in the Schenectady Gazette 9 Mar 1950.Brief biographies of Simmons and Noonan are in the Citizen 12 Nov 1911. The NY Times 7 Mar 1956 has Merrill's obituary. Noonan is further described in Brooklyn Weekly People, 12 July 1903**

[177] **Utica Herald-Dispatch 15 Nov 1902**

membership of over 2000. The most militant union was that of the Metal Polishers. Its leaders, Frank Dujay and Charles Noonan were among the most radical, committed, and controversial of Schenectady's Socialists. Joining them in the union's leadership was that former Republican committeeman from the Second Ward, Martin Clune.[178]

In April, 1902, the Metal Polishers began in a small way what would become the Schenectady Works' first big strike. They led out of the Works some 40 polishers and buffers. The immediate cause was a new piece work rate that the men claimed had reduced their average pay by $3.50 a week.[179]

Behind that, however, lurked a deeper grievance. One metal polisher described his trade as "deadly." He explained that "inhaling brass, copper, and iron dust from the [grinding] wheel causes lung disease. " This worker did not mention, and probably did not know, that just three weeks earlier, General Electric, represented by a future prominent progressive federal judge and legal scholar, Billings Learned Hand, had opposed before the New York Legislature a proposed employer's liability bill that might have covered such workplace harms.[180]

Emmons initially refused to talk to the Metal Polishers Union strikers. They were, however, soon followed out by others: first the punch press opeerators, then the moulders, then many groups of machinists, including the Dorpian Lodge. On the strike's second day, a newspaper estimated that 2400 workers were out.[181]

Idwal Jones pictured a General Electric strike of that era.

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[178] **Knickerbocker News 27 June 1915.Charles C..Ford, Secretary of the IBEW to C.N. Ripley of GE. 11 Jan 1924. Swope Papers. MiSci asserted that the IBEW had "thoroughly organized" GE by 1903. See also Stone.Collection, Box 6, File 10, "Labor Unions" at the City Hall History Center, Schenectady, including statements by Herbert Merrill, and by representatives of IBEW locals 247 and 536.**

[179] **Schenectady Daily Union 17 Apr 1902**

[180] **Schenectady Daily Union 9 Apr 1902**

[181] **Schenectady Daily Union 18 Apr 1902**

> The men pushed out in solid blocks into the aisle and the march was on. It wound down the stairs, joined the stream in the thoroughfare of the plant, and was augmented by the throngs gathered at the doors of the other shops. When the flood was abreast of them, intersecting masses merged into it..The flood was conscious of itself, egoistic, and if it had any regrets it was that it could not watch its own intimidating magnificence flow by...
>
> Every window in the facade of the main office bristled with heads. The clerks were thankful for a moment's diversion from the ledgers. On the steps were the corporation officials, chiefly in double-breasted blue serge suits and with sleek hair and clipped whiskers.[182]

That 1902 strike saw a surprising intervention. Schenectady Mayor Horace Van Voast was a Republican and insurance executive whose electoral success was based on personal popularity, not partisanship or ideology. He was reputed to know more voters by name than any other Schenectady politician. Far from being a progressive reformer, he was criticized by the reformers for his friendships with saloonkeepers and operators of disorderly houses.It was Mayor Van Voast who invited both sides to a conference. That innovation is sometimes incorrectly attributed to Schenectady's later Socialist mayor, George Lunn, who actually followed Van Voast's precedent.[183]

The unions and George Emmons both accepted the mayor's invitation. Before the end of the strike's third day, the newspaper announced, "the first big strike the company has ever had is over." That ending was a union victory. The company statement read:

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[182] **Jones, Idwal. 1929.Steel Chips. Knopf. p. 223**

[183] **Schenectady Daily Union 19 Apr 1902. New York Daily Tribune 20 Apr 1902. Schenectady Evening Star Wed 6 Nov 1907**

> The difficulty with the employees of the company has been compromised...all employees are to return to work Monday morning...The dispute over piece work prices in the polishing department will be taken up and adjusted promptly on an equitable basis.

Announcement of that result was received with "cheer after cheer" from an "orderly" crowd estimated at 7000 striking workers from "all the organized trades". They thronged city streets, leaving the Works appearing "like a deserted city." Especially cheered both by the workers and by "hundreds of spectators" was the principal union negotiator, Edward Utting.[184]

Emmons appears to have kept to his agreement to adjust the metal polishers' piece rates. He did, however, retaliate on December 11, 1902, when he discharged strike leader Utting. Emmons denied this was union related, attributing it to nine days of unapproved absence. Utting claimed his absence was due to illness, but the discharge stuck. Staying in Schenectady, Utting redoubled his union organizing from outside the Works. He became a paid agent for the Schenectady Metal Trades Council, an AFL related umbrella organization founded in 1892. It coordinated the efforts of many local trades unions, not just General Electric's. [185]

At the Trades Assembly, Utting's arrival coincided with the departure of that Assembly's President, Henry V. Jackson. After his success at leading the IAM Dorpian Lodge to its influential position at the Works, Jackson had moved on to wider organizing efforts through the Metal Trades Council. There he met failure in a 1902 campaigns against the Schenectady Street Railway Company, then a General Electric subsidiary. In February, 1903, he lost his bid for re-election to the Assembly's presidency. His rejection appears to reflect both his recent strike defeats, and his political turn to the

[184] **Schenectady Evening Star 19 Apr 1902**

[185] **Schenectady Daily Union 11, 12, 14,17 Dec 1902**

Socialist party. His victorious opponent was both an AFL leader and a Democrat city alderman.[186]

Back at the Works, George Emmons stayed on a conciliatory path. "We have had some troubles in the past year, " he admitted at the start of a January 1903 talk to the Foreman's Association. However, "difficulties have been amicably settled." The result, he said, had been a banner year in 1902. Production at the Works went up 30% . Two thousand men were added to the payroll. There was one small dark cloud, Emmons noted . "The company was about to build a large incandescent lamp factory here last year. When the strike occurred, the matter was then reconsidered, " and the plan was scrapped.

This was followed by the longest pronouncent Emmons ever made on the subject of unions.

> the time has come when the manufacturer must recognize the fact that the trades unions are here, and are here to stay, and they have rights that must be recognized. ..I have had extensive dealings with the representatives of the various local unions and I have found them.honest and honorable in all their.dealings...Their object is praiseworthy and they only become harmful when radical,and.unscrupulous men shape their.policies.[187]

Organized labor in Schenectady agreed . A December, 1902, statement from the Schenectady Trades Council concluded that

> As to conditions in the General Electric Works, it is safe to say that in no manufacturing plant.employing the same number of men will you find the same harmony as exists here between the management and the employees. [188]

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[186] **Schenectady Evenng Star 18 Dec 1902, ES 25 Feb 1903**

[187] **Schenectady Evenng Star 12 Jan 1903**

[188] **Schenectady Evening Star 27 Dec 1902**

The 1902 strike and its aftermath set a pattern for almost all of the strikes that from followed, from 1903 to 1919. They typically were sparked by a small grievance, such as a disputed piece work rate, or the discharge of a few individuals. They quickly grew to massive scale, involving thousands of workers. Most were short, days rather than many weeks. Even the long ones were orderly.The typical conclusion involved a small company concession on wages or hours. Nothing that was agreed to, however, weakened the company's total control of the workplace, or officially recognized any union as the bargaining agent for any worker (barring that small, unofficial, and rarely mentioned Patternmakers exception). Emmons avoided using the provocative phrase "open shop", but the General Electric Works remained one.

The strikes were conducted in a strikingly disciplined and orderly manner. For example, in 1915, the Schenectady Works unions went on strike in support of a national movement seeking an eight hour day. The orderly march out of the Works of more than 6000 workers was led by 1000 women singing , to the tune of the recent hit song "Put on Your Old Grey Bonnet", the "8-hour battle hymn":

Put this in your bonnet

With eight hours on it

And don't mind what the bosses say

For when the fight is over

We'll all be in clover

We'll all work eight hours a day[189]

Two days later, those same workers marched back into the plant. This was not to surrender, but to collect the pre-strike pay owed to them, then march back out again. Watching from his office window, Emmons expressed to an accompanying reporter his "appreciation", saying

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[189] **Words to the 8 hour hymn are in the description of the Schenectady strike in Newark NJ Evening Star 9 Oct 1915.**

> It was wonderful. Think of 10,000 strikers walking into a plant, receiving $240,000, and.marching out again without a loud word being spoken, or a drunken man appearing among them. [190]

The strike lasted eight weeks. It ended, as had become usual, with a compromise. The workers got a reduction in the work day from 10 to 9-1/2 hours, and a 5% pay increase.[191]

Missing from this series of strikes are the standard tropes of the 1900- 1920 era's labor strife. The company brought in no Pinkerton agents, no ranks of armed vigilantes or off duty police, and few company spies and strikebreakers. Union leaders neither urged or permitted physical attacks or sabotage much less assassination or bomb throwing. Schenectady city officials and courts issued no injunctions, encouraged no police intimidation of strikers, and did not call out national guard troops. Instead, at least on two occasions, Mayors hosted bargaining sessions. Company discharge of union leaders, either in calm times or in after-strike retaliation, was very selective, involving only a few individuals. Emmons always explained the discharges, albeit unconvincingly, as not union related. Instead he attributed them to routine causes such as absence, insubordination, or poor job performance.

Two strikes in this era, however, had unusual features. The first was a 1906 strike led by a union that had not even existed in 1900. In 1904, national union leaders dissatisfied with the conciliation and craft union policy of the AFL met to form a new industrial union. From this emerged in 1905 the Industrial Workers of the World (IWW), popularly known as the Wobblies.The IWW is sometimes depicted as the creation of foreign born members of the Socialist Labor Party, the most revolutionary wing of socialism. Actually, the organization of the IWW drew from across the Socialist spectrum. For example, creators of the IWW included William

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[190] **Albany Argus 9 Oct 1915**

[191] **Newark NJ Evening Star 9 Oct 1915; Albany Argus 9 Oct 1915; 24 Oct 1915**

"Big Bill" Haywood of the Western miners, and Indiana's Eugene V. Debs, former President of the Locomotive Engineers' Union and soon to be the most successful Socialist presidential candidate in U.S. history. In the East, Schenectady's Henry V. Jackson would help organize the IWW at the Schenectady Works and become its local union president.

The IWW declared itself One Big Union, welcoming all workers. It was less welcoming, however, to management overtures, preferring confrontation to conciliation. It would not settle for token wage and hour concessions. Its short run goal was recognition as the the workers' bargaining agent. Its long term goal was workers' control of the workplace.

The IWW went on the attack across the nation in 1905. The 15 strikes it called that year were, however, overwhelmingly unsuccessful. There was no 1905 IWW strike in Schenectady. Instead, Henry Jackson recruited successfully from all parts and ranks of the Works. This included prestigious highly skilled trades such as tool and die making and machining, semi skilled crafts such as punch press operation and coremaking, and the less prestigious ranks of the insulation workers and metal polishers. The metal polishers' organizers Charles Noonan and Martin Clune joined Jackson as IWW leaders. By mid 1906 the IWW claimed 2500 members.[192]

As noted, the depiction of the IWW as a tool of foreign born radicals was an exaggeration. Nevertheless it is true that in Schenectady, Socialist Labor Party radicals and foreign born unionists, many of German descent, were more visible in the IWW's 1906 efforts than in any other Works organizing effort of the era. For example, a speaker at a 1904 Schenectady rally was the national leader of the Socialist Labor faction, Louis De Leon. He was born on the Caribbean island of Curacao of Netherlands, Catholic and Jewish descent, and educated in Germany. He was a teacher at New York City's Columbia University when recruited into the Socialist Labor ranks .

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[192] **Haag, Catherine. 2023. Mainstream Radicalism. Ph.D. Thesis. U. Albany., p. 312, ES 1 Dec 1906**

At Schenectady, in 1904, he blasted " the capitalistic education and practice of the so called leaders of the craft unions in aping their masters." In that novel Steel Chips. Idwal Jones calls him Daniel LeTigre. In his fictional speech.

> LeTigre leaned back and talked ex cathedra like a superior and disillusioned ecclesiastic. His head was an arsenal of terrible knowledge. ...Through the century his mind winged tirelessly over dreary and frost nipped tundras, swooping now and then over a roe's egg of facts that glittered to their fascination, then dropping it with indifference. He knew too much.[193]

Schenectady IWW leader Henry Jackson was identified as a De Leonite by some of the local newspapers. The actual DeLeonites in Brooklyn quickly, indignantly-- and correctly-- set the Schenectadians straight. Jackson was a mere Social Democrat, a "corruptionist" whom.they accused of "betrayal of union trust " and "dickering with Schenectady politicians" .[194]

In this way a leader who had been driven from city labor leadership because he was alleged to be too radical was then attacked by the real radicals for being not radical enough. This sort of infighting would prove to be a fatal flaw of both unions and Socialism in Schenectady. Despite this two sided criticism, Jackson held on to leadership of Schenectady's IWW. Working beside him was another Schenectady IWW leader, GE metal poliaher, and former Republican Party committeeman Martin Clune. Speaking in 1905 on behalf of the new union Clune defied hecklers, who likely were AF of L members. “ You will unseat us,” he began

> but the Industrial Workers of the World are ready to do it over again. The cause we have taken up is sacred to us and can never be torn from our lives . It is sincere, and not a graft affair like the Federation. [195]

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[193] **Brooklyn Weekly People 18 Aug 1904; Jones, Idwal. 1929.Steel Chips. Knopf. p. 285**

[194] **Brooklyn Weekly People. 7 Mar 1903**

[195] **Brooklyn Weekly People. 23 Dec 1905**

In late November, 1906, Schenectady IWW agitation began. As a local newspaper reporter described it, "the draftsmen in the Switchboard Drafting Department, who are foreigners mostly, were to form a union to be affiliated with the IWW. Foreman J.W. Upp proceeded on Dec 9, 1906,to fire two draftsmen Heinz Schwabe and Louis Bosky, with a third, J. Weingreen quitting in anticipation of discharge. The alleged reasons were insubordination and incompetence. The suspected reason was union activity.The IWW immediately threatened to shut down the plant if the three were not reinstated. Behind that shutdown threat was the rumor that the IWW had organized the Works Power House. It was poised to turn off delivery of electric power not only to the Works but also to the city.[196]

Before any action was taken, on that morning of Dec 10, 1906, Emmons, and the Company's Chief Lawyer, Hinsdill Parsons, held a 3 hour meeting with the IWW leaders. Emmons offered to transfer the three draftsmen to another department, or give them 30 days severance pay. The IWW leaders would accept nothing less than full reinstatement.Here negotiations broke down. " It is not a question of unionism but of discipline, " said Emmons. The newspapers added: "General Manager Emmons says strike will mean a fight to the finish."[197]

At 2 PM of that day, some 2000-3000 men, mainly from three of the Works's several dozen shops quit work. What they did next is unclear. A New York City labor newspaper would later report that they stayed in place. This caused some later historians to label this event the nation's first sitdown strike. No evidence, however, indicates how long the strikers stayed in the plant, or that they ever sat down at their benches or desks.

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[196] **The account here follows the more detailed treatment of the 1906 IWW strike at Schenectady in Haag, Catharine. 1923. Mainstream Radicals. U. Albany. See also Schenectady Evening Star 10 Dec 1906**

[197] **Schenectady Evening Star, 10,12 Dec 1906**

Before the day ended they had walked out of the Works in the conventional manner.[198]

If the IWW did intend to shut down the Works , it failed. At the Power House, when the IWW strikers walked out, Superintendent A.L. Rohrer walked in with a team of Test Men and office workers who kept the power flowing. In addition, none of the major machine shops was affected by the strike. There was a reason for this ineffectiveness. The AFL unions, the majority of organized labor at the Works, rejected the IWW call. The president of Schenectady's Trades Assembly said that "the Federation locals have not been approached and...have not considered joining the IWW." The Trades Assembly would soon add that "we do not recognize the Industrial Workers of the World as a bona fide labor organization, or its members as union men. "[199]

Though some workers trickled back to work from the strike's beginning, a hard core stayed out for two weeks before finally agreeing to terms. Emmons announced that he "cannot recede from the position on the three draughtsmen" [that, is, their discharge was final]. "Practically all" the strikers, however, could return to their jobs. Even a union newspaper depicted him as keeping this promise. "Some foremen tried to discriminate,"

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[198] **Evening Star 11 Dec 1906. Dubofssky, Melvin. 1960. We Shall Be All. Quadrangle, p. 126 accepts, without citing evidence, the description of this strike as ‘ the first sitdown strike in American history.” This seems an exaggeration. Catharine Haag, accepts the claim by contemporary IWW organizer Elizabeth Gurley Flynn that this was one of the first sit down strikes in the U.S., but rejects as exaggerated historians claims that the sitting down lasted 65 hours (Philip Foner) or even overnight (Fred W. Thompson and Patrick Murrin). Haag, Catherine. 2023. Mainstream Radicalism. Ph.D. Thesis, Albany U. pp. 338-341**

[199] **Schenectady Evening Star 11, 13 Dec 1906**

that radical Brooklyn paper reported, " but Mr. Emmons, trying to be 'fair', rebuked them. "[200]

Even for the IWW leaders, discharge was selective. One of them, Timothy W. Hunt was fired. Charles Noonan, however, was not only not fired, but not long afterward was promoted to foreman. Martin Clune also kept his job. A casualty of the strike was local IWW President Henry V. Jackson. He was reported as "deposed" by the IWW membership. Jackson and Hunt both stayed in Schenectady, working as insurance agents. Hunt would rise in Socialist politics. Jackson's political and union leadership days were over.

The second strike that broke from the usual pattern happened later, in 1917. The General Electric Works had by then taken on each year as summer employees several Union College students. One of the 1917 candidates seemed especially promising. Wendell King was a native of nearby Troy NY. He was not only an engineering student at Union, but also an expert in a new field of technology General Electric had just entered, wireless telegraphy.

He was also Black. When sent in to run a drill press in Building 23, the machinists immediately rose up on strike. They were not, they said, opposed to the company employing a colored man. What they opposed was white men and colored men working together. "We ask no more than the U.S. government, " explained striker Joseph Lefkowitz. "In the U.S. Army...colored soldiers are not allowed to mingle with the whites."

In this segregationist stand, the Building 23 machinists were supported by their union. Emmons, however, did not agree. General Electric, he proclaimed, "will tolerate no discrimination against any worthy individual on account of nationality or color." Under pressure from both the unions, and the U.S. Navy customer whose work was being delayed, however, Emmons backed down. King was moved out of the Building 23 machine

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[200] **Schenectady Eveing Star 20 Dec 1906; Brooklyn Weekly People, "History of Schenectady Labor Movement," 12 July 1908.**

shop to a job where no further issues arose. After that summer, he appears not to have returned to GE. He went on to a career, outside General Electric, as a pioneer in the new industry of radio. It would be some 20 years before the Works saw its first full time Black machinist[201].

At the time of King's employment, a Schenectady Works spokesman estimated that six Black people worked in the Works' offices, two in its shops, and "a hundred or more in the yard," that is, in such outdoor jobs a loading trains or maintaining the grounds. The first Black person ever recorded as a GE professonal employee had been Lewis Latimer. In the 1890s he was the inventor of improvements in lamp filaments. He worked for Edison General Electric and GE mainly in the legal department as a draftsman and patent testimony adviser. He was transferred to the GE Westinghouse Patent Board, leaving that Board, and GE, when that Board was dissolved in 1911.[202]

By then the Schenectady Works had at least one other Black professional. Lawrence De Witt Simmons joined the company in 1906. He was a native of New Orleans. He graduated from Talladega College in 1903 and from Yale's Sheffield Scientific School in 1906. Light in color, his family later recalled that he was sometimes regarded as white. From 1906 to 1908 he worked in the General Electric Experimental Turbine Department at Schenectady, most likely as a Test Man. He continued with Turbine until 1911. His occupation is given in the city directory as draftsman. He joined the company's Consulting Engineering Department in 1911 and worked there at least until 1914. He would move to a farm in a Schenectady suburb, and live there the rest of his life. The only other Black professional found in the early GE records was King David Commack, a physician. The sole

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[201] **I thank James Caufield, who first told me about the 1917 strike. Details can be found in the Schenectady Gazette, 18 Jue 1917, p.3; 19 June 1917, p.1; 20 June 1917, p. 1; 27 June 1917, p.i.**

[202] **Denver Star 20 June 1917 provides details both on the Wendell King incident and the role of Black workers at the GE Schenectady Works. A well researched summary of Latimer's career can be found in Fouche, Rayvon. 2003. Black Inventors in the Age of Segregation. Johns Hopkins. Pp. 82-134**

reference is the announcement, accompanied by a picture, of his winning first prize in a “How to Avoid Shop Accidents” essay contest. He may have been hired to provide segregated care to injured black workers.[203]

Of the hundred "yard workers", less is known. A few do appear in photographs in the company’s Schenectady Works News . Six of them show up in the front row of a 1919 photo of the Transportation Department Team of the GE Baseball League. They all wear baseball uniform shirts of various origins, in contrast to the seven uniformless white men in the back row. Transportation Department work may have been a second job for players from Schenectady's recent entrant in the Negro League. With the aid of these possible ringers, the Transportation team achieved its best ever league finish in that year of 1919, barely beaten out for the championship by a team of Test engineers.

Four more young Black men appeared in a July 1919 Works News Photo. They were the Dixie Quartette from the Transportation Department. They offered “some good dancing as well as singing,” the caption explained. “Anyone who wants to give their associates a real treat should get in touch with these Transportation boys.” [204]

By contrast, in portraying White workers the emphasis in the company’s Works News was not on unusual talents, but on cheerful, complacent job satisfaction. A typical example was the cover story featuring “ Big Bill Riedy”, a.k.a. Boiler Maker Bill, shown in a photo using his air hammer to chip off rough spots from a boiler casting. He was described as"a mighty man...a good worker... Good natured always, Bill never complains."[205]

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[203] **The Crisis (NAACP Magazine), 7 April 1914. Works News 14 Nov 1919. p. 19**

[204] **Works News 25 July 1919 p. 14.Works News 25 July 1910, p. 10**

[205] **Works News 2 Nov 1923. P. 1**

Idwal Jones tried to dig a little deeper. He found among skilled workers workers both a pride of craftsmanship, and an awareness of insecurity. On the one hand,

> they were mechanics who had served their apprenticeship.... who wore celluloid collars, did their own figuring from blue prints, and managed, because of their tacit equality with bosses, to get home at least ten minutes before anyone else.

On the other hand,

> To be thrown out was the probable fate of every one of them, but none, save the eccentric, brooded overmuch on it. They cherished their egoism, which was a sort of gyroscope that flexibly held them to the track. Living amid machines and in a routine in which the scale and the micrometer were the inevitable masters, and a false stroke of the file might mean deprivation for their families, something rebellious in their hearts made them love the perverse, the odd, and the laughter makers who jeered at their dead gods.[206]

The number of those ordinary workers who were also card carrying union members is unknown. It was probably in the thousands, but a minority. The description of the strikes suggest, however that the majority of workers were, on repeated occasions, willing to follow dedicated union leaders out of the Works.

Many of the men who led them out, such as William Turnbull, Herbert Merrill, John Bellingham and Frank Dujay. were also leaders of Schenectady's Socialist Party. Yet while their unions could call several thousand workers out on strike, the Socialist leaders could , in the 1909 city election, convince only about one thousand of Schenectady's 13,000 voters to vote for their party. Yet in 1911 that Schenectady Socialist Party suddenly rocketed to control of the city government. What propelled this

[206] **Jones, Idwal. 1929.Steel Chips. Knopf. p.6, 60**

sudden rise? It was a dynamic Protestant minister turned muckraking newspaperman turned first time candidate named George Lunn.[207]

In 1901, Lunn, then 28 years old, had been called to the pulpit of Schenectady's oldest church, the First (Dutch) Reformed. He had grown up on a Nebraska farm, had volunteered for military service in the Spanish American War, had finished his studies at the New York Theological Seminary, and had served briefly in a Brooklyn church. He started at Schenectady energetically, but conventionally. He was most noted for leading a city revivalist campaign. Only gradually did his attention drift leftward. In 1906 speaking at Lyceum in Schenectady he could still say that "socialism is not the cure", choosing instead "the principle of democracy".[208]

By 1909, however, a First Reformed Church faction was accusing him of spreading socialism from the pulpit, and was demanding his ouster. A vote of the full congregation supported him by 280- 171. Then, however, the 20 member Consistory, the Church's ruling body, voted decisively, 18-2, that Lunn should go. (The two General Electric employees on that Consistory split on the issue, with engineer Maxwell Day supporting Lunn and accountant Ernst Berggren opposing him).[209]

Lunn resigned, and in 1910 redirected his charisma and energy at two new efforts: the pulpit of a newly created People's Church, and his own muckraking weekly newspaper, the Citizen. Here he made his first alliance with General Electric's union and socialist leaders. Harvey Simmons had both led that Dorpian Lodge of Machinists at the Works and run unsuccessfully for office on the Socialist Ticket. He now became one of the organizers and board members of the People's Church. Metal Polisher and IWW leader, and then General Electric foreman Charles Noonan had left the

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[207] **Buell, William.2019. George Lunn. Troy Book Makers. Esp. p 47**

[208] **Schenectady Gazette 16 Dec 1906**

[209] **Lunn's ouster is described in detail in the newspaper Cold Spring (NY) Recorder, 4 Dec 1910**

company in protest of the policies that, as foreman, he had been required to enforce. He was in 1910 chairman of Local Schenectady, the Socialist Party's small inner circle of leadership. He and IBEW bargaining agent Herbert Merrill now helped set up a company to support and manage Lunn's newspaper, the Citizen.

That newspaper's reforming fire was mainly aimed at local evils. This included corrupt County Supervisors siphoning off money from construction of a new County Office Building, and the monopolizing of the city's lucrative street paving business by a couple of politically connected contractors. Lunn did, however, occasionally take on General Electric. For example, he blasted company executive Hinsdill Parsons for seeking to make the city pay for a General Electric error. The company has supplied an electrically powered turbine pump to send water from the city's aquifer through the water supply pipes. When the pump proved inadequate, Parsons urged the city to build an expensive reservoir to remedy the situation. Under Lunn's protests General Electric eventually gave in and instead replaced the pump.[210]

Lunn and General Electric could also, however, take the same side. A prominent example was the six-for-a-quarter controversy. The Schenectady Street Railway Co. had been owned by General Electric. In 1904, however, it was sold to the Delaware & Hudson Railroad. At that time, riders could buy six fares for a quarter. In 1910, citing cost pressures, the fare was changed to a straight nickel a ride. Joining George Lunn in a demand for restoration of six for a quarter was General Electric's George Emmons. He said General Electric would not increase its work force in Schenectady without this transit fare relief. Addressing that six-for-a-quarter issue, Lunn proclaimed in early 1911 that "the City is in the throes of a panic which has been brought about by the thieves of BIG BUSINESS" He did not, however, mean General Electric. He meant the D&H and it's Street Railway, which had "squeezed out GE and is now squeezing Schenectady." [211]

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[210] **Citizen 1 July 1910, 17 Feb 1911**

[211] **Citizen 3 June 1910, 20 Jan 1911, p.1; 10 Mar 1911, 14 July 1911 p. 1**

Lunn also allied with General Electric on a national issue. The year 1911 saw the culmination of the campaign by the Republican administration of President William Howard Taft to use the Sherman Anti Trust Act to attack giant monopolistic corpporations. Targets, as earlier mentioned, included Standard Oil, American Tobacco, and General Electric. Should trusts be busted? Lunn said no. Economic logic, he argued in an editorial, endorsed the efficiency of these giants. They should be left big, so their control could eventually be transferred from stockholders to society as a whole, in the form of socialism.

On this antitrust issue the views of Schenectady's newest Socialist met those of Schenectady 's most famous Socialist. Charles Proteus Steinmetz had long been making a argument similar to Lunn's . He would put the idea this way in his 1916 book America and the New Epoch:

> The corporation may be considered as the first step toward socialism, and the industrial government of the nation by the united corporations as [a] preliminary and crude form of socialistic society.[212]

In his nearly 20 years working for a giant capitalist corporation, Steinmetz had not hidden his youthful Socialism. Nor, however, had he practiced it. As the manager of a dozen or so laboratory workers, he sought labor relations advice not from socialism's labor theory of value, but from his fellow capitalist bosses. When addressed in a letter as "Dear Comrade", he answered politely "Dear Sir." When he voted in local elections, he voted Republican.

A second hand but intriguing story suggests Steinmetz had departed even further from his youthful direction. GE employee Richard Arthur said he was told by Steinmetz's protege and close friend Ernst Berg that in 1905 Steinmetz had applied his mathematical skills to the stock market. He made

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[212] **Steinmetz, Charles. 1916. America and the New Epoch. Harper. p.166**

so much money that he was planning to retire and return to Germany. Then his winnings were suddenly wiped out by the crash of 1907. [213]

When, on April 7, 1911, Steinmetz spoke publicly for the first time on social and political matters, he did so not at a Socialist rally, but at the Schenectady Board of Trade. That was the meeting place of top city business men such as Willis Hanson and Henry De Forest, and General Electric leaders such as Albert Rohrer. Speaking to that Board of Trade's "largest assemblage of the year," Steinmetz chose as his topic The Vitality of Schenectady. "We have not kept step with the phenomenal growth of the city", he said. Though "we have an efficient board of health, board of education and police department," the street railway system poorly served the rapidly growing work force. Street lighting was patchy and of poor quality. The solution to all this, he concluded "is up to the citizens. You must be willing to contribute more money"

This program for a better Schenectady was not mere boosterism. It was a local version of a national trend called progressivism. Like Socialism, this program came in many flavors. Underlying them all was the concept of a constructive, professional approach to such urban problems as sanitation, schools, public transit, and health, education , policing, street railways and street lighting, all subjects highlighted in Steinmetz's speech.

Like streetlights and street railways, both of which GE sold, and on both of which Steinmetz had worked, progressivism was perfectly acceptable to GE. A short time after Steinmetz's speech, the Works Manager George Emmons, entertained a delegation led by Schenectady's Mayor, and including the leaders of the Board of Trade. They had come to protest the moving of one of GE's businesses, an Electric Transit Department, from Schenectady to Erie PA. Not to worry, Emmons assured them. There was plenty of work for everyone. The key was progressivism. As the reporter covering the meeting

[213] **Richard Arthur, Oral History, undated, HoH Collection, MiSci.**

put it " "Mr. Emmons, however, did strongly intimate that the company expected the city representatives to be at all times as progressive as the city desired the company to be."

Within two weeks, Steinmetz himself had accepted a second speaking engagement,. This time his intended audience was a new group called the Progressive Republican Club of Schenectady. That club had a definite meaning for progressivism. It was a new way of organizing cities called the Commission Plan. It would replace the current system of electing Aldermen by Wards with five Councilmen all elected city wide, on a non-partisan basis. The council would hire experts, chosen from a nationwide pool on the basis of their expertise, to run city departments such as sanitation education, and public safety. [214]

Steinmetz stated his "agreement with the progressive aims of your organization" and begged it to "give us an organization, which will utilize the economic laws of the modern industrial development for the benefit of all the nation." The vision of a government run by professional experts operating according to laws of economics had an interesting electrical parallel. The reason Steinmetz could not attend the next meeting of the Progressive Club was that he had been called to an important meeting in Chicago. Commonwealth Edison, Chicago's major electric utility, was finding that attempts to operate simultaneously its two newest power plants were accompanied by system instabilities that were potentially dangerous. Since General Electric had supplied the equipment, General Electric experts were called in to solve the problem.

The attendees included major executives of Commonwealth Edison and GE. Dominating the meeting, however, were Steinmetz and his protégé Ernst Berg, then chairman of the electrical engineering department of the University of Illinois. Their leadership was not due their place in the

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[214] **The details of Steinmetz's 1911 venture into Progressivism are in Wise, George. 2021. Steinmetz Between Socialisms. Blog of the Library and Archives, Schenectady County Historical Society.**

corporate hierarchy, which was relatively low. It was due to their command of the mathematical laws of alternating current electricity. At the meeting, Steinmetz spoke scientific truth to corporate power. When asked by a Commonwealth Edison executive about the current safety of the system, Steinmetz replied that "the safe performance so far owed more to luck than to good design."

Steinmetz and Berg proceeded to analyze the problem and present an answer. It consisted of the specifications for and placement in circuits of electrical components called reactances. The result was a technical solution to the instability problem -- and also another order for GE. This suggested an analogy. Because the problems of power systems were best solved by application of scientific laws a council of corporate executives must delegate to specialized electrical professionals the solution to electric power system problems. In the same way, because the problems of social systems were best solved by application of the " economic laws" mentioned by Steinmetz, a council of city leaders should delegate to specialized economic and social science professionals the solution to urban problems.

Lest one think that this analogy between electricity and progressive reform was unique to Steinmetz, or a figment of the imagination of a later historian, consider an nationally syndicated article that appeared in the Schenectady Daily Union just three days after those progressive club and Chicago utility meetings. In that article, a U.S. Senator from Iowa argued in favor of that Commission Plan. He illustrated his argument with his own version of the analogy. The old Alderman-ward system, he said, was inefficient and unwieldy, a product of unscientific tinkering like the old method of of powering factories with belts and pulleys driven by small steam engines. The Commission Plan by contrast, was scientific, streamlined and efficient, like the delivery of power via electricity in a modern factory.

George Lunn, not yet officially a Socialist, appears to have considered Progressive Republicanism. On 16 June 1911 a "Commission Government Association of Schenectady County" was created, with General Electric's

A.L. Rohrer as President, and George Lunn as a member. When the Progressive Republicans tried to gain control of the Republican City Committee, however, the party's conservative wing easily vanquished them. It gave the Mayoral nod to "Billy" Herron, a GE Works machinist and former member of the Dorpian Lodge of the IAM-- but one who had since taken a post as a General Electric foreman, and had his IAM card revoked by the Union. The Socialist Party now saw its chance. It had filled most of its 1911 electoral slate with party regulars. This included labor leaders Merrill, Turnbull, Noonan, Simmons and Hunt. With the collapse of Progressive Republicanism, Lunn was now available. Noonan and Simmons offered him the candidacy for mayor. Lunn accepted.

In the election campaign, Lunn's energy and oratory left his rivals, the Republican working man and a Democrat ward heeler, in the dust. Perhaps the only surprising thing about Lunn's decisive election day victory was how unsurprising it was to the city. On his coattails came in Herbert Merrill as New York State's first ever Socialist State Assemblyman, and a Socialist majority in the Schenectady Common Council, including Turnbull, Simmons, Noonan , and Hunt.

Who were the voters who multiplied the usual Socialist vote sixfold? A surviving 1911 Voter Registration Book records the party preferences of about three fourths of Schenectady's voters. Socialist registrants came preferentially from two groups: General Electric shop employees and voters of German and other eastern European descent. Socialism was strongly rejected by the main mid nineteenth century Catholic immigrant group, the Irish, who stuck almost unanimously with the Democrats, and by the small Jewish community, which stuck with the Republicans. The other major ethnic groups, the long time Dutch and the recent Italians, were average for the city in choosing Socialism.While expressing general tendencies, these results should not be taken as absolute . Among GE skilled workers, for example, previously encountered toolmaker Jacob Weller was no Socialist but rather one of the leading Prohibitionists of his Schenectady suburb of Scotia. Running for Overseer of the Poor in 1910, he promised “to attend to the needs of those who are deserving, while refusing those capable of

supporting themselves."[215]Similarly, among those of Irish descent, James J. Madigan indeed stuck with the Democrats in 1911. However, the unrelated Turbine Department foreman Billy Madigan registered Republican, while Enos Madigan, unrelated to both, not only registered Socialist in 1911 but subsequently served in that party's city administration.

The socialist sympathy of progressive Republicans, was most evident in the voting pattern of Schenectady's 11th Ward. That was the location of the GE Realty plot. It was normally overwhelmingly Republican. In 1911, however, It had been the center of the Progressive Republican movement that has temporarily attracted Lunn and Steinmetz. Though few of those 11th Ward residents switched to Socialist registration, many of them voted Socialist on that 1911 election day. Enough of them did so to come within 17 votes of winning this normally overwhelmingly Republican ward for Lunn. Those 1911 Socialist voters included some of General Electric's best and brightest. This included not only the company 's greatest engineer, Steinmetz, but also its greatest scientist, Irving Langmuir. Langmuir was one of 29 General Electric Research Laboratory employees who, in a 1911 laboratory straw poll, voted Socialist, This was more than twice the vote for either of the other parties. In contrast to these scientists, however, and to "Supreme Court" Steinmetz, almost all the 11th Ward's engineers who registered with a party did so as Republicans.[216]

None of General Electric's top executives appear in the voter registration book. The statements they later made about their new Socialist mayor were, however, sympathetic. General Electric's President Charles Coffin described Lunn in 1912 as " the best man who has ever been Mayor of Schenectady " and said he planned "to work hand in glove with him." George Emmons said of Lunn " I think he will try very hard to give us a good administration." To Emmons, the Socialist government was a welcome change from the corrupt politics of the old parties. "There has long been a feeling in

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[215] **Schenectady Gazette 9 Nov 1910**

[216] **Rosenfeld, Irving. 1960. The Quintessence of Irving Langmuir. Col 12 of Collected Works of Irving Langmuir. Pergamon. P. 94.**

Schenectady," he said, " that the Republicans and the Democrats were playing together. "[217]

More alarmed by Lunn's potential than those capitalists were Schenectady's most doctrinaire Socialists. On the very eve of his inauguration, Lunn had a Dickensian encounter with the ghost of Socialist future in the form of Charles Noonan. He was Chairman of Local Schenectady, the Socialist Party's central leadership. Noonan insisted on, and Lunn agreed to, the need for Local Schenectady to approve his administration's appointments.

Where possible, Lunn did hire capable Socialists. This included, as Commissioner of Charities, Walter Kreusi, the Socialist son of Edison associate John Kruesi, and a rising star in the field of social reform. As Corporate Counsel, Lunn chose Morris Hillquit, a successful lawyer and a national Socialist Party leader. As his Secretary, Lunn hired a recent Harvard graduate enjoying a brief Socialist phase before settling in as one of the 20th century's leading public intellectuals, Walter Lippman. When it came to a choice between competence and Socialism, however, Lunn chose competence. This was the case for the patronage-rich post of superintendent of street construction, for which Lunn hired a non-partisan expert from Milwaukee, Charles Mullen, instead of the local man proposed by Local Schenectady. .

In office, Lunn continued to vex doctrinaire socialists. His emphasis was on traditional progressive causes such as better schools, public health, parks, and construction of a garbage processing plant. This gained him that derisive label "sewer socialist", an epithet applied to Socialists who acted

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[217] **Coffin's remarks at in David I. Belle to Ralph Easley, Feb. 15, 1912. National Civic Foundation fi les. Quoted in James.Weinstein. 1967. The.Decline of Socialism in America. Monfhly Review Press. P. 81. Emmons' statement is in MY Evening.Post, 13 Nov 1911, quotedi in Bassett,Michael. Municipal Reform and the Socialist Party, 1910- 1914. 1969. Australian Journal of politics and History. 21. P. 18**2. **See also Jaffe, Julian F. 1972. Crusade against , radicalism. Kennicott. P. 21**

too much like mere progressives. Even when Lunn took steps toward public ownership, they were not directed at the city's giant capitalist corporation. Instead, he targeted the smaller local companies supplying the city with two energy essentals, ice and coal.

On labor issues, Lunn indeed vigorously intervened on the workers' side in a bitter strike, even to the extent of being arrested. That strike, however, occurred 56 miles up the Mohawk River at a textile mill in Little Falls, New York. When General Electric's Schenectady workers went on strike, in 1913, over the discharge of a pair of union organizers, Lunn was markedly less militant. Nor did he need he be. During the strike, a local newspaper reported " not an arrest was made; there was absolutely no disorder."As Republican Mayor Van Voast had done in 1903, Lunn chaired a meeting in his office between Emmons and the Schenectady Metal Trades Council. A compromise was reached which returned the two organizers to the Works, along with a promise by Emmons of no future discrimination against union leaders.

At the end of Lunn's first term, in November, 1913, the panicked old parties united behind a Fusion ticket that briefly returned the mayoralty to traditional political hands. When three-party competition resumed in 1915, however, Lunn again decisively won the Mayor's office. His also victorious running mate, as President of the Common Council, was Charles Proteus Steinmetz[218].

So, in conclusion, what might the experience with socialism and unions of GE and the the city of Schenectady suggest about the course of the nation's contentious politics and labor relations of the first two decades of the 20th century? The success of both socialism and unions in 1900-1916 Schenectady rested on the pragmatic approach of socialists, union leaders, and GE management. Indeed, the socialism might be viewed as a version of progressivism,, with the two leading figures Steinmetz and Lunn, nearly declaring for progressive Republicanism rather than socialim. In office, the

[218] **This election is covered in the Schenectady Union Star 27 Oct- 3 Nov 1915.**

Schenectady sewer socialists concentrated on the same small steps as their conventionally progressive predecessors.The majority of local union leaders stuck to craft unionism, rejecting more radical varieties. As for corporate managers, their need to keep production flowing led to a pragmatic acceptance of sewer socialist local government, and of craft unions, the least political and most pragmatic brand of unionism. This suggests that labor historians might look nationwide to see how often this pragmatic approach was chosen by workers and citizens over more radical versions of socialism and union organizaton.

The year George Lunn re-assumed office, 1916, marked a full generation, 30 years, for the General Electric Works at Schenectady. Edison's machine works had fled New York City to escape crowding, politics and unions. Now, in 1916, it appeared that all three had caught up with it. As for crowding, the Works had in 1886 employed 300, and in 1893 had forecast an expansion to 6000. Now, in 1916, it held 20,000 workers. The Works' more than 200 buildings filled to capacity the nearly square mile triangle of land between the recently deactivated original Erie Canal and the railroad tracks. Schenectady General Electric was one of the bigger, but not the biggest Works in the U.S. Some steel and auto works were bigger. It was, however, certainly the most versatile, making everything from tiny vacuum tubes that nobody had yet figured out what to do with, to the system controlling the locks of the new Panama Canal and giant turbine-generators producing an increasing share of the nation's electric power.

As for politics, as now a tax- paying corporate citizen of Schenectady, General Electric was now governed by a mayor dedicated, theoretically at least, to its ultimate expropriation. General Electric's giant size, explained General Electric Chief Consulting Engineer and Schenectady Common Council President Charles Proteus Steinmetz, was but a step toward the inevitable destination of Socialism. Finally, as for unions, the threat of radicals, such as the IWW, had been banished, but the presence of moderate AFL unions had been accepted. Works Manager George Emmons had proclaimed that "the trade unions are here and.they must be recognized and respected". Union leaders, in turn, accepted Emmons as a man with whom they could work.

In sum General Electric ran a bustling, crowded Works, surrounded by the anti - capitalist politics of Socialism, and infiltrated by the accepted presence of Unions. It had accepted the very trends it once had fled.

Or had it?

Ch 7 Good Growing Weather 1916-1923

On Oct 4, 1915, ranks of women singing the eight hour anthem led thousands of striking General Electric workers out of the Schenectady Works. Many of those strikers then gathered for a rally in Schenectady's Crescent Park. Among the speakers was machinist and strike leader Harvey Simmons.This was, he explained, a good time to go on strike. For General Electric had good reason to settle fast. It had just signed a $1.5 million contract, via purchasing agent Drexel Morgan & Co., to manufacture munitions for the British, French and Russian forces fighting in World War I.

Years later, novelist John Dos Passos would express the thought more poetically:

> Wars and panics on the stock exchange,
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> Machine gun fire and arson,
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> bankruptcies, warloans,
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> starvation, lice, cholera and typhus:
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> good growing weather for the House of Morgan.[219]

Good growing weather also for that creation of the House of Morgan, General Electric. Over the five years 1915- 1920 General Electric would record the greatest sales increase for any five year period in its entire history, a more than tripling from $86 million to $276 million . The only

[219] **Dos Passos, John. 1930. U.S.A. p.294**

comparable five years sales growth, also just over a tripling, occurred during the war years 1940- 1945. [220]

What did this good growing weather bring forth for the Old GE and Schenectady? That is the question this chapter answers.That tripling of sales (with profits restricted to a mere doubling, due to income and excess profits taxes) was only part of the impact of World War I on General Electric. Some 7000 GE employees, 2500 of them from Schenectady, would serve in the U.S. armed forces. Sixty four Schenectady Works employees would give their lives.

As the Simmons speech indicated, Drexel Morgan and GE had become heavily committed on the Allied side well before the U.S. entered the war. By 1915 the GE Schenectady Works was making things it had never made before, such as artillery shells for the Russian Army.[221]

The Morgan contracts also provided good growing weather for workers' wages. With the labor supply tight, the company increasingly relied on piecework to combine higher wages with even higher productivity. This kicked off a rise in wages and productivity that lasted well beyond the war. For example, over the ten years 1914-1924 the average wage for a worker in

[220] **For a general understanding of the role of U.S. industry in World War 1, this book relies on. Hawley, Ellis. 1992. The Great War and the Search for Modern Order. St. Martins. Cuff, Robert D. 1969. Woodrow Wilson and Business Government Relations during World War 1. Review of Politics. 31.385-407. Koistinen, Paul. 1967. The Industrial Military Complex in Historical Perspective: World War 1. Business History Review. 41. 378-403. Rockoff, Hugh. 2004. Until it's Over Over There. NBER 10580.**

[221] **The GE-Morgan contracts are in Box 6a Series 4000-5000 Contracts, FF 4036-FF4078. MiSci . Dated 1915-1917, they cover such topics as field artillery ammunition for Russia, and fuses and cartridge cases for Great Britain.**

the Schenectady Motor Department doubled to 67 cents per hour while the labor cost per motor fell by 15%.[222]

The Works had been a significant military contractor ever since that 1886 Edison Sims torpedo, but never before like this. As the U.S. began a rearmament effort in 1915- 1916, the U.S. Navy did not just ramp up orders for such established products as searchlights, shipboard generators, motors, light bulbs, turret drives and controls. It also became more receptive to new ideas.[223]

One such new idea had been brought to the Navy and GE in 1910 by independent inventor Reginald Fessenden. He was born in Canada, had worked for Edison, moved to Pittsburgh as a professor of electrical engineering and, briefly, as an employee of Westinghouse. He then worked for the Weather Bureau, and finally became a full time inventor entrepreneur. In this last role he combined a remarkable ability to come up with major new ideas with an inability to profit from them.

[222] **F.H. McKnight to General Electric Co. 27 May 1915, Secretary's File, Hall of History. GE Annual Report for 1915. Schenectady Wages. Shop Cost Indicator - Motors. 5 Dec 1924. Swope Papers.**

[223] **A Summary of GE's World War 1 Work is in a series of articles in the magazine GE Review, 1919.**

Fessenden addressed ship propulsion. By 1910 steam turbines were being used to drive ship propellers directly through mechanical gears. In his agreement with GE in 1900 that put GE into the turbine-generator business, Charles Curtis had reserved for himself this use of turbines to drive ships directly. So GE was receptive in 1910 when independent inventor Fessenden proposed his alternative. Use a shipboard turbine generator to produce electricity that would be sent through wires to an electric motor driving the propeller. Beside evading Curtis' reserved patent rights, this indirect turbine drive method also had benefits. Turbo electric drive could transmit power more reliably and efficiently than the gears available in 1910. That higher efficiency translated into a larger radius of action for a navy now seeking to operate on a full two ocean scale. In addition, electric drive allowed the turbine generator to be nestled in the bowels of the ship, protected from enemy shells. These advantages had to be balanced against a slightly lower top speed and a higher initial cost compared to direct turbine drive.

GE assigned Fessenden's idea to an engineering team led by turbine expert William Le Roy Emmet. The technology looked promising, but marketing proved difficult. Navy leaders preferred to use a direct drive turbine system proposed by a retired chief of naval engineering and developed by Westinghouse. It was scheduled for tests driving a new collier. GE and its Washington lobbyists managed in 1912 to secure an extension of that trial to three colliers. One would have the Westinghouse direct turbine drive, one the GE turbine electric drive, and one a conventional steam engine drive. In the test, the GE system decisively outperformed its rivals. The timing was opportune. The still neutral U.S. was about to commit to rearmament. After a bruising political and lobbying battle, the navy decided in 1915 to equip the first of its new battleships, the New Mexico, with GE turbo-electric drive. This seemed to be the opening of a long term multi- million dollar opportunity to equip the next generation Navy . The next four battleships and the next four cruisers were then scheduled for electric drive. Longer

range plans called as many as 19 electric drive warships. For GE it was the inside track to a big new business-- if the good growing weather held.[224]

Earlier, an even more visionary idea, had also been brought to GE by Fessenden. It dated back to 1903, and addressed a weakness of the new technology of wireless telegraphy.

In 1903, wireless dots and dashes were sent by striking electrical sparks. This achieved transatlantic range but made inefficient use of the electromagnetic frequency spectrum. Each different spark system produced a wide range of frequencies, overlapping and interfering with others. Fessenden proposed instead sending the signals by changing the amplitude of a continuous electrical wave produced by a very rapidly rotating electrical alternator (AC generator). This would restrict the signal to a narrow frequency range. This idea had occurred in the 1890s to other scientists and engineers. Some dismissed it as impractical. Those who tried it could not achieve the very high rotating speeds needed for radio signals. Such an alternator would have to spin thousands of times as fast as one used to generate electricity. This put very severe strains on the alternator 's materials and structure.

Fessenden planned on 1902 to make such an alternator not in his own workshop, but by placing an order with an experienced alternator manufacturer. He first tried his former employer, Westinghouse, but was turned down. Next trying GE, he succeeded in interesting Steinmetz. A 1903 alternator built to Steinmetz's design at Schenectady fell short, but showed enough promise for Steinmetz to turn the effort over to a protege, Ernst Alexanderson

Alexanderson had been well educated in electrical engineering in his native Sweden and in Germany. He had come to the U.S. just after 1900 for

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[224] **McBride, William. 1992. Strategic Determinism in Technology Selection: The Electric Battleship and U.S. Naval Industrial Relations. Technology and Culture. 33. 248-277.**

economic opportunity, then moved to Schenectady specifically to work with Steinmetz. Perhaps as impressive as his technical virtuosity over the next few years was Alexanderson's ability to work both productively and harmoniously with the tempestuous Fessenden, who normally left behind him the debris of wrecked technical, business, and personal relationships.[225]

On Christmas Eve, 1906, Fessenden sent out from his laboratory on Brant Rock MA, using an Alexanderson alternator as a transmitter, the world's first radio broadcast. Ships' wireless operators heard, instead of the usual dots and dashes, the voice of Fessenden and the strains of his violin.GE now possessed the world 's best wireless transmitter. It did not, however, leap enthusiastically into the wireless business. Instead, it required the enthusiasm of Alexanderson, Steinmetz, and a few other GE leaders, such as lighting department manager, Edmund Edwards and sales executive Caryl Haskins, to keep the project barely alive. From 1906- 1914 GE sold perhaps a dozen alternators, all for experimental purposes, and mainly to Fessenden's ultimately unsuccessful communications company, NESCO. [226]

By 1914, however, good growing weather for alternators had arrived. Germany, fearing correctly that in a war Britain would control undersea telegraph cables, had developed its own alternators. One, placed at the German company Telefunken's station at Sayville, Long Island, quickly gained a sinister, probably much exaggerated, reputation for transmitting warnings to German ships and espionage results to the homeland. This got the U.S. Navy interested in alternators, of which Alexanderson's was the U.S. best. All this at last helped GE land major customers. By 1917, a 50 kw Alexanderson alternator was in operation at the New Brunwick, NJ wireless staction of the British Marconi Company, proving itself superior to that company's old spark transmitters. A 200 kW model was under construction. GE was by 1917 clearly in the wireless business. Marconi expressed a

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[225] **Brittain, James. 1992. Alexanderson. Johns Hopkins.**

[226] **Neil Reynolds Collection, Box 1, Folder 8, Series 1. Extracts from Sales Committee Minutes. P. 31.**

desire to become the sole buyer of Alexanderson alternators. The request would soon have big repercussions.

Even as alternators were becoming a business, back in Schenectady, a team of researchers was unwittingly targeting radio alternators for early obsolescence. This second and longer lived GE entry into wireless would branch off the Edison Elm from light bulbs.[227]

In 1912 Coolidge and Langmuir each got a burst of research freedom as a reward for their commercially valuable light bulb successes. They picked new targets for their tungsten and theorizing. One of the suspects in the case of light bulb blackening had been a process called the Edison effect, named after an 1880s discovery by the Wizard himself. Choosing to explore it was Irving Langmuir. As part of that exploration, in the fall of 1913, Langmuir attended in New York City a meeting of the American Physical Society. There a British physicist, Owen Richardson told how new physics explained the Edison effect. Richardson's mentor, British physicist J.J. Thomson, had earlier identified the elementary particle of electricity, the electron. Richardson had subsequently explained the Wizard's discovery. Hot light bulb filaments "boiled off" electrons into the surrounding vacuum. For this discovery Richardson would win the Nobel Prize. Langmuir, however, greeted the discovery with skepticism. Langmuir and Coolidge had done experiments on heated tungsten components in very high vacuum, and had not observed the sort of electricity flow that Richardson's theory predicted.

Langmuir invited Richardson to Schenectady. Preparing for that visit, two important events occurred. First, Langmuir repeated his experiments and found that Richardson had been right. The currents were present, just much smaller than the Richardson theory predicted due to a sort of electron traffic jam effect. Just at the same time, in October of 1913, Ernst Alexanderson learned about, and told Langmuir about, a device called the Audion invented back in 1906 by a Ph.D. physicist turned independent inventor named Lee

[227] **The following story relies on Wise, George. 1986. Willis R. Whitney. Columbia.**

Dr Forest. It had recently been licensed by AT&T for telephone use. In this light bulb looking device the filament was accompanied by two other electrodes, one to receive the Edison effect current, the other to control it.

Langmuir quickly produced mathematical models based on his experiments and the earlier work of Thomson and Richardson. Those models not only explained how that Audion worked, but also showed how to make it work better. This included operating it in a higher vacuum and using new electrode arrangements and higher voltages to overcome that electron traffic jam effect. This brilliant work educated the world about the physics of the vacuum tubes that created the first electronics revolution. Langmuir's theorizing was not however, an invention. As AT& T later correctly claimed, it was scientific knowledge providing a guide to better use of De Forest's patent. One of AT&T's physicists, working independently of Langmuir, came up with the same model and used it in the same way that Langmuir did . That work turned De Forest's invention, the Audion, from an erratic curiosity into the building block of that first electronic revolution.

Blocked by the De Forest patent, GE had perhaps the world 's best vacuum tube technology, but no legal way to make money from it. The company's patent attorneys did their best to break the De Forest -AT&T monopoly. They depicted Langmuir's work as the invention of a new class of devices called "pure electron discharge devices". They even invented a new language for naming these devices, a language dubbed by a GE physicist "Greco-Schenectady." It combined the suffix " tron" with a prefix indicating the tube's controlling force. Examples included, "magnetron", "kenotron", and "pliotron", the last being Greco-Schenectady for GE’s rival to the De Forest's Audion. This legal and semantic hand waving kept the courts busy for a decade, before finally accepting AT&T's more sensible version.

By then the good growing weather of war had accomplished for GE what attempted Greco-Schenectady misuse of the patent system could not. When the U.S. entered the war in 1917 it learned that the British and French had accomplished their own first electronic revolution. Electronic devices similar to those of GE and AT&T were in use at the battle front. The U.S. government immediately paid GE to mass produce vacuum tubes based on

the French military version. Using skills built up over four years at its Research Lab, GE was soon producing thousands of vacuum tubes a day at the Schenectady Works and at its Harrison NJ and Cleveland OH lamp plants. When the end of the war threatened to put an end to this production, the government, as will be seen in the next chapter, stepped in to keep it going. [228]

Meanwhile, back in 1913, Coolidge had applied Langmuir's model to build an X-Ray tube. It combined tungsten electrodes, high vacuum, and a pure electron current. It quickly showed sharply superior performance to previous X-Ray tubes. GE was not, however, in the X-Ray equipment business. It had earlier been in that business, but dropped out. This was not because X-Ray equipment was too hard to build, but because it was too easy. A giant corporation's scale gave it no economies over smaller manufacturers.

Again the war provided good growing weather. The U.S. Army, seeking a portable X-Ray system for use near the sites of battles, paid GE to develop one, based on the Coolidge tube.So when the war ended, GE had not only the world's best X-Ray tube, but also, thanks to its Army contract, a well engineered system to use it in. That “X-ray outfit”, a GE publicist wrote in 1920, “rendered service of a high order in the European War.’ He added that GE’s “new and more compact outfit is the peace outgrowth of that Army set.”[229]

The Coolidge tube’s high-tech production requirements now rewarded economies of scale . It was protected by Coolidge’s patent. (A German inventor had claimed the same invention in an German patent issued earlier than Coolidge's American one. His U.S. claims were, however, taken over after the war by the U.S. Alien Property Custodian and not pursued.) In 1920 GE bought a major X Ray Company, Victor X-Ray of Chicago. Thus was

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[228] **Details of the GE vacuum tube story are in The Development by the GE Company of Radio Receiving Tubes. CONFIDENTIAL. 1 Mar 1924. MiSci.**

[229] **Works News 16 July and 10 Dec 1920**

born GE Medical Systems, later renamed GE Healthcare, one of the three companies that would in the 21st century succeed the New GE.

Electric drive for ships, alternators for wireless communication, vacuum tubes for electronic communication and control, and X-Ray tubes of unprecedented performance were just a few examples of the way engineering and research excellence were amplified by wartime good growing weather into business opportunities. Another example was work at Lynn MA by GE engineer Stanford Moss. He convinced the U.S. Army to support development of airplane superchargers enabling high altitude flight. It would take another war, however, to convert this success into a GE business. At Schenectady, military request for high speed recording of wireless messages and instrument readings led GE engineer C.A. Hoxie to develop a way of converting those signals into a light wave that could be imprinted onto a paper tape or photographic film. In the 1920s this would be one of the ways sound was brought to the movies.

Finally, another Reginald Fessenden invention led to a pioneering effort at industry -university- military cooperative R&D. Here GE and AT&T researchers, rivals in the patent law courtroom, teamed up with the Navy and university physicists at Nahant MA to develop better methods for detecting submarines. The team included GE's Coolidge and Langmuir, and drew on suggestions from British physicists, including the great Ernest Rutherford. With remarkable rapidity and efficiency, some promising methods were developed and went into experimental use. Those methods, some purely acoustic, some electronic, were too late to effect the course of the war. They did result in at least one unconfirmed, most likely erroneous, claim of a submarine sinking. More important they offered a head start on combatting future outbreaks of the submarine menace. Sadly, the participants, including GE, failed to follow up adequately in the 1920s and 1930s. This left the US nearly as unprepared for the submarine menace in 1941 as it had been in 1917.

The antisubmarine story typifies the U S.'s arsenal of democracy efforts in World War I. The efforts of American companies , workers, engineers and scientists were impressive. The duration of U.S. participation in the war was,

however, short. Too short for the mounting flood of U.S. production to reach the front. Americans soldiers went into battle behind barrages by British artillery. American pilots flew French planes. Combatting the submarine was a British effort, relying on the convoy system, not new gadgets.[230]

That anti-submarine project was one of the few effective initiatives of the Naval Consulting Board, a much ballyhooed 1915 effort to put the giants of American ingenuity to work combating that submarine menace. It was formed just after the German sinking of the liner Lusitania had taken the lives of 128 Americans. Members of the Naval Consulting Board included Thomas Edison and GE's Willis Whitney and William Le Roy Emmet . Conspicuous by his absence from that board was GE's, and perhaps even the nation's, most publicized engineer, Charles Proteus Steinmetz. This was not due to doubts about his technical eminence, but to doubts about his loyalty. Steinmetz's outspoken prewar opposition to the U.S. tilt away from neutrality and toward the Allies-- a tilt evident in that munitions production at the Schenectady Works - drew national comment . "Steinmetz, exile from Germany, sides with her in war" read a headline in the New York Times on September 13, 1914.

Steinmetz's major local effort was a May, 1915, chairmanship of a Pro-Neutrality mass meeting at Schenectady. With its German immigrant chairman, and with its principal speaker being a champion of Irish independence, the meeting was strongly anti-British rather than pro-German. Its timing however, was bad. The meeting was held just four days after the sinking of the liner Lusitania with the loss of many American lives. Schenectady supporters of the Allies proceeded to brand Steinmetz as a pro-German danger . One GE engineer took this to the extent of informing the predecessor of the FBI, without any accompanying evidence, that Steinmetz was a German spy.Such completely erroneous suspicions may

[230] **Herman, Arthur. 2012. Freedom's Forge. Random House.**

well have kept Steinmetz off that Naval Consulting.Board. They appear, however, not to have hurt his popularity in Schenectady. In the Fall of 1915, Steinmetz decisively won election as the city's Common Council President, a sort of vice-Mayor.

Almost immediately however, the winning Socialist team of Mayor George Lunn and Steinmetz split apart over that neutrality issue. While Steinmetz stuck to Socialism and anti-British neutrality, Lunn declared for the Democratic Party's advocacy of strong rearmament and a tilt toward the Allies. Lunn would be elected to the House of Representatives in 1916 as a Democrat. Never again would a Socialist win an election in Schenectady.

So World War I delivered the final blow to the Schenectady Socialist Party. That party was, however, already on the way to extinction before that blow struck. That 1915 Lunn -Steinmetz victory was a salute to two popular citizens, not an endorsement of Socialism. The Socialist Party, which had held a majority on the 16 member Common Council as recently as 1913, held on in 1915 to only two of those 16 seats.

Schenectady Socialism's sudden fall was in part due to a conflict between the doctrinaire Socialists of the party's inner circle, called Local Schenectady , and Lunn's "sewer socialist" faction. In April, 1915, this led to physical violence at a meeting of the Socialist County Committee at Steinmetz's home laboratory. This escalated into a movement by Local Schenectady to expel Lunn from the Socialist Party. This narrowly failed, but in the process fatally damaged both factions.

Working class Socialist political leaders, such as GE Turbine employees John Bellingham and William Turnbull turned away from politics and returned to union organization at the Schenectady Works. For this effort, World War I provided, briefly, yet another kind of good growing weather. This came in the form of a new U.S. Government agency, the War Labor Board. The Board's main purpose was to prevent strikes from hampering the war effort. The Board's chairmen, ex-president William Howard Taft, and progressive lawyer Frank Walsh, chose to do this by consensus and conciliation.

This government policy complemented the policy George Emmons had already been following. In the Spring, of 1918, Emmons called union leaders to his.office. "Now, boys," he reportedly said, "if you will come to me with a reasonable proposition, I will put it to our people and I think I can put it over." By a reasonable proposition he meant a pay raise of 10%. The Union leaders came back with a proposal for a 25% wage increase coupled with a reduction in weekly hours from 48 to 45 . The resulting impasse was not fought out by a strike. Instead the War Labor Board came to Schenectady in 1918 to take testimony and reach a ruling. This testimony is a boon to historians. Drawing mainly in that testimony, supplemented with a few other sources, ranging from General Electric's publicity to that Idwal Jones novel, a picture of the early 20th century GE Schenectady Works emerges[231]

A day at the Works began in darkness, long before even the first trolley ran. Some 100 scrubwomen, such as Mrs. Abbie Richmond, walked in, sometimes a mile or more, to arrive at 5 AM. "If we are late, they scold us," she said. " If we are kept from reporting they dock us a day's work. " For a thirty hour week of sweeping, mopping, dusting, and cleaning lavatories she earned $6 a week. It went toward the support of nine children, "one of them a soldier in France."

As she was completing her morning.work, light was filtering down through the skylights, girders and overhead crane tracks. The world's greatest electrical works still depended heavily on natural light for illumination. By 7:20 AM clanging trolleys had already discharged streams of shop workers, many of them makers of the very motors that powered those trolleys. Half an hour later, the white collar run arrived , carrying clerks, bookeepers, draftsmen, and.engineers.On the grease stained wooden block floors of dozens of shops, the workers took their places. Around them, sound rose like an orchestra tuning up. The hollow roar of steam filled the pipes.

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[231] .**The following description of life at the Works combines Hearings of the General Electric Co. Before a Section of the War Labor Board, 22 June 1918. National Archives RG 2. WLB Case Files. With excerpts from Idwal Jones. Steel Chips.**

Chains clanged and compressed air pipes hissed. The thundering roll of the overhead cranes joined in, accompanied by the rat- tat of pneumatic hammers, and finally the rasp of metal from the meeting of cutting tools and gigantic castings rotating in great electrically driven machine tools. All this was punctuated by explosive bangs from. "squirming blue hot chips that, every five or six yards, broke off with loud reports, and bounced crazily on the floor like cobras. "

Those spectacular sound effects were typical in Building 60, where the steam turbines were being made. On that factory floor machinist William Turnbull, now returned from a stint as a Socialist city Alderman, worked alongside his chief foreman, company loyalist Billy Madigan. All four of Madigan's sons had enlisted in the armed forces. One was already in France.

In the second biggest manufacturing effort at the Works, electric motor manufacture , the sound symphony, though ever present, was more muted. The workers were regarded as steps below the elite turbine machinists. "We were told we were unskilled", said coil winder R.P. Wilkie. He went.on, however, to relate how he noticed, in instructions passed on to him by his foreman, that the design engineer had made a mistake. "All of us knows what works around there," he said. " we always carry a little record book of windings and spools and forms, " he explained. "I found out that this coil was wrong, and took it to the assistant foreman and showed him that this work was wrong."

Down through the job categories ranged the ranks of men and women, clearly marked by a pay level, typically in the range of $15- $35 a week. Increasingly, that pay was not a wage, but a piece work target. Working conditions ranged widely, in heat, strain, repetitiveness and even sometimes altitude. For example, in the intense heat of the Foundry, exhausted foundrymen poured molten metal into containers and hurriedly carried that hot heavy load to the sand molds. In Building 17, machine tenders stood all day long at giant presses that punched laminated motor disks out of sheet steel hundreds of times a minute.

Overhead might be seen painter Harvey Sanders, working 30 feet up on a swaying scaffold. Also at high altitudes, in the upper reaches of cathedral shops such as Buildings 10 and 12, lordly crane men piloted their cabs along steel rails with the dignity of locomotive engineers. Down below, lowly crane followers hitched steel ropes, descending from the cabs to the part to be moved. One hopes they did so with care. Fully half the Works' 1400 annual accidents (only two of them in 1916 fatal) resulted from improper lifting or securing a load.[232]

Other dangerous conditions, such as airborne metal particles and noxious vapors, were still present where the Metal Polishers worked. Now, in 1918, serving as their assistant foreman, and returned politically to the ranks of the Republican Party, was former Socialist, strike leader, and IWW organizer Martin Clune. He now also served as Chairman of the of GE's Committee of 1000 promoting the sale of War Bonds. Martin Clune's son Donald, a shop worker in the GE Controls Department, had enlisted in Schenectady's Company E of the 105th Infantry. In 1918 he was in action in France. [233]

Those shop men who remained at the Works typically earned enough to support a family in good times, though little or nothing to save for the bad. The shop women received far less, perhaps half as much for similar skill demands. Their pay was assumed to support a single woman, still living with parents, or to be family supplement, not support-- assumptions not always correct. Ruth Rice, for example, supported herself by running a drill press for only $9 a week, of which a dollar was taken out to buy a War Bond in a plant-wide campaign that was only nominally voluntary. Catherine Kennedy

[232] **Works News. July 1917. P.8.**

[233] **Schenectady Gazette 12 Jan 1915. Works News Jan 1918,Vol. 2 p.6. Schenectady Gazette 27 Feb 1920 p. 18** .

told how she had to support her husband and family on her coil-winder's pay of $15 a week.

George Emmons objected. These wages were low because these "young girls" were still learning. The " old girls " did much better. Charlotte Ross, a Works veteran, disagreed, speaking at first too softly for Mr. Taft to hear. Speaking up, she told how she had been seven years in the.Wire and.Cable Plant and.still took home only $11 a week. A few women did move into the empty places left by those men who enlisted. An estimate by a GE executive in 1917 that women would move into thousands of former male jobs, however proved a great overestimate. A 1918 study at the works found only 65 women doing what what was traditionally designated men's work. The number of women did increase by hundreds. This was, however, mainly due to increased demand for work traditionally done by women, such as coil wimding, or new jobs in their way to becoming women's work such as assembling electronic vacuum tubes.[234]

Moving beyond the shops, more than 4000 men and women worked in the offices. There the surface appearance of white collar privilege masked a life of demanding work at a lower pay scale than in the shops. For example, John Murray had started eight years before in the shops at a daily wage. He worked his way up to a piece work slot paying "fairly good wages,"

Then the lure of a white collar caused him to transfer to the job of cost clerk in the production department. This proved disppointing. He missed out on the rapid rise in shop wages, and his request for a return to the shop was denied.

The office workers began belatedly, in about 1915, the same response that the shop workers had carried out more than a decade earlier. They were in the process of forming a Stenographers', Typists', and Bookeeper's Union.

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[234] **Mark L .Obenauer, "Investigation into the Displacment of men by Women," 17 July 1918, in Hearings of the General Electric Company Before a Section of the War Labor Board, 22 June 1918. Case #20.**

So far, however, it had achieved neither results nor recognition. "It is really getting the clerical work force, I might say, warm under the collar," said bookkeeper Scott Uecker, "to see the shop workers get so many raises, raise after raise, while we remain stationary."

On the other hand, the offices and laboratories were places where women's work expanded, slowly, but irreversibly, beyond traditional boundaries. In the offices, as early as 1910, women had become not just stenographers, but also bookeepers. Examples were 46 year old Ellen Pipper, 21 year old Anna Seeley and 38 year old Nellie Bekenie. At the GE Research LabEdna May Best, a recent MIT grad, was in 1902 researching light bulb filaments. In the process she became perhaps GE's first woman professional in science and technology.[235]

One last group at the Works, though numbering in the thousands, remains invisible. These were the laborers,a group made up increasingly of immigrants from Eastern or Southern Europe.They were rarely called on for testimony, perhaps because their English was halting or even nonexistent. Former machinist Idwal Jones, condescendingly described the laborers as remote and foreign; men with "heavy feet swathed necks, and faces grey with morning pallor" or "simple ox- like beings with China-blue eyes lined with awareness of ignominy."[236]

For all these workers, from the newest, least skilled laborer to longest serving most irreplaceably skilled tool and die maker or patternmaker, the long exhausting work day would finally conclude, nine and a half hours after punching in, often in outside darkness. Even inside one of the great cathedral shops, if one leaned over the gallery rail and looked below

> it was a crater of blackness at this end, distant from the lighted machines; a gloomy well, with phosphorescent gleans over motors.

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[235] **1910 U.S. Census, Schenectady Ward 1, Dist. 177, Sheet 3A. Wise, George, 1986. Willis R. Whitney. Columbia**

[236] **Jones, Idwal. 1929. Steel Chips. Knopf. P.7.**

> Two Government jobs, marine turbines were humming like giant bumblebees. The sleepy test-engineers, stumbling around them with late-night in hand to read the thermometers that were stuck on the bearings with putty, would keep their watch until dawn.

Like that envisioned ordinary work day, the War Labor Board investigation would also eventually come to a close. Not, however, before the Board heard the company's side, as presented by George Emmons. As usual, his tone was reasonable and conciliatory. He presented figures indicating that workers' wages had gone up more rapidly than the local cost of living (while not mentioning that General Electric sales and profits had gone up even faster). He alluded briefly to the sacrifices be made by American boys fighting for their country in France (leaving it to his listeners to make the comparison to workers safe at home while receiving rising wages)

After all that testimony, the War Labor Board returned a mixed decision. It ruled in favor of a wage increase for all shop workers. The women were to get a higher proportionate increase than the men due to past inequities, though the Board did not require equal pay for equal work. At the personal urging of Taft himself, Abby Richmond and her fellow scrubwomen got a substantial raise.On the other hand, on the size of the men's pay increase, the Board ruled for Emmons' 10% raise rather than the worker's proposed 25%. The office worker's petition was ruled to have been submitted too late for consideration.

In all, the rulings left labor relations at the.Schenectady Works about where the War Labor Board had found them.The unions could conclude that their informal bargaining relationship with Emmons had been ratified. It now had the endorsement of the Government through the War Labor Board. Emmons could conclude, conversely, that the.decision left his company in full control of how it ran its Works. Both sides could perceive, if not a happy, at least a satisfactory ending to recent labor strife. Any such conclusion, however, was rapidly overruled by another ending: the end of the Great War.

As that ending approached, Martin Clune became one of the most popular speakers at the works, extolling the war effort and selling those war bonds. At the same time, Donald Clune was advancing across France in the drive of the 105th Infantry to pierce the Germans' Hindenburg Line. On Sept. 25, 1918, less than two months before an Armistice ended the fighting, Donald was killed in action.[237]

That Armistice of Nov 11, 1918, while not officially ending the war, was the beginning of the end for the War Labor Board. The Board did deal with some post Armistice appeals, including one from the Schenectady Works unions, which it ruled against. By 1920, however, the War Labor Board had faded away. At Schenectady union leaders such as John Bellingham had a plan to lock in the union acceptance that the War Labor Board had supported. This was a single industrial union representing all the workers at the five biggest GE plants, Schenectady, Lynn, Pittsfield, Erie and Fort Wayne. The union would encompass the great majority, perhaps three-quarters, of GE's shop employees.[238]

Had the war, and the War Labor Board, lasted longer, say as long as World War II, this plan might have worked. The U.S. was, however, in World War I for only 1-1/2 years, compared to the 4-2/3 years of World War II.The plan for the Electrical Workers Union was put underway just before the November, 1918 armstice. Before it really got going, growing weather for unionism suddenly turned bad. By the beginning of 1919, the.U.S. was already cancelling military orders and winding down the War Labor Board. GE no longer felt the need to conciliate workers.

Bellingham led a meeting at GE's Erie PA Works in December, 1918, to begin the organization of the new union. This was immediately followed by a strike at Erie. The workers there asked workers at other GE plants,

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[237] **Works News Feb. 1919 Issue 2, pp.6**

[238] **McCartin, Joseph N. 1987. Labor's Great War. U. North Carolina, pp. 41-46, 123-129.**

especially Schenectady, to support them with sympathy strikes.This created a dilemma for Bellingham and the industrial union leadership. GE was in a good position to withstand a strike, given the sudden armistice driven drop in business. On the other hand, failure to support Erie would surrender the momentum for creation of one big GE union.

Bellingham and the Schenectady unions chose to support the strike. In this, they failed to gain the support of either the AFL or the IAM national leadership. Nor would they be met with the accustomed pragmatic, conciliatory reaction of George Emmons. Instead, Emmons treated the strike not as about issues at the Works, but as a sympathy strike. This type of strike was one on which GE had consistently refused to compromise. Rather than bargaining, Emmons announced coming layoffs."The General Electric Company", he explained "preferred conservative unionism to the Bolshevism tendencies of some groups of workers." He also encouraged a workers anti-strike campaign. [239]

Over the opposition of the national officers of the AFL craft unions, Schenectady workers overwhelmingly approved Bellingham's motion to go on strike. The strikers stayed out for a winter month. The company, taking advantage of slack demand, held firm, and won a total victory.A subsequent appeal to the War Labor Board was unsuccessful. The Board accepted the Company's position that this was a sympathy strike, refused to step in, and then went out of existence.

This was the last major Works-wide strike in Schenectady for more than two decades. A small but determined single-craft strike did follow. The iron molders went out at Erie, Lynn and Schenectady in the summer of 1920. At Schenectady some 400 workers stayed out for 10 months. This proved long enough for the company to decide to close its Schenectady iron foundry. For two years, Schenectady GE bought castings from outside vendors, until

[239] **David Montgomery. 1979. Workers Control in America. Cambridge. pp. 444-452. Albany Argus 23 Mar 1919.**

it was able to reopen the foundry on a non union basis, hiring back only half the strikers.[240]

Those episodes appears to have resulted in a selective, rather than a general, purge of union leaders. That the purge was selective was not just a GE claim. It was verified by the Socialist newspaper the Citizen . In addition, a later look at a sample of a dozen top leaders of unions at the Schenectady Works found six of them still listed as GE workers in 1925. This was not too different from the turnover rate for all workers. Still on the GE payroll in 1922 were, for example, the two leading unionists, John Bellingham and Bill Turnbull.

So, what did this good growing weather of 1914-1919 bring forth? Summing up those years, good growing weather for GE had been bad growing weather for unions and for socialism. The 1920s would see both reduced to the minor status they had occupied before 1900. This did not, however, represent, either for the city or the company, a complete reversion to past policies. In the city, the gains of decades of progressivism would be retained and extended. These gains, achieved not only by the Socialists but by their progressive predecessors and successors , ranged from professional police and fire departments to a clean and abundant water supply to better public health and education, to making such hazards as the stagnant Erie Canal and street level railroad crossings things of the past. For GE, management attitudes would not freeze into the simple anti-union attitudes of the most reactionary parts of U.S. business. Instead, a new management, would adopt a professionalized version of George Emmons's flexible pragmatism.

During that 1910- 1920 decade, GE had taken advantage of the good growing weather to add new works and factories at new new locations. For example at Bridgeport CT, an arms factory built to meet wartime demands became empty in the post Armistice cutbacks. It became over the next two

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[240] 1 **July 2 1920.Butler County Press Hamilton OH July 2 1920 p.1. Albany Knickerbocker Press 17 Oct 1920. The ending of the strike is described in New York Herald Tues 17 May 1921.**

decades one of GE's major Works. The GE Schenectady Works was by 1921 just one 40 GE manufacturing locations stretching across the Northeast U.S. in an arc from Baltimore to Chicago. It was still the biggest of those works, but had fallen in relative size from over one-half of GE employment in the 1890s to under one-third in the 1920s.

In its first generation, GE sales had multiplied by a factor of 12, from $20 million in 1892 to $240 million in 1922. Over those same 30 years, the U.S. GDP had multiplied by a factor of only 2. GE had retained its dominant role in a booming electrical manufacturing industry while expanding well beyond that industry. This expansion in scope followed from GE's continuing reliance on the fast follower strategy. In this strategy, the main role of research was not discovery, though discoveries of up to Nobel Prize quality would be made. The more important role of research was to be smart and knowledgeable enough to understand new inventions made anywhere, pick the ones likely to lead to profitable products and productive processes, follow fast, and where possible pull ahead. Researchers could leave it to the lawyers to turn this fast following into (sometimes dubiously valid) patents.

Wartime government funding supported, amplified, and speeded up this exploitation effort. By 1920, GE seemed poised to step into such new areas as electric ship propulsion, airplane superchargers, radio, vacuum tube electronics, sound movies and medical diagnostic equipment. GE had proved itself a critical resource in time of war. Its new technological and managerial initiatives of those war years 1914-1920 were not due to new management strategies. They were adaptations to the social, political, economic, and global constraints of those war-dominated years.

The war also had assured the failure of two challenges to the capitalist order, unions and socialism. The individuals who had led those challenges faded into the background. George Lunn became a conventional Democrat politician. He rose to the post of Lieutenant Governor of New York, then lost the Gubernatorial nomination to newcomer Franklin Delano Roosevelt. The one-time Socialist firebrand then settled for a state political appointment and a home in the GE Realty Plot.

Onetime socialist and labor radical Martin Clune, now a full foreman, became in 1920 Chairman of the GE Schenectady Works Foremens' Association. In March, 1921, he and his family went to the Schenectady Train Station to receive the coffin of his son , returned from France. At the reception ceremony, Martin collapsed and died. For the March 28, 1921, double funeral of Donald and Martin Clune hundreds of mourners filled St.John's Catholic Church, Schenectady's largest. The procession to the cemetery, led by the Metal Polishers, passsed flags that, by order of Mayor George Lunn, were lowered to half mast. [241]

Charles Proteus Steinmetz kept his Socialist faith. He made an impressive, though losing, run on that party's ticket in 1921 for the elective post of state engineer. He exchanged letters with the new leader of Russia, Lenin, offering his aid in that country's electrification. (At the same time, a Vice President of GE International was quietly exploring resuming business with Russia and its new regime, though that agreement would not be finalized until 1928.) [242]

Steinmetz remained active right up to his sudden death in 1923. Novelist John Dos Passos would memorialize that death in his novel The 42nd Parallel :

> Steinmetz was the most valuable piece of
>
> machinery General Electric had,
>
> until he wore out and died. [243]

As that ambiguous tribute suggests, Steinmetz had uneasily combined the role of progressive socialist and capitalist tool. He engaged, perhaps excessively, in manipulating his own myth. He overrated his ability to devise

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[241] **Schenectady Gazette 29 Mar 1921**

[242] **Kline, Ronald. 1992. Steinmetz. John's Hopkins, p. 256. GE 374th Board Meeting, 8 Nov 1928 p. 121.**

[243] **Dos Passos John. 1930. 42nd parallel, Houghton Mifflin. p. 257.**

a mathematical theory of everything, sociopolitical as well as scientific.Yet all this faded before his commitment to, and effectiveness at, making life better for his fellow citizens. He would best memorialize himself in the introduction to his 1916 book America and the New Epoch. Addressing the issue of giant capitalist corporations , he wrote that "If I was an unknown and unimportant employee, I would rather take my chances with the huge impersonal industrial corporation than with the most well meaning individual employer." Reflecting on his own experience, he concluded.

> Now, personally, I have no fault to find with existing society. It has given me everything I wanted. I have been successful professionally in engineering and have every reason to be personally satisfied, and the only criticism that I can make is that I would be far more satisfied with my advantages if I knew that everyone else could enjoy the same.[244]

Other less heralded Schenectady Socialists, not yet worn out, remained also committed to the idea of everyone sharing in the advantages that were confined to the few . John Bellingham and William Turnbull, for example, stayed loyal to the union idea while back at work at the Turbine Department of the GE Schenectady Works. Addressing the War Labor Board in 1919, Bellingham had said: “keep your eye on what the Schenectady and the allied plants are doing. What Schenectady thinks today, the United States does tomorrow, so far as organized labor is concerned.”

By 1920, this seemed highly unlikely. Yet Bellingham would live to see it happen-- and Bill Turnbull would live to help make it happen.[245]

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[244] **Steinmetz, Charles Proteus. 1916. America and the New Epoch. Harper. P.viii**

[245] **The Bellingham quote is from McCartin, Joseph A. 1997. Labor’s Great War. U. North Carolina. P. 225**

Chapter 8. Cooperationists 1923- 1929

On March,1923, just seven months before he wore out, GE's most valuable machine met with his new boss. GE's new president Gerard Swope was known for doling out his time in 5 minute portions and insisting that all communications to him fit on a single page. Yet Swope's March 23, 1923 visit to Charles Proteus Steinmetz's summer camp just off the Mohawk River lasted over an hour. Steinmetz followed up on that meeting by sending Swope not a one page letter, but a 13 page "confidential" memorandum. It contained no company secrets. Instead it focused on a word: cooperation.

Swope was not converted to cooperation by Steinmetz. The purpose of the visit was probably more for image than for information. Swope had, however, come independently to the view that cooperation was the way of the future.[246]

Historians have categorized Swope and a minority of U.S. corporate executives of the 1920s as practicing a new variety of capitalism. That new variety has been given various names by those historians. Martin Sklar and Kim McQuaid called it "Corporate Liberalism". Stuart Brandes termed it "Welfare Capitalism. " Ronald Schatz chose "Corporatism." Swope did not use any of those labels. "A corporation, in many respects" he said " is a matter of coordinated cooperation." Do not be too quick to dismiss this as a corporate cliche. It captures the essence of the 1920s Old GE.[247]

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[246] **Memo from C.P. Steinmetz to Gerard Swope, attached to Swope to C.P. Steinmetz 28 Mar 1923. Swope Papers. MiSci. See also Remscheid, Emil.1977. Recollections of Steinmetz. GE R&D Center, p. 22**

[247] **Sklar, Martin .1960. Woodrow Wilson and the Political Economy of U.S. Liberalism. Studies on the Left. 1960. McQuaid, Kim.2002. A Response to Industrialissm. Beard Books. Brandes, Stuart. 1984. American Welfare Capitalism,**

What was the GE version of coordinated cooperation? That is the question this chapter answers. Coordinated Cooperation emerged at GE from 1900 to 1930 not as a new idea but as an evolving policy. Inside GE, coordinated cooperation meant management coordinating and workers cooperating. Outside GE it meant less competition and conflict, and more coordination and cooperation, both among Giant Corporations, and between those corporations and the Federal government.

Regarding the inside part, GE had, before World War I begun a series of worker benefit programs aimed at cementing worker cooperation and loyalty. This included personal insurance and company support for housing by cosigning worker second mortgages. Starting in 1912, GE offered half-salary pensions to employees who reached 70 years of age with 20 or more years of service. In 1920, responding to a motion at a GE Stockholders meeting by induction motor salesman Sidney Paine, the company offered 50,000 shares of its stock for purchase by workers without broker fees and on a payroll deduction installment plan.[248]

That stock purchase program would soon expose what happened when coordination and cooperation came into conflict. After recovery from the brief 1921 depression, the price of GE stock went up sharply . Several worker-stockholders sold their small GE holdings to reap their capital gains. In other words, the workers weren't just cooperating with capitalism. They were acting like capitalists! Management immediately stepped in. It announced a modification of the employee investment program. Workers must be protected from the consequences of dangerous speculation. From now on, they could not buy GE stock, but only fixed-return bonds issued by a GE Securities Corporation, run by a board combining workers and management. When the change was announced, in 1924, the workers were invited to nominate, by write in ballot, their representative on the board of

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1880- 1940. Chicag0. Schatz, Ronald.1983.The Electrical Workers.Illinois. The Swope quote is from "Excerpts from talks to employees. Young, Owen D. and Swope, Gerard. 1930. Selected AddressesSwope and Owen D. Young. . GE.p. 97.

[248] **Works News 22 Oct 1920. P.3. Charles G. Marcy, Interview HoH, 23 Oct 1975.**

directors of this securities corporation. The winner at the Schenectady Works, and first holder or the new board seat, was Socialist Bill Turnbull.[249]

In its public image making, GE emphasized the cooperative elements. Coordination, however, was always lurking behind the curtain. Swope put it this way in an address to top company management on 1923

> If you could guarantee conditions of autocracy, there isn't any doubt it would be the best form of organization, for there isn't any doubt that the manager could run the business better than any democratic conclave[250].

The best evidence for this elitist version of coordination can be found in Swope's papers. One of the largest portions documents the detailed system for identifying and rewarding the 1000 or so individuals whom Swope described as "the brains and leadership of the company." Identifying that brains and leadership elite began with the compiling of a PYM List. The initials stood for Promising Young Man. Selection each year began with 100 -200 nominees, 20 or more from each big Works, fewer from each factory. The choice was made by sending the nominees list to the company's 20 top managers for evaluation. The chosen would replace those who that year had graduated from PYM to full member of the elite, or had fallen by the wayside. This let the number on the company elite list stay relatively constant at about 500-1000, the number in 1938 being 773.[251]

GE had installed in the 1920s a general plan under which employees of five years or more service got a 5% annual bonus. This did not apply to that thousand man elite, however. Their bonuses were much bigger. Their extra compensation began with an annual bonus exceeding the company's mean annual employee pay. On top of this was added various levels of stock grants. In a rare summing up of all this largesse, in the middle of the Great

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[249] **Works News 1 Feb 1924. The entire story is summarized in Works News 15 Feb 1929. Pp.4-5.**

[250] .**Swope, Gerard. 1923. Speech to Camp Emmons, Association Island. Collected Speeches of Gerard Swope.**

[251] **See, e.. Box 3 and Box 36. Swope Papers. MiSci. Quote is from The First 50 Years of the Elfun Society. 1978. GE. Copy in Schenectady County Historical Society. L. D. Defevre to Swope 6 Nov 1038, Swope to Managers List 2 Dec 1938 and other items in Swope Papers. Box 3, Folder 102.4. MiScI**

Depression, Swope said, regarding "Extra Compensation" that $1,000,000 had been divided up among 40,000 ordinary employees, while another $1,500,000 had been distributed among 851 elite employees.[252]

Even this however proved insufficient. Company legend depicts the management elite, at the peak of the Roaring Twenties boom, spending so much time on the phone with their personal stock brokers as to seriously interfere with corporate business.Whether for this reason, or just to add another perk, Swope created in 1928 a very exclusive mutual fund called GE Electrical Funds. Through it, the GE elite could entrust their money with the help of blue chip investment specialists previously available only to titans such as Swope and Young. Membership in this exclusive investment club, its name abbreviated to the Elfun Society became the mark of making it in GE. Initially only 900 of GE's 70,000 employees were tapped for membership. It remained a sort of secret society until the early 1950s when it would begin its evolution into a much less exclusive company-wide community service organization.[253]

So keep in mind, when considering coordinated cooperation inside GE, that it rested on a foundation of elitism and extreme pay inequality. This sense of antidemocratic elitism on the part of upper level management and a few lionized and privileged technical contributors persisted through the whole history of GE, old or new. This provides evidence against any claim that GE had a “corporate culture” shared by all company employees. Instead, it was a company of many clashing, cultures. The principal dividing line was between two cultures, with the top 1000 or so self-identified brains and leaders on the favored side of the line, and all the other tens of thousands of employees on the other side. The gulf between those two groups, far from being most extreme in the 1920s, was actually less than typically extreme under the leadership of Gerard Swope, GE’s all time most progressive president.

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[252] **Gerard Swope, Speech to Camp Inca 8 July 1936. Swope Papers, Box 7, F2F 112, 2AB. MiSci.**

[253] **Details of these perks are on Electrical Fund #1, Nov 1925. Swope Papers. Box 36. Folder 420.9.1 #1. MiSci. The First 50 Years of the Elfun Society. 1978. GE. Copy on Schenectady County Historical Society.**

Outside GE, the company's coordinated cooperation with other giant corporations had also begun before 1920. A pioneer here had been a New York born and German trained engineer, Magnus W. Alexander.He was a design engineer at GE's Lynn MA works when he became one of the company's first employee relations professionals. In that role, he demonstrated with data the high cost of employee turnover, especially in hiring semi-skilled machine operators. He went on to advise GE President Rice on labor matters, and to write and speak publicly on the topic of labor policy. In this role he combined pragmatism, progressivism, and a rigid personality that some GE colleagues described as "Prussian"[254].

His main motive was not progressivism but pragmatism. Commenting on a proposal for expanding employee benefits, he wrote to Rice that

> while I recognize the spirit of altruism in the proposal, I assume that the primary motive is the desire to attract capable men and women into the employ of the company,make them efficient and contented workers,and as such keep them in the company's service for a long period of time.[255]

Nationally, the years of Alexander's main activity, 1910-1915 were years of labor disasters, turmoil and violence. Examples included the bombing of the Los Angeles Times, with 20 fatalities, the New York City Triangle Shirtwaist Fire that killed 145, and the "Ludlow Massacre", an attack by militia hired by the Colorado Coal and Iron Co. upon striking miners that left 45 dead. An early cooperative response to this perceived spiral toward labor relations chaos had been the National Civic Federation. It included corporate executives, labor union officers , and civic leaders. GE had been a corporate member, but not an active one.

In 1915 Alexander stepped up GE's cooperationist game. He led a small group of mid level industry professionals that organized a series of conferences for executives from several big companies, including GE. In the quiet setting of a resort called Yama Farms in New York's Catskill Mountains, they considered those rising labor tensions. Out of those "Yama Conferences" came a permanent organization, the National Industrial

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[254] **Gitelman, H.M. 1984. Management's Crisis of Confidence and the Origin of the National industrial Conference Board, 1914-1916. Business History Review. 58. 153-177.**

[255] **Magnus W. Alexander to Edwin W Rice,Jr. 19 May 1919. Rice Papers MiSci.**

Conference Board (NICB). Depending on one's preconceptions, this could be viewed as a semi-secret corporate cabal aimed at union avoidance (the strongly anti union National Association of Manufacturers was a corporate member) , or a liberal think tank (it claimed to be driven not by preconceived positions but by "pertinent economic facts"). [256]

Actually, the NICB stood firmly in the middle. It described itself as an "instrument for cooperative action", seeking "satisfactory relations between employees and employees" . It rejected the robber baron rapacity of the past. It also, however, rejected what it perceived as the radicalism of the present. One NICB report, for example, objected to what it saw as left-leaning professors' efforts to brainwash students with "propaganda in favor of the eight hour day... minimum wage laws, factory inspection laws, provisions for social insurance," and " national health insurance."[257]

Unlike many efforts to address the labor crisis of the 1910s, the NICB persisted. Under the name The Conference Board, it continues in the 21st century to provide a middle of the road voice of corporate America. Another effort at inter-corporation cooperation was similarly named but separate and shorter lived. The Special Conference Committee was created in 1919 by a committee of corporate executives. George Emmons, now a GE vice president, was on that committee, along with executives from such companies as Du Pont, Standard Oil and General Motors.

The committee concluded that

> Progress depends on cooperation, and in industry cooperation must be based on the acceptance by employers and employees of some practical application of the principle that capital and labor are interdependent.

That practical application included an acceptance of the need for "collective dealing" with employees on "wages, hours, working conditions and complaints." That acceptance was , however, hedged by proclamation of

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[256] **Dawley, Alan. 2003. Changing the World. Princeton. P. 203.**

[257] **National Industrial Conference Board. 1919. A Case of Federal Propaganda in Our Public Schools. NICB.**

"the Open Shop...Each employee should be safeguarded in his right to join or not to join any union."[258]

For GE, coordinated cooperation also encompassed the Federal Government. After that 1911 Consent decree that saved its lighting business, Charles Coffin decided to adopt a more cooperative approach to corporate citizenship. This led, in 1912, to GE hiring an outside lawyer to serve as a Steinmetz - like "Supreme Court" to assure that GE would avoid future antitrust violations.

This newcomer was Owen D. Young. Born in 1874, he was the son of a moderately prosperous upstate New York farmer. He graduated from St Lawrence College, then moved on to Boston and a career in law. He specialized in the legal issues of the new electric utility industry. Tall and lanky, folksy and friendly, yet also articulate and scholarly, he has been described as "Lincolnesque". Though never a candidate for political office, in 1926 he came close to running for the Senate as a Democrat. " I think Owen Young would make a wonderful candidate, " said Eleanor Roosevelt . In 1932, he was mentioned as a dark horse presidential possibility[259]

Young had come to GE Board Chairman Coffin's attention in 1912 while effectively representing Stone and Webster, a major electric utility holding company that competed with GE's Electric Bond and Share. Young accepted in 1912 a job in GE's Law Department. There in 1913 he got the responsibility to vet all GE business agreements to assure antitrust compliance. He served, however, as a toothless watchdog. Subsequent company violations of its 1911 consent decree, such as agreements with Corning Glass that effectively monopolized control over low cost bulb making, continued, with Young's knowledge and nonintervention. So did GE's use of its Electric Bond and Share subsidiary as a significant and likely illegal competitive advantage in selling electrical equipment.

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[258] **Report of the Special Conference Committee. July 24, 1919; Dec. 15, 1922. Dec.6, 1923.**

[259] **Details of Young's early career are taken from the most thorough biography, Case, Josephine Young and Case, Everett . 1982. Owen D.Young. Godine. The Eleanor Roosevelt quote is on p. 343.**

Young quickly ascended to a Vice Presidency. He moved beyond anti trust to coordinating many aspects of GE's increasing cooperation with the Federal government. For example, In April 8, 1919, Young, Coffin and three other GE executives met with two U.S. Navy officers, Admiral William Bullard and Commander Sanford Hooper. The subject was GE's Alexanderson alternator for sending wireless messages. The Navy men did not want this crucial defense technology to fall into the hands of a foreign power, even a friendly one such as Great Britain.

Bullard, according to Young, "strongly urged the officers of the General [Electric] Company as patriotic Americans to decline to sell these machines to either Marconi Company [i.e, either the British parent company or its American subsidiary]". To achieve this. Bullard, again as quoted by Young, said that "the U.S. would be sympathetic to the formation by the General [Electric] Company and other clearly American interests of an American - owned radio-operating company that could deal with the Marconi Company worldwide on equal terms." Thus did GE receive, in Young's version of events, the authority to sidestep antitrust considerations and coordinate the cooperation of itself, AT&T, and later Westinghouse and United Fruit, to create a wireless communications monopoly, the Radio Corporation of America (RCA).[260]

The creation of this monopoly did not turn out to be necessary for national defense. The Alexanderson alternator would soon be replaced by vacuum tube electronics, a development independently achieved by all the major powers. Point to point or ship to ship wireless communication would from 1920 on be dwarfed in importance by radio broadcasting. The pioneer here would not be GE, AT&T, or RCA, but Westinghouse, led by engineer Charles Conrad. RCA would, despite its unnecessary creation, inherit by government fiat a business bonanza . RCA's new leader, a Russian born, New York City raised former telegraph operator named David Sarnoff, would manage rings around his company's corporate creators. He ended up in possession of the an unearned monopoly based on the GE and AT&T electronics patents, and ownership of the first national radio network, NBC.

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[260] **Aitken, High GJ. 1984. The Continuous Wave Princeton. esp. Pp. 339-342. Case, Josephine and Everett.1982 Owen D. Young. Godine. esp. Pp. 177 -185. Beilby,Kenneth. 1996. The General. David Sarnoff and the Creation of RCA. Pp. 45-58.**

Thus did GE, in 1919 the company with the world's best technology in radio and electronics, pass up its chance to become the world leader in those businesses. For a decade GE did manufacture radios to be sold by RCA. By the 1930s, however, RCA had also taken over that manufacturing role. Looking back on this experience in 1929, Wilbur Rice wrote to Young that

> I am depressed by the surrender of our company of some $60 million of radio manufacturing business. Our research, manufacturing and engineering will be seriously handicapped...This is the first time in history that we have surrendered the right to manufacture an important electrical product to a company not under our control.I regard this as a serious step backward. [261]

Young also ascended to a coordinating role with the government on labor matters . In 1919 President Wilson called two Industrial Conferences in response to that year's labor strife. For the second, Wilson asked Young to serve as a representative of industry. To accept this post, Young had to threaten resignation from GE in order to overcome the unanimous objection of the GE Board of Directors' Executive Committee. [262]

At the Conference, he championed an effort to extend into peactime the relatively progressive policies of the War Labor Board. This won the unanimous support of the committee. Its Final Report to that effect was, however, immediately rejected by organized labor as too paternalistic, and by most business leaders as too permissive. It was also immediately abandoned by otherwise beleaguered President Wilson.[263]

Back at GE, Young took charge of efforts to implement privately that publicly rejected approach. He had never run a business or managed labor. He did not turn for advice to people who had, such as GE's own George Emmons. Nor did he seek out the voice of the workers themselves. Instead, he consulted with a new kind of professional, the labor relations specialist.

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[261] **Memorandum E.W. Rice to O.D. Young. 30 Oct 1929. Young Papers 1-17. MiSci.**

[262] **Case, Josephine Young and Case, Everett . 1982. Owen D.Young. Godine. p. 195**

[263] **Wickersham, George. 1920. Industrial Stability and the President's Second Industrial Conference. Annals American Academy of Political and Social Sciences. 90. 134-137. New York Times. 2 Dec 1919.**

In 1919, Young turned to two such consultants. Atherton Brownell was a magazine editor. Mackenzie King was a Canadian scholar and politician who would later become that country's Prime Minister. Both, after brief and shallow investigations, told GE management, especially newcomer Young, what it wanted to hear. GE, they said, had made a mistake of leaving labor relations for too long in the hands of old time Works Managers such as George Emmons. Those old timers may have had good rapport with the workers. They lacked, however, modern techniques. For example, instead of taking advantage of the powers of modern publicity techniques, that old guard had relied on "the rightness of its intentions." As a result, it had been outmaneuvered by wily union radicals, resulting in the Works being "largely in control of the socialists." The War had made matters worse, creating "well nigh irresistible " pressures " to "invite outside intervention known to be sympathetic to labor's point of view. " That "outside" intervention was, of course, the Federal Government's War Labor Board. [264]

Fortunately for GE, however, that War Labor Board was now defunct. Before expiring it had suggested a promising way forward. That new approach avoided the three previous, and to GE undesirable, choices: permanent government involvement in labor relations, return to Gilded Age labor-management warfare, or recognition of unions. The new approach followed labor troubles in 1918 at GE's Lynn MA Works. There wartime pressures had been exacerbated by a Works Manager who had exerted an un-Emmons like brand of old fashioned autocracy. Worker resistance and the resulting production problems had prompted the War Labor Board to step in. This led not only to departure of the Works Manager and a pay raise for the workers, but also to application or a new idea, called a Works Council.This was a council at which representatives of the workers, chosen by a democratic process, met with management representatives on a regular basis to discuss workplace issues. A Works Coucil had earlier been implemented at the Colorado Coal and Iron Co. by Mackenzie King for owner John D. Rockefeller Jr. after the 1914 violence there. At Lynn, the Works Council not only helped restore peace and productivity, but, to GE's pleased surprise, preserved nearly intact the previous management

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[264] **Brownell, Atherton. 1919. General Electric Industrial Relations. Owen D. Young Papers. Van Horne House, Van Hornesville NY . King, MacKenzie. 1919. Confidential Memorandum Respecting Employees' Committees in the Works of the General Electric Co. Item C26857. HG 26.34. File 196. MacKenzie King Papers. Public Record Office of Canada. Ottowa Canada.**

prerogatives. So the company was receptive to the Brownell and King recommenactions of installation of Works Councils throughout GE.

Young, however, was not the man to carry out this recommendation. He had no taste for or skill at, day to day management. He was far better suited to be GE's "Mr. Outside". In the the 1920s, GE would loan him to the government to help coordinate U.S. policy on the repayment by U.S. allies of their World War I debts. One major such plan would be named the Young Plan in his honor.

The company needed a "Mr. Inside" . To find that person, Charles Coffin again looked beyond GE's internal ranks. The reason for this external search was literally accidental. Earlier in the Coffin regime, two GE executives has stood out as leading candiates for GE President. S. Dana Greene, an engineer and then a sales executive, had led GE into AC, and at following fast behind Westinghouse at Niagara. He helped put GE into the lead at supplying equipment for the Universal System of electricity. Hinsdill Parsons, a Vice President in charge of GE's Law Department, had proved himself an aggressive prober of the boundaries of antitrust, and an effective manager of GE subsidiaries.

The two had hobbies. Greene was an enthusiastic outdoorsman. In January, 1900, he was pursuing one such hobby, skate sailing, with his wife on the frozen Mohawk River. The two fell through a hole in the ice and drowned. Parsons' hobby was fast cars. Pursuing it, in 1907, he may have injured his reputation. Stopped for speeding by a pair of constables, he invited them into his car, then drove off. "Autoist steals constables" read a 1907 New York Times headline. Parsons would later confirm his unavailability for further promotion in 1912 when, back at the wheel, he died in a one car crash.[265]

It was the unavailability of these two leading candidates that led to Wilbur Rice's installation as GE President from 1912-1922, with Chairman of the Board Charles Coffin in actual charge. Ultimately that presidential post would go to an outsider. Gerard Swope was born in 1872, the son of a St. Louis watch case manufacturer. He earned an electrical engineering degree from MIT, then moved on to Chicago for a job with Western Electric. There he roomed and taught science at Jane Addams' Hull House. He formed relationships with such leaders as Addams herself, occupational health expert Alice Hamilton, labor relations expert Alzina Stevens, and Mary

[265] **Schenectady Gazette 2 Jan 1900, p. 1. New York Times. 24 Sept 1907.**

Hill, who became his wife. Meanwhile, he moved up the Western Electric hierarchy, from engineering to sales to a Vice Presidency. Along the way, not only his Hull House connections but also a focused and intent remoteness distinguished him from the stereotypical salesman or upwardly mobile manager. His hawklike facial features rarely displayed emotion. He kept fit by daily horseback riding, avoiding what he termed the pot bellied complacency of other executives. His disciplined formality and brusque manner kept him at arms length from colleagues.[266]

This aloofness was perhaps also related to his being a Jew, a rarity among chief executives in his industry. One of his few expressions on the topic in his surviving business papers is a response to a correspondent who had heard that Jewish students of engineering would find it "impossible" to get a job "with any worth while institution. " Swope denied that this was the case, either at MIT (where he was an active alumnus) "and surely not in the General Electric Company."[267]

Like Young, Swope came to Coffin's attention by his effectiveness as a competitor. In 1914, as Western Electric vice president, he had ably negotiated the sale of that company's electric power equipment manufacturing business to GE. He would turn down two GE job offers before accepting a third in 1919. In between, he spent World War I as a dollar-a-year -man in Washington, assisting U.S. Army officers George Goethals and Hugh Johnson at reorganizing the U.S Army's purchasing system. This early experience at coordinated cooperation among government and industry leaders would later be echoed not only in Swope's 1920s coordinated cooperation efforts, but also in his 1931 moment in the national spotlight, his Depression-fighting "Swope Plan".

He was hired in 1919 to run GE international business. He accepted on the condition that the business be reorganized as a separate company, International GE, with him given the title of President. His brand new six story office building was deliberately and conspicuously located just outside and in front of the Schenectady Works.

Like Young, he continued Coffin era tactics. For example, under Coffin, GE had created or purchased major shares in electrical manufacturing companies

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[266] **Loth, David. 1958, Swope of GE. Simon and Schuster.**

[267] **Robert D. Kobin in to Gerard Swope 13 June 1939; Swope to Kobin 15 June 1939. Box 3 Folder 102.4 Swope Papers. MiSci.**

around the world. This enabled GE to use tactics such as price-stabilizing cartels that were illegal in the U.S. but legal elsewhere. In May, 1919, Swope hosted a meeting at Briarcliff Manor NY of 23 presidents of GE's international affiliates in countries ranging from France and Italy to the Phillipines and Japan. A U.S. Senator gave the keynote address. He reminded the attendees that in April, 1918, Congress has passed legislation aimed at boosting U.S. exports. This law, the Webb - Pomerene Act, granted antitrust exemption to associations of U.S.companies formed for or the purpose of trading overseas. Swope urged full GE participation in this export initiative. U.S. anti trust law, he said, "does not affect our business, as we understand it, from Belgium to Argentina, or from France to Greece." To exploit this opportunity, GE should "establish a much closer and more intimate connection among associated companies,in Europe and throughout the world ...to get each company to adopt the methods of all the others." The aim was " to have in each country the best company, and have throughout the world a group of the best companies. " In pursuit of this goal in the 1920s, GE would buy up 19% of France's CFTH, 32% of Germany's AEG, 50% of Italy's Cognel, and 51% of Tokyo Electric and 21% of Shibaru Electric (the two companies that would later merge to form Toshiba). In other words, organizing a profitable GE- dominated world cartel, not boosting exports to create jobs at home, was the aim of of Swope's International GE. This effort to outflank U.S. antitrust laws would continue throughout Swope's presidency. Only later would it be found in court to be illegal.[268]

Like RCA, however, this effort did not have its intended effect. Europe's best electrical manufacturing companies, such as Siemens, Phillips, ASEA, and Brown Boveri, stayed out of, or shook loose from, GE's clutches. They remained dominant in Europe. The only area where GE was able to extend its product domination overseas was in light bulbs. There a market-dominating cartel called Phoebus reaped high profits while keeping foreign made light bulbs out of the U.S. until the Japanese entered in the 1930s. This cartel was a profitable exception to GE’s otherwise lackluster international performance. As Swope's son, a GE Lawyer put it in 1973: "GE's attempt to extend its interest outside the historic 'family" [the original

[268] **Swope, Gerard. Speech to International Affiliates Conference, May 1919. O,D, Young Papers 1-10.**

overseas extensions of Edison and TH] ran into trouble and were liquidated.” [269]

Global light bulb monopolizing proved more successful, Nine of the world’s light bulb leaders met at the Inteernational GE office in Paris in 1930 to sign the International Notification and Control Agreement (INCA). They agreed not to invade each others' home territories. This helped maintain GE’s high light bulb profits of up to 40% of sales until after World War 2. [270]

In 1922, with the post-war political and social controversies settling down, and the nation recovering from a sharp but short depression, Swope and Young officially assumed the presidency and board chairmanship of General Electric. GE annual sales had climbed back in 1922 to the World War I peak of $250 million. This kept the company on a track of doubling in sales every decade or so. That roughly matched the growth rate of U.S. electricity production, and far exceeded the growth rate of the U.S. GDP.Total company employment, about 70,000 in 1922, had also roughly doubled every six years since GE's founding. A deceleration had, however, already begun. Employment would peak at 87,000 in 1929, then fall in the depressed 1930s. Recovering to about 90,000 early in World War 2, GE's U.S. employment would double only twice more in the remaining 80 years of the Old and New GE. Schenectady's share of total company employment had fallen from one half in 1892 to one third in 1922. The number of manufacturing locations had grown to 40. Besides Schenectady, six others were big and diverse enough to be considered Works. These were Lynn and Pittsfield MA, Bridgeport CT, Erie and Philadelphia PA, and Fort Wayne IN.

At the Schenectady Works by 1922, the failure of the post-war strike and the following selective layoffs had resulted in a sharp decline in unions. Membership in the once powerful Dorpian Lodge of the IAM had fallen from over 1000 In 1913 to 125 in 1923. Total union membership was

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[269] **Gerard Swope Jr Summary of GE international Business.GE.1973.p.3. MiSci**

[270] **Supply of Electrical Equipment and Competitive Conditions. FTC, U.S. Senate Doc. #46. 1927. Epstein, Barbara and Newfarmer, Richard.International Electric Association a Continuing Cartel. Report for the Use of the Committee on Interstate Commerce.House of Representatives.June 1980 96th Congress,2nd Session.Committee Print 96-IFC-49.**

estimated at only 5% of the Schenectady Works' 20,000 enployees. GE's young radical workers of earlier decades had, by the 1920s, either departed, or toned down their radicalism. More characteristic in the twenties was an organization GE had created in 1916. The Quarter Century Club recognized workers who had put in 25 years of company service. A company newspaper begun in 1919, the Schenectady Works News promoted this image of satisfied and loyal employees.

That cooperative image of smiling job satisfaction was, of course, a selective exaggeration. More objective statistics did, however, support a picture of decreased exit and increased loyalty. The fraction of workers departing a typical large U.S. manufacturing works each year, the "labor turnover rate" had typically been, before 1910 ,100% or more. GE's pre-World War 1 turnover met this average. By 1920, at the GE Schenectady Works, turnover had fallen to 50%. During the next decade it would fall further, to 22%. For workers with five years or more of service in the 1920s only about 10% would leave in a given year. A 1919 account asserted that three fourths of the employees at the Schenectady Works had been there five years or more, and one fifth ten years or more.[271]

The ethnic composition of the work force also stabilized. Schenectady had experienced four main waves of immigration. The Irish had begun arriving in the 1830s, then Germans in the late 1840s, and finally Eastern Europeans (often generalized as "Polish") and Italians at the turn of the 20th century. The fraction of Schenectady residents born outside the U.S. reached its all time peak of 25% in 1910. With the passage of national immigration restriction in the 1920s, there would be no more immigration waves for decades.

Schenectady's population had grown since the Edison Works' arrival from 15,000 in 1886 to 88,000 In 1920. At least one billboard in the 1920s optimistically proclaimed it a city of 100,000. In fact, it never would reach that figure. Instead, over the rest of the 20th century its population reached a peak below that 100,000 figure, then declined to 61,000 . In the 1920s about 40% of employed Schenectady residents worked for GE. The majority of people who tried out a job at GE Schenectady, however, left within a

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[271] **Employees Leaving Service During 1924. Folder 113.3 C. Swope Papers. MiSci. Ripley, Charles. 1919. Life in a Large Manufacturing Plant. G.E.**

year. The Works was mainly staffed not by itinerant loners, but by people who already had a family in Schenectady, or arrived at Schenectady with a relative.

This led to extended families of two or more nuclear branches, each often with two or more family members working at GE. Over time this often enabled those GE families to achieve unspectacular but cumulative upward mobility. It was not unusual to see the sequence within those families from common or unskilled labor to highly skilled labor or a foreman's job in a generation, and on to college education and professional employment in the succeeding generations .

For the "Yorkers", families with two or more generations born in New York State by the 1890s, such mobility had already begun. Consider again Jacob Weller. He had moved from laborer to highly skilled tool and die maker in the 1890s. His son would graduate from GE's Apprentice Program. So would his grandson and eventually great grandchildren. The great grandchildren would go on to college and professional careers. .

The main 19th century immigrant groups, the Irish and the Germans, were by the early 20th century also well established at GE, and in some cases launched on that trajectory of upward mobility. Among the previously noted working class families, for example, the Irish Clunes, were, despite the loss of Martin and Donald, represented in the 1920s Works by Dudley in the insulation department, Thomas, a crane operator, Thomas F. in the Engineering Department, Dorothy, a motor winder, Sarah, a shop worker, and Irene, who worked in the Stock and Order Department until her marriage in 1923. The German Schwenkers in the early 20th century included Charles, General Electric's chief drafting inspector at Schenectady , J. Edward, an engineering graduate of Union College working as aa contractor, and Fred, a Schenectady Alderman who was instrumental in setting up the city's park system.[272]

Among the newer immigrant groups, each making up about 8-10% of Schenectady's population, were the Poles, (actually Polish speaking

[272] **Information in 1920-1930 Schenectady Occupational Directories, SCHS.Directories, and Family File, SCHS.Warrensburg NY News Thurs Nov 29 1956; Schwenker Family File, Schenectady County Historical Society, Schenectady Gazette, 10 May 2013.**

Russians, Germans or Austrians), and Italians. For example, Vincent Sarnaki, of Polish ethnicity, had served in the Russian Army before emigrating to the U.S. He came to Schenectady by way of New Jersey and a Vermont stone quarry before getting a job running a punch press at the Schenectady Works. Frank Nigrini of Hungary had also travelled widely across Europe before coming to Schenectady. He arrived there in 1890, followed in 1896 by his brother Jacob. Frank's first job was in that hot and dangerous tube works. There he would establish close ties with foreman Chris Rach. When Rach moved on to the still dangerous but less exhausting Punch Press Department Frank went along. Along the way he fathered seven sons. By 1924 six were working at GE, in departments ranging from punch press to radio to publicity. The seventh son was in that year 1924 attending high school. A third generation Nigirny would graduate from college, a fourth generation would add Medical School.[273]

The wave of Italian immigration and its impact on GE can be traced by the examples of two relatively common family names, Gabriele and Mangino. Neither can be found in Schenectady censuses or organization directories before 1900. The brothers Tobia and Leo Gabriele came to Schenectady from Italy in 1905. From a beginning as laborers, they moved up to semiskilled shop work at GE Schenectady. That that may have had some doubts about permanent U.S. , however, is suggested by the fact that, in contrast to those early Irish and Germans, the Gabrieles did not seek naturalization papers until the 1920s. They did so through the Americanization Program that GE had set up at the Works. It provided courses ranging from English language and literacy to help in filing for those first papers. Tobia got his in 1925, alongside some 45 Polish and Italian classmates. In 1934, a next generation Gabriele, Leo J. was among the graduates of the Apprentice Training Program. [274]

The first Manginos in the Schenectady area appear to have arrived in 1905-1906. They were Raffeale, a grocer in the city, and brothers Joseph and Pasquale, railroad workers in the suburb of Rotterdam. They were joined by 1910 by Frank, a barber, and Carlo a saloonkeeper. Italians initially mainly

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[273] **Sarnacki, Ray. 2020. A Brief History of My Grandparents. Schenectady County Eastern European Roots Newsletter, Vol.7. No. 3. (On line). Nigirny Family File SCHS. Works News 2 May 1924.**

[274] **Gabriele Family File, SCHS. Works News 20 Nov 1931, p. 14, 7 Apr 1927 p. 15. 4 June 1934 p.4**

worked on the railroad as laborers or freight handlers, or in city jobs such as barber or shoemaker. Those who took industrial jobs went first to the Locomotive Works, mostly as laborers. By the 1920s, however, there were half a dozen Manginos at the GE Schenectady Works, including foormer saloonkeeper Carlo, for whom Prohibition might have caused a career change. There were still many Manginos at the Locomotive Works including Desiderio, who had come to Schenectady from New York City in about 1920. His son Joe would begin his working career at the Locomotive Works, but after World War 2 would move over to GE. There, after passing up an opportunity to be a foreman, he became a union activist[275].

Another of the Eastern European emigrants, Frank Emspak, came to the U.S. from Austria-Hungary and joined GE in 1905. He had trained as a blacksmith, but became a GE machinist, practicing his old trade only during layoffs when he traveled the nearby countryside shoeing horses. A son recalls his being a 1911 Socialist, though in the 1911 registration book he left his party affiliation blank. As a husband and father of three sons he was moving the family goods to a new residence in suburban Mt. Pleasant in 1913 when, at a not yet raised railroad level crossing, he was fatally struck by a train. His widow Theresa kept the family together. She went to work for GE as a cleaning woman, alongside Abbie Richmond. She also sued the New York Central Railroad over her husband's accident and won a cash settlement. Two of her three sons, Frank jr and Victor, both under 16, were already working at GE as messenger boys. They went on to skilled positions at the Works. The youngest brother, Julius, took on jobs ranging from paperboy to pinspotter at a bowling alley. Soon he too was able to take the jobs of first messenger boy, then machinist, at the works. By the mid 1920s, the family, all still living together, had the very respectable income of $100 a week and owned a house and car.[276]

Finally, the Jandreau family had come from Quebec to New England in the 19th century to work in the textile industry. The first to move to Schenectady was Camille, not as a factory worker but as a skilled confectioner. He ran a

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[275] **Much of the information on Manginos came from the HIstory Forge Project and Mangino Family Fileat the Schenectady County Historical Society, plus information from Census records,Schenectady Occupational Directories and Works News 20 Nov 1931, p. 14, 7 Apr 1927 p. 15. 4 June 1934 p.4**

[276] **Julius Emspak Oral History. Columbia University**

confectionery shop in Schenectady,and his sons Elmer, Everett, and Eugene went to work at GE. At least one, Eugene, became a 1911 Socialist. Eugene's son Leo would in the early 1920s complete the GE Apprentice Program. By 1925 he was one of six members of the Jandreau family working for GE at the Schenectady Works.[277]

An exception to this ethnic diversity, GE family opportunity, and mobility was Schenectady's Black families. Schenectady appears not to have been a destination for the World War I era Black migration from the South. There were in the 1920s still probably about 200 Black employees at the Schenectady Works. They still almost all worked in the Transportation Department unloading materials and loading products, or in "the yard" maintaining the buildings and grounds, , or at such tasks as elevator operator or janitor. They faded to even greater invisibility than before 1920. Looking over the hundreds of worker's photos in the 1920s GE Schenectady Works News has not yet turned up a single Black face. No more photographs appeared of even Black ragtime performers or Black GE League baseball players.

The low level of Black workers at GE in the 1920s was not an characteristic of U.S. manfacturing as a whole. Nor was it necessarily an indicator or management prejudices. Labor historian David Montgomery notes that Black employment varied widely among 1920s U.S. manufacturing companies. Blacks made up one-fifth or more of the labor force in such Giant Corporations as Armour and U.S. Steel, while being near zero in others, such as GE and Remington Rand. Those company identities suggest that geography and technological maturity may have influenced the levels.[278]

A Schenectady legal battle highlighted the complexities of race at GE in the 1920s. Shankar Laxman Gokhale was 42 years old and the holder of master's degrees in physics and chemistry when he arrived in Schenectady from India in 1911 to work at the GE General Engineering Lab. He obtained his U.S. citizenship in 1920. Then, in 1925, under a racially restrictive new U.S. citizenship law, he was classified as a "Hindu" from Asia, and therefore, for legal purposes, non-White. His citizenship was revoked."I am neither an American citizen nor a British subject, but a man

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[277] **The early history of the Jandreau family in the U.S. has been pieced together from U.S. Census records and Schenectady Occupational Directories. .**

[278] **Montgomery, David.2024. A David Montgomery Reader U. Illinois. p. 188**

without a country, " he said in 1926, “an outlaw of the world, having been punished in this way for my unpardonable crime of pledging my allegiance to the only flag which at one time had offered to treat me as a 'free white person.”He then fought that decision all the way the Supreme Court. He regained U.S. citizenship in 1928, continued a successful technical career at GE, while making lifelong contributions to Schenectady civic and progressive causes[279].

In contrast to race, the area of gender, saw slight, highly selective, but genuine progress. There were about 2500 women at the works in 1924, about 15% of the work force. About 600 were secretaries or clerks, and 1400 were operatives. Some 500 did more skilled shop or laboratory jobs, ranging from operating drill presses to analytical chemistry. The operatives worked in areas ranging from radio assembly to coil winding to shaping porcelain insulators. They were almost all paid by the hour at significantly lower rates than men. They had no chance of entering the Apprentice Program, and little chance for even moving to a new craft. Dora Weaver, for example, had wound cable for the world's first electric chair in 1888, and was still winding cable in 1924. (In between, however, she had been a member of one of the Works’s first all woman labor union locals)

Women did work on some new technologies. "In the Works," began a Works News story, "radio means hundreds, yes thousands of girls, and girls mean radio." The women in the radio shop were, however, mainly doing the same sorts of things that women had been always doing at the works, such as winding coils or doing simple tests with gauges. "Testing with gauges is such monotonous work that men will not do it," explained Works Manager Charles Eveleth. "Women do not object to it.... Women's ability to endure monotonous tasks is due to their having taken care of children on earth for thousands of years." [280]

Yet at the same time as most stereotypes were being reinforced, others were being challenged . Margaret O'Hara, for example, was a college graduate who got one of those analytical chemistry jobs. She recalled being treated

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[279] **Shifting Definitions of Race and Citizenship: The Case of Shankar Gokhale. Grems-Doolittle Library Collections Blog. 7 Jan 2013. SCHS.**

[280] **Works News 4 July 1924**

like "one of the boys" in the lab, whether at putting together a radio from spare parts, or becoming one of the Works' most capable spectroscopists. After 1930, when both she and her husband were laid off, she was the one who was first called back. The GE Research Lab hired a succession of women researchers, beginning with that earlier mentioned MIT grad Edna May Best in 1905. The list came to include in 1920 GE's first female Ph.D., chemical engineer Margaret Brophy.

The most accomplished GE female scientist was Research Lab physicist Katharine Blodgett. She also had an intriguing personal story. Shortly before she was born in Schenectady in 1899, her father, a GE patent attorney, was shot and killed inside the family home. It remains Schenectady's most notorious unsolved murder. Effects of that event on Katharine Blodgett herself are unclear In the 1980s, Elfrieda Underhill, daughter of a Schenectady psychic, told a friend that one participant in her father's seances was "that famous lady scientist from GE" , [281]

Company memory of the 1899 tragedy may have contributed to Katharine Blodgett 's welcome on visiting the GE Schenectady Works in 1917 , as a recent Bryn Mawr graduate. She got special attention from chemist Irving Langmuir who recommended she take graduate studies. Returning to GE two years later with an M.S. in chemistry from the University of Chicago, she became one of Langmuir's research assistants. At his suggestion she went on in the early 1920s to the Cavendish Lab of the University of Cambridge, England. There she earned the first Ph.D. in physics awarded to a woman by that institution. Returning to GE, she became Langmuir's colleague at pioneering the field later to be called nanotechnology.That field involves understanding and manipulating matter on the scale of atoms or molecules. Among Blodgett's major contributions was the invention of layers one or a few molecules thick that could be coated on glass to reduce glare. This may have been the first nanotechnology product to be based on modern scientific understanding of atoms and molecules.[282]

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[281] **Interview with Alice O'Hara 10/25/77. Evening Star 14 Feb 1898. The psychic story was told to the author by Mrs. Underhill's friend, Bonnie Wise.**

[282] **Interview with Blodgett by Leonard Reich 21 June 1977. Interview by the author with Katharine Blodgett's neices, Katharine Gebbe and Katharine Alkena.**

Blodgett's GE engineering counterpart was Edith Clarke. After a 1909 degree in mathematics from Vassar she did two years of private tutoring and a year studying engineering at Wisconsin. She wanted to be hired as an engineer, but settled for a job as calculator at AT&T. Despite working with prominent AT&T theorist George Campbell, earning in an M.S. In electrical engineering from MIT, and then joining GE in 1919, she found herself, at age 36, still stuck with that calculator designation. So she left. Moving all the way to Turkey, she spent 1921-22 as Professor of Physics at the Constantinople Women's College. When GE invited her back in 1922, it was, at last, with the title of Engineer. Clarke proceeded to make major contributions to calculation of the performance of electrical transmission lines and other complex electrical systems. In the same manner as Steinmetz, the methods she developed, greatly simplified the laborious calculations needed to design electric power systems. For this work, she became the first woman admitted to full membership in the American Institute of Electrical Engineers (AIEE).[283]

Slowly in the 1920s Clarke was joined by other women hired more directly as engineers. For example, Florence Folger, an MIT graduate, worked for the Turbine Engineering Department applying the laws of thermodynamics to improve the process of steam extractions from turbines. Susan Diehle, daughter of a GE Foreman came to the Schenectady Works in 1923 with a B.A. in languages from Cornell. She then did postgraduate studies in a electrical engineering at Union and got a position in the Requisition Supply Engineering Department.[284]

Another small GE step toward gender equality occurred in 1922. After the Schenectady Works management chose 250 male workers to put in place that labor relations innovation called a Works Council, the men voted to add 18 female workers to the 84 men assigned with drawing up a constitution. . That Work Council idea had been mandated by Swope. GE Vice President George Emmons explained that it "gives the employees a voice in matters

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[283] **Brittain, James E. 1985. From Computer to Electrical Engineer. IEEE Trans. Education 184-189.**

[284] **Works News 16 Feb 1923 p. 11.2. , 18 May 1923. P. 12**

pertaining to their employment and working conditions" and sets up a "procedure for adjustment" of disagreements between workers and management.”

The constitution emerging from this management coordinated process. was then submitted in 1922 to the entire Works labor force for a ratification vote. The workers decisively rejected it, with only 3549 for versus 5704 against.[285]

Swope reacted to this rejection by replacing the Works manager with one of GE's rising stars, Worcester Poly trained engineer Charles Eveleth. Eveleth had worked in the Railway Department, then successfully managed GE participation in the World War I Nahant antisubmarine project. He combined the personal touch and pragmatism of Emmons with outstanding engineering credentials. Extending that Emmons's approach, he set out in 1923 to conduct informal group sessions with as many workers as possible, about 50 at a time. He would achieve, within a year, at least one goal of that constant presence on the factory floor. He noted that when he came in sight, workers would no longer either speed up to impress him, or slow down to show that they were not afraid of him.[286]

Reporting on these sessions, Eveleth tended to tell Swope what the President wanted to hear. The work force, Eveleth reported had fully bought in to the program of coordinated cooperation. They were ready for a Works Council. In 1924, a notice appeared in the Schenectady Works News. A Works Council would be put in place at Schenectady. This time no ratification vote was deemed necessary. The workers were invited to go directly to the nomination of council members. Caught off guard, opponents could only recommend writing on the nomination form "not acceptable". The company claimed to have counted only 13 who did so Many, however, did not vote. While more than 90% of Lynn MA employees voted in Works Council elections, only about 60% of Schenectady workers did.

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[285] **Works News 6 Jan 1922 p. 1, 3 Mar 1922, 6 April 1922**

[286] **Works News 19 Jan 1923. Edmund Eveleth of Dothan AL generously shared with me family papers and his memories of his father. Eveleth to Swope 27 Dec 1923; contents of Swope Papers Box 17 Folder 113.22**

By this time, Works Councils had became common in U.S. industry, with some 500 in place. Some, such as the GE Lynn works council, were highly successful meeting places where significant issues surfaced. Others were mere tokens. Where did GE Schenectady rank? A later student of non union employee representation, Bruce Kaufman, dismissed GE's works councils as "little more than window dressing or a stopgap device to keep out a trade union." He based this verdict on a study carried on at Schenectady in 1927 by a Cornell graduate student Margaret Meyer. She reported that the council lacked a grievance procedure. "Questions concerning wage rates were ruled out of order, " she wrote, while "a complaint of "discriminatory layoffs of older workers was met by a pledge of 'we'll investigate it', after which nothing more was heard."[287]

Even more scathing was the evaluation of the Schenectady Works Council by the Schenectady Socialist newspaper the Citizen. It dismissed this " GE Company Union" as a "large sized joke" and the "Mussolini brand of industrial control." Imposed on the workers from above, the Council, said the Citizen, dealt only with trivial matters, while " nothing that will increase wages or cost the company any money is tolerated."

Another investigation of the Schenectady Works Council was carried out in 1929 by the Conference Board. One might expect a more favorable verdict from an organization of corporations to which GE belonged. The verdict was, however, at best lukewarm. It reported the worker response as mixed. Some approved of the Council , some "thought the Council was a management device, and were suspicious." One district showed its contempt by electing a representative of alleged "low intelligence" who did not speak English. The most general evidence of a lack of worker enthusiasm was continuing relatively low voter turnout, staying at about 60%.On the subject of wages, the Council still in 1929 had no formal role. The most that was offered was a "theory of management" that any changes in wage policy would be "discussed in advance" with the Council.

The Council had by 1929, however, established a grievance procedure. A Council reprepresentative played a role not altogether different from the one later played by a union shop steward. If the representative's constituent had a grievance about workplace policy, the councilman could represent that

[287] **Kaufman, Bruce. Nonunion Employee Representation. 2000. Sharpe.p. 49**

constituent at hearings starting with the foreman, and if necessary proceeding up the line all the way to works manager.Most such grievances concerned piecework. For example

> In one department employing a large number of female workers, a woman [Council] representative, when she receives a complaint about an alleged "tight" rate tries the job herself or gets another woman of admitted ability to try it. If these experiments indicate that the rate is fair, she tells the complaintant that she has no case. On the other hand, if she is convinced that the rate is too low, she goes to the foreman and seldom or never fails to secure review..

Other successes of the Council included improvements in the vacation plan, and the modification of the pension plan to include voluntary worker contributions.[288]

Swope occasionally appeared before the Schenectady Works Council in person to explain company policy, and to answer questions. He did not, however, rely on face-to-face exchanges with shop workers for inputs into employee relations policy. Instead, his main source on labor matters was a consultant with labor union credentials. John Leary had been fired from GE's Lynn plant for union organizing. That, however had been back in the 1890s. He had since become labor reporter for the New York World, under editor Herbert Swope, Gerard's then more famous brother. Leary's ties with the union movement remained strong, but they were with the old time AFL leaders, not with the younger generation. Leary's inputs to Swope ranged from the superficial to the comforting. Especially superficial was Leary's 1923 placement of company spies on factory floors. They mainly reported trivial violations of company policy. Swope expressed his dissatisfaction, and the espionage effort was short lived.[289]

One of the spies, identified only as X, found in the shops more than he had bargained for. His undercover job, as a molder's helper at the Lynn Works, involved repeatedly filling a ladle with molten iron, carrying it 300 feet at a run, and then pouring it into a mold. "It required every inch of energy that I could expend " he wrote. "A molder (Italian) across from my machine, in

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[288] **Citizen 20 May 1927. Special Conference Committee. Representation in the GE Company. 6 Sept 1929. Swope Papers Box 20. Folder 113.4**

[289] **The program, labeled a "survey of Labor conditions" is in Swope Papers Box 17 Folder 113.2 J. and Swope to Miss A.A. Marratt 12 May 1923. Swope Papers. MiSci.**

very broken English, told me I wouldn't last over a week." Actually, he lasted one day. The next morning "I was so sore and stiff that every time I took a step I thought my back would break. " He spent the day first sleeping late in his hotel room, then taking a Turkish bath. He never returned to that factory floor.[290]

More consequential and comforting were Leary's reports to Swope from annual meetings of the American Federation of Labor . AFL organizers there repeatedly told him how little progress they were making at GE. James Murray, chief IAM organizer at GE, for example, told Leary that "nobody can do anything in Schenectady now." Leary may have also played a part in an initiative involving the AFL and GE . In 1926 Swope and Young met privately with recently chosen AFL President William Green. Swope's biographer David Loth quotes Swope as saying that he proposed an initiative that "if successful, would have led to a single union of workers not only in the General Electric Company but in the plants of all electrical manufacturers." He adds that "Swope and Young had been trying to get union organizers into their plants." [291]

This claim, presented without supporting evidence, has led to some exaggerated interpretations. Historian Colin Gordon, for example depicts Swope and Young as using the Green meeting " to accomplish sponsorship of an industrial union. " Gordon admits that the Loth version of the meeting might be taken "with a grain of salt". So it is worth presenting a first hand version by Swope himself. Here is an account from a memo written by him shortly after he, Young and Green met at 9:30 AM on 8 Dec 1926 at the Metropolitan Club of New York. Swope begins:

> I suggested to Mr. Green, for his consideration, that now at a number of our works, comprising thousands of workers, the workers had an organization and a committee for collective bargaining [the world councils] and that he might try to have those organizations as auxiliary bodies, as it were, of the American Federation of Labor, to

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[290] **"X" to Leary, forwarded by Leary to Swope, 14 May 1923 Swope Papers.**

[291] **Leary to Swope 18 Oct 1923, 19 Aug 1925.Swope Papers. MiSci. Loth, David. 1958. Swope of GE. Simon & Schuster. P. 171-172.**

> which they would pay maybe not the regular dues but partial dues, and these funds then could be used to further the movement in the shops where no organization existed at that time, and of course,to improve working conditions, hours, and wages in those shops.

That Swope proposal appears far from a call for a new industrial union. Rather, it seems to offer a role to the A.F. of L. in consulting with and supporting the Works Councils that GE had already established. "Such plans of representation," Swope went on to say, " were really industrial organizations. " Swope and Green continued to meet, but apparently without progress. “I had a long talk with Mr. Green yesterday,” Leary wrote to Swope in June 1928. “ He will be glad to see you when he returns to New York.” Leary added, however, that “on the matter of works councils he [Green] did not seem to be much interested.” Nor was Swope then interested in welcoming a fully independent union into GE. It would take a Great Depression to change his mind. [292]

Higher on Swope's priority list than amplifying the worker's voice was burnishing the GE image. Again, this was an acceleration of initiatives already underway. The company had created a publicity bureau at Schenectady in 1896. In 1899 it had chosen a corporate logo, an art nouveau depiction of the letters GE. That distinctive monogram persists into the 21st century, even on products GE no longer itself produces. In 1918 GE Iaunched its first corporate image advertising campaign, though only on the small scale of $100,000.[293]

That gradual adoption and tentative early corporate public voice met with the opposition of many managers. They feared that the name "General Electric" still connoted a giant octopus strangling its industry, much as the original Standard Oil had done, and U.S. Steel was still doing. That fear of

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[292] **Loth, David. 1958. Swope of GE. Simon & Schuster. P. 171-172. Gordon, Colin. 1994. New Deals. Cambridge. P. 119-120. Swope 's account of the 1926 meeting is included in Labor Relations in the General Electric Company 9-25-35. Box 17. Folder 113.2-I. Swope Papers.**

[293] **Those early efforts are described in Neil Reynolds Collection, Box 1, Folder 8, Series 1. Extracts from Sales Committee Minutes. Esp. P. 5.**

being permanently branded with the words "electric trust" had supported a two part marketing strategy. Apparatus such as turbines and motors were sold to public utility and industrial manufacturing customers under the name General Electric. To those elite, knowledgeable, managerial customers, the name connoted technological excellence. To the ordinary consumers who bought lower tech GE products such as irons and stoves another marketing method was used. For these customers, perhaps lingering believers in that electrical trust accusation, GE's identity was hidden behind the name of a purchased company. These included Hotpoint irons, a company created by a California utility executive Earl Richardson, and Edison electric stoves, a venture unconnected with the Wizard but created by by a Chicago entrepreneur George Hughes. [294]

In 1922 Swope called a company conference, ostensibly to seek the opinion of the company's sales professionals on publicity and advertising matters. Actually, it was to inform them that GE image making was being taken out of their hands and put into those of an outsider. New York City advertising executive Bruce Barton was already a pioneer in image advertising, He would also soon write a best-selling business-themed biography of Jesus. He had earlier worked with GE Lighting on image ads illustrated by a young Norman Rockwell. First, however the GE participants were permitted to voice their fears. "I do not believe we ought to do anything so far as the GE Company is concerned to convey to the public, the ultimate consumer, that a great octopus is absorbing all the [appliance] lines,"said one. "You are attacked by the Federal and State courts and are apparently very unpopular and monopolistic," added another. " Institutional advertising at the present time would be a great mistake. " .

Then Barton, speaking last on the program, banished those fears. "You have a great idea to sell," he said. " the electrical idea. " To sell it "reputation is repetition". Repeat the message that electricity enables better lives-- from "the flashlight that saved General Pershing's life on the fields of France" to "Jane Addams sitting in the cool breeze of one of your electric fans. " Barton 's proposal was accepted. Throughout the 1920's that “initials of a friend campaign” was repeated in numerous full page illustrated examples. They

[294] **GE Appliance Specialist's Sales Manual. (Und.) Section #1The History of the Edison Electric Appliance Co. MiSci**

did not so much push specific GE products as tell how, thanks to GE and that electric idea, life was becoming easier, brighter and more productive.[295]

Meanwhile, at the apparatus end of the business, that electric friend was still using an unfair, likely illegal, advantage to gain an edge over competitors. Through the company's financial arm, Electric Bond and Share, GE had significant stockholdings in about one sixth of the electric utility industry. Those utilities bought 90% of their turbines from GE, compared to 60% purchased by other private utilities, and 35% purchased by municipally owned companies. "Attempting to sell to the Electric Bond and Share companies," complained a competitor, "is like selling to the General Electric itself."In the U.S. Senate , progressive Republican Senators led by George W. Norris of Nebraska were attacking GE both for its Electric Bond and Share advantage, and as "the water power trust". They accused the company, of conspiring to monopolize the so far undeveloped water power resources of the nation, especially the abundant resources on the St. Lawrence River and at Muscle Shoals, Alabama. Norris and the other critics favored the public development of water power, a preference that would ultimately be realized in the 1930s when Muscle Shoals became part of the Tennessee Valley Authority (TVA).

GE's response to that Senate criticism surprised the critics. In 1923, Owen D. Young had warned in an internal company letter that " the more powerful the Electric Bond and Share Company becomes...the more dangerous the situation becomes for the General Electric Company. " Just as Norris's attacks were peaking, in December, 1924, the company announced that it was spinning off that Electric Bond and Share business. Ownership of that company was passed on to GE stockholders in proportion to their GE holdings. This represented a substantial sacrifice of profit by GE . Changes in the way the company reported its income from 1924 to 1926 makes the amount of sacrifice difficult to determine exactly, but it appears to have been in the range of from one to three million dollars per year. [296]

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[295] **Meeting of gen elec co its associated interests and distributing jobbers held at the Mohawk Golf Club July 25 26 1922. ; G. Swope to Bruce Barton 28 Feb 1923. Swope Papers. Folder 201.2 B. See also Marchand, Roland. 1998. Creating the Corporate Soul. California, esp. Pp. 123-153.**

[296] **O.D. Young to E.W. Rice. 14 Mar 1923. Young Papers. 1-97. MiSci. Board Minutes 30 Dec 1924. P. 302.**

As a public image move, however, the tactic paid off. George Norris did successfully pass a Senate motion that the Federal Trade Commission investigate GE dominance over the electric power industry. That investigation, however, coincided with a changing of the guard at that hitherto antitrust watchdog. The Coolidge administration put in place a new FTC chairman friendly to big business. In 1927, the FTC report that Norris had requested found GE innocent of any monopolistic or other illegal actions in its electric utility related businesses. [297]

The "initials of a friend" campaign and the Electric Bond and Share divestiture show that Swope clearly had a public relations goal : to replace the harsh "electric trust" image with a softer, gentler one. Did he also have a product strategy?

Assertions that he did have been presented by GE itself, by Swope's biographer David Loth, and by business historian Alfred Chandler. They credit Swope with a 1922 strategic decision that GE would enter the large consumer appliance business (e.g, washers and refrigerators) in a major way under that corporate monogram. None of them presents any evidence of such a strategic decision. Nor can any such evidence be found in Swope's voluminous business papers. Instead, the evidence supports the story given by Ted Quinn, who would later run the GE refrigerator business. "Gerard Swope started his administration by continuing the path of his predecessor," Quinn wrote. " He did not believe in long chances or quick changes. " [298]

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[297] **MiSci.Senate Resolution 329 (68th Cong., 2nd Session) adopted 9 Feb 1925, summarized in New York Times 4 Feb 1925. p. 34. Annual Reports of The Federal Trade Commission for the Fiscal Year Ended 30 June 1926, 1927, 1928. New York Times 13 June 1926, p.38, 3 Apr 1927. Federal Trade Commission Report 12Jan 1928. Davis, G. Cullom. 1962. The Transformantion of the Federal Trade Commission, 1914-1929. Mississippi Valley Historical Review. 49. 437-455.**

[298] **Loth, David. 1958. Swope of GE. Simon & Schuster. p. 117. Chandler's claim, based on vague references to Fortune Magazine, GE Annua l Reports and Loth's biography of Swope , of Swope's "explicitly defined" strategy of entering the appliance business is Chandler, Alfred D. 1962. Strategy and Structure.p. 365. Loth's claim that Swope, from the first wanted to convert GE from simply a producer of heavy equipment to mainly a consumer products company are presented, also without evidence, in Loth, David. 1958. Swope of GE. Simon & Schuster. pp. 126 and 117. GE' s statement is in Oakes, Eric. 2017. GE's History of**

Swope began his regime not by imposing a new strategy, but by confirming and continuing the old one. GE's major products would continue to be turbine generators, electric motors, and light bulbs. These would be supplemented by everything else it took-- transformers, switches, cables, controls, and the rest of what was labeled "supply" -- needed to help electricity unleash the protean possibilities of energy conversion. Rather than launch a new GE-named business in major consumer appliances, Swope initially continued the process of not making refrigerators or washing machines. Instead, GE would sell electric motors to the companies that made those major appliances. The consumer products GE did sell would be less complex, mostly involved with converting electricity into light or heat, and continuing to bear such names as Edison, and Hotpoint.

To set a standard for GE sales, Swope had In 1922 asked the company's Accounting Department to determine GE's share of the U.S. electrical manufacturing business . The answer was that the share had increased from 18% in 1915 to 24% in 1920. Swope would in 1923 publicly depict GE as content to serve 25% of the existing electrical manufacturing industry. "It is much more important that you have a fair proportion of the available business yielding a fair and reasonable profit, " he said, "than to get a little more business and have misunderstanding throughout the industry".[299]

In a 1926 speech, Swope further distanced himself from the idea that the goal of a corporation is profit maximization. "A business, " he said, " is an institution for service". Its responsibilities are not just to its stockholders. As he put it:

> I want to look at the Responsibilities of Modern Indistry-- first from the standpoint of the public; second from the standpoint of the employees, third from the standpoint of the share holders; and fourth from the standpoint of the industry itself.

Innovation. GE, online. Quinn, T.K. 1953. I Quit Monster Business. Exposition Press, pp. 77-79.

[299] **Swope to Charles Neave 19 June 1922. Swope Papers Box 32.Folder 422B. Swope, Gerard. 1923 Speech to Electrical Manufacturers Club Hot Springs AK 15 Nov 1923 in Young, Owen D. and Swope, Gerard. 1930. Selected Addresses. GE.**

In that order, which implicitly if not explicitly seems to be a priority order, the responsibilities were as follows. For the public, the responsibility was "for service, for the quality of products, and the continual progressive reduction in product prices." For the employee

> It comes down to adequate consistent and reliable wages, life insurance to remove uncertainty in death, proper housing and opportunities for saving, investments to provide pensions for old age. Those who put their lives in the business deserve this much

For the shareholder

> the responsibility is for a fair, regular, uniform return so that when capital is needed for the extension of the business it will be forthcoming

And finally, for the electrical industry, the responsibility was mutual benefit, and fair competition . [300]

To get GE's fair and uniform return in an electrical manufacturing industry that was doubling in market size every decade, all GE had to was to keep its 25% share . Indeed, that is roughly what GE did. Between the short, sharp depression of 1921 and the Great Depression of 1929, GE sales doubled from about $250 million a year to about $500 million a year. This 100% increase far exceeded the 30% increase in the U.S. GDP.

The main product of the Schenectady Works' remained large Steam Turbine Generators. Here GE's market share stayed above 50% as these giant, technologically complex machines grew steadily bigger and more efficient.The main challenge that business met was not competition. It was a dislocation of scale that appeared in 1919 and put the business in danger. Suddenly, rotating disks on some of the latest and largest turbines (20 MW) began breaking apart, sometimes in hazardous explosions. In 1924, such an explosion at the Schenectady Works killed one worker and injured others. At one time around 1920, GE turbine expert Glenn Warren later said, every one of the largest GE turbines in the hands of utilities had either broken down or been shut down in fear of such an accident.

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[300] **Swope, Gerard. 1926. Speech to Associated Business Papers Convention in Young, Owen D. and Swope, Gerard. 1930. Selected Addresses. GE.p. 35.**

The effort to meet this challenge showed the giant works of a giant corporation at its best. GE quickly assembled, under the leadership of Charles Eveleth, a team of experts with a wide range of skills. The work of one team member best captures the effort's spirit and strengths.[301]

Wilfrid Campbell was born in Wales and served a seven year apprenticeship on a British railroad, emerging as a draftsman. He came to the U.S. in 1904 and to the Schenectady Works in 1907. There he was recalled as a man of both "ready ingenuity" , " genial good nature and unfailing optimism", and an open mind. For example, he was willing to entertain the possibility that he could communicate with his brother in South America by mental telepathy. He advanced in GE not by eccentricity, credentials, ambition or aggressiveness but by demonstrated ability at solving problems. His self taught expertise at analyzing vibration led to his choice as principal investigator of the turbine crisis. His efforts ranged widely. He visited the sites of failures. He studied broken disks and the fragments of disk explosions. He launched an experimental program, making rubber models of the turbine disks, spinning them, and recording their deformation with oscilloscope readings and spark photography. He verified results from these model tests with tests on actual disks. [302]

In this way, the team tracked down the source of the problem.It stemmed from an effort to increase turbine efficiency. To do so, disks had been made larger in radius, thinner, and lighter. This had introduced two sources of vibration, one related to air resistance, the other to material structure. Neither by itself caused a problem. But when they combined, a standing wave formed. It grew bigger and bigger until the strain on the disk became unsustainable.Once the failure process was understood, it became possible to predict what sets of disk dimensions caused the vibrations to combine dangerously, and to avoid those sets of dimensions. By 1923, Campbell was able to write that

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[301] **Doran, John B. "Recollections of My Career in the Turbine Department at the GE Company" 25 Oct 1971.**

[302] **Campbell's biography accompanied his article Campbell, Wilfred and Heckman, W.C. 1924. Protection of Steam Turbine Disk Wheels from Axial Vibration. Trans. ASME. pp. 31-60.**

> examination and verification of predicted properties is at the basis of the remarkable freedom from vibrational troubles exhibited in the behavior of recently built turbines.[303]

He would not see this conclusion in print. Perhaps showing more concern for the turbines' internal health than for his own, he suffered in July, 1924, an attack of appendicitis, and died on the operating table. His memorial is a graphical method he developed for analyzing mechanical vibrations. It proved valuable far beyond its original turbine application. It lives on in mechanical engineering under the name Campbell Diagram.

This problem solving potential of the deep and diverse human skills of a large manufacturing works also showed up in 1922 in consideration of a more general issue. GE leaders were aware that some other companies, such as Du Pont and General Motors, were abandoning what historian Chandler later called the "Unitary" or "U- Form" structure. This was that organization structure consisting of a single hierarchy, operating out of one or a few giant works. In its place was being put a decentralized structure, called by Chandler the "M form". In the M form, each separate business got its own work force at its own location with its own manager in full control. The top executives confined their efforts to decisions affecting the corporation as a whole such as allocating capital and strategizing.

The M-Form established clearly defined lines of management authority, pushed day to day decisions down from corporate headquarters to the local manager, and avoided the threat of the whole company being shut down by natural disaster or a labor uprising at its biggest works. A GE study in 1926 weighed the advantages of these two forms of organization. A central focus was the Works, a central feature of the U-Form. At issue was on one hand " the opportunity to become a specialist in a certain line" by entrusting every aspect of that line to an M-Form factory. On the other hand,the U-Form offered, at its giant works, "a more diversified line of production" Weighing the advantages, the experienced manufacuring managers leading the study recommended that the company stick to the U form and the Works. They

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[303] **Campbell, Wilfred and Heckman, W.C. 1924. Protection of Steam Turbine Disk Wheels from Axial Vibration. Trans. ASME. p. 62.**

concluded that Works based diversity of the U-Form outweighed in value the scattered specialization of the M-Form Factories.[304]

While sticking with the U form, Swope and his team did not shape it into a Chandler style pyramidal hierarchy. Indeed, Swope retained the Coffin-Rice dependence on committees, consensus and cooperation. Management responsibilities were loosely defined and often overlapping. "the best way of guaranteeing a succession of good managers" said Swope on 1923, " is to have them grow in the open. ". [305]

Organization charts were rare and sketchy. Olaf Vea, who became General Manager of GE's electric motor businesses, described Swope's management system this way:

> Let the individual expand his responsibility to the extent he would even though he took over from others. We never saw an organization chart in those days. Expansion was restrained only by the similar expansion of responsibility by others. Those others would pick up if someone made a mistake and keep them from turning that little mistake into a big one.[306]

The U form and Works also offered more stable employment. Workers could be shifted from products facing lower demand to those facing higher demand, rather than being laid off. In addition, as that 1926 report concluded.

> diversified manufacture would give the opportunity for the employment of both male and female labor which often would result in more than one member of a family being employed and give to such families a more satisfactory economic condition, and, by reason of better condition, a lesser demand on the company for wage increases.

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[304] **"Erben H.F.T, Dalton, William, Maxwwell, G.S. 1926. Report on the Mfrg Situation 2 Aug 1926. MiSci. Simmons to F.C. Pratt 2Aug 1926. Swope Papers**

[305] **Swope, Gerard. 1923. Speech to Camp Emmons, Association Island. Collected Speeches of Gerard Swope.**

[306] **Olaf F. Vea. Oral History 24 Oct 178. HoH Collection. MiSci.**

A works personnel specialist out it more colloquially. "We could take the top guy in the family into turbine, and we could take the women who wanted work into the controls department. " [307]

Rather than a single works, however, there would be a giant one at Schenectady, and lesser ones at Lynn and Pittsfield MA, Bridgeport CT, Erie and Philadelphia PA, and Ft. Wayne IN . This not only avoided the threat of a company shutdown by a accident or strike , but also offered the capability for competition between Works, such as one that had recently improved the performance of GE's induction motors. These manufacturing centers had works councils, benefit programs, and a new generation of managers. In 1922, a company study urged replacement of the "old, hard boiled drivers of men" with lower key, more professional college graduates. By the mid 1920's this new corps of what was sometimes derisively called "velvet glove" managers were in place. They included. Eveleth at Schenectady, Nelson Darling (son of GE's corporate treasurer) at Lynn, and Harold Emmett (nephew of turbine pioneer W.L.R. Emmett) at Erie.[308]

They carried out a labor policy based on a model called "the Plan." The company, it proclaimed, wanted minimum cost per unit of goods produced. The worker wanted maximum pay per hour worked. The way to satisfy both was more piecework, more worker cooperation, and strengthened management coordination. "Labor relations," Swope said, " is only a question of management. " He described "a machinist, a man who, to my mind is not adequately paid, a man of great skill...who cannot make any wrong operation without spoiling thousands of dollars worth of property." The problem, Swope went on to explain, was not only to get him to work error free, but also faster. To do this, get him to believe that he will earn substantially more money. Not merely $ 6 a day in place of $5, but $10 or $15 or more. The efficient and ambitious worker will thrive. The slackers and troublemakers will be weeded out.

The details of the Plan survive in the Swope Papers beginning with a statement that “the underlying principle of the plan is that each participant is

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[307] **Louis Male Interview HoH 2 Sept 1979.**

[308] **Labor Report 30 April 1922. Swope Papers.**

a member of a group which is working to improve the Company's business," and moving on to a long descripton.The Plan was, however, summed up more informally succincly in a letter from Swope to an engineering manager.

> I notice that there is an increase in men, and an even greater increase in payroll. This means, of course, that we are paying our men more, which is good and of course the effect we look for as a result of employing better men is to have fewer of them.[309]

Swope had already in 1923 heard from his agent Leary that piecework was achieving one of its purposes. A Machinists' Union organizer told Leary that organizing Schenectady remained hopeless: "Why in GE they have machinists who are making $75-$80 a week. Anyone who is any good at all can knock down $50. They have piecework there you know. "That new piecework Plan began in 1924 with a foreman rating all men in four classes. Class A, the most efficient and ambitious, immediately got a significant wage increase. Class B got a smaller increase. Class C got no increase, and was marked as first to be laid off during the next business downturn. Class D, the slackers and troublemakers, were to be laid off immediately.[310]

Meanwhile more rate setters were hired, and the piecework system was both expanded and overhauled. Eveleth claimed that in the year 1924 more than 15,213 piecework prices were changed. Use of detailed time studies had become common throughout the shop, which was, he wrote, "a change in conditions which is very desirable in order to set fair prices". Fairness was the key. "The danger is," Swope told an audience of foremen in 1927, "that on the piecework basis the piece rate hasn't been very well set, so that when the men have become more skilled and their earnings increased, the rates have been cut. There isn't anything more disastrous." Swope decreed that,

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[309] **Swope to H.W. Allen 29 July 1926. Swope Papers Box 10 FF 110.1 #1. That Folder, and many more in Boxes 9-11 spell out the Plan in greater detail**

[310] **Eveleth to F.C. Pratt.Schenectady Works Annual Report for 1924.Swope Papers.B. L. Delack to Swope 13 Nov 1928 and 6 Mar 1930. Box 17. Folder 113.23 Swope Papers. MiSci.**

once an initial rate has been established, a rate change could only increase pay, not cut it. This solved the problem in theory, but not in practice. Parts were constantly being redesigned, justifying a new rate setting session that could result in a de facto rate cut. Company piecework plans of the 1920s have often described as "scientific management", the application of plans designed by the new breed of management consultants. GE did indeed in some places adapt its own version of one of those plans, the Bedaux System. It did indeed occasionally contract with professional time and motion study consultants, such as Lillian Gilbreath. At Schenectady, however, instituting piecework was a more often improvisation than science.[311]

For example, piecework at the Schenectady Works iron foundry was instigated not by a scientific study, but by worker complaints about low pay. Louis Male, a former blacksmith, and 1911 Socialist who had been recently promoted to rate setter, was assigned to deal with the trouble. He called the foundry workers together, and, working with them on the spot, convinced them to accept piecework in place of the unsatisfactory day wage rate. Only then did Male take this agreement back to his department and develop a piecework plan.[312]

The end result was indeed more output from the foundry at lower unit cost. It was achieved by fewer, and better paid, workers. The excess employees were, however, not fired. Those who had performed well under the new piecework program were transferred to other areas of the Works to spread the piecework gospel . Those workers who resisted the program, "soldiering" just fast enough to get by, were transferred to dead end jobs and marked for layoff at the next business downturn.Schenectady employment was thus somewhat stabilized, fluctuating in the 20,000- 25,000 range through the 1920s. In that decade total GE employment rose from 50,000 to 70,000.

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[311] **Swope Gerard. 1923. Speech to Camp Emmons, and 1922. Notes from Talks to Foremen.Both in 1930. Collected Speeches of Gerard Swope and Owen D.Young. C. Eveleth to F.C. Pratt Schenectady Works Annual Report for 1924, 27 Feb 1924, Swope Papers.**

[312] **Louis Male, Interview, HoH 2_September 1979.**

How did this emphasis on productivity impact the ability to innovate? GE almost never itself invented what it helped innovate. The Works system instead strengthened two parts of the innovation process where giant corporations excelled. These were overcoming dislocations of scale, and absorbing without adverse consequences the cost of failed innovation attempts.

Most GE innovation efforts in the 1920s did fail. For example, GE had been prepared to make millions equipping Navy battleships with turbine-electric drives. Then, in 1922 the U.S. signed a naval disarmament treaty and the battleships were cancelled. Two GE powered electric drive cruisers were converted into the U.S. aircraft carriers, Lexington and Saratoga, and later saw action in World War II. Overall, however, the cancelled electric drive warship effort was a 1920s disappointment, only partly compensated for by sales of electric drives for peaceful vessels. Alexanderson's alternator also never became a major product. Vacuum tubes (also partly pioneered by GE) quickly took over in radio broadcasting. GE did put in place profitable vacuum tube transmitter and radio receiver assembly lines at Schenectady and other works. Profits were limited however, since the equipment was sold wholesale to RCA, rather than retail to consumers.

A third opportunity, electrifying main line railroads, also refused to take off. The railroads would be too short of capital, to embark on electrification. Between the electrification of the Milwaukee, St.Paul and Pacific Railroad before 1920, and the electrification of large stretches of the Pennsylvania Railroad in the 1930s, no big railroad electrified a main line. When electric drive did later come in, it was via less capital intensive diesel electric locomotives, not fully electrified main lines. GE would later profitably enter this diesel-electric locomotive business , but not until General Motors had shown the way. Other delayed or failed innovaton attempts included the effort to make a business of the turbosupercharger developed by Sanford Moss, which drew only minor defense department interest before the development of improved aircraft in the 1930s, the attempt to put sound into movies, where AT&T's system won out over GE's, and a eventually abandoned decades long effort to build a combined cycle turbine generator system using mercury vapor as a working fluid. [313]

[313] **W.L.R. Emmet to F.C. Pratt. 30 Dec 1922. Swope Papers Folder 422 A. MiSci.**

The crop of good- growing- weather World War I innovations did result in one winner: the GE X-Ray business. Coolidge's patent on the pure electron discharge X Ray tube, and government suppression of the competing German patent, gave GE a legal monopoly for over a decade. This led to acquisition of the Victor X Ray Company, and a rapidly growing and profitable GE X Ray systems business.

It would be another GE innovation of the 1920s, however, that would bring in by far the biggest profits. This was mechanical refrigeration using electric motors .The independent inventor who brought the idea to GE was Marcel Audiffren. He was a French Roman Catholic clergyman and physics teacher. His new idea for refrigeration, patented in the 1890s, was called a "hermetically sealed" system. The entire electric motor driven cooling mechanism was sealed within a metal shell. This offered high reliability. It was, however, so expensive to produce as to be suitable only for large commercial uses such as wineries and restaurants. It was far too bulky and costly for the family kitchen.In 1912 GE bought the American rights to Audiffren's patents. The initiative here did not come from corporate strategy, but from the enthusiasm of James J. Wood, the manager of GE's Fort Wayne Works, a self trained "practical electrician" dating back to Thomson Houston days. He personally led the building of GE's first version of the Audiffren refrigerator, then launched manufacture of it at Fort Wayne. This small and not very profitable business produced large and expensive refrigerators that were sold to commercial customers.

By 1920, a few other companies had developed home refrigerators. Guardian Refrigerator, for example, was started in 1916 by two former GE engineers from the Fort Wayne Works. They tried to adapt the Audiffren idea to home use, failed, and sold out to the young General Motors company. Dropping the Audiffren idea, GM marketed by 1920, with success, a simpler, less efficient, and less reliable model named the Frigidaire. Like the product of its main rival, Kelvinator, its cooling components were not sealed in an airtight shell. The system also had to be hooked up by a plumber to the house's water pipes[314].

[314] **Donaldson, Barry and Nagengast, Bernard. 1994. Home Refrigerators. American Society of Heating, Refrigerating & Air Conditioning.**

At Fort Wayne, a GE team led by chief engineer Clark Orr, stuck with the Audiffren concept. They did this on their own initiative, not by corporate directive. They came up by 1919 with a promising design. Twenty of these refrigerators were successfully tested in the homes of GE executives. The Fort Wayne team was unable, however, to lower production cost enough to offer a a competitive product.There matters stood in 1923. What brought this small Fort Wayne project to top level corporate attention was not corporate strategic planning. It was an offer by General Motors Frigidaire to buy the GE design. This offer went up the management chain to Vice President of Engineering Francis Pratt. When he conveyed the offer to Swope at a meeting of the GE Advisory Committee, Pratt urged rejection. GE had a uniquely promising technology on its hands and ought not to give it up. Owen D. Young agreed.[315]

Swope did not decide on the spot. He commissioned a study. It was carried out by engineer Alexander R. Stevenson. In great detail, Stevenson analyzed the technical challenges, investment requirements, and business opportunities presented by turning the Audiffren - Orr refrigerator into a product. His main conclusion was positive. If GE was willing to make the multi-million dollar, five year investment needed to perfect and mass produce this technically challenging design, it would have a refrigerator greatly superior to anything currently on the market. It would be a product that competitors could not soon match. At a sales price of $600, higher than current models yet affordable to many customers, GE could make big profits before others caught up. Swope accepted this conclusion. In 1925, two rival GE development projects were launched, one at Fort Wayne, the other at Schenectady.[316]

Here, as in the story of solving the 1919- 1923 turbine crisis, what proved crucial was the presence in each Works of a wide range of skills that could be instantly applied. This was exemplified by a skilled craftsman who had turned himself into a problem- solving engineer. Chris Steenstrup was born

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[315] **Linkous, Clovis E. 1941. GE at Fort Wayne Indiana. Gateway, expecially pp 176-180, 195Francis Pratt to Gerard Swope 17 Aug 1923. Included in Stevenson, A.R. 1923. Report on Domestic Refrigerating Apparatus. GE Technical Information Exchange. MiSci.**

[316] **Stevenson, A.R. 1923. Report on Domestic Refrigerating Apparatus. GE Technical Information Exchange. Holliday, William L. 1994. The GE Monitor Top Refrigerator. ASHRAE Journal. Sept. 1994, pp. 49-55.**

in Denmark into a moderately prosperous family, Steenstrup chose shop apprenticeship over a high school school education. He moved to the U.S. at 16. Working as a machinist at an arms factory in Bridgeport CT, he quickly demonstrated his initiative as a problem solver. Then, idled by a strike, he moved on to GE at Schenectady. He moved up the management chain, to foreman and then supervisor, by inventing improvements in both the speed and the safety of machines. He did not forget his shop origins. He became known as a strong advocate for craftsmen who found their ideas appropriated by credit-hogging foremen. This role was formalized when Steenstrup was made chairman of the Schenectady Works Suggestion System. He also extracted special privileges from his valued status. He set up his own private machinery business in Schenectady while still a full time GE employee. Another Works craftsman followed Steenstrup's example, but was rebuked by management. When he asked why, the answer came back "you're not Chris Steenstrup." [317]

Steenstrup was the supervisor of a machinery design department in 1925 when the refrigerator opportunity arrived.He brought to that opportunity an unplanned advantage. A keen observer as well as an inventor, he had learned of a technological advance made at the GE Research Laboratory. It was the use of a welding torch fueled by pure hydrogen to produce a hot, clean flame ideal for brazing airtight seals in the manufacture of vacuum and X-Ray tubes. Against current assumptions, Steenstrup showed that this laboratory process could be scaled up for factory use. It proved effective on turbine parts. When used to make boiler tubes for GE's experimental mercury turbine it helped prevent leaks of hazardous mercury vapor. The hermetically sealed cooling unit of the new GE refrigerator provided a similar opportunity.

Steenstrup, however, went beyond merely providing his hydrogen brazing technique to both the Schenectady and Fort Wayne competitors. He also developed a third competing design, a higher performance, lower cost, modification of Orr's Fort Wayne design. In a three way cool-off

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[317] **Interview with Carl Steenstrup (son of Chris). 1986. 16A Steenstrup File. MiSci. Harry Hillis Oral History. 11 July 1975. HoH Collection. MiSci. Steenstrup, Christian. 1941. The Importance of Effective Leadership. Talk to Association of Suggestion Systems.**

competition, Steenstrup's model emerged victorious. Complaints that he had secretly employed a hidden container of liquid air were dismissed as sour grapes. It was Steenstrup's version of Clark Orr's version of Marcel Audiffren's original idea that became GE's "Monitor Top" refrigerator (so named because the cylindrical cooling unit on top resembled the turret atop the famed Civil War ironclad "Monitor").[318]

Emphasis on Steenstrup's contribution illustrates, but also exaggerates. A crusty throwback with not only the demeanor but even the appearance of a snapping turtle, Steenstrup was a natural for the attention of GE publicists and later historians. A more balanced approach recognizes again the collective nature of innovation. Audiffren had an original idea, combining the thermodynamics of refrigeration with the possibility of hermetically sealing into a metal shell the then new AC induction motor. James J. Wood seized the opportunity for GE to license the invention. Clark Orr, similar to Steenstrup in background and contribution but less colorful and therefore less publicized, contributed the key design. The competitors at Kelvinator and Frigidare perceived in the 1910s that the time for the electric home refrigerator had arrived. When Frigidaire's representatives asked to buy GE's technology, GE Vice President of Engineering Francis Pratt intuited that GE should hang on. Engineer A.R. Stevenson supported Pratt's intuitions with data and arguments.Where does visible hand strategy come into this? It doesn't. Far from strategizing GE's entry into refrigerators, Gerard Swope's main contribution was not strategizing, but accepting the good advice of Pratt and Stevenson.While the GE Monitor Top was far from the first home refrigerator, it was the one from which today's refrigerators descend. The hermetically sealed idea was a giant step forward in convenience and reliability. "All you have to do is plug it in to an electric outlet and you can forget it," read a GE ad. "It hasn't any belts, drains, fans or stuffing boxes."[319]

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[318] **Truman S. Fuller, Interview, HoH, 22 Mar 1978. The cool off competition is described in Whitsel, H.A. 1926. Domestic Refrigerator. GE Technical Information Exchange. The liquid air story is in James F. Young Oral History. 1 July 1977. HoH Collection MiSci.**

[319] **An excellent treatment placing GE's refrigerator in the context of a technical path not taken, the gas-powered refrigerator, is Cowan, Ruth. 1985. How the**

Swope's next contribution was to pick the refrigerator department's top manager,Ted Quinn. He occupied , in one turbulent and unconventional career, first the role of one of GE's most effective and energetic leaders, then the role of one of its most angry and articulate critics. He was also the only GE employee to be fictionally portrayed as a major character in a drama by a major playwright (Arthur Miller's "An American Clock").

In some ways, Quinn was an obvious choice to run a new consumer business. GE had on 1925 one major consumer business, light bulbs. The most promising of the 1925 Lighting Department's Promising Young Men was Ted Quinn. In other ways, however choice of Quinn for a coveted management slot was less obvious. His father had been a union organizer. In an era when GE increasingly recruited its new professionals from colleges and universities, Quinn went to work after high school, learned accounting on the job, and then earned a night school degree.[320]

Refrigerator Got its Hum. In McKenzie, Donald and Wajeman, Judy. 1985. The Social Shaping of Technology. Open University Press. Pp.202-219. See also Rees, Jonathan. Refrigeration Nation. John's Hopkins. especially pp. 150- 153. Advertisement reproduced in Blackford, Mansel and and Kerr. Austin. 1986. Business Enterprise in American History. Houghton Mifflin. p. 268

[320] **Quinn, T.K. 1953. I Quit Monster Business. Exposition Press. Quinn obituary, New York Times 29 August 1961.**

His practical experience helped him build on Stevenson's analysis. Quinn recognized that the key to success was a high volume of sales that would justify investing millions of dollars in assembly line production faciltities. This also required confidence that human assets such as Steenstrup and the GE Research Laboratory would overcome the dislocations of scale likely to emerge.That scaling up took four years. There were many hiccups along the way. For example, when a first 1000 were tried out in 1927 with actual customers, Research Director Willis Whitney suggested to Quinn that he keep them close to Schenectady "to admire them." This good suggestion assured that the subsequent unexpectedly large number that failed were conveniently near the Works, to which they were returned for analysis and improvement[321].

It was not until 1929 that the GE monitor top refrigerator became a reliable and profitable GE product. It did so just in time. It was the profits from refrigerators and light bulbs that would enable GE to pay dividends throughout the Great Depression. Following up on this success, GE would enter the home laundry field in 1930. Initially it sold machines purchased from the Hurley Machine Co. It followed up with machines of its own design, an electric washer in 1933 and an electric drier in 1934.[322]

Refrigerator success rode in part on business innovations previously unseen in GE. Quinn assembled a nationwide network of dealers, including some of whom, such as New York City promoter Rex Cole, were disdained by other GE managers as shallow flashy showmen. In action, they proved instead effective salesmen. To support their efforts Quinn put in place a warranty of unprecedented duration and comprehensiveness. To expand the share of consumers who could meet the falling but still steep price tag , Quinn recommending following the precedent of General Motors, which was using its automobile financing unit, GMAC, to finance purchase of Frigidaire refrigerators. In response, the GE Board of Directors approved in 1932 the creation of a “GE Financing Company” with an initial appropriation of $5 million. This was the origin of GE Financial Services, the business that would by the year 2000 earn half of GE’s profits. [323]

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[321] **Quinn, T.K. 1953. I Quit Monster Business. Exposition Press. P. 93**

[322] **Elfun Historical Society.1987. A Walk In the Park. Elfun, p. 20**

[323] **GECorporate Administrative Collection. Series Minutes. 23 Sept 1932. MiSci.**

Even in the the anachronistic, feudal organization of the Old GE, the refrigerator business was ramshackle. From an office building in Cleveland OH, Quinn managed his national dealer network, his technology team in Schenectady and Fort Wayne, and assembly lines first within the Schenectady Works, then in Bridgeport CT and Erie PA. It would not be until the 1950s that this important consumer business got its own dedicated production site, Appliance Park in Louisville KY.

The Schenectady assembly line was far from a model of safety conscious scientific management. John Lake was 16 years old In 1927 when he went to work on the Schenectady Refrigerator assembly line. " It was hell", he recalled later. "I put together the evaporator...We made 1250 evaporators every day. If you didn't make your 1250 evaporators in your eight hours, you stayed until you finished the 1250. You were working 50 or 60 hours a week. You didn't step away from your machine... the machines were jammed in. You could hardly move. " He he recalls how the copper tubing and pickling solution turned his skin a green color "that didn't come off very well". In the summer, the temperature on the assembly line climbed to 120 degrees. Among the accidents Lake witnessed were a man next to him having his eye put out by a rivet, and another being"scalped" by a falling fan. "It was tough to work in Refrigerator", Lake concluded. "But refrigerators put us through the Depression. "[324]

Despite such manufacturing problems, a company safety program achieved a steady decline in significant accidents in the 1920s . At Schenectady this fall was from 170 in 1924 to 106 in 1926. Deaths also fell, to a low of only six in 1928. They would subsequently turn upward, if only mildly, until the depression. Regarding particular health and safety issues, GE typically did no worse than other giant companies. Like many, it failed to respond adequately to some major perils to workers' health, such as asbestos, silicosis from inhaling airborne particles , or the dangers to workers from the mercury used in vacuum tube technology and that experimental turbine.[325]

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[324] **Lake, John. Interview 11 May 1976. HoH.**

[325] **E.Z. Steever to H.F.T. Erben. 10 May and 9 June 1926. C.C. Conover to Gerard Swope. 2 May 1929. Swope Papers. Box 25.A. Folder 118.14. MiSci.pf GE and the silicosis issue is in Rosner, David and Merkowitz, Gerald. 1991. Deadly Dust.**

Sometimes, however , GE did better than average. For example, to complement GE's internal safety efforts, Swope hired as a consultant in 1925 an old friend from Hull House, Alice Hamilton, then at the Harvard School of Public Health. She undertook at Swope's request an inspection of GE works and factories. This was no token effort. Two very thick notebooks in the Swope Papers hold the many suggestions Hamilton made. "It was gratifying to find in every plant that I visited for the second time" Hamilton reported to Swope, " that all of almost all of the suggestions had made on my first visit had been carried out."[326]

Swope pioneered not only in employee health and safety, but also in employee income security. In 1925, after extended study, he proposed an unemployment insurance plan funded by a deduction of 1% of each employee's weekly wage and a matching company contribution. This entitled the worker, if laid off, to collect half pay (up to $20/week) for up to 10 weeks.The plan was tried in the Schenectady Works in 1926. It was to go into effect company wide if approved by 75% of all workers. In 1926 that level of approval was not attained. In 1930 Swope would try again and this time get approval.[327]

By 1929, Owen D. Young was arguing that such progressive programs showed that giant corporations had already evolved into vehicles for community service. Fears of an electrical trust could now be buried. From the pulpit of an upper crust New York City church, Young proclaimed in 1929 that

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Princeton. P. 76. In her interview, Alice O'Hara describes taking part in a company wide test of mercury in employees's bodies, and the company alarm at the high levels measured. Interview with Alice O'Hara 10/25/77.

[326] **Alice Hamilton to Swope 1 June1925. Swope Papers. Box 20. Folder 113.81 B. MiSci**

[327] **The Unemployment Plan's progress is described in Folder 113.3C, Swope Papers, MiSci. The 1930 GE Annual.Report, p.20 describes how the Unemployment Plan was offered company wide but "at that time unemployment was considered remote, and the plan was not accepted". Its 1930 acceptance is described in Works News 15 Aug 1930 p. 3.**

> Big Business has not justified the fears of our people. Exploiters no longer own the big concerns. Bankers no longer own them. Their shares, like motor cars, are spread from one end of the country to the other in every city and village[328].

In Schenectady, that conclusion remained contested. Wages at the company already sarcastically labeled "Generous Electric" were, on a national basis, only average. Employment, as elsewhere, was precarious. Benefits, though generous by 1920s industrial standards, were minuscule by later 20th century standards. In the 1920s GE, the company's vision of a model worker was male, middle aged and paid by piecework. He had family members also at GE, typically in less skilled roles. Other units of this extended family , also GE employed, lived nearby. That ideal worker owned a house (perhaps with a second mortgage cosigned by GE), a car, a radio and perhaps even a refrigerator. He held GE life insurance, and had savings invested in GE's bond purchase plan. He could look ahead to membership in GE's Quarter Century Club, and, if he made it to 70, retirement with a half salary pension.

He also enjoyed the possibility of his children continuing through high school instead of going to work at 15. Daughters could then work in a GE office or shop until marriage. Sons might enter the GE Apprentice Program, or even go to college. Beyond that white male householder, GE's employment vision was narrow. Most female workers saw continued stereotyping of "women's work " and low wages. This overshadowed the slight but real progress by the outstanding few. For Black workers in the 1920s there were no opportunities even for an outstanding few. Restricted to outside cleanup and maintenance in "the yard," dangerous lifting and carrying in "transportation" , and jobs as janitors or elevator operators , Black workers faded into deeper invisibility.

What, then, was Coordinated Cooperation? The cooperation part had three levels: cooperation by workers with their foremen and managers; cooperation by giant corporations with other corporations, including competitors; and cooperation by business with government, especially on the national level. The coordinator of all this would be the corporation itself,

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[328] **Owen D. Young to Dr. Frederick's Church in New York. 20 Jan 1929 in Young, Owen D. and Swope, Gerard. 1930. Selected Addresses. GE.p. 35.**

not the government or the public. Coordinated Cooperation was not consensus, but elitism. It was not philosophy but practicality. It was a way for GE to avoid three dangers: first, the public's "electrical trust" opprobrium, second the work force's unionization, and third the government's intervention.

Yet coordinated cooperation was also adaptatable. Later historians such as Daniel Nelson, Andrea Tone, Gerald Zahavi and Stephen Meyer have seen such efforts as more than merely paternalism or union busting. Management sometimes sought the workers' cooperation by genuine efforts at creating a better workplace. This was seen at GE, for example, in Swope's not only hiring Alice Hamilton as a consultant but also taking her advice. It was also seen in the Schenectady Works Council first lacking, but then adopting a grievance procedure. [329]

One can only speculate how coordinated cooperation might have evolved if the calm economic seas of the 1920s had continued. A possibility is suggested by the later experience of Europe. A 2011 study reported that in Europe Works Councils are in place. In some places, such as Germany, they are mandated by Government. They coexist with labor unions, which in turn are major constituents of labor or left wing political parties. Researcher Edward Lazear concluded that these European Works Councils "involve real information sharing by companies, and real engagement in cooperative solutions. "[330]

In conclusion, perhaps coordinated cooperation was, and would have continued to be, mere hypocrisy. Perhaps, however, from pretending to take the workers' interests to heart, management might have evolved toward actually doing so, especially if the economic calm of the 1920s had continued. The calm did not, however, continue. In the difficult 1930s, coordinated cooperation would have different, but not entirely negative, consequences. It would be a way station, from which a few constructive corporate minds could glimpse prospects for more genuine cooperation, and methods of more democratic coordination.

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[329] **Nelson, Daniel. 1987. The Company Union Movement, 1900-1937. A Reexamination. Business History Review. 56. 335-357. Tone, Andrea. 1997. The Business of Benevolence. Cornell. Zahavi, Gerald. 1988. Workers, Managers and Welfare Capitalism. Illinois. Meyer, Stephen. 1981. The Five Dollar Day. Albany**

[330] **Lazear, Edward. 2011. Inside the Firm. Oxford. pp. 120-127.**

Gerard Swope would become one of those constructive minds. Two others emerged on the factory floor, members of two of those earlier mentioned GE-employed extended families. Leo Jandreau, followed a conventional path in the 1920s. His few mentions in the Works News were for such things as his effective recitation of "The Boy Stood on the Burning Deck" at a Turbine Department Christmas Party. Meanwhile, he graduated from the Apprentice Program, worked skillfully as a toolmaker, and received, and may have briefly tried out, a promotion to foreman before returning to the bench,

Julius "Joe" Emsback, the youngest son of Hungarian immigrants Frank and Theresa, had a less conventional story. He was also an Apprentice graduate, but, as he admitted later, a machinist of only average skill. His attention was captured instead by his sub foreman, a longtime member of the Socialist Labor Party who, Joe said, "thought Daniel De Leon was the fount of all knowledge." In 1927, at the age of 23, Joe, who had left school early to help support his family after his father's death, obtained a leave of absence from GE to attend Schenectady High School. He completed the four year course in just two years, with a 90 average. In 1929, GE initiated a set of education financial aid programs for workers and their children. This included a Charles Steinmetz Scholarship Program , and a Gerard Swope Loan Fund . Joe became a recipient of a Swope Fund college tuition loan.[331]

In September of 1930, just as GE's era of coordinated cooperation was coming to an end, the GE Schenectady Works News carried the following item by its reporter in the Tool Design Section.

> We are pleased to welcome in our midst for a short period Joe Emspak. Joe is returning to Union [College] for the fall semester.

Before long, his Swope loan paid back in full and his education completed in ways that his employer had not anticipated, Joe would be back.[332]

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[331] **WN 18 Oct 1929**

[332] **Works News 5 Sept 1930.**

Chapter 9. New Deals, 1931- 1945

When the Great Depression hit GE in 1931, the inadequacy of coordinated cooperation quickly became apparent. Gerard Swope did not offer an

immediate next step. He did have, however, the energy to take arms against this sea of troubles.

Not so for all his colleagues at the top of GE. The company's usually optimistic Research Director Willis Whitney, fell into a personal depression as deep as the national one. When asked to make up a list of layoffs he is said to have replied "put my name first" before resigning his post and retiring to his country home.

Owen D. Young's reputation as industrial statesman took a serious hit in 1932 when his name appeared in the newspapers as one of the people on a preferred list of early access to lucrative stock market opportunities. This was then neither illegal nor unusual for a person in his position. It conflicted, however, with the enlightened, progressive image he had created for himself. He then suffered serious financial losses in the Wall Street crash. Swope, who had sold his stocks before the crash, bailed out his GE partner. Young retreated to a much reduced Mr. Outside role. [333]

Coordinated Cooperation would also be a casualty of the Great Depression. What caused Coordinated Cooperation's demise? What replaced it? Those are these chapter's questions. That demise and replacement happened via what will be described here as not just one, but three, New Deals The first New Deal, in 1933-1934 resembled coordinated cooperation, but with key differences. The second , in 1935- 1936 definitively buried coordinated cooperation. The third New Deal, the 1939- 45 industrial response to World War 2, produced coordinated cooperation's successor.

None of this had been anticipated back in 1930, even as the severity of the business downturn became clear. Swope then told his colleagues "If we

[333] **Wise, George. 1985. Willis R.Whitney. Columbia. Young and Case. 1984. Owen D. Young. Godine. Friedel, Frank. 1979. FDR. Launching the New Deal.Little Brown.p.39**

come to a reduction of salaries in the GE company , it will be a reflection of the fact that we have not done our job, including myself. " [334]

The succeeding years would see such salary reductions appear across the board. Swope's own annual pay fell from $100,000 to $60,000, that of a scientist at the GE Research Laboratory from $3000 to $1500, and that of a spot welder at the Schenectady Works from $1000 to $300. Prices also fell. This led GE to claim that those still employed were actually better off in real terms than in 1929. This claim is disputed by at least some later economists such as economic historian Peter Temin.[335]

Behind the statistics were voices."I worked for 22 years," said Paul Adeler, "and was laid off in March,1932. They were laying them off in hundreds. Of course I laid it to the foreman. Him and I had a little trouble quite a few years back and he told me he would get me. I went back to see Mr. Spicer and they shoved a $500 settlement under my nose." When the Works Managers had first proposed that men like Adeler, aged over 45 and with more than 20 years of service, should be discharged, Swope had objected: "it would be cruel to let those men go." The men were, however, soon let go, the lucky ones with lump sum payouts like Adeler's.[336]

Less lucky was the unnamed employee who wrote to the Socialist newspaper the Citizen in 1932 about, after 20 years service at GE, being given one week's notice of departure, and no cash settlement. "I 've stood by the company," he wrote. "Today I have about $500, a mortgaged house, high taxes, and 47 years of age."[337]

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[334] **Swope to Camp INCAS. 25 July 1930. Swope Papers.**

[335] **"Wage Rates in GE". Report 113-22, Swope Papers. Research Lab salary data from Louis Navias. Temin quoted in Dimand, Robert W. 1994. Irving Fisher's Debt Deflation Theory of Great Depressions. Review of Social Thought. 51. 92-107. P. 100**

[336] **Paul Adeler quoted in Report on GE Stockholders' Meeting, Rice Hall Schenectady, 21 April 1936. Swope to William Burrows. 28 Oct 1930. Swope Papers.**

[337] **The Citizen 22 April 1932**

The GE unemployment compensation program put in place in the 1920s would continue until 1935, when it gave way to corresponding provisions of the Social Security Act. In December, 1930 Swope increased its payments to $15 a week. Over the next three months some 7600 workers received a total of $330,000. Worker reaction was mixed, ranging from "Fifteen dollars a week -- well, the children will still have Christmas" to "is the office force really making contributions.. The boys in the shop find this hard to believe." While more than a drop in a bucket, this plan was far from the scale needed to meet a crisis that saw about half the employees of the Schenectady Works laid off. As early as September, 1932, Swope himself was admitting to the plan's inadequacy.[338]

GE hit bottom in 1933. Sales of $130 million were one third the 1929 level. Employment of 45,000 was just over half the 1929 level. Both the company and its workers did what they could to cope. On the company side, Schenectady Works Manager Burton DeLack wrote to Swope in July 1931 that " we have made a vigorous and honest endeavor to remove all married women from our payroll."[339]

Workers also made adjustments. For example, the Sarnacki family was able to send three sons, Joe, Charlie and Hank, to work as messengers at GE despite the depression, while daughter Alice did seamstress work. Father Vincent learned to repair shoes for the family, and used or sold the produce from two grapevines, two peach trees, and a few chickens and ducks. When he was laid off temporarily, GE sent food baskets. Most of the other families focused on in this book were similarly able to keep at least one family member at work at GE.[340]

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[338] **Hammond, J.W. 1931. The GE Employees Unemployment Plan. Copy in Swope Papers. Swope to Works Council. Schenectady , 19 Sept 1932. Swope Papers.**

[339] **Burton DeLack to Swope 2 July 1931. Swope Papers, Box 16 Folder 113.3B.**

[340] **Sarnacki, Ray. 2020. A Brief History of My Grandparents. Schenectady County Eastern European Roots Newsletter. V0l 7, N0 3**

While reducing his own salary and that of other top executives, Swope unapologetically and publicly kept up the special profit sharing payments to the people identified as the company's top 500 or so contributors. This extra payment in 1932 averaged over $2000 per recipient, more than the average worker's annual wage. GE stockholders also never missed a dividend. In 1933 and 1934 this required paying out more money in dividends than the company earned in profit. Indeed, in those years, only the light bulb and refrigerator businesses made much money. Almost all other businesses recorded losses. In 1932, GE got only one order for a steam turbine. For the first time in memory, there were work days when the usually roaring machine tools in Schenectady's giant Building 60 turbine shop all stood silent. [341]

Swope did more in those dark times than address GE's troubles. In 1931, on an ocean trip via the Panama Canal, he sketched out on scrap paper and the backs of envelopes a plan to save the nation. He first introduced his "Swope Plan" to the public on 16 Sept 1931 1931 speech to the National Electrical Manufacturers ' Association at the Hotel Commodore in New York City. He then cooperated with business journalist George Frederick to lay out the details in a book.[342]

A "plan of stabilization" is needed, the book explained, because "America has paid for its economic debauch by a loss of about one half of its national wealth... War is a Sunday school picnic beside it. "Needed now, in 1931, was a peacetime version of World War 1's "admittedly effective centralized power of the War Industries Board". To achieve this stabilization "production and consumption must be coordinated". However, "coordination of production is impossible under our present laws".Swope's plan of coordination began with employee benefits: "a system of benefits

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[341] **Warren, Glenn B. to Herman Hill, 1 Apr 1974. Glen Warren Papers Box 1, 95.78.18 MiSci.**

[342] **Loth, David. 1958. Swope of GE. Simon & Schuster. P. 202.Frederick, George. 1931. The Swope Plan. Business Bourse.**

accruing through the life of the worker, and following him where he might go, from shop to shop at a particular company, or from branch to branch of industry as a whole." The package included improved worker compensation for injury, life and disability insurance, old age pensions, and unemployment insurance.

As for business coordination, " All industrial and commercial companies with 50 or more employees doing an interstate business may form a trade association". These trade associations would outline trade practices, business methods, standard accounting methods and other forms of information, aiming to stabilize prices and production levels for the industry as a whole. The anti trust laws would have to be amended to allow all this to be done legally.

The book frankly admitted that the plan raised "questions of power, coercion and dictatorship". The conclusion it reached was stark: " apply in a fully American way the modicum of dictatorship which she seems now ready to admit and that fuller industrial efficiency calls for," The book went on to make three nominations for the post of "Organized Enterprise Appointive Dictatorship." Those were CEOs Walter Gifford of AT& T, Patrick Crowell of the New York Central RR, and Gerard Swope of General Electric.

While getting guarded praise from such progressives as Walter Lippman, the Swope Plan got a scathing rejection in 1931 from President Herbert Hoover. He called it grandiose, statist, unconstitutional, dehumanizingly bureaucratic and probably inspired by the Five Year Plan of the Soviet Union.[343]

This did not disturb Swope. He and and Young were both longtime supporters of the Democratic Party. They had recently advised Hoover's 1932 challenger, Franklin D. Roosevelt. They first anticipated, then welcomed, FDR's November, 1932, victory . "I don't think we have much to fear," Swope told a 1932 GE Management Meeting. "Roosevelt comes

[343] **Wilson, Joan Hoff, 1975. Herbert Hoover, Forgotten Progressive. Little Brown.**P. 152- 154

from a very good family in the East, a family of coupon clippers. Coupon clippers are never radical." [344]

Roosevelt proceeded in 1933 to announce a Depression fighting program resembling the Swope Plan. Roosevelt's plan, the National Industrial Recovery Act (NIRA) quickly passed Congress and became law. It sought control of competition and overproduction via cooperative industry trade organizations, much as Swope had proposed.[345]

There were, however, big differences regarding coordination. Swope would have assigned this job to industry itself (indeed, perhaps to Gerard Swope himself). Government would look on as a sort of referee. The NIRA, in sharp contrast, mandated government coordination. This was put under the command of a dynamic and choleric former Army General, Swope's World War 1 partner Hugh Johnson. In addition, while the Swope Plan had avoided any mention of unions. Section 7A of the NIRA, written by New York's progressive Senator Robert Wagner, empowered workers to be represented by bargaining agents of their own choosing.Swope immediately wrote to NIRA head Johnson to get Works Councils included as acceptable forms of worker representation.[346]

To make that suggestion more palatable the name of GE's Works Councils were changed to Workers Councils. Swope would tell the Schenectady Workers Council in 1933 that "we in GE rather like the idea of collective bargaining. " What management sought to avoid was "radical tendencies" of "irresponsible people in the field. "[347]

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[344] **Swope to Cleveland Elfuns, 25 Aug 1932. Swope Papers. MiSci.**

[345] **Committee of Industrial Analysis. 1937. The National Recovery Administration. Washington DC 17 Feb 1937.**

[346] **Swope to Hugh Johnson 2 June 1932. ; "Plan for Industrial Collective Batgaining" 10 Aug 1933. Swope Papers. Box 16. Folder 113.D. MiSci.**

[347] **Fn 15 Swope, Address to Workers's Council 18 Oct 1933. Swope Papers**

Despite the differences between his plan and Roosevelt's, Swope strongly supported the NIRA. In late 1932 he accepted Roosevelt's request that he serve as Chairman of the new Economic Advisory Board of the Department of Commerce. It would be the most powerful voice of big business in Washington.

Swope assembled a distinguished board, including Pierre Du Pont, Walter Gifford of AT&T, Walter Teagle of Standard Oil of New Jersey, Thomas Watson of IBM, Alfred Sloan of GM, and Robert Wood of Sears, Roebuck. The Board would not be "just another committee," Swope wrote to Gifford in 1933. "We will really accomplish something. "The things Swope aimed to accomplish included working with trade associations on trade practices, business ethics, elimination of unfair competition, and the simplification and standardization of products. An overall aim was "to prevent over-production", then believed to be a major cause of the depression. Swope decided to go public with his intentions. In a press release from the Chamber of Commerce in November,1933, he proclaimed that "It is highly desirable that the great adventure of the NIRA be made permanent." However, he added, it should be done in a way that "would render unnecessary the creation of an extensive Federal organization." Instead, coordination of the economy should be vested in a "National Chamber of Commerce", a sort of industrial senate made up of representatives from the major trade associations.[348]

The furore that exploded over this proposal indicated how badly Swope had misjudged the public mood. Condemnations from New Deal brain trusters, labor leaders, and Congress volleyed through the press. Roosevelt insiders condemned Swope's new plan as "business fascism." The President himself commented that business is "unready for self rule." It was likely at Roosevelt's request that Swope soon went on national radio. He had not, he

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[348] **Swope to Walter S.Gifford 5 July 1933, Swope Papers. Swope, "Memo--Suggestions to Discuss with Secretary Roper", 28 June 1933. Minutes of 4 June 1933 Organization Meeting in Daniel Roper to Swope 6 June 1933, Swope Papers. Opening Statement of Gerard Swope at Meeting of Business Advisory Council. Released 1 Nov 1933.Swope Papers.**

explained, intended to criticize or undercut the NIRA or the policies of the administration. He had not, it seemed, meant much of anything at all.[349]

With this, any hopes of applying to the nation the principle of coordinated cooperation, with big business as the coordinator, passed from the scene. A perhaps chastened Gerard Swope did not, however, fade away. Instead, as that First New Deal gave way, in 1935, to a Second one, he and GE had perhaps their finest hour of corporate citizenship. For example, in shaping the Social Security Act, Swope and other progressive corporate leaders such as Eastman Kodak's Marion Folsom, played important advisory roles. Historian Daniel Nelson identifies Folsom and Swope as the "outstanding" big business supporters of government administered unemployment insurance.[350]

Swope's most important role, however, was in the field of labor relations. Back in 1933. Swope's acceptance of the NIRA, including Section 7A , had drawn criticism from industry colleagues. Writing to Swope about an October, 1933, meeting of the electric utility trade association, GE Director B.F. Sunny reported that

> At the banquet last night, when one of the songs that was sung, when the line was reached"I've got unions that hound me, " there was shouts of "Swope". ..at which there was some laughs and jeers.

"The Chicago men," , Sunny explained, saw "the present situation" as " a destruction of the defense they have created at so great a cost against complete unionization. " [351]

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[349] **For examples of Press reaction see New York Times 1 Nov 1933 p.1 and New York Herald Tribune 1 Nov 1933, p.1. Roosevelt's remark is in the Herald Tribune story. Text of Swope radio address, 4 Nov 1933, Swope Papers.**

[350] **Nelson, Daniel. 1969. Unemployment Insurance. Wisconsin. Pp.45-47. Brents, Barbara. 1984. Capitalism, Corporate Liberalism, and Social Policy. Mid American Review of Sociology. 9.23-40.**

[351] **Fn 23 B.F. Sunny to Swope 10 Oct 1933, Swope Papers.**

Swope was undeterred by this criticism. He proceeded in 1933 to accept a position on FDR's National Labor Board, a collection of industry, labor and government leaders. Swope took a hands-on role, accompanying Secretary of Labor Francis Perkins on road trips explaining Section 7A to resisting businessmen. Perkins described one such encounter, in August, 1933. An owner of a Reading PA hosiery mill was adamantly opposed to unions. Section 7A did not prescribe how the workers were to to decide on representation. Swope said, why not let the workers vote on it? Why, asked the owner dismissively, should I do that? Here is how Perkins recalled Swope's answer:

> Because, said Swope quietly, though he was boiling and furious by this time, "this is America, and that is the way we do things here!"[352]

Swope's initiative led to a voting procedure called the "Reading Formula" for implementing Section 7A. Unions won more than 80% of the initial Reading Formula elections. The formula quickly impacted GE. Its Lynn MA Works had held the company's most effective Workers Council. Two of Lynn's leaders now seized the opportunity that Section 7A offered.Al Coulthard was a pattern maker who had served as a foreman before returning to the ranks. He became a formidable opponent. , as well as a victim of a Depression layoff. Leary described him to Swope as "Clean cut, the harrier type...hard as nails ... intelligent... articulate.. non-political". He found an effective ally in Gale Smith, a former clergyman who could appeal as effectively to the native born Protestants as Coulthard could to the Catholics and foreign born. Leary described Smith as "an idealist, but withal a very practical one, well versed in trade union work." Swope called him " a conscientious and serious man, and also a good worker. "[353]

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[352] **Perkins, Frances. 1946 The Roosevelt I Knew. Viking. p. 239; Severn, Bill. 1976. Frances Perkins. Hawthorn. P. 156**

[353] **Leary to Swope 5 April 1934, Swope Papers. Nevachea, Gerardo. Emergence, Development and change of a local union. MA thesis, U-Mass Boston. 1971. UE Archives. Leary to Raymond Moley.22 Aug 1934, Swope to Leary, 21 Aug 1936. Swope Papers.**

Their proposed union was to be an industrial rather than a craft union, much like the one John Bellingham and others had tried unsuccessfully to launch at Schenectady in 1919. Coulthard and Smith's meetings in workers' homes and in the halls of fraternal organizations such as the Odd Fellows and Hibernians showed surprising recruiting success. In 1934 the new union successfully petitioned the New England Regional Labor Council for an election, Swope's response was "let them hold as many elections as they want to. " Coulthard described GE as cooperative throughout the election process. In that 1934 election, the new union trounced the Lynn Works Council, 82%-18%. "This is the first defeat of Mr. Swope's much advertised liberalism, " Coulthard proclaimed.[354]

Within the rest of GE, Swope's name change to the Workers Council, may have been initially intended as merely cosmetic. In practice, however, it was followed by a significant strengthening of a Council, which even the Company newspaper now admitted had previously been "totally unsatisfactory to the workers. " Changes included a broader range of grievances that the Council could handle, and input into wage decisions. When management announced a 10% wage increase in April, 1934, it gave credit to the Workers' Council. The Workers Council also supported, and saw management approve, a 1935 item that was more likely a consequence of slack demand than managerial benevolence. Still, it may have warmed the hearts of any remaining of those women who sang the Eight Hour Hymn as they led the 1915 strikers out of the Works. The item, approved by a vote of 79 to 23, read:

> Workers Council approves maximum of 40 hours as the regular work week at the plant. [355]

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[354] **Fn 32 Handler and Bartlett, 8 Mar 1934, NLRB-Box 108, Misc. , U.S. National Archives. Coulthard to John Burns 30 Mar 1934. Coulthard to J. Colburn, 31 Mar 1934, copies in Swope Papers.**

[355] **Fn 26 Schenectady Works News 9 Nov 1933, 1 Apr 1934, 13 April 1934., 23 August 1935, p. 1**

Individual Workers Council representatives seized these new leadership opportunities. Bill Hodges, for example, a British born cabinet maker had been a long time councilman by the 1930s. He was described by the Cabinet Department's Works News Reporter in 1931 as " our own very active councilman

> a very busy man these days looking after the interests of the unemployed [356]and short-time workers. He is always ready to offer his services and advice to his co workers.

He would evolve from effective Councilman to Council President, and , ultimately, to Vice President of an actual union. May Schilling had gone to work on the refrigerator line and was first elected to the Works Council when that was no great honor. On the Workers' Council she became one of the most effective champions of her fellow workers when they filed grievances against management. Alfred Stevens, who joined management's labor relations ranks in the early 1930s, later recalled Schilling as a capable and determined adversary. GE's Vice President of Manufacturing Wlliam Burrows described her to Swope as "very interesting, very reasonable".

These matters took a new turn in 1934 when the Supreme Court, declared the act creating the NIRA unconstitutional. Section 7A became void. In GE, this delayed any union hopes of immediately following up on that Lynn victory with a company wide industrial union.Soon, however, Senator Robert Wagner of New York led the revival of Section 7A as the 1936 Wagner Act. It empowered workers to choose their bargaining units by election. It established a National Labor Relations Board to oversee the process.Meanwhile, in Schenectady, there had emerged an industrial union movement paralleling the Lynn effort. The leader of this new Electrical Industry Employees Union was a familiar face: the pre-World War 1 labor

[356] **Works News 18 Sept 1931. Burrows to Swope 5 Oct 1932. Interview With A.C. Stevens.**

leader, Socialist alderman, post-war turbine inspector and board member of the GE Employees Security Investment Fund, Bill Turnbull.[357]

A second aspiring Schenectady GE union was also in the field. This was the Metal Workers' Industrial Union, a part of the Communist Party's Trade Union Unity League. In June, 1932, under the leadership of Communist organizer Jack Rand, a "Committee of Laid-off GE Workers" held a rally in Schenectady's Crescent Park. Schenectady Works Manager Burton DeLack reported to Swope that most of the crowd of about 200 were not workers. Four who were GE employees accompanied DeLack back to his office for a"pleasant chat " As labor unrest picked up nationwide, uneasiness grew at Schenectady. A Swope informant on the Schenectady labor situation reported back with exaggerated alarm in the Fall of 1934 that "a fighting strike is in the making for next Spring." [358]

Actually the nascent Schenectady unions were far from fighting strength. Turnbull recognized this local weakness, and turned instead to a national stage. He appeared, in February 1935, before a Senate Committee investigating the labor situation . There he presented a list of alleged employer violations at the Schenectady Works, such as forcing some turbine workers into hours of overtime while hundreds of others were laid off, and speeding up the refrigerator assembly line. On the local level, Turnbull again ventured into politics. In 1933 he ran for the New York State Assembly on the Socialist ticket, receiving only 1000 votes out of more than 20,000 cast. It was his last gasp of political partisanship. "Let us concentrate

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[357] **The following discussion of the unionization of the Schenectady Works relies heavily on Schatz, Ronald. 1983. The Electrical Workers. Illinois. and Kannenberg, Lisa. 1999. The Product of GE's Progress. Rutgers Ph.D. Dissertation.**

[358] **Kannenberg, Lisa. 1998. The Product of GE's Progress. Ph.D. Diss, Rutgers. Pp. 31-43 Burton Delack to Swope 3 June 1932, Swope Papers. Col. E.Z. Steever to Swope, 12 Sept 1934. Swope Papers**

on our big job-- perfecting our union in the economic field," he wrote in 1934, "but politically leave our officers free to use their best judgment."[359]

On that local Schenectady political front, the parties on the left were disunited . Charles Noonan continued to run unsuccessfully for office on the Socialist ticket. Two other minor parties, the Socialist Labor and American Labor Parties squabbled over which got to use that word Labor on its ballot line. More success was achieved by the more conventionally progressive Charter League. Here leaders such as GE chemist and former Socialist Irving Langmuir, now a Nobel Laureate, and prominent GE electrical engineer and former Progressive Philip Alger, led an effort that succeeded via referendum in changing the Schenectady city government to a City Manager form. This initiative was, however, quickly captured and tamed by the two established parties.[360]

Two sons of 1911 Socialists now entered the picture seeking to blend far-left politics with union organizing. Leo Jandreau had quietly put in over a decade as a machinist in the GE Turbine Department. Julius Emspak had graduated from Union College in 1933 and begun graduate work in philosophy at Brown. There he had what he described as "a great awakening". He decided that "I had better been back to where I had been if I wanted to find answers." In 1934 he returned to the shop, this time at RCA in Camden, N.J.[361]

There he joined in the union building efforts successfully initiated at the nearby Philco Company by a organizing neophyte, Philip Carey. It was as a member of this new industrial union, soon to bear the name United Electrical, Radio and Machine Workers (UE), that Emspak returned to Schenectady.In 1935, Jandreau and Emspak ran as candidates of the United

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[359] **Turnbull testimony 27 Feb 1935. Swope Papers Box 16. Folder 113.2 D.Turnbull to Philip Carey. 11 Oct 1925. File 17BLE UE Papers, U. of Pittsburgh.**

[360] **Schenectady Gazette 2 Nov 1936, p. 7**

[361] **Julius Emspak Oral History. Columbia University.**

Labor Party in the Schenectady city election. They finished far behind the winners. Their minor party was considered Communist inspired. Whether Emspak and Jandreau were, then or later, members of the Communist Party was a question that would dog their careers. Both denied it. Emspak would be convicted of contempt for refusing to appear before a Red-hunting Congressional Committee. His conviction would be overturned by the Supreme Court. Jandreau's politics were never tested in court. The consensus of subsequent historians is that both, by 1936, were Communists.[362]

Perhaps following both personal predilection and Communist Party instruction, Emspak and Jandreau chose solidarity over conflict in 1935. They and their local of that Metal Workers' Industrial Union joined forces with Turnbull's Electrical Industry Employees Union. This alliance would become UE Local 301. At Schenectady its strategy was two pronged. One was standard union building. This avoided ideology, and concentrated on the resentments chronic to every large industrial plant, and made worse by the Depression.

It was these abuses that some Schenectady union pioneers later recalled most strongly. Alan Townsend remembered being in the bathroom only a moment when the foreman came banging on the door shouting for him to get back on the floor. "They were not fair, " Townsend said. " That's why the union won over. " Mario Biagnetti recalled his father walking out on Sunday to the foreman's house with a bottle of wine in one hand and a chicken under his arm, as a required tribute payment to the boss. "To get a welding job, " he added, "you had to buy a car from the foreman."[363]

The worst abuses took place at the Schenectady Works Employment Office. It was an open secret in the early 1930s that a well placed bribe could secure

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[362] **Zahavi, Gerald. 1996. Passionate Commitments: Race, Sex and Communism at Schenectady General Electric. 1932-1954. Journal of American History. 93. 514-548. Professor Zahavi is the authority on Communism in Schenectady, and this illuminating article goes far beyond the GE part sketched out here.**

[363] **Labor at General Electric. Program at Schenectady County Public Library. 10 Jan 1983.**

a GE job that was almost impossible to get by normal means. One applicant recalled waiting in vain in a mob on the street in the bitter winter cold of 1933, then hearing the rumor that only those who had paid the bribe knew the secret hand signal that would gain an interview. The bribery finally resulted, in 1936, in the arrest trial and conviction of the employment office manager.[364]

The other prong of union strategy was an attempted takeover of the Workers' Council. Bill Turnbull, Leo Jandreau, and Julius Emspak's brother Frank became Works Councilmen. This effort fell slightly short of a majority. Company actions such as putting the Works on a 40 hour week, an improved vacation plan, and a 10% pay increase were credited by the company to the Council, not the UE . Motions to the Council by Frank Emspak for another pay increase and recognition of the union were voted down. "At present Schenectady is in a deplorable state, " Jandreau wrote to Julius Emspak in April 1936. "The employees don't show any self respect but take anything that is offered to them. "[365]

Jandreau looked for a place to mobilize action. In June 1936, he thought he had found one in the Wire Mill. There an effort by management to change the wage formula had created discord. Union leaders called a sit down strike, a tactic recently carried out successfully by rubber workers in Akron OH. Manager Elmer Spicer stood firm. When the men were back at work, he said, negotiations could begin. Turnbull got UE president Carey to mobilize Miners' Union leader John L. Lewis, who told Labor Secretary Frances Perkins that the strike would shut down Schenectady and spread to other GE plants.The threat was a bluff. Swope, who was well informed about the situation, left matters in local hands. Within a week the strike had collapsed without even temporarily spreading to the rest of the plant, and the Wire Mill was humming smoothly. "We certainly are in one hell of a fix," a union

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[364] **Works News 9 Oct 1936.**

[365] **Jandreau to Emspak. 24 April 1936. 160- ocal 301, Jandreau. UE Archives. U. of Pittsburgh.**

member wrote Emspak. "The 109 [Wire Mill] gang are clamoring for money, they are not satisfied with with being called heroes."[366]

By July, no further action had followed. " If we could get something started," Jandreau wrote to Emspak, "it would have a good effect."That something was found not within the Works, but on the national level. The Wagner Act decreed that with enough signatures on a petition, the union could force a representation election. Through the Spring and Summer of 1936, Turnbull, Jandreau and their union colleagues combed the Schenectady Works for those signatures.[367]

To understand this campaign for signatures, envision the corner of Cable and Braddock Avenues within the Works, at lunchtime on a summer day, August 31, 1936. Bill Turnbull is speaking to lunching shop workers-- and also to a company observer who is taking careful notes. " The Company union was founded on the theory that the interests of the employee and the company were identical, " Turnbull began, but "the worker's interest lies in shorter hours and higher rates, while the company's lies in longer hours and lower rates. " Will workers continue to stand by while a wage earner gets $15 a week compared to the company President's $1750 a week,"even though he could only wear one suit of clothes and one pair of shoes at a time."You can't wait until 99% of the workers join the union to make up your mind, Turnbull said. He told of a bee collecting honey in a field of clover. A cow came along and gobbled up clover and bee. In the cow's mouth, the bee considered stinging and held off. In the throat, the same thing, then in the stomach. That was nice and warm, and the bee fell asleep, "and woke up in the field in the nice bright sun, but the cow was gone. " In

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[366] **The Wire Mill Strike is described in RG 260, 165-1632. U.S. Department of Labor. National Archives. Suitland MD**

[367] **Jandreau to Emspak. 11 July 1936. Local 301 Correspondence. File 161. UE Archives. U. of Pittsburgh.**

an abrupt shift of metaphor, Turnbull concluded: "remember the banana-- it's the one that's plucked from the bunch that gets skinned."[368]

By the fall of 1936, the union had collected enough signatures. Now Swope had a decision to make . Other companies similarly subjected to union petitions were stonewalling. The Wagner Act's constitutionality would not be determined by the Supreme Court until 1937, and then by only a 5-4 margin. Even after that decision some companies, notably Ford, Republic Steel, and Westinghouse would be able to stall unionization well into the 1940s. Historian Howell John Harris has categorized corporate responses to unionism after the passage of the Wagner Act. . He described Bethlehem Steel, Standard Oil of New Jersey, Du Pont and others as practicing "sophisticated antiunionism." He described others, such as General Motors and U. S. Steel with following "the course of realism". He put U.S. Rubber and General Electric in a class by themselves in their having "accepted the labor movement with little hesitation or apparent regret."[369]

After only weeks, rather than years, of delay, Swope agreed to a vote. Before, however, attributing this entirely to Gerard Swope's devotion to democracy, consider the external circumstances.Arrangements for the vote were not solidified until early December,1936. In the preceding month, FDR had been re-elected President in U.S. history's greatest landslide-- with the strong support of organized labor. No longer could FDR be dismissed as a harmless coupon clipper. "We have a difficult situation ahead of us with Mr. Roosevelt's overwhelming victory," Swope told a GE management group in November 1936 "This is a mandate from the American people, and labor

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[368] **Speech delivered at the corner of Cable and Braddock Ave., August 31, 1936. Swope Papers. Box 16. Folder 113.2 D. MiSci.**

[369] **Howell, Harris John. 1982. The Right to Manage. Wisconsin. P.32. A similar conclusion is reached in Mizrachi, Mark. 2013. The Fracturing of the U.S. Corporate Elite. Harvard. P.86. See also Schatz, Ronald. 1983. The Electrical Workers. Illinois. pp. 70- 75.**

has gone along with him...labor is going to take advantage of it... we must play ball."[370]

In addition GE had reasons to believe it might win the vote. Membership in the UE was still small, 1000 or less in a work force climbing toward 10,000. The Workers Council had made significant strides toward respectability and independence. Hours per week, and wages were heading back up. Would workers really want to rock the boat? [371]

Only eight days separated the final arrangement of election details from the actual election date, December 15, 1936. This was fifty years since the Edison Machine Works had fled unions and moved to Schenectady. Now, at last, each of the 9675 employees at GE's Schenectady Works would have a clear choice: put your X in a box marked "Workers' Council", or in a box marked "United Electrical, Radio and Machine Workers".

The short ensuing campaign had its hiccups. The union complained when its attempt to put a spokesman on Schenectady's radio station WGY, a station created by and still licensed to GE, was turned down on the grounds that the election was "of only local, not national interest." Pressed on the matter, GE blamed NBC, the RCA-owned network that ran the station. The decision was then reversed. On its part, the Workers' Council objected, to the exclusion of some 1500 office workers from the voting. This exclusion was not reversed.[372]

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[370] **Speech manusc, Swope to Elfun Society, November, 1936, Swope papers. MiSci.**

[371] **Howell, Harris John. 1982. The Right to Manage. Wisconsin. Pp. 34, 44 also attributes GE's response to "GE's confidence in its own power and the weakness of the UE."**

[372] **Details of the election are in Schatz, Ronald. Union Pioneers.Union Pioneers: The Founders of Local Unions at General Electric and Westinghouse, 1933-1937. Journal of American History, Vol. 66, No. 3 (Dec., 1979), pp. 586-602 Schenectady Gazette 7 Dec 1936, p. 2; 9 Dec 1936, p. 6**

Mostly, however, the election was run without conflict or company interference. GE lived up to the 8-point declaration of neutrality it posted throughout the Works, which began "1- this is a secret ballot." The company stood by as the two sides make their cases. The Workers' Council pointed to its democratic processes of council election, and to the the improvements in wages, hours and benefits it had been a voice in promoting.

The UE emphasized is role as a genuine, rather than a company controlled, union. It denied any intent of radical boat-rocking. "A strong healthy union inside the Schenectady Works does not necessarily mean or foreshadow strike action, " said Jandreau. "Organized labor uses the strike weapon only in the way that Uncle Sam uses his battleships-- only in emergencies, when all other peace efforts are defeated."[373]

At 12:01 AM of December 15, 1936, voting began for night shift workers. At 9 PM, the 23 polling places around the Works were closed. The ballots were quickly counted, under the supervision of National Labor Relations Board officials Frank Moore and Elinore Herrick. Perhaps the most impressive result was the turnout. Of those 9675 eligible voters, 9272, or 95.8% cast their ballots. Their verdict was decisive. For the United Electrical, Radio and Machine Workers, 5011. For the Workers' Council, 4033. By this 55%-45% margin, the Schenectady Works had become the third link, after Lynn MA and Ft. Wayne IN, in what would become a UE-represented chain of GE works and factories .

The now officially certified Schenectady local still faced a daunting task. It had to translate that vote into sufficient plant-wide union membership to secure the credibility needed to negotiate a contract. Here Bill Turnbull played the key role. He especially appealed to his own generation, whom he described as "life long residents of Schenectady with homes and families here". Many of them had been participants in the union surge that lasted through World War 1. Many had endured, a subsequent 15 years of disillusionment with unions. Some had become Works Council stalwarts.

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[373] **Schenectady Gazette 9 Dec 1936 p. 11 Dec 1936, p. 1; 12 Dec 1936 p.9; 14 Dec 1936 p. 6;**

"We know that there are men in the works who have high organizational experience, " Turnbull said. "We say to them, don't tell us what good union men you used to be in the old days. Get in where you belong and show us how good a union man you are now."[374]

They did. The UE campaign started slowly, was interrupted by the sharp short depression beginning in 1937, but moved on to success. UE 301, which had only 650 members in early 1936, had by the end of 1938 enrolled 8000 of the 10,000 Schenectady GE workers. About 20% of the union members were women, roughly the same fraction as women in the Schenectady GE shop force.[375]

For the future, the new young and radical leaders of UE Local 301 took over from aging sewer socialist Turnbull. "In regards to Bill", Jandreau wrote Emspak in January, 1937, "I did have it out with him...I am preparing the agenda for all meetings...I have the floor...I am free to discuss any motion that might arise, and without being criticized for 'railroad tactics.' " Turnbull would be on the committee that would negotiate with GE national management. He would become a UE national vice-president. In Schenectady, however, his leadership work was done.[376]

Meanwhile, Swope and his management team faced another choice. Should its first formal encounter with this newly recognized union, over a proposed company-wide contract take the form of negotiation or confrontation ? The GE leadership chose negotiation.

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[374] **Schenectady Gazette 21 Dec 1936 , p. 11**

[375] **Kannenberg, Lisa. 1998. The Product of GE's Progress. Ph.D. Diss, Rutgers. P.54 d Us. Beacon. P.65. Matles, James, and Higgins, James. 1974. Them and Us. Beacon.**

[376] **Jandreau to Emspak, 11 July 1936. Local 301 Correspondence, File 161, UE Archives, Pittsburgh PA.**

Again, this was driven not merely by democratic impulses. A pragmatic policy of conciliation also reflected management hopes that, as in the past, the inexperienced new union with its internal ideological divides, might destroy itself. "We have had 95% AF of L union at times and now almost none," a manager wrote on the back of a 1937 draft of a national contract. "We have been completely unionized at Schenectady.These movements go in great swings."When a GE manager asked Swope "Do you consider a signed agreement with such irresponsible people worth the paper it is written on?" Swope gave this answer.

> Yes, and for this reason. GM whether it was wise or not, signed an agreement. The very fact that after they signed the agreement the union could not control its people, because its leaders maybe were irresponsible and ignorant communists and the people were undisciplined has shown the people that the brunt of the trouble is with them and not with GM.[377]

If Swope really believed that GE's new, Communist influenced, union would prove undisciplined, ignorant, and irresponsible, he was proved wrong. In the first round of contract negotiations, in 1937, union negotiators Bill Turnbull, Al Coulthard and Leo Jandreau proved disciplined, well informed and responsible. After a slow cautious negotiating minuet, the two sides agreed to a national contract largely adapted from a company policy stayement. [378]

Swope again became the New Deal's poster boy for labor peace. Swope and Senator Robert Wagner exchanged letters on a “Dear Gerard” and “Dear Bob” basis. Wagner wrote to Swope in April, 1937, praising GE as "an outstanding example". Thanks to Swope, wrote Wagner, "the reasonable

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[377] **Note on the back of "Draft 10 Points presented to the Electrical Industry Employees Union by the Managers of Several Apparatus Works, 1937. Swope Papers.. Swope to Camp Manufacturing, 11 July 1937. Swope Papers.**

[378] **For details on both Bill Turnbull's key role in organizing GE, and the subsequent contract negotiations, see Matles, James, and Higgins, James. 1974. Them and Us. Beacon. P.61-88.**

solution offered by the Labor Relations Act triumphed over the alternative recourse of trial by combat." Swope in reply expressed the hope “that its administration will lead to labor peace.” [379]

Soon, however, on another front, the Roosevelt administration was gearing up for a trial by combat with GE. For most of the 1930s, busy with regulating the banks, stock market and utility companies, the New Deal administrators had left the giant manufacturing corporations alone. Indeed, the NIRA had encouraged government- coordinated cooperation. Now, after a sharp depression within the Depression, in 1937, a new group of advisers convinced Roosevelt that the corporate giants were a problem. "One of the primary causes of our current difficulties is the absence of price competition" , Roosevelt would say in a 1938 speech, "particularly in manufacturing where concentration of economic power is most evident"[380]

As one of those most evident concentrations of economic power, GE was the target of three anti trust lawsuits. One target was GE's oldest and most profitable business, light bulbs. Another was one of its newest products, an new alloy of tungsten and carbon offering unprecedented strength that GE called Carboloy. A third was GE 's international business.

The charges against GE Lighting, filed in 1940, claimed that GE was still monopolizing its most profitable business in ways dating back to the company's founding. GE, along with Corning Glass, and NV Phillips of the Netherlands were accused in 1940 of illegaly using economic power to prevent entry of new competitors into the incandescent lamp business. Tactics the conspiracy was accused of included threats of harassing patent suits, control over lamp making machinery, price fixing, output quotas, and an agreement under which GE paid NV Phillips to back out of an agreement with Westinghouse on a U.S.bulb making plant.The government pointed out

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[379] **Sen. Robert Wagner to Gerard Swope 8 April 1937,Swope to Wagner 13 April 1937 Swope Papers. Box 16 FF 113.2C MiSci**

[380] **Kirat, Thierry and Marty, Frederick. The Late Emerging Consensus on Economic Ideas in the 2nd New Deal. History of Economic Ideas 39. 11-51. P. 20.**

that the key GE lighting patents, Coolidge's on tungsten processing and Langmuir's on gas filled lamps had expired by 1930. Since then, GE had extended its dominance less by invention than by intimidation. For example, a spokesman for competitor Hygrade Sylvania described how, in 1933 negotiations, GE threatened suit for infringement of subsequent patents of a far less fundamental nature than those of Coolidge and Langmuir. "These patents, " the spokesman said, "regardless of their validity, would have been made the basis of bona fide suits which would have harassed and annoyed Hygrade and would have caused it vast expenses, damage, and injury, even if unsuccessful. " Hygrade gave in, signed a new licensing agreement, and submitted to GE dictation of prices and output. "[381]

In its defense, GE pointed out that its behavior, far from bilking consumers, benefited them. The price of a 60 watt incandescent lamp had fallen from 45 cents in 1920 to 13 cents in 1940. Coupled with the falling price of electricity, also in part a GE achievement, this had completed the job of converting electric lighting from a luxury for the few to an amenity for most. Internal to GE, however, surviving documents tell a different story. "Personally I am very sorry that the General Electric Company has ventured to extend the license of the Westinghouse Company, wrote patent attorney F.P.Fish in 1928.

> there is a very great danger that the government and the courts will conclude that the renewal of these licenses is primarily for the purposes of stabilizing the incandescent lamp business and restraining competitive conditions...so far as we can see there will be no patents of the slightest consequence in existence after the expiration of the Langmuir Patent...if the General [Electric]

[381] **U.S. of A. vs. Corning Glass Works et al. Docket #C-108-164. District Court of the U.S. for the Southern District of New York. August Term 1940. Copy in Swope Papers. MiSci.**

> Company grants the licenses now, it may very much regret its action[382]

Another major patent case was less threatening to GE's profits, but more threatening to its image. In 1941, the government charged GE with conspiring with the German company Krupp to restrict the availability to U.S. companies of a material crucial to making armor- piercing artillery shells.The newspapers had a field day. "Nazi Monopoly Perils U.S.Arms" read one headline. Yet the story was more commercial than conspiratorial. In 1927, well before the rise of Hitler, GE researchers were looking for a hard metal from which to make better wire-drawing dies for use in the Coolidge light bulb filament making process. They learned of the recent invention, cemented tungsten carbide, for which Krupp held key patents. The GE researchers tried to invent their way around those patents. They failed to do so but obtained improvement patents significant enough to negotiate a patent pooling agreement with Krupp.The two companies, anticipating a limited market and high costs in educating users, agreed in 1928 on a strategy of high price for the new product. During that introductory period GE sustained a loss of more than a million dollars.

So far, little evidence of illegal behavior. GE's subsequent behavior, however, was sometimes cavalier and insensitive. For example, the original Carboloy price of $453 a pound was not the result of economic analysis, but an arbitrary decision to set the price at $1 a gram. Also, GE was still extending its partnership with Krupp as late as December, 1939. By then the threat of Nazism and the military importance of Carboloy had become clear. A GE negotiator did at least have the good sense to suggest "that the Krupp name be kept out of any correspondence. " Was all this illegal under the antitrust laws? GE offered in 1940 to accept a consent decree that included

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[382] **F.D. Fish to Charles Neave 25 September 1928, Reed File, Swope Papers; Testimony of Philip D. Reed in U.S. vs. GE, 20 March 1946, p. 1892, Reed File, Swope Papers.**

dropping the Krupp alliance. The government refused the offer and took the case to trial[383].

[383] **F. Gerald Toye to P. Reed, 14 April 1942; Summary Statement of John Henry Lewin, 14 April 1942, Swope Papers. Interview with Sam Hoyt, 6 Feb 1979. Draft Statement "To the Employees and Stockholders of GE" 5 September 1940. Mogerman, W.D. 1973.Zay Jeffries. American Society of Metals, 1973.Philip. D. Reed to Thurman Arnold, 1 August, 1940; Thurman Arnold to Philip D. Reed, 13 August, 1940, Swope Papers. U.S. vs. GE, Fried Aktiengesellscaft et. al. August term, 1940, District Court of the U.S. for the Second District of N.Y., August Term, 1940. A later scholar found that the story was less a matter of monopoly and aiding the Nazis that it was a complex story of a new material that was a "hard sell" to U.S. companies in the 1930s. Gaffard, Hermone, 2015. A Hard Sell. Technology and Culture. 56. 895-922.**

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The third suit involved those international agreements Swope had made after World War 1. The government charged that this effort at international cartelization had domestic consequences in violation of the Sherman Antitrust Act.

When the three cases came to trial in 1942, GE had a new approach. In letters to the U.S. Attorney General and Secretary of War It explained that trial of these cases " will seriously interfere with the production of War Materials by the General Electric Company." The entreaty succeeded. The cases were postponed for the duration of the war. They would be tried not in the atmosphere of the New Deal, but in the aftermath of a war won with the help of technology, including light bulbs and Carboloy, supplied by the giant corporation that the New Deal had attacked. [384]

The story of GE's contributions to World War 2 victory have been told in detail elsewhere, including in GE's own book Men and Volts at War**.** The ability of the Depression- battered U.S. manufacturing industry, GE included, to turn plowshares into swords was a decisive cause-- perhaps the decisive cause -- of allied victory. It was also a story of remarkable teamwork betweem those corporations and their previous New Deal critics. Historian Mark Wilson concluded that the war's production miracle owed as much or more to Federal Government effectiveness as to private enterprise productivity. Big Government specified needs, mobilized effort, controlled prices and profits, prevented profiteering, led an uneasy peace between management and labor, built or paid for new plants, guided R&D, and, oh yes, ran a secret project that produced the most fearsome weapon in world history.[385]

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[384] **Vaughn, Floyd. 1956. The U.S. Patent System. Greenwood Press. P. 164.Flanigan, M.L. 1945. International Co-Operation and Control in the Electrical Industry. Notes on Conference between Mr.Arnold and his Associates and GE Counsel for the Defendants in U.S. vs. GE, 6 April, 1942; Charles E. Wilson to Secretary of War et. al. 4 April 1942, Reed Filr, Swope Papers.**

[385] **Wilson, Mark. 2016. Destructive Creation. U. of Pennsylvania. Pp. 1-5**

In GE's case, as indeed in the case of almost all the giants, becoming an arsenal of democracy was done with some controversy, but in general without foot dragging or excess profiteering. By war's end, GE had produced $4 billion worth of military equipment. It won about 4% of the nation's prime wartime defense contracts, the ninth most of all U.S companies. It had also paid about a billion dollars in taxes. Unlike in World War 1, this kept wartime profit rates at, or even below, prewar values.[386]

Those GE, contributions sprang from every corner of the company. First and foremost stand the the more than 50,000 GE employees who served in the armed forces. 1051 of them gave their lives. GE's civilian wartime employment would peak at 167,000, twice the prewar level. While operatives and laborers exercised old skills or learned new ones, top executives went to Washington as "dollar a year" men. This included the chosen successors of Swope and Young, president-select Charles E. Wilson and chairman-select Phillip D. Reed.That "dollar -a- year" designation, giving up their salaries of as much as $100,000 per year for that nominal $1 annual wage, proved controversial. Critics suggested that those executives might steer an excessive share of the defense budget to their employers. When peace returned, those grateful employers would more than make up in salaries and perks for that dollar a year sacrifice.

Particularly focused of these charges was the committee investigating national defense expenditures chaired by Senator Harry Truman. A memo by a GE representative attending the Truman Committee hearings noted that “Mr. Philip D. Reed [recently named GE’s next Board Chairman] received rather rough treatment during some of the hearings.” Some 70% of the nearly $100 billion of U.S. defense contracts did go to the 100 largest U.S. companies. Criticism by Truman and others led to creation of a Smaller War Plants Corporation to increase small business's share. The imbalance,

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[386] **McCraw, Thomas. 2000. American Business 1920-2000. Harlan Davidson. P.94**

however, seems more related to the technological and labor readiness of the giants than to undue influence of their dollar a year men[387]

Overall, however, a later study concluded that heavy participation in the war effort did prove a postwar competitive advantage. “Firms most involved in the war effort grew large relative to the others,” the study concluded, “ while those least involved grew smaller.” Sources of that advantage included the Second Revenue Act of 1940, which allowed firms that build plant or equipment used in the war effort, as GE did, to more than double their depreciation rate, to 20%. Firms that built such plants with government assistance during the war were often allowecd to buy them at bargain prices after the war, another perk of which GE would take advantage. [388]

What did the nation receive in exchange for such benefits? In World War 2, GE's main contribution to war production was doing faster and better in wartime what it already did in peacetime. The protean power of electricity now went on triple duty. It continued to serve the civilian population. It powered newly built, largely private enterprise operated arsenals of democracy. Finally electricity went directly to work in weapons on sea, in the air, and on land.

At sea, though GE did not make ships, half of the new U.S. warships had their propellers driven by GE turbines, with each of those turbines at least powerful enough to electrify a good sized town. Those major warships were driven through gears. The Navy also, however, found a use for GE's capability to build turbine -electric ship drives. In 1942 it commissioned a new class of anti-submarine vessels, the destroyer escort. GE turbo- electric drives would power 244 of them. Hundreds of naval support vessels and

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[387] **Koistinen, Paul. 2004. Arsenal of World War 2. Kansas. P.328 329.Memorandum on the U.S. Senate Special Cmmittee Investigatng the National Defense Program. Owen D. Young Papers, Box 24, FF 9-24 #4. MiSci Herman, Arthur. 2012. Freedom's Forge. Random House. esp. P. 118, 248.**

[388] **Luchansky, Bill and Hooks, Gregory. 1996. Corporate Bneficiaries of Mid-Century Wars. Social Science Quarterly. 77. 301-313**

merchant ships were also GE turbine powered and electrically driven. Over all, powering ships was GE's greatest direct military contribution to the war effort[389]

In the air, though GE did not make airplanes, it became the major supplier of the turbosuperchargers they enabled B 17s to fly to their targets at unprecedented high altitude. GE built turret drive control and aiming systems. This enabled gunners on bombers to fight back more effectively against enemy fighter planes. On land, GE produced electrical systems providing each tank with the electric power used by a house. It converted houseware and appliance assembly lines to the production of bazookas and howitzers. It put the skills used to make radios to work making radar systems. Scientists Irving Langmuir, Katharine Blodgett, and Vincent Schaeffer applied their research on atoms and molecules to the development of improved smoke screens for hiding ground troops from attack or naval vessels from kamikazes.

Other GE scientists and engineers moved in directions that GE had previously rejected or downplayed. For example, in 1937, Owen D, Young had sent GE Research Director William D. Coolidge a stockholder query. Was GE doing anything about the idea of getting enormous amounts of energy from splitting atoms? Coolidge assured the questioner that GE scientists were aware of the concept, but placed practical atom splitting far in the future, if indeed possible at all. [390]

Just three years later, In February, 1940, the GE Research Lab was using its capabilities in physics and chemistry to separate the rare Uranium isotope U-235 from the vastly more plentiful isotope U-238. Soon a GE researcher was riding the New York Central to New York City carrying half a

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[389] .**Study of Monopoly Power. Hearings Before the Committee on Judiciary of the House of Representatives. Nov 21-30, 1949. Serial #14. Part 2B. U.S. GPO. 1950.Miller, John. 1947 Men and Volts at War. McGraw Hill. p.6**

[390] **William D, Cooolidge to Henry L. Doherty, 8 Nov 1937. Young Papers, ODY File 2-74-A.**

microgram of pure U-235. This was half the total U.S. supply of that rare and suddenly extraordinarily precious material. At Columbia University a team headed by physicist Enrico Fermi then used that sample to verify experimentally that it was U-235 in which a chain reaction could occur, and therefore it was U-235 from which a bomb could be made. All this happened so early in the U.S. effort that, far from being shrouded in secrecy, the story was featured in the both New York Times and the GE Review. Both stories downplayed the significance of the discovery, stating that hundreds of kilograms of enriched uranium would be needed to produce any practical effects .

By 1941,however, secrecy had been clamped down, and Coolidge was appointed to a National Defense Research Committee evakuating the prospects for nuclear energy. That Summer physicist Marcus Oliphant visited Coolidge in Schenectady and told him of a surprising finding achieved by German emigre physicist Rudolf Peirls. Only ten kilograms of U-235 would be needed for a bomb. By 1943 GE was supplying controls, high voltage electrical equipment and mass spectrometers to secret uranium enrichment programs in Tennessee and California, as one of the hundreds of subcontractors on the bomb project.[391]

Another GE meeting raised another radical idea. The February, 1941, meeting of the GE Engineering Council has been called to discuss an old idea that was becoming a new competitive threat. The Swiss company Brown Boveri was selling gas turbines to provide peaking power for electric utilities. Here one of the youngest participants chimed in. "The development, " said mechanical engineer Alan Howard, "might lead to gas turbines for airplanes." The meeting's oldest participant then took matters one step further. Sanford Moss' pioneering efforts since before World War I had made GE a world leader at making airplane turbosuperchargers. He now told the meeting about the invention by Great Britain's Frank Whittle of an

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[391] **Hewlett, Richard and Anderson, Oscar. 1972. The New World. History of the Atomic Energy Commission Vol.1. U.S. AEC. Pp. 43-46 , 128. “From Submarines to A-Bombs”, GE Research Laboratory Bulletin, 1959. “Another Step Toward Atomic Power.” 1940. General Electric Review. 43. 40-42.**

aircraft engine similar to a turbosupercharger that was a step beyond merely driving a propeller with a gas turbine. That next step was the turbojet. Moss' team at Lynn had analyzed the idea and found it challenging, but feasible.The meeting's chairman, GE Vice President of Engineering quickly brought things back down to earth. GE's interest here was on land based gas turbines for power generation, not aerial inventions. He restricted consideration to whether the company should follow Brown Boveri's land gas turbine initiative. After discussion, GE Research Director William Coolidge summed up the verdict: "I do not see how we can afford not to go ahead. " The immediately practical land based gas turbine for electric power generationwas approved. The highly speculative turbojet idea was put aside.[392]

While the GE Engineering Council was thus proposing, the wider world was differently disposing. By the time of that 1941 GE meeting, U.S. Army Air Forces General Hap Arnold had already been introduced to that Whittle turbojet. In February of that year, at Arnold's urging, the U.S. government's National Advisory Committee for Aeronautics (NACA, predecessor of NASA) set up a jet engine research committee, including a GE representative. In April, 1941 British officials offered to the then still officially neutral U.S., via General Arnold, both the plans of the Whittle jet and the consulting services of Whittle himself. This would assure its development for possible use against Germany whatever the fate of Great Britain. By July, 1941, Arnold had chosen GE to make a U.S. copy of Whittle's jet. Soon the plans and an early model of the Whittle jet were on their way via B-17 from England to Lynn MA. They were followed in 1942 by a visit by Whittle himself, disguised with the not very deceptive alias of Frank Whitley[393].

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[392] **Minutes of the Meeting of the Engineering Council. 24 Feb 1941. Swope Papers. MiSci**

[393] **Gifford, Hermione. 2016. Making Jet Engines in World War 2. Chicago. Pp. 140-145.**

The choice of GE to make the U.S. Whittle jet has been given at least three interpretations. One is that Moss' successful turbosupercharger efforts marked GE as the best technical choice. Another interpretation is that the choice avoided distracting aircraft engine makers Pratt and Whitney and Curtiss Wright from their already large piston engine committments. Yet a third is that only a newcomer would have the flexibility to overcome a bias towards the current overwhelming superiority of the entrenched piston engine.

Whatever the balance of these motives, GE's immediate availability of a wide range of diverse technical skills played a major role. The GE engineers immediately began making improvements in its version of the Whittle engine, such as more heat resistant alloys for use in turbine blades. In September, 1941, GE signed the Army Air Force contract. Just over a year later, on 1 Oct 1942, at Muroc Dry Lake, California, two GE-built Whittle type turbojets powered a Bell Airacomet into the air for the first ever U.S. jet flight.

The performance of this pioneering effort, howwever, proved disappointing. Improvement proved difficult and slow. Despite the early start, by the war's end U.S.-made jet powered aircraft had not advanced beyond the testing and training stages, and never saw combat. They had, however, put General Electric into the aircraft engine business to stay. [394]

Meanwhile, other secret wartime military products presaged future civilian spinoffs. For example, a key wartime material was industrial diamond, used for cutting metals used in shells and armor. The main supplier of that diamond, South Africa, was a questionable ally. To insure an adequate supply. the U.S. enlisted the world leader in high pressure physics, Nobel laureate Percy Bridgman of Harvard. He led in a project to make diamond by squeezing graphite hard enough to change its structure. GE was brought in because Bridgeman needed that hard metal Carboloy to make his diamond

[394] **Dawson, Virginia. 1991. Engines and Innovation. NASA/U.S. GPO. Pp. 41-55. Garvin, Robert. 1998. Starting Something Big. AIAA. pp.5-10**

press. Bridgman's project did not succeed. A few years after the war, however, GE would pick the project up again, with results to be discussed later.

Similarly, the wartime demands of a Navy procurement officer named Hyman Rickover for better insulating materials led for support for a new GE Research Lab process for making a versatile new class of polymers called silicones. This was the first step in turning a previously minor GE Plastics business into a major GE advanced materials moneymaker.

GE would later publicly emphasize peaceful spinoffs of its wartime work, such as wire developed for heated flying suits that was later used in electric blankets. The biggest result of GE's weapons work was, however, more weapons work. This would range from an electric motor driven version of the Civil War Gatling Gun to ballistic missile re-entry vehicles to devices for triggering H-bombs. Labeled publicly with the peaceful sounding label "Aerospace", this weapons work ultimately rose to over one fourth of company sales.

In wartime labor relations, change was more evolutionary than revolutionary. "No general conversion was needed" wrote a GE induction motor engineer. A main challenge was doubling production and the the work force while replacing military volunteers and draftees. By war's end, GE had doubled the number of its manufacturing locations, from 34 to 68. For management purposes, many of the new war plants were satellites of the older Works: for example, Fitchburg and Everett MA were satellites of the Lynn Works, Syracuse and Fort Edward NY were satellites of the Schenectady Works , Darby PA of the Philadelphia Works, Buffalo NY of the Erie Works, and Kokomo IN of the Fort Wayne Works. Almost all the new plants were in that industrial belt quadilateral bounded by St. Louis MO, Minneapolis MN, Portland ME and Baltimore MD. A significant exception was a new plant at Oakland CA.[395]

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[395] **Report Department. On the War Years of the Induction Motor Department. 1 May 1945. Hall of History Collection. MiSci. Miller, John. 1947. Men and Volts at War.McGraw Hill p.240**

Veteran workers of those war years expressed pride in the sense of unity that permeated those wartime plants. They warned, however, against overglamorizing wartime unity. Meyer Siegel, a 50 year old World War 1 veteran, found at the Schenectady Works a way to contribute to another war effort. He also found, however, scrawled on the wall of a Works restroom, the words " You dirty Jews.You kikes go home.Get out of GE. Go back to Palestine. "[396]

Woman workers too encountered an ambiguous welcome. Their share of the growing GE Schenectady Work force rose from a prewar 15% to over 30%. Those women initially encountered ongoing wage discrimination dating back over the company's entire history.The UE took the lead in battling this discrimination. "Sex discrimination must end", proclaimed bargaining agent Leo Jandreau in a June, 1942, issue of the UE News. Making this happen proved complicated. Some male workers feared equality might be approached not by raising women's pay, but by reducing that of the men. In 1945, the National War Labor Board did decree wage equality. That decree, however, went away with war's end. The tide was however turning, and, with continued union pressure, wage equality would be achieved.[397]

As significant as what women were paid was what they did. For many, probably most, women workers , wartime jobs were not all that different from the jobs women had been doing since the creation of the electrical manufacturing industry. Nell Giles, a reporter for the Boston Globe, spent eight weeks working at GE's West Lynn MA Meter and Instruments Factory and reported on this typical experience. Manual dexterity was the main thing female applicants were tested on. The half that passed were told to come

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[396] **Siegel, Meyer. Und. Memoirs. American Jewish Archives. Cincinnati Campus. Hebrew Union Colllege Jewish Institute of Religion. Cincinnati OH.**

[397] **Kannenberg, Lisa. 1999. The Product of GE's Progress. Rutgers Ph.D. Dissertation.p.100-103. Matles, James, and Higgins, James. 1974. Them and Us. Beacon. p. 147**

back the next day with their nails cut short. They were then taught three basic movements called the finger, the shoulder and the hip-and-back, and practiced keeping both hands doing different moves at once. Actual work began with simple tasks, such as blowing off metal chips with an air blast. Giles moved on to operating a small drill press. "Once you mastered the technique of the job," Giles wrote, " your mind slides into a beautiful vacuum of space, cool and green." Breaking a drill bit brought from the setup man a brusque "helping Hitler again?" Completing 1000 operations without breaking a drill bit brought an approving "Hi babe."Giles noted that constant patriotic exhortation did not prevent a daily absenteeism of 6%. Nor was there any management response to suggestions that might help lower that absentee rate, such as the suggestion that "day nurseries might keep more women at work."[398]

Unlike in World War 1, however, many women moved into skilled jobs requiring initiative and skills. As a GE spokesman said at a 1948 Congressional hearing, before the war **"**It was not the practice to have men and women working on identcal jobs" and that in the past GE had paid men and women differently for " roughly comparable" work." During the war years, however, "of necessity" women took over many of the jobs performed exclusively by men. The pay system had become by 1948 based primarily on skill, and secondarily on physical labor required From 1940 to 1948, GE's average hourly wage rate for men increased 62% while the average hourly rate for women increased by 98%[399]

Exemplifying these changes was Helen Quirini. In 1941 she was a recent high school graduate who could not afford college. Nor could she save enough money for it by running with her brothers a small grocery store. Applying to Schenectady GE, she was offered the choice of an office or a shop job. For her, the choice was easy. She had heard that a shop piece

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[398] **Giles, Nell. Punch in Susie. 1943 A Woman.s War Factory Diary. Harpers.**

[399] **House of Representatives, Subcommittee on Education and Labor. Equal Pay for Equal Work for Women. 1948. 80th Cong. Second Session. Feb 1948. p.247**

worker could make 15% more than an office worker. She began in the radio transmitter department.The job had a set Anticipated Earning Rate. A beginner was given 4 weeks to show that she could meet that rate. Quirini not only passed that test, but quickly moved on to wiring jobs that required not merely repeated motions, but skill, initiative and understanding. She read blueprints, interpreted wiring diagrams, and wielded a soldering iron. After six months on the job, she was earning as much as her sister, a GE office worker who had been with the company for five years.

Urged to join UE Local 301, she replied that in her neighborhood and family the union was "not held in high regard" . Many believed it to be Communist. Quirini instead initially participated in company sponsored activities, playing on the company basketball and softball teams, and serving as a board member of the GE Athletic Association and as a reporter for the GE Works News.

What changed her views began after UE 301 had secured the placement of one union Shop Steward for every foreman. Working beside one female Shop Steward, Quirini heard the standard stories of the pre-union days: exploitive and abusive foremen, favoritism in layoffs, job selling at the employment office. "Then," recalls Quirini, " I asked her the $64 question: are you a Communist? " She replied, "I am not." Admiration of this particular person helped Quirini choose to join the union.

Subsequently, "I looked for any evidence that communism was a factor," she recalled. " I found none. "This communist question was a prominent one throughout the U.S. labor movement at this time, and especially in regard to the UE. It will be discussed in more detail in the next chapter.[400]

For some women workers, some of the greatest changes went beyond shop jobs or secretarial duties. Adelaide Oppenheim had not set out to work in

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[400] **Quirini, Helen. 1997. Helen Quirini and General Electric. On file at Schenectady County Historical Society. The full story of Communism in Schenectady can be found in Zahavi, Gerald. 1996. Passionate Commitments: Race, Sex and Communism at Schenectady General Electrc. 1932-1954. Journal of American History. 93. 514-548.**

technology or for GE. She was a Cornell history graduate who went on to write an M.A. thesis on Thomas Mann's ideas on space, time, and death. To earn money, she first sold eggs, then worked as a home lighting advisor. Then, in 1941, she applied for a job at GE Schenectady.After false starts as a blueprint tracer and a file clerk, she tried the GE General Engineering Laboratory. The hiring manager said, "Oh, you are history major. What did you think about Spengler's Decline of the West? " Though not having read it, she took the hint and proclaimed it a great book. He proceeded to mansplain Spengler for half an hour, then offer her a job.

The job was as a calculator. A top GE engineer who brought her problems noticed her aptitude ran far beyond operating a mechanical adding machine. She wound up replacing a junior engineer who had been drafted.There she worked beside other women, many of them teachers of math and science at women's colleges. They were hired with the understanding that after the war they would return to the classroom, giving their GE jobs back to the "real" engineers. Oppenheim did not have a classroom to go back to. She stayed at GE and entered a new field called project engineering. She did project analysis at the plutonium plant GE ran at Hanford WA, wrote part of the proposal for GE's first nuclear reactor, and ended up managing a group of 35 people. She became the first woman admitted to that earlier mentioned elite Elfun Society. [401]

Though Oppenheim's career path was exceptional, many women stayed on the job after the war. Post-war female employment at GE Schenectady stayed well above the prewar share of 15%, going as high as 25%. The range of jobs done by women also, though at first only slowly, expanded irreversibly. Women were admitted into the Apprentice Program, and subsequently into engineering and finance training programs.

Another employment issue also got off to a slower and more controversial start. Wrote Nell Giles in 1943, "there was a problem ahead with Negroes."

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[401] **Adelaide Oppenheim, Interview by Ruth Anne Evans for the Columbia Oral History Project. 30 April 1976. Copy in HoH Oral History Collection. MiSci.**

No longer confined to "the yard" and janitorial duties, wartime demand sent some black applicants into the offices and shops. it also led some White female workers to complain "do we have to share a bathroom with these Negro women?" At Schenectady, a group of white women launched a grievance on this issue, seeking segregated rest rooms. UE 301 refused to support them. The company rejected the grievance all the way up the management chain.Partly out of wartime needs, opportunities for Black workers slowly increased. Edna Bailey Miller had attended Howard University and worked as a secretary before she applied for a job at the Schenectady Works in 1942. She was offered the choice of sweeper or elevator operator. She left, and came back with a form to be sent to the Federal Government protesting GE's illegal discrimination. This time she was offered a factory job. Helen Quirini later recalled Miller saying that, on her first day on the new job, when she walked down the long aisle to the foreman's office "she knew how a convict feels as he walks down the aisle to execution." She was, however, accepted on the factory floor. She subsequently left for wartime Army service, then returned to GE and a career as a worker and equal rights advocate.[402]

Another milestone had been passed just before the war. Two decades after Wendell King had been driven from a summer job in a Schenectady GE Works machine shop, Jim Stamper became GE's first Black machinist . He was born in Atlanta GA in 1913. After the death of his father, a bricklayer, his mother brought Jim in 1930 to Schenectady. He found it, he said later, " like a little Southern city up North, only with the racism subterranean." There his uncle, head waiter at the city's best hotel, provided him with his first job. In 1937, Stamper graduated from high school, completing a technical training course. He was initially turned down by GE. Then his high school shop instructor told the GE personnel department that if it turned down an applicant as outstanding as Stamper, the school would

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[402] **Giles, Nell. Punch in Susie. 1943 A Woman's War Factory Diary. Harpers.Quirini, Helen. 1997. Helen Quirini and General Electric. Privately Printed. Ira R. Terry. Oral History. March 1981. HoH**

send no more applicants to GE. This got the verdict reversed, and GE hired Stamper as a machinist. After serving in the military in World War 2, Stampler would return to GE and go on to become the Schenectady Works' first Black Supervisor, and one of Schenectady's leading civil rights advocates. Another milestone was passed in the early 1950s when Lytle Cheeks became the first Black graduate of the Schenectady Apprentice Program.[403]

For Black employment at the Schenectady Works, however, time was out of joint. Just as a black migration into Schenectady was turning upward, in 1945- 1955, employment at the Schenectady Works peaked and was turning downward. GE would never provide to Schenectady's Black population the upward mobility opportunities it had earlier provided to White ethnic groups.

In summary, decades after what turned out to be a false alarm in 1900- 1920, GE came by 1945 to accept, however reluctantly , the very things it had been fleeing since its origins; crowding, politics, and unions. Regarding crowding, the Schenectady Works was in 1945, packed with 30,000 people, working in three shifts. In the city, housing was nearly impossible to obtain. The streets for the four wartime years were clogged with traffic, sometimes including tanks on tests runs after their production at the city's ALCO locomotive plant. Politically, industry went to Washington in the form of dollar a year men. Controversy ranged over distribution of contracts between big and small business. Even before D-day, a debate over reconversion to peacetime production began . GE and other Giants were accused of delaying that reconversion so they could milk the last dollar out of of their war contracts while monopolizing the scarce materials that smaller companies were hoping to use to get a peacetime head start. Unions were now solidly installed not merely in a few GE plants, as in World War I,

[403] **Williams, Matthew N. 1994. Redefiining the Apprentice. M.A. Thesis, U. Albany. Schenectady Gazette 29 Nov 2006; Albany Times Union 28 May 1996.**

but company wide. This time around they would not be routed immediately after the war by a depression and an employer offensive.

So, to answer this chapter's questions, what caused Coordinated Cooperation's demise? What replaced it? Coordinated cooperation had proved not to be a destination, but a stop in the road to this new world of vastly bigger government, vastly more powerful unions, and more gigantic than ever, but less independently dominant, corporations. Moving along this road, GE had not been guided by top management visible hand strategizing. It had adapted to circumstances. Those circumstances were a depression, the rapid growth of Federal Government power, and another world war. In completing these changes, World War 2 had proved to be, for GE, nothing less than a third New Deal. The first New Deal had replaced industry-coordinated cooperation with the somewhat similar but government coordinated NIRA. The Second New Deal finished the demise of coordinated cooperation, replacing its welfare and labor relations policies with Social Security and the Wagner Act. The Third New Deal of wartime mobilization solidly entrenched unions as a countervailing power to management.

Gerard Swope, a model of graceful and constructive adaptation to those new circumstances, now turned over the reins of GE to a very different company president. Swope would die in 1957. GE tradition holds that at his own previous request, he was buried, without ceremony or headstone in the garden of his Ossining NY estate. If so, he lacks an epitath. A good one might be: "this is America, and that is the way we do things here!"

Chapter 10. Progress, 1945- 1954

To contrast GE's emergence from World War 2 in 1945 with its emergence from World War 1 in 1919, consider the odyssey of GE Installation and Sales Engineer W.H. Denny. In the aftermath of the 1941 Japanese attack on Pearl Harbor, he and 57 of his colleagues voyaged across the Pacific to the site of that disaster. Their job was to restore the motive power of two salvageable battleships, West Virginia and California. They accomplished this challenging task ahead of schedule . Before the war's end, the California was unleashing its salvos on the Japanese island of Honshu.

Following their wartime achievements in 1919, GE engineers had returned to their peacetime pursuit of electrifying America. Not so in 1945. Denny and several of his colleagues were instead sent to White Sands, New Mexico. There they met 80 train cars filled with machinery brought back from Germany. Their job was to assemble these parts into 75 V-2 rockets, and preside over test firings. As the U.S. flowed rapidly from hot to cold war, GE ventured into a new world of rockets, jet planes, atomic energy, new types and uses of electronics, and computers [404]

How did that transition from hot war to peace and cold war affect GE's policies, structure and products? That is the question this chapter answers. Regarding policies, the buck stopped at the desk of Gerard Swope's successor as president , Charles E. Wilson. Everyone called him Charlie. By contrast, the only GE employee alleged to have called Swope "Gerry" was also allegedly drunk at the time.

Wilson was born in 1878 in New York City's Hell's Kitchen. His father, a bookbinder, died when Charlie was three. Charlie became an office boy at 12 at a company GE later bought. His steady rise featured mentorship by a foreman, a night school education, experience as a semipro basketball player and boxer, promotion to assistant superintendent by age 21, specialization as a manufacturing manager, and, from 1942-1944, Vice Chairmanship of the War Production Board. He ended as a GE lifer, credited with 50 years service.

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[404] **W.M. Denny. Oral History undated. HoH Collection. MiSci.**

A description of Wilson by War Production Board colleague Bruce Catton, later a well known historian, emphasized the pugilist perspective: "massive, powerful, abrupt, with a rasp to his voice like a top sergeant's", Wilson "rather looked like he had been hewed from a block of weathered hardwood with an adz." [405]

Wilson brought to Washington a reputation as the top manufacturing man in the country, a status he enhanced by effectively directing previously stalled programs producing airplanes, radar, and antisubmarine escort vessels. His management style, however, drew less praise. Historian Paul Koistinen summed up the criticism. "While powerful and shrewd, he was insecure and ruthless… [He] surrounded himself with yes men [and] often threatened to resign to get his way. "[406]

On the other hand, Wilson's World War 2 performance impressed Harry Truman sufficiently that he later chose Wilson for a pair of key government assignments. One, in 1951, was to head the Office of Defense Mobilization during the most intense phase of the Korean War. Another, in 1946, was Chairmanship of the Federal Civil Rights Commission. Wilson was recommended for that post by Walter White of the NAACP, who viewed Wilson as a strong supporter of racial equality. The Commission's report, entitled "To Secure These Rights," was a milestone both in its specific recommendations and its condemnation of racism. Wilson approved both the report's progressive slant, and its frank exposure of what he called the "bad side of our record."[407]

Within GE also, Wilson would receive both high praise and strong criticism. By the management elite he was revered. One manager recalls Wilson, at GE's annual summer management retreat, responding to a claim that Westinghouse would overtake GE. "They should live so long!", he proclaimed. "Their children should live so long! Their grandchildren should

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[405] **Catton, Bruce. 1948. The War Lords of Washington, Harcourt Brace p.242, see also pp. 277-282.**

[406] **Koistinen, Paul. 2004. Arsenal of World War 2. Kansas. P.32**

[407] **Hamby, Alonzo. 1973. Beyond the New Deal. Columbia P 446 , Berman,William 1970. The Politics of Civil Rights in the Truman Administration. Ohio State, p. 64, 70, Gardner, Michael. 2002. Harry Truman and Civil Rights. Southern Illinois.**

live so long!". The cheering crowd then marched from the hall to the strains of "Onward Christian Soldiers".[408]

GE union leaders, by contrast, were more likely to see Wilson as an arrogant plutocrat who had forgotten his origins. In 1946, Wilson's dismissive attitude and demeaning pronouncements would infuriate and stiffen the resolution of GE strikers. In reality Wilson was neither exceptionally charismatic, nor merely a caricature capitalist. He was a typical CEO of his time. Capitalism has been good to Electric Charlie (so named to avoid confusion with his contemporary, General Motors CEO "Engine Charlie" Wilson). So it was not surprising that Electric Charlie was good to capitalism. Nor was there anything surprising about his alleged statement that the twin dangers to the U.S. were communism overseas and labor unions at home. This sentiment was likely shared by perhaps most CEOs, and many ordinary citizens. Also typical among corporate executives was his combination of public service in New Deal/Fair Deal governments and opposition to New Deal/Fair Deal policies.

When Wilson returned to GE from wartime Washington service in 1944, a management-labor truce uneasily prevailed. A National War Labor Board with management, labor and public interest members had secured from the unions for the duration of the war a sometimes briefly violated but generally respected no strike pledge. It had supported further increases in union strength. It had sharply limited wage increases, to perhaps 10%, following the so-called "Little Steel Formula".[409]

This truce began to break down by early 1945. After the war ended, the two sides squared off. The focus became wages. The "big three" industrial unions, auto workers, steel workers, and electrical workers had their wage hopes fueled by Truman administration pronouncements. Truman himself said in a radio address that a raise for workers was "imperative". A government economic agency's study concluded that manufacturers could raise wages 24% without raising prices and still keep profits at prewar levels.

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[408] **Olaf Vea Oral History, 24 Oct 1978, Hall of History Collection.**

[409] **Harris, Howell. 1962. The Right to Manage. Wisconsin. Pp. 32-44**

The UE rounded this off to 25% , or in other words an increase of "two bucks a day".[410]

Beginning in August, 1945, UE delegations began meeting with Wilson and his associates at GE headquarters in New York City to bargain on a national contract. Negotiations continued, on and off, until mid January, 1946. Looking back, one UE negotiator, James Matles, summed up the process by recalling one meeting in the GE president's office. Wilson conducted it while bathing in the rays of a sun lamp (a product GE was then promoting). The meeting lasted only 30 minutes. Matles summarized it this way. The union asked for that two-bucks-a-day 25% raise. Wilson offered 10%, implying, in the union negotiators' view, that it was a take it or leave it offer. " Mr. Wilson", answered Julius Emspak,"in that case, we'll just have to leave it."[411]

Actually there were many meetings, and some give and take. GE subsequently offered a slight increase over that 10% to workers making less than $1 an hour. The UE found this inadequate. On Jan 15, 1946, the first company-wide strike in GE history began. It was part of a massive national strike wave that included, in addition to the United Electrical and Machine Workers, the United Steel Workers and the United Auto Workers, as well several smaller unions

The GE strike began at 6 AM in bitter cold with a vigorous demonstration at the Schenectady Works front gate by 7000 workers. It quickly settled down to orderly daily picketing that kept out the Works all but several hundred permitted maintenance workers. Nationwide, the UE got the publicity upper hand. Picket lines included recently discharged servicemen carrying signs reading "GIs versus GE". Members of the clergy and students from such womens' colleges as Mt. Holyoke and Vassar joined those picket lines. At Schenectady, artist and CIO union member Rockwell Kent, whose painting of a winter scene currently graced the January, 1946, GE calendar, took his turn on the line, asserting "artists are workers too."[412]

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[410] **Seidman, Joel. 1976. American Labor from Defense to Reconversion. Chicago, pp. 230-231**

[411] **Matles, James, and Higgins, James. 1974. Them and Us. Beacon. Pp 140- 141**

[412] **Schenectady Union Star 25 Jan 1946 p. 21**

Public opinion in Schenectady was less clear. Looking back, Schenectady UE officer Joe Mangino felt the strikers got little community support. Midway thru the strike, the City Council refused a UE request that it approve the strike More influential than community support was pressure from the Federal government. President Truman called Charlie Wilson to a meeting on January, 1946. In February a Federal Conciliation Commission met with both GE and union representatives in New York City. The government position began to focus on an 18-1/2 % raise. This was just over half way between GE's proposed 10% increase and the UE demand for 25%. [413]

The UE went along, switching its demand from 25% to "at least" 18-1/2%. On February 11, General Motors settled with its electrical workers on that basis. GE balked. Wilson said he would only raise the company offer if government restraints on appliance prices were also removed. The government replied, settle wages first, then we will issue price policy guidelines.[414] Back in Schenectady, a by now familiar message was heard. A local newspaper columist wrote on February 13 that

> GE officials are quietly but determinedly discussing removing the commpany's general office workers from Schenectady.

Then came a key break in local attitude. On March 2 some 125 small merchants and professionals in Schenectady came out on the union side, both in a mass meeting and in a full page newspaper advertisement. Nationally also, the tide turned. That 18-1/2 % figure came to be the standard for autos and steel as well as electrical manufacturing. Wilson held out for a couple of weeks, but on March 12, 1946, gave in and accepted 18-1/2%.[415]

At the time, this settlement was considered a great union victory, celebrated in Schenectady with a torchlight rally. Looking back from the 21st century, however, progressive labor historian Norman Lichtenstein was less happy. He identified 1946- 1948 as a different kind of turning point. Labor turned

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[413] **Interview with Joe Mangino, 12 Aug 1983 HoH MiSci. Schenectady Union Star 5 Feb 1946 p. 9**

[414] **Schenectady Union Star 11 Feb 1946 , 13 Feb 1946**

[415] **Schenectady Union Star 13 Feb, 2 Mar 1946, p/ 10**

away from advocacy of industrial democracy within the workplace. Instead, the big industrial unions became just another interest group, focused on higher wages and better benefits for themselves(including employment - based medical insurance). "The 1946 strike settlement," wrote Lichtenstein, " ended left liberal hopes that organized labor could play a direct role in reshaping class relations for the society as a whole."[416]

This setting aside issues of industrial democracy in favor of an immediate pay increase had been evident on the Schenectady picket line. When a quartet of union women that included Helen Quirini sang "Solidarity Forever" on that picket line, they supplied new lyrics. Ralph Chaplin's original had included such sentiments as

> Is there aught we hold in common with the greedy parasite
>
> Who would lash us into serfdom and would crush us with his might

TheUE Local 301 version, in contrast, proclaimed

> We need two bucks -- we want two bucks, that's the offer we present
>
> So come across and we'll come back and we'll all be friends again.[417]

If the strike changed the union, it also changed the company. In the 1930s GE had been praised by progressives and panned by conservatives for its calm acceptance of unions. After 1946, it would be praised by conservatives and panned by progressives, for its aggressive anti-unionism.

Charlie Wilson seems to have taken the GE defeat personally. He had some reason to do so. The UE succeed in making him look both heartless and clueless. Before the strike, in discussing complaints that wages had not kept up with the cost of living, Wilson had praised the nutritional qualities and low cost of beans. The union positioned him as a 20th Century Marie Antoinette, proclaiming "let 'em eat beans". After the strike began, the UE

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[416] **Lichtenstein, Nelson. 2013. A Contest of Ideas. Illinois.pp. 79,88**

[417] **Schenectady Union Star 9 Feb 1946 p.2.1**

publicized Wilson's alleged characterization of the woman workers on the picket line as "bobbysoxers".

In response to the defeat, in May, 1947, Wilson called to his office a recent GE hire named Lemuel Boulware. The assignment given Boulware was to find a better way of dealing with "the employee and community relations problem."

Lemuel Boulware was not an employee relations or community relations expert. He was the son of a Kentucky banker, and a graduate of the University of Wisconsin. He then became a washing machine salesman, then a manager at such companies as Easy Washing Machine and Carrier Air Conditioning, and then a World War 2 dollar-a-year-man. Wilson brought him to GE as the corporate staff coordinator for seven GE-owned affiliate companies. Though some of these companies were unionized, none, while on Boulware's watch, was hit by the 1946 strike.

Responding to Wilson's 1947 assignment, Boulware came up with an employee and community relations program that would become known, over his protests, as "Boulwarism." He preferred to call it " doing right voluntarily." Critics, such as historian Kim Phillips-Fein, would call it "highly politicized antiunionism". She saw it as not merely a labor policy, but as a key part of a capitalist counterevolution. She credited Boulware himself with a significant role in developments ranging from the creation of the Business Roundtable to the rise of Ronald Reagan. [418]

Though Boulware's supporters and critics disagreed on the program's name and its implications, both agreed on what the program did. It sold the company's position on wages, benefits and working conditions in the way one might sell a washing machine. It was an exercise, said Boulware, in " job marketing". The product was a GE job. The employee was the " job customer". Some 12,000 GE foremen and supervisors were the "job salesmen". The product was advertised by a flood of messages both in company publications and the public media, aimed not only at workers but their wives, family members and the community. This flood was aimed at

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[418] **Phillips-Fein, Kim. 2006. American Counterrvolutionary: Lemuel Rickets Boulware. In Lichtenstein, Nelson. American Capitalism. pp.249- 270. See also Bella, Salvatore J. 1962. Boulwarism and Collective Bargaining at General Electric. Cornell U. Ph.D. Thesis, and Boulware, Lemuel. 1969. The Truth About Boulwarism. Bureau of National Affairs.**

convincing all stakeholders that, when the time came to renew the GE- UE contract, the company offer was in the balanced best interest of them all. So they all ought to put pressure on the union to accept it.

Where did collective bargaining fit into this program? It did not fit. To Boulware, collective bargaining meant either the union was trying to get credit for the good things the company was ready to do voluntarily, or the union was seeking terms that would be destructive to the successful operation of the enterprise. So, instead of bargaining, the company would, by itself, design the best job product possible, and put it on the table. That offer could, Boulware said, be changed in response to "new information, " but never on the basis of "haggling."

In practice, things only intermittently followed that planned pattern. From 1948 to 1955, sometimes Boulwarism prevailed, but sometimes bargaining happened. In neither case did GE workers' settlements differ much from those of other giant corporations. In the key 1955 negotiation of a five year national contract, GE and its unions engaged in more or less normal collective bargaining. The workers came out with a generous medical plan and cost of living raises.

The settlement of grievances under Boulwarism also assumed a corporate and confrontational form. Helen Quirini recalled the first time she, accompanied by three other women shop stewards and Leo Jandreau, took a grievance to GE headquarters in New York City. She recalled her exchange with a management representative. Rejecting the description of the skill level of a particular job, the management man said "my five year old son could do any of the jobs that women worked on." Replied Quirini:

> Mr.so-and-so, you know, I have a three year old nephew who could do your job.Because all you do is say "no", and he could do that as well as you do.

"There was silence in the room," Quirini recalled later, "and I was never again afraid to take on anyone."[419]

Meanwhile, Boulwarism's impact was being blurred by other aspects of the class struggle. Regarding class in general, national UE leader James Matles expressed the traditional view by titling his 1967 memoir "Them and Us."

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[419] **Quirini, Helen. 1997. Helen Quirini and General Electric. Privately Printed.**

Employee relations at GE was not however, simply a face off between the "them" of management and the "us" of the union. About half of GE's employees in 1945- 1950, were neither.

The thousands of foremen, for example, were often recent skilled workers with sympathy to union claims. During the strike, UE urged the foremen to join their union, or form their own. However, after winning decisively in the 1946 Congressional Election, Republicans eliminated that possibility with the 1947 Taft Hartley Law. One of its provisions forbade foremen's unions. Boulware subsequently drafted GE's foremen into that job salesmen role. Also in labor limbo were graduates of the GE Apprentice Program. They were seen by management as workers and potential union members. The union, however, saw them as management favorites not to be trusted. Occupying the middle ground between management and its now unionized shop workers were engineers, laboratory workers, and office workers. Engineer Charles Elston recalls that the GE engineering force added during wartime some "atypical engineering types." Some of them invited fellow engineers to a meeting at the UE union hall aimed at forming an engineers 'union. Instead, Elston became an officer in a new GE Engineer's Association. It aimed not at union activity but at making management's secretive salary policies more transparent, and proposing plans for developing affordable housing in Schenectady.A GE Office Workers Association also emerged by 1946. It enrolled an unknown fraction of Schenectady 's 3000 office workers and 500 or so laboratory workers. It held a meeting early in the 1946 strike urging its members to join the picket line. Later its organizing committee, which included a prominent GE “atomic scientist”, John Blewitt, endorsed the union's position in a newspaper ad.[420]

In the "them" of GE management , enthusiasm for Boulwarism was far from unanimous. This was especially the case for those who had day to day manufacturing responsibility. Alfred C. Stevens, for example, the Schenectady Works Manager, found Boulwarism less than helpful in carrying out his production responsibilities. "I'm sure", said Stevens, "that Mr. Boulware suspected me of getting in bed with the union to a hazardous degree."[421]

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[420] **Charles Elston. Interview. 19 July 1984. HoH Collection. MiSci. Schenectady Union Star 20 Feb 1946 p. 11-**

[421] **AC Stevens Interview 26 Feb 1975 HoH. MiSci**

Even managers who approved of Boulwarism in principle disapproved of the way it was carried out. Motor Department General Manager Olaf Vea, for example, called Boulwarism a "great concept" but added:

> Unfortunately, however, in the end negotiators didn't come out with humility, only the expression of management knows best.[422]

The biggest division within management, however, did not involve Boulwarism. It involved an invitation. A GE manager knew he had made it when he got invited to attend GE's annual top management meeting called "the Island". What happened on Association Island in the St. Lawrence River was part standard speechmaking, part summer camp, and part notification of membership in the management elite. . Teams in different colored T-shirts would vie on the athletic field. Speeches would follow, interspersed with opportunities to engage informally with Charlie Wilson and his entourage in the Black Catte bar. All these were, however, mere preliminaries to the big Island moment: the "Charge to the Rookies", held in the shade of the Elfun Society's Sacred Elm.

" There were 25 or so of us initiates gathered around a campfire, under the biggest elm tree I ever saw, " one of those rookies later recalled.

> It was a clear summer night with a big half moon...Coming down the St. Lawrence River paddled an Indian in a canoe-- standing up. He came ashore and opened the ceremonies...Electric Charlie Wilson read the charge...he told us about good fellowship and how we did not stand alone...about success through individuals...the challenge of change...a great company as an association of people and purpose..and then led us in singing the Battle Hymn of the Republic. It was 31 or 32, already becoming a cynic-- but it was a spine chilling experience.[423]

So management ranged from this small Island elite to lowly middle managers, from Boulwarism enthusiasts to pragmatic production men. It was far from a unified "them". Nor were even the shop workers a unified "us".

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[422] **Interview with Olaf F. Vea, 24 Oct 1978, HoH. MISci.**

[423] **Jim Peterson, "Charge to the Initiates", Pittsfield MA 4/20/83. MiSci.**

The UE was not the only union at the Schenectady Works. Early in the 1946 strike, some of those other unions settled with GE on the company's terms . This included the old but small (65 member) Patternmakers Union, and the larger (900 member) Draftsman's Association. Even within the UE the unity displayed on the 1946 picket line only briefly papered over differences among workers of different skill levels, political preferences, and cultural backgrounds. Schenectady union leader Joe Mangino described differences between the pieceworkers, "the more aggressive guys and gals," and the dayworkers, " who just wanted to coast along. " He described the "union people" as "mainly pieceworkers", adding "most of the grievances and strikes were by pieceworkers."[424]

Divisions also occasionally sprung up among the pieceworkers. In 1943-1944 for example, a complex dispute about pay and promotion arose between the company and its toolmakers, some of the most skilled of the pieceworkers. Dissatisfied with the support they were getting from the union, the toolmakers then led a revolt which briefly overthrew the union officers. It took intervention by the Local 301 Board to settle this issue and restore the original leadership team.[425]

In contrast to the importance of being a pieceworker, Mangino recalled that in Local 301 in the 1940s, "being a communist wasn't a big thing." He described how

> a guy [who] joined the communist party was single and out of work...He could get coffee and something to eat. He went to the conventions to meet the girls...when he got a good job and settled down he lost interest in the communist party.

The number of communists in local 301 was probably never large, perhaps dozens rather than hundreds. If their presence was no big deal to the Schenectady rank and file, it was, however, a big deal to two other groups. One was the communist party itself. It had installed what Mangino referred to as "the New York people" -- party regulars, some from New York City, others trained there by the party-- in such such Local 301 positions as attorney, office manager, assistant bargaining agent, treasurer, and

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[424] **Interview with Joe Mangino, 12 Aug 1983 HoH OH**

[425] **Schenectady Gazette 17 Jan, 1944.**

switchboard operator. Another of those New York City people was Leo Jandreau's second wife, Ruth Young.

Communism in Local 301 was also a big deal to Congressman Charles Kersten of Wisconsin. Though in 1948 only a freshman, he had gained the chairmanship of a subcommittee of the House of Representatives Committee of Education and Labor tasked with Investigation of Communist Infiltration of the Union of Electrical, Machine, and Radio Workers. In September, 1948, exactly when his friend and fellow Representative , Richard Nixon was vaulting to national notice by agressive participation in the more sensational investigation of Alger Hiss by the House Un American Activities Committee, Kersten took his subcommittee to Schenectady.[426]

There he had a star witness. Salvatore Vottis fit both of the above descriptions of Schenectady communists. He had, in 1935, been injured and subsequently laid off by GE. He found coffee, something to eat, and refuge with the communist party. He also then went down to New York City to attend communist school, and came back as the New York City person installed as Local 301 treasurer. He would quit the party after World War 2 for what he describes as disgust with the policies of the Soviet Union. Now, on Sept 30, 1948, he was ready to tell all. That included his role as collector of Communist Party dues in Local 301. He claimed to have collected these dues from some current union leaders, most notably Leo Jandreau. [427]

A dozen Schenectady workers were called to testify under oath, ranging from the current local president to former Workers Council President Bill Hodges. Unanimously, and unequivocally, they rejected Vottis' testimony, and refused to discuss anything about the political opinions of their co-workers. Notable was the testimony of Helen Quirini, now union recording secretary, the first woman to hold a Local 301 office. Asked "do you share the view that to expose the communists in your union would cause the union to be busted" she answered . "I believe very strongly in our constitution, because you are starting with communism. Tomorrow it will be married

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[426] **Investigation of Communist Infiltration of UERMWA. 1948.Hearings Before a Special Subcommittee of the Committee on Education and Labor. House of Representatives 80th Congress. September 2, 28 and 29, 1948, Schenectady NY. U.S. GPO.**

[427] **Investigation of Communist Infiltration of UERMWA. 1948 pp 191-217.**

women, the next day jews; next day Negroes; next day Italians; next day poles."[428]

Leo Jandreau also rejected subcommittee questions, in the process dismissing Vottis as "a degraded rat". When asked for his views on Joseph Stalin's foreign policy, Jandreau replied.

> I am not an authority on foreign affairs....I am only a fellow who came from the shop, elected as an officer of the union, and try to do my job honestly.[429]

Had Leo Jandreau been a communist agent, he probably would have said something similar. In fact, however, in making this simple statement, Leo Jandreau told the simple truth. Even Vottis said he never heard Jandreau address any matters of ideology. This was echoed over the years across the GE ranks. Top GE executives, such as Albert Stevens, Don Craig, and Charles Elston, who contested bitterly with Bargaining Agent Jandreau, praised his non-ideological honesty, integrity, effectiveness, and constructive approach. Union members, such as Julius Emspak, Helen Quirini and Joe Mangino, who saw Jandreau from the inside, and not always from the same side, agreed with this evaluation. Mangino summed it up:

> Leo was from Schenectady, a toolmaker..At one time he was a foreman. He had great leadership ability. He was smart as hell. He was a real mechanic.[430]

A final note on the Kersten hearings, and similar exercises in Red-hunting at Schenectady, concerns a primary motive: the search for spies. As of 2024, there is no evidence that any member of the UE in Schenectady ever spied for the USSR. So far, the only known communist spy at Schenectady GE during World War 2 or in the Cold War era was Martin Sobell, an electronics engineer. He worked for five years for the GE Marine and Aeronautics Division at Schenectady, where he had access to GE

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[428] **Investigation of Communist Infiltration of UERMWA. 1948 pp. 200-206.**

[429] **Investigation of Communist Infiltration of UERMWA. 1948. pp. 207-273**

[430] **Interview with Joe Mangino, 12 Aug 1983 HoH**

information on military electronics systems such as fire control radars, which he likely passed on to the USSR.[431]

Despite this absence of evidence for worker espionage or disloyalty to the nation, in 1949 the UE came under fire not only from anticommunists in Congress, but from those in the Congress of Industrial Organizations (CIO). It expelled the UE and chartered in its place a new anti-communist electrical workers union, the International Union of Electrical Workers (IUE). It was led by a UE founder, James Carey, who had been voted out of the post of UE president in 1941. GE did not, at this point, jump on the anti-communist bandwagon. "A plague on both your houses" read a 1948 GE ad. GE successfully petitioned the National Labor Board for a vote to determine which union would represent the workers. In 1950 the UE emerged from that election still representing two thirds of the nation's electrical workers. At Schenectady, the UE won by 7761- 5847. A second election at Schenectady, in 1951, increased the margin in favor of the UE to 9005- 5179.[432]

The national tide, however, was turning. So was the tide within GE. The company came under criticism for being soft on communism. GE's Vice President of Public Affairs noted in 1953 that "the semi annual Link Audit [a national survey of public opinion] gave us clear signals we should have been more concerned over the public relations aspects of domestic communism." He concluded that " the time was ripe -- perhaps over-ripe -- for an unequivocal policy on communism. " On December 9, 1953, GE announced a new "Policy Concerning Admitted Communists, Saboteurs and Subversives." Any GE employee who admitted to being a communist would be discharged immediately. Any employee who took the Fifth Amendment when asked if he was a communist would be suspended from employment for 90 days. If he did not produce in those 90 days a certificate from an "accredited security agency of the United States government" testifying that there "was no evidence that the employee is a communist or otherwise a substantial risk" the employee would be discharged. "[433]

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[431] **Usdin, Steven. 2009. The Rosenberg Ring Revealed. Journal of Cold War Studies.11.91-143. See especially p. 115**

[432] **Bella, Salvatore. 1962. Boulwarism and Collective Bargaining. Cornell Ph.D. Thesis. Pp. 194, 218.**

[433] **Chester H. Lang. 1954. GE Public Relations Services Division Management Confrence. 6-7 Jan 1954. MiSci. GE Monogram. Winter 1953-54**

GE had made an employee's exercise of Constitutional rights inconsistent with GE employment. It had ruled that an employee suspected of "substantial risk" was guilty until proven innocent. Leo Jandreau wrote an open letter to GE's president saying "I am shocked at the un-American and anti-labor stand you have just announced." GE could not act against Jandreau, who worked for the UE, not GE. One who could go after him however was Wisconsin Senator Joseph McCarthy. In late 1953, coincident with yet another round of UE vs. IUE elections, he called Jandreau and other Local 301 leaders to secret hearings in Washington. Then, in January, 1954, he announced public hearings in Albany NY..On the day the hearings were to begin, 2000 GE workers rallied to protest the "McCarthy Smear Sessions".

Jandreau, however, never appeared. Two weeks earlier, he had met with Philip Carey in a New York City hotel room.They reached a deal. In exchange for substantial independence for Local 301, Jandreau agreed to support the IUE in the coming union election. McCarthy then lost interest in Jandreau, who was never subsequently called on to testify publicly. The IUE then won the Schenectady election by a 2 to 1 margin. Nationally also, the IUE gained a majority. The UE held on to a significant minority, a status it still retains, in particular keeping control of GE's Erie PA works. It took years for the bitterness of this internecine union battle to die down. How would the new IUE predominance fare against Boulwarism? That would not become clear until the next two decades.[434]

In the immediate postwar period union leaders were not the only GE employees called before an unfriendly Congressional committee. It also happened to Charlie Wilson. The House of Representatives Judiciary Committee called on Wilson in 1949 to testify in its Hearings on the Study of Monopoly Power. The hearings were chaired by a redoubtable opponent of monopoly, Rep. Emanuel Cellar of New York.[435]

The tone of Cellar's reception of Wilson is captured in the following exchange. When asked in how many anti trust cases GE had been a

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[434] **UE News 11.18 Dec 1953. UE 301 Information Bulletin 11 Mar 1954. Local 301 File 858, UE Archives.** .

[435] **Study of Monopoly Power. Hearings Before the Committee on Judiciary of the House of Representatives. Nov 21-30, 1949. Serial #14. Part 2B. U.S. GPO. 1950.**

defendant, Wilson said he did not know. After telling Wilson that the number was 16, from 1911 thru 1947, Cellar asked " do you believe in the anti trust laws? " Wilson replied "I do." "Why," Cellar then asked, "is it that you cannot operate under them? " [436]

The reference was to the three antitrust cases that had been postponed by the war, on monopolizing light bulbs, cooperating with Krupp on Carboloy, and suppressing international competition. GE was found guilty of violating the antitrust laws in all three. As in 1911, though the image was embarrassing, the effects were small. They were most severe in light bulbs. GE was required to share its patents and refrain from controlling prices. The business was left intact, however, and remained profitable, though at a much lower profit-to-sales ratios than before the war.

GE also stayed in the Carboloy business, though it and some executives, including a distinguished metallurgist, Zay Jeffries, were found guilty and fined. (Jeffries was, much later, pardoned posthumously by President Donald Trump). As for the international verdict, the guilty verdict had little impact on GE. The European economy was devastated by war, and it would be two decades before GE received serious competition from that direction.[437]

Similar to the way the Kersten hearings had relied on Salvatore Vottis, Cellar also had a friendly witness with inside information. He was Ted Quinn, last seen in this book leading GE's refrigerator business to profitable success. Quinn and Charlie Wilson had been GE's most Promising Young Men of the 1920s. They were named GE Vice Presidents on the same day in 1930. By 1934 they appeared neck and neck in the race to be Swope's successor. Quinn later claimed that in that year he was offered the post by

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[436] **Testimony of Charles E. Wilson to Study of Monopoly Power. Hearings Before the Committee on Judiciary of the House of Representatives. Nov 21-30, 1949. Serial #14. Part 2B. U.S. GPO. 1950. p. 1185**

[437] **Testimony of Charles E. Wilson to Hearings on the Study of Monopoly Power. 1949. House Committee on the Judiciary 81st Congress. 1st session. Wash.dc pp.1207-12. Trump's pardon is Described in Washington Times 10 Oct 2019.**

Swope himself. Then, at the end of 1935, Quinn suddenly and unexpectedly left GE.[438]

Asked by the Cellar Committee to explain, Quinn and Wilson gave different answers. Quinn said he quit as "a matter of conscience". Wilson said Quinn was "eased out" in a " face saving manner" after Swope " desired to dispense with his [Quinn's] services".Quinn would give his side of the story in full in a 1948 book entitled "I Quit Monster Business." At the 1949 Cellar hearings, he summed up his case against GE in particular, and Monster Business in general, in one very long sentence.

> I quit monster business because it is unnecessarily undemocratic, because it is big only for the sake of bigness or for purposes of concentrated power and control, because it is inefficient, because it is creating a dependent society where only masses count, genuine individual freedom languishes, and opportunity and expression are restricted, and because through its collectivistic forms and methods and mockery of free enterprise, it is leading us toward a brand of totalitarianism which is a perversion, so far as what is inherent individualism, civil liberties and the democratic process, as Russian communism.[439]

Wilson replied that

> in an expanding economy and in a growing world there is a need for economic institutions of such sizes as are best adapted to cope with the ever growing problems-- scientific, technical and economic-- of that world. Our economy demands the most efficient, the most able, and the most aggressive business institutions which a free competitive system will produce. This demand is interpreted in some cases by very small companies, in others by medium sized companies, and in still others by large companies.

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[438] **Works News 10 Jan 1931 p.3. Quinn, T.K. 1948. I Quit Monster Business. Privately Printed.**

[439] **Study of Monopoly Power. Hearings Before the Committee on Judiciary of the House of Representatives. Nov 21-30, 1949. Serial #14. Part 2B. U.S. GPO. 1950. pp. 544-545.**

In presenting an example illustrating the role of large companies, Wilson chose not one of the the high technologies of the day, such as atomic energy, jet engines, or electronics. Instead, he told the story of the humble garbage disposer.

This idea of grinding garbage fine enough to dispose down the sink and through the existing sewer system had been brought to GE in the early 1930s by Morris Cohen, a Schenectady public health official. GE applied to Cohen's idea the resources of its giant Schenectady Works, from craftsmen to engineers to its world class research laboratory. A product went on the market in 1935. GE shared its patents on generous terms with competitors and sustained millions of dollars in losses in order to build the market. With success in sight, in 1941, production was frozen for the war's duration. Only now, in 1949, was GE beginning to see the fruits of it more than 15 years of costly effort. Only a big company, Wilson concluded, could have both supplied the needed skills and showed such expensive patience.[440]

There was, however, another reason for Wilson addressing the committee with uncharacteristic humility. Secretly, he knew that there was some truth in Quinn's indictment. Furthermore, he was about to put in place the very cure for the problems of bigness that Quinn had suggested. The particular truth in Quinn’s indictment was the accusation of giant business inefficiency. GE manufacturing expert W.W. Beardslee would later recall Wilson's secret acceptance of this accusation. Beardslee and other manufacturing "shock troops" were brought in from other companies after the war. They were told how Wilson's Washington duties had enabled him to compare GE with its peers. He was not pleased by the comparison. Wilson concluded, Beardslee said, that "General Electric had a long way to go if it was ever to come up to the standards of the top industrial suppliers to the war effort." GE had slipped from its previous technology leadership.[441]

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[440] **Study of Monopoly Power. Hearings Before the Committee on Judiciary of the House of Representatives. Nov 21-30, 1949. Serial #14. Part 2B. U.S. GPO. 1950. p. 1164-65. Hay, Suellen. 1985. The Garbage Disposer, the Public Health, and the Good Life. Technology and Culture. 26. 758-784 is a well researched account of the garbage disposer (disposall is its GE trade name) history.**

[441] **W.W. Beardslee. Oral History 15 Feb 1983. HoH Collection. MiSci.**

This was most evident in electronics. Promising young electronics experts joining GE at Schenectady were quickly disillusioned. Stanford graduate David Packard would later say “I enjoyed my experience at GE,” but also expressed dissatisfaction about the opportunities there for a believer in the future of electronics. He was told on arrival in Schenectady in 1937 that there was no future in electronics for a GE engineer. After a stint of refrigerator quality control, and another at getting the bugs out of the dangerous manufacturing process for a mercury vapor based power device that dated back to Steinmetz, Packard returned to California and an entreprenerial startup with fellow Stanford grad William Hewlett.[442]

Simon Ramo, later a founder of the major high-tech company TRW, was more scathing in his recollections of his 1936- 1945 GE employment. He began at GE's Research Lab in Schenectady. There he found its publicity-generated image as the "House of Magic" much overblown. "Most of GE's R&D stars were well past their prime," he concluded. He went on to describe GE as "a very minor player, however, in the research and development effort needed to create new military technology". More generally:

> The company had become bureaucratic. Creativity at the management level was modest. Being careful was adequate. The engineering executives of GE were badly out of date... as secure as civil servants...

Other future leaders of the electronics revolution also passed briefly through GE before finding more productive and personally satisfying careers at newer, smaller, more specialized companies. These included Cecil Green of Texas Instruments and Charles Sporck of National Semiconductor.[443]

Charlie Wilson was aware of all of this. He not only secretly accepted parts of Quinn's indictment. He also had begun adopting Quinn's proposed cure.

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[442] **Packard, David. 1995. The HP Way. Harper Collins. P.27 Malone, Michael S. 2007. Bill and Dave, Penguin pp. 48-52**

[443] **Ramo, Simon. 1988. The Business of Science. Hill & Wang pp. 21-28.Cecil and Ida Green. Benefactors and Philanthropists. 1979. Web Site of Cecil and Ida Green Institute Astrophysics and Planetary Physics. Charles Sporck. 1984. Computer Museum Web Site.**

Presenting that cure to the disease of giant business, Quinn had proclaimed in his testimony that "the ultimate solution is decentralization, total and complete"

Quinn was practicing that solution. He had gone back into the appliance business. This time he was organizing not a giant appliance business, but a cooperative alliance, named Monitor after Quinn's refrigerator triumph. It was a cooperative of small or middle sized appliance makers. That this effort failed in the post-war environment of inflation and materials shortages does not prove the idea invalid.[444]

Wilson did not say so at the Cellar Hearings, but he agreed with Quinn. Decentralization was the cure for the growing pains of the giants. He also believed, however, that decentralization could be achieved while doubling down on bigness. In 1946, he practiced both solutions. To finance the doubling down on bigness, GE went into the investment market for $200 million in loans, its biggest borrowing ever. It bought up 31 out of 135 factories built by the government for war production, at the bargain price of three- fourths their construction cost. Meanwhile, Wilson appointed a former dollar a year colleague, Ralph Cordiner, as his GE assistant. Cordiner's special assignment was developing a plan to decentralize GE. Here GE was in the familiar position of follower. As earlier mentioned, other companies such as Du Pont and General Motors had long since adopted the decentralization form that Chandler called the multidivisional or "M-form" structure. By the 1940s even Westinghouse had begun to adopt it. Ralph Cordiner would take six years to propose and install GE's particular version.

Decentralization seemed needed because GE could see a leveling off of strictly electrical innovation. The disposall and the air conditioner would be its last big home appliance opportunities. At the other end, the steam turbine generator was approaching its limits of efficiency, about 30% and power, several hundreds of (or perhaps as much as 1000) megawatts. The big growth opportunities seemed the ones publicized by the war, notably atomic energy, jet engines, rockets, electronics and computers. In none of these had GE been a pioneer or even wartime leader.

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[444] **Study of Monopoly Power. Hearings Before the Committee on Judiciary of the House of Representatives. Nov 21-30, 1949. Serial #14. Part 2B. U.S. GPO. 1950. pp.544- 545. Kiplinger Magazine Feb 1947 Little Monitor Battles the Giants. p. 41-41**

In the atom bomb project, GE had been a significant subcontractor but not a major player. In jet engines, it had been brought in by the government to make a copy of the British Whittle jet. In electronics, GE often bragged about sending out the first U.S. television broadcast in 1928. It did not point out that this was done with an immediately obsolete electro-mechanical technology. In that same year Philo Farnsworth, the principal inventor of the ultimately successful electronic system, came to GE seeking to sell his system and patents to cash rich GE. Alexanderson recommended against purchase. GE made was low offer, and Farnsworth refused it.[445]

Some GE engineers were working on all-electronic television. For example, Camille Sabah, a Saudi Arabian born, MIT trained electrical engineer at the Schenectady Works obtained between 1925 and 1930 at least two patents on "cathode ray scan" TV systems. GE demonstrated an all electronic system in 1930. Then, however, as part of a 1932 government mandated settlement of old radio industry issues. GE sent its television effort to RCA . As a result, when it got back into television on its own account in 1938 GE was far behind RCA.[446]

GE also, as Packard and Ramo said, trailed in electronic device development. In the first electronics revolution, the vacuum tube revolution, GE had run neck and neck with AT&T. In the second, post-World-War 2 solid state, electronics revolution AT&T Bell Labs would invent the transistor, leaving GE in the dust.

In computing, University of Pennsylvania engineers built the first large scale digital computer, the ENIAC, and its principal inventors then commercialized it as the UNIVAC. IBM supported a competing approach at Harvard. Bell Labs sponsored the major digital conceptual and circuit advances at Bell Labs of George Stibitz and Claude Shannon. By contrast, GE did not move immediately into this new digital arena. Instead it built more immediately useful analog computers for its power businesses. Its digital computers in 1945 were still mainly women punching adding

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[445] **Fisher, David and Marshall. 1996 Tube p. 156**

[446] **Schenectady Gazette 2 April 1935. U.S. Patents 1,694,982 and 1706, 185. GE Historical File 54-10-54-24 MiSci. Series 1. Board of Directors Minutes. 22 Apr 1938.p.23. My thanks to Chris Hunter for informing me about Sabah's work.**

machines. (One of them, Marian Kellog, would go on to become GE's first female Vice President).

GE's lags were not fatal. The nuclear , jet engine and digital computer areas were new and undefined. They offered plenty of opportunities for a fast follower. Immediately after World War 2 ended, GE launched those fast follower efforts. In aircraft engines, GE went to work on efforts at Schenectady and Lynn (which became its jet engine headquarters) on improving the British Whittle jet. At Schenectady a development program, Project Hermes, began the design of rocket engines and the development of new kinds of rocket fuels. This led to an initial government project in air-to-air missiles.In electronics, in 1948 GE created at Syracuse NY, an Electronics Park devoted to development and manufacture of devices and products ranging from vacuum tubes to televisions. The " electronics czar" chosen to run it, Walter R.G. Baker was so highly respected within GE as a leader of the earlier radio and vacuum tube revolution that a close colleague credited him (erroneously) with coining the word "electronics". Baker was also an old style authoritarian who kept a bullwhip mounted on his office wall. Despite that, he was admired as a champion of new ideas. He helped create national standards for future color televisions, and led GE into such new fields of transistors and computers. [447]

In "atomic energy", henceforth, nuclear power, GE built on a 1946 opportunity. Du Pont had been in wartime the reluctant builder and operator of the giant secret plant at Hanford WA that produced plutonium. That human-made fissionable material was the explosive element of the Trinity bomb, and the planned basis for subsequent ones. Du Pont had, after producing gunpowder in World War 1, been labeled a "Merchant of Death." To avoid a repeat, it sought to shed its World War 2 Hanford responsibilities as soon as possible. The government asked GE to take over. GE agreed, but only as part of a deal. It would take over Hanford if the government would build a separate $20 million GE-run nuclear power laboratory near Schenectady. That laboratory would explore peaceful uses of nuclear power, as a government contractor.

Even before this agreement, GE recruiters were heading for such wartime nuclear locations as Los Alamos and Oak Ridge. They brought back members of the rising younger generation of nuclear physicists, the first

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[447] **Metcalf, George. 1992. Making Waves in the Information Age. Binford and Mort. P. 27. W.R.G. Baker Oral History. Columbia U. Oral History Project.**

such generation trained in the U. S. Examples were Harvard Ph.D. Henry Hurwiz, and Princeton Ph.D Thoma Snyder. The most eminent of the new hires was George Placzek, a renowned theoretical physicist from Czechoslovakia . He spent 1946-1948 at GE in Schenectady before moving on to the Institute of Advanced Study in Princeton NJ. Other Los Alamos veterans and future Nobel laureates, such as physicists Hans Bethe and Richard Feynman, became GE consultants.[448]

In addition to these catch up efforts, the late 1940s were a great time for researchers already at GE to get a hearing for radical ideas. Two examples were an old idea, rain making, and a new one, automation. In 1947, GE researcher Vincent Schaefer demonstrated that if you dropped dry ice into cirrus clouds you could cause rain. Soon, with government support, GE's Project Cirrus was under way. It explored everything from seeding clouds to reduce the severity of hurricanes to putting a more effective seeding agent, silver iodide into clouds in New Mexico with the goal of making it rain thousands of miles away.Was weather control the next superweapon? No less a scientist than GE Nobel laureate Irving Langmuir claimed success in early long distance rainmaking experiments.

Meanwhile, at Schenectady, engineers were experimenting with a similarly explosive idea. This was using the new technology of magnetic recording to record the movements of a skilled machinist. Henceforth the recording could run the machine-- the machinist was no longer needed. Soon the term "automation", of which this GE "record playback" technology was just one early example, drew widespread public concern.[449]

For both ideas, both optimism and fears soon proved overblown. Langmuir's long distance rainmaking proved an illusion. On the spot rainmaking proved scientifically valid but difficult to control. As for job-destroying automation, the record-playback technique did not prove practical. It was an analog approach to an automation future that would be

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[448] **Gottvald, Ales. George Placzek. P. 62. Seminars were given at GE Schenectady Spring Summer 1946 by Bethe Teller Placzek and Feynman. Weisskopf, Victor.1956. George Placzek, Theoretical Physicist. Science.123.409**

[449] **On Rainmaking, see Fleming, James Rodger. 2012. Fixing the Sky. Columbia. On Automation see Louis T. Rader, Interview with AC Stevens, 5 April 1983, HoH., and Rader, Automation Over the Years, " unpublished ms., 6 Nov 1980.**

dominated by the digital computer. The initial versions of that digital approach, called numerical control, initially proved too expensive for use in any but a few industries, such as aircraft and steam turbines. GE manager of industrial control Lou Rader recalls that the first numerical control his department built for one of GE's conventional businesses, Low Voltage Switchgear, experienced a 100% cost overrun, and he never got an order for the second.[33] By the early 1950s, spurred by a big order from the Air Force, automation was firmly linked to the high-tech, high-cost defense businesses. GE's President would say :

> We are not interested in making any product for the defense area that is easy to manufacture, that requires very little engineering. We are searching for items that require basic research and advanced development, that have enough direct labor content so that you can adequately tool up your shop and put in more and more automation or cybernetics as they call it in MIT— automatic processing of the product. [450]

GE's experience parallelled the rest of U.S. industry. Automation and numerical control remained in the 1950s and 1960s concentrated in the high technology end of the defense business. As late as 1980, only 5% of U.S. machine tools were run by numerical control. [451]

There was however, one immediate consequence of the two radical ideas, rainmaking and record playback. The inventor of silver iodide cloud seeding was a GE Research Lab physicist named Bernard Vonnegut. He was soon joined at the Schenectady Works by his brother, then on the mend from a traumatic war experience and failure as an anthropology graduate student. As a publicity writer for GE from 1948 to 1951 Kurt Vonnegut wrote press releases about such GE advances as the record playback machine. This

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[450] **Cordiner. Ralph. Remarks. GE Services Management Meeting 1954.**

[451] **"The Machine Shop Computer Arrives at Last", Business Week, September 13, 1976, 44R; Robert W. Breiken , the NC Story, GE General Management Meeting, 1/15/84, SN, HoH. ; GE Monogram, Winter, 1987, p. 14.Interview with John Cassidy, 7 October 1986.**

became the basis of his first novel, Player Piano (1952). Its main character, Paul Proteus, echoed Charles Proteus Steinmetz. A subsequent novel, Cat's Cradle echoed brother Bernard's work on possible world shaking consequences from messing with water. A principal character in Cat's Cradle was recognizably based on Irving Langmuir.[452]

Despite the immediate collapse of its own radical ideas for making rain or making machinists obsolete, by the early 1950s GE had come a long way. No longer was it the electrical manufacturing company of 1892- 1940, content to ride the electrification wave. Its sales had increased from $500 million in 1940 to over $3 billion in 1953. Even adjusting for inflation, this far exceeded its traditional rate of more than doubling its sales every decade. It also far outraced the growth of U.S. electricity use, and the growth of the U.S. GDP.

The difference between this newer Old GE and that older Old GE was the extent of diversification. By the early 1950s, GE was investing serious amounts of capital, both financial and human, in exploring a wider range of future possibilities than it had ever explored before -- indeed, wider than it would ever explore again. From rockets to rainmaking it was seeking entry into technologies that might change the world.

Its product line might have been summed up in 1940 as 80% electrical manufacturing and 20% all other. By 1954 that product line rested by 1954 on four roughly balanced legs. About 25% was defense related products and services, heavily subsidized by the federal government. About 25% was products sold to the electric utility industry. About 25% was equipment and materials used by other industries. At a little more than 25% was its now biggest business, consumer products. GE had in 1945- 1950 balanced markets and doubled down on diversification. These were not strategies cooked up in the office of the CEO, either by Swope or by Wilson. The new look of GE was an adaptation to Hot and Cold War.

Regarding people, the main thing to be adapted to was unions. They were not, as they had done after World War 1, going away. Vanquishing, or neutering, unions became not an immediate but a long term goal. Hence Boulwarism. This program of "doing right voluntarily" was a way of operating within the letter of, while defying the spirit of, the Wagner Act. For all its controversy, Boulwarism would not be the main shaper of GE

[452] **Strand, Ginger. 2015. The Brothers Vonnegut. MacMillan**

labor relations in the decade. Half of the labor now being related to was neither the "us" of the dominant union not the "them" of management .

Increasingly, standing between the two was the rapidly growing number of college trained professionals, especially engineers. A retrospective cross sectional hint at this demographic comes from a random sampling of 50 early 21st century Schenectady obituaries collected by GE's Elfun Society, of people who joined GE just before, during, or just after World War 2.

Though GE was recruiting nationwide, 25 (50%) of those professionals were born in New York State, 8 (16%) of them in Schenectady. Only two were born West of the Mississippi and two overseas. Their college attendance also skewed local. Both RPI in nearby Troy NY with 5 (10%) and Union in Schenectady with 4 (8%) edged out MIT with 3 (6%) as the top supplier of engineers and scientists. Only 2 (4%) went to prestigious top tier universities (one Columbia, one Stanford).

All but two were white (the exceptions being Asian-Americans), all male, and (based on their funeral arrangements) overwhelmingly Protestant, with some Catholics and two Jews. Twenty two (44%) specifically listed wartime military service, with the most common specialty being pilot. That predominance of military service had a policy effect. From its early days , GE had initiated new engineers through that earlier described program called "the Test". It served three purposes. First, it was a source of low cost electrically knowlegeable people for testing newly manufactured apparatus. Second, doing this testing on the shop floor put the new engineers in daily face to face contact with shop workers, learning from their skills and experience and establishing mutual respect. Third, the Test smoothed the transition from college. The test men lived in fraternity-house- like lodgings, with such names as the Rut, the Monastery and Wimpy's. They took part in organized sports: golf or tennis at GE's Edison Club, baseball and basketball in GE leagues. In early decades a Test football team took the gridiron against local colleges.[453]

Lou Rader recalled that, though he came with a Ph. D. from Caltech, “when interviewed for my first job in GE in 1937, I opted for their factory floor test course instead of their research lab.’ He went on to conclude

[453] **Furnas, J.C. 1941. How America Lives.Holt p. 55.**

> Despite the hand dirtying work, looking back on my choice of industrial training causes me no regrets for as I later found when trouble-shooting designs, the knowledge accumulated in those months of testing was invaluable.

For the new crop of World War 2 veterans, these benefits of the Test became liabilities. The vets were older, more mature, often married, and eager to get started immediately on a career. This made a combination of menial labor and a college fraternity less attractive. "Returning veterans, " said engineer Charlie Elston . "were not interested in dragging cable or cleaning oil tanks. "In 1946 the Test was ended. With it something important was lost-- a chance for GE's leaders to get to know, daily and face to face, those skilled people on the shop floor.[454]

So, in sum, returning to the question with which this chapter began, how did that transition from hot war to peace and cold war affect GE's policies, structure and products? In policies, GE moved from its 1935- 1945 cooperation with unions to what it called, pompously and deceptively, "doing right voluntarily," a.k.a. Boulwarism. In structure GE belatedly began following the Chandlerian progression from unitary to decentralized form. Even before World War 2, GE's unified structure and lack of an organization chart was becoming unwieldy. Once again a follower, GE followed such leaders as Du Pont and General Motors at choosing the multidivisional (M- form) structure. The particular twist GE put on that M-form would not become apparent until the mid 1950s, and will appear in the next chapter. Beside the unwieldiness of its unified structures the war had revealed other weaknesses. GE had lagged in electronics, had been a mere subcontractor on the first nuclear bombs, and had been perceived by manufacturing wizard Charlie Wilson as a mediocre manufacturer. The solution chosen to all this was not to focus in or specialize but to to diversify and double down.

In characterizing its products, changes were less a product of strategy than a result of adaptatio*n.* This new emphasis was exemplified in that decade in

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[454] **Rader, Louis T. 1980. Automation over the Years. Unpubl. MiSci. Charlie Elston Oral History. 19 July 1984. HoH Collection. MiSci.Interview with Joseph I. Whittlesey, Feb 4, 1985. HoH Collection . MiSci**

the 1950s both concretely and conceptually. Concretely, two brand new structures went up on the banks of New York's Mohawk River, five miles east of the Schenectady Works. Each cost tens of millions of dollars, and was capable of supporting the efforts of more than a thousand scientists, engineers, technicians, and support staffers. One was the new home of GE's now 50 year old corporate research laboratory, paid for with GE's own money. The other was the new GE-run Knolls Atomic Power Laboratory (KAPL), paid for by the U.S. government.

Conceptually, GE public relations sought a corporate slogan that could express this diversified doubling down. The old "initials of a friend" was too folksy. The recently tried "you can put your confidence in General Electric" was too pedestrian. The question was: how do you tell the world that GE is moving in the right direction, when even GE did not yet know what that direction was?A next attempt got closer: “big business means big progress”. It also, however, reminded people of recent antitrust crusades against big business. Better to get rid of any reminders of the curse of bigness.With that last tweak, the right approach had, in 1954, at last been found. A new slogan graced that year's Annual Report. "Progress, " that report proclaimed, "is our most important product."

Chapter 11. Wink 1950-1960

In the 1950s, , GE's initially vague promise of progress would be embodied in products. GE jet engines would power airplanes, GE reentry systems would bring rocket payloads safely down to earth. GE nuclear power plants would generate electricity, and GE digital computers would serve banks and stand poised to serve laboratories, offices and schools. Supporting this wide range of businesses, GE would radically change its structure by decentralization. It would replace a unified bureaucratic structure run by committees with a federation of Business Departments, each run by its Department Manager with only limited direction from the corporate office.

All this progress had, however, would have an anticlimactic ending . In 1960 an old nemesis would rise up and bite GE. Its source was not the icons of the new age, such as nuclear reactors, rockets or computers. Instead its source was GE's old electrical equipment manufacturing businesses. Its symbol was a human gesture: a wink.

This chapter addresses three questions .How did GE's vague 1954 concept of progress get embodied in specific products? How did GE's decentralization compare to the structural changes of other giants? What's with that wink?

In embodying progress in products, the most straightforward evolution was in aerospace.technology Aeronautics for GE before 1940 had been focused on its pioneering but struggling turbosupercharger effort. This had influenced the Army Air Force's choice of GE in 1941 to build a U.S. version of the British Whittle jet. By 1946, GE and had designed and built, on its own, two entirely new aircraft engines. The two illustrated a business dilemma. One was a turbojet. It employed improvements pioneered in Germany and developed at the government's NACA laboratories, such as an axial compressor, and an multiple can combustor. GE's own contributions included high temperature resistant alloys and improved combustion chambers. All this doubled the power of the Whittle jet. That paid off in the higher speed the Air Force wanted -- but at the cost of very low fuel efficiency. Concentrating on turbojets might earn GE steady income from military cost-plus contracts. The low efficiency, however, might sacrifice the

potential of serving the emerging and potentially much more profitable civilian airline industry.

The other new GE design addressed that efficiency issue. It was a turboprop, a gas turbine that drove a propellor. This gained efficiency but sacrificed speed. GE engineers and many others had by 1950 guessed the ultimate civilian airliner answer: combine turboprop and turbojet to get the best mix of speed and efficiency. The first effort to do this had been straightforward. On a 1940s experimental airplane, the XF 81 Orion, a 2000 hp. GE turboprop drove a propeller on a plane's nose, while a 500 hp.GE turbojet blasted hot gas out the tail. It flew, but proved no improvement on conventional piston engines. Only after 1960 would the right turbojet-turboprop combination be perfected.[455]

In the 1950s, GE's engine successes were a pair of military turbojets. The first, the J47, enabled U.S. Sabre Jets to fight on equal terms with the previously superior Russian MiGs in the skies over Korea . The next GE engine, the J79, powered U.S. fighters and bombers of the 1950s to world speed records. This performance enabled GE to outlast many aircraft engine rivals. Some were prewar engine makers, such as Curtis Wright. Others, such as electrical turbine- generator rivals Westinghouse and Allis Chalmers, had been, like GE, brought in on the turbo jet opportunity during World War 2 by the Army Air Force . By 1960 GE had outperformed all but one of its U.S. aircraft engine competitors. It had even gained overall leadership in some smaller markets, such as corporate jets. It was however, far behind the leader, Pratt and Whitney. GE had put its main 1950s civilian engine efforts into powering two ultimately unsuccessful Convair airliners. Meanwhile Pratt and Whitney had extended its lead by jet-powering the planes that made Boeing the world's leading airframe maker, first the military B-52, then the civilian 707.

Without government sales and support, GE Aircraft Engines would not have survived the 1950s. Without a larger role in the growing civilian airline market, GE's Aircraft Engine's post-1960 future was very much in doubt.

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[455] **Sources for the description of GE's 1950s aircraft engines efforts include Schoenberger A. et al. 1979. Seven Decades of Progress. Aero Publishers. Garvin, Robert B. 1993. Starting Something Big. How GE Got into the Aircraft Engine Business. AIAA. Rowe, Brian H. The Power to Fly. Pen and Sword. 2005. Bruce Buckland Oral History. 25 Feb 1980. HoH Collection. MiSci.**

In the "space" part of aerospace, the 1946 GE effort on V-2 rockets had led in 1948 to the company's development of an air to air missile under government contract. In the early 1950s the company briefly considered buying the Hughes Aircraft Company and using it to follow up on those early missile efforts. By 1954, however, GE had decided not to be a missile maker. “The missile was really an aircraft type product,” said Herbert Slate, a partcipant in the GE project, “ and aircraft companies had that capability.”[456]

Then, in 1955, a Missile Crisis emerged. The Soviet Union appeared to be developing rockets capable of delivering H-bombs to North America. This caused the Air Force to come to GE with a $100 million opportunity.It involved not sending rockets up, but bringing their payloads down. These "re - entry vehicles" faced extreme technical demands. Falling from the near vacuum of space into the denser atmosphere generated heating of up to 12,000 degrees F. This was hotter than the surface of the sun. That atmosphere also slammed on the brakes. The deceleration was the equivalent of stopping a 60 mph car within a distance in of 2 feet. It had to be done without diverting the vehicle from its intended trajectory, or disturbing its delicate electronics. These stiff demands helped GE get the contract. It could immediately divert dozens of engineers and scientists already on hand to meeting the challenges. This helped it beat out smaller companies and start ups, who would have had to build such capabilities from scratch.

The urgency of the challenge was well understood at the Pentagon. It did not reach the general public, however, until 1957, when the USSR's Sputnik soared into orbit, while the U.S. answer, the Vanguard, fizzled on the launch pad. Talk of a "Missile Gap" filled the media. Less publicized were the U.S. military successes. In Dec 1956 an instrumented GE-built re-entry vehicle flew successfully on an experimental Air Force missile. In the Sputnik year of 1957, the first two U.S. long range missiles Thor and Atlas, achieved successful flights of thousands of miles. The head of the Air Force missile program later pronounced the 6000 mile flight of the Atlas in December 1957 as the turning point in the Missile Crisis. By June, 1958, the Air Force officer in charge of the re-entry vehicle contract was able to

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[456] **Metcalf, George. 1992. Making Waves in the Information Age. Binford and Mort. P. 91. Interview with Herbert Slate. 27 Nov 1981. HoH Collection. MiSci.**

make a pronouncement that combined technological pride with a chilling intimation of apocalypse . "The re-entry problem had been overcome" he proclaimed. "We could safely deliver and detonate a 'live' warhead on target" . That live warhead would carry the recently perfected hydrogen bomb.

In 1960, a secret U.S. satellite above the USSR snapped its first spy-in-the - sky photographs. A secret GE project helped safely recover them by catching in mid air a film capsule dropped from the satellite. The pictures showed that the USSR did not have the feared large number of operational ICBMs. The U.S. was already taking the lead. [457]

That re-entry vehicle success was only one of a wide range of GE government funded aerospace projects in the 1950s and 1960s. These included guidance systems for submarine launched Polaris missiles, a rapid-fire airborne machine gun, torpedoes that delivered at last on Edison's 1886 initiative , various radar systems, space satellites for navigation, communication and photography, and, in the most ambitious, though unsuccessful, effort, attempted development of a nuclear powered airplane.

GE rose in the 1950s to the nation's second place in defense contract dollars, behind only General Dynamics. Defense work held many attractions. For examp!e, the cost plus fixed fee arrangement assured profitability. Government defense contracts also offered "progress payments". That is, the government paid while the work was going on, rather than waiting for the final product. ‘One factor that has been most helpful in eliminating the need for outside borrowing,” said CEO Ralph Cordiner in 1954,

> has been a contribution by those involved in defense activities. At present, 79% of our inventories and accounts receivable for defense production are covered by progress collection that amounts to $400 million.[458]

The Government also helped GE acquire new facilities, often at bargain prices. Most notable was a surplus wartime plant of Wright Aeronautical near Cincinnati OH, which became the main location of GE Aircraft

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[457] **Neufeld, Jacob, et. al. eds.1997. Technology and the Air Force. Air Force History and Museum Program. Day, Dwayne A.et.al. 1998. Eye in the Sky. Smithsonian. Pp. 117, 216-218**

[458] **Cordiner to GE Management Conference. 27 Jan 1954. MiSci.**

Engines. Despite these attractions, GE announced in 1955 an intention to reduce the defense share of its total sales, from 25% down to 20%. This was not due to regret about being a merchant of death. Rather, it was because the defense industry seemed insufficiently profitable.The fixed fees amounted to a low profit rate. Claims of "spin offs" from defense into useful and profitable civilian products proved exaggerated. Missile re-entry vehicles , for example, achieved their high performance under highly demanding conditions by using materials and designs too expensive for civilian applications. Temperatures of 12,000° F. were unlikely to be encountered in the kitchen. [459]

The intended defense reduction did not, however, immediately happen. Government demands due to that Missile Crisis accelerated rather than decelerated GE defense efforts. Meanwhile, non-defense sales grew more slowly than expected. As a result, rather than shrinking to 20%, by 1960 the defense share of total GE sales rose to 26%.

In nuclear power, hopes for peaceful spinoffs from weaponry seemed brighter. The entry fee for GE was , as mentioned earlier, yet another military contract . This was for operating the massive secret effort at Hanford WA that produced plutonium for nuclear bombs. In portraying its Hanford effort in 1950, GE painted an optimistic picture. This was misleading. The best history of the U.S.Atomic Energy Commission (AEC) reports the initial GE effort at Hanford as being characterized at the time as "inadequate", "precarious," "dreadfully inefficient" and "deplorable". [460]

Serious as those surface problems at Hanford were, vastly more serious problems came to lurk literally beneath the surface. Over the decades after 1945 Hanford became a contender for the title of “most polluted place in the Western hemisphere”, perhaps missing out for the world title only because the USSR did even worse with its nuclear waste. At Hanford 177 underground tanks, some decaying dangerously over the years, came to hold some 54 million gallons of nuclear waste, the residue from the production of the plutonium used in 60,000 nuclear weapons. To fully clean

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[459] **Annual Report 1955**

[460] **Hewlett, Richard and Anderson, Oscar. 1972. The New World. History of the Atomic Energy Commission Vol.1. U.S. AEC. Pp 39, 43, 63, 85. General Electric. 1950. Four Years at Hanford. (Online)**

up this mess and safely enclose the remains was estimated in 2023 as a decades-long project that would cost more than a more than half a trillon dollars. Immediate health effects have so far proved less dire. A study of Hanford workers from 1945- 1981, which includes the years of GE's involvement, found that "Hanford workers continued to exhibit a strong healthy worker effect with death rates substantially below those of the general U.S. population" and that

> comparisons by level of radiation exposure within the Hanford worker population provided no evidence of a positive correlation of radiation exposure and mortality from all cancers combined or of mortality from leukemia.[461]

Compared to Hanford's complex production of plutonium, the peaceful nuclear effort had a simpler goal: to boil water. Steam thus produced would, in the conventional way, turn a steam turbine generator to make electricity. Whether that nuclear boiler could ever compete economically with a conventional coal-fired boiler was very much in doubt in the early 1950s. By then, however, economics was not the driving force. The Eisenhower administration, the AEC, and Congress' Joint Committee on Atomic Energy, were determined to show the world that the U.S. could beat the USSR in the race to the peaceful atom. Hiroshima and Nagasaki might thus be justified, and Communist technology might be outclassed. "The United States knows," said President Eisenhower to the United Nations in December, 1953

> that if the fearful trend of atomic military build-up can be reversed, this greatest of destructive forces can be developed into a great boon, for the benefit of all mankind. [462]

In 1947, the AEC had begun funding multi-million dollar peaceful atom efforts at 13 major labs from Brookhaven NY to Berkeley CA. GE's Knolls Atomic Power Laboratory (KAPL), near Schenectady, was a major participant. GE set out to develop a nuclear reactor that could run on the

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[461] **Galluci, Maria. 2023. A Glass Nightmare. IEEE Spectrum Online. Vartibdun, Ralph. 2023 . A Poisonous Cold War Legacy. New York Times. 31May 2023.Gilbert, E.S. et al. 1989. Mortality of workers at the Hanford site: 1945-1981. Health Physics 56.1-25. U.S. Government Accountability Office (GAO). 2020. Hanford Cleanup. GAO Highlights. Jan 2020.**

[462] **Address by Mr. Dwight D. Eisenhower, President of the United States of America, to the 470th Plenary Meeting of the United Nations General Assembly Tuesday, 8 December 1953**

plentiful uranium isotope U238, and produce both power and the bomb ingredient plutonium. Sale of that plutonium to the government could help meet defense needs, reduce power costs, and stretch out the domestic uranium supply. That GE's candidate for a civilian reactor design was called an Intermediate Breeder Reactor (IBR). The name referred to the breeding of plutonium using an intermediate level of kinetic energy of the neutrons that performed the atom-splitting breeding process. The GE design also sought to make the whole process more efficient by the use of molten sodium instead of water to carry the reactor's heat. Sodium, though a better heat-carrier than water, was also far more hazardous. The GE researchers believed, however, that sodium's added efficiency outweighed its serious but manageable dangers. In 1948, this dual-use (power and breeding) IBR concept was extended to a third purpose. At the request of the Navy's Hyman Rickover, GE agreed to also explore the use of a sodium cooled reactor to power a submarine.

Almost immediately, a key part of this ambitious effort ran into trouble. In 1948-1949 , tests at KAPL and Hanford indicated that the Intermediate Breeder Reactor would not breed enough plutonium to be of practical use. GE dropped the breeding, but pushed on at exploring the sodium reactor for civilian power and for military submarines. Then, by 1950, Rickover convinced the AEC to focus the GE reactor effort entirely on submarine propulsion. In this hijacking of the GE Knolls Atomic Power Laboratory effort, the GE sodium cooled approach became only a backup. Rickover had already enlisted rival Westinghouse to develop a simpler reactor also aimed at submarine use. Its coolant was water, not sodium. Water, unlike sodium, would not burst into flame if leaked into the substance in which a submarine was immersed. [463]

It was this Westinghouse pressurized water reactor (PWR) that in 1954 successfully powered the world's first nuclear submarine, the U.S.S. Nautilus . Two years later the U.S.S. Seawolf, the first and only U.S. sub powered by a GE sodium cooled reactor, limped to completion. It quickly encountered problems that made it obsolete. The Seawolf is now remembered mainly for one of its officers, Lieutenant Jimmy Carter.

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[463] **Cohen, Karl. 1953. Atomic Power as a Risk Venture. Bull. Atomic Scientists.Oct 1953. 305-308. Hewlett, Richard and Anderson, Oscar. 1972. The New World. History of the Atomic Energy Commission Vol.1. U.S. AEC. pp. 192. 213, 217, 473**

GE put its best face on the situation. A test version of the sodium cooled reactor was installed in 1953 just a few miles north of Schenectady, at West Milton NY. On July 18, 1955, it generated what GE proclaimed to be "the free world's first commercial atomic -electric power" . Visitors posed for pictures in front of the reactor's iconic spherical pressure vessel. Some then ate "the first hamburgers cooked by atomic - electric power." [464]

After the hoopla, this already obsolete GE sodium reactor at West Milton was quietly replaced with a Westinghouse PWR. Its use would not be to provide power to the people but to train future Naval submariners. GE's KAPL was assigned henceforth to work only on PWRs for naval vessels, in competion with Westinghouse's Pittsburgh PA Bettis Lab. This cooperative competition continues to this day, though GE has not managed KAPL since the 1990s.

Back in that same year of 1955, Westinghouse held at Shippingsport PA a more realistic public peaceful atom ceremony. Westinghouse immediately set out adapting the PWR to civilian power use. Support for this industrial effort narrowly won out in Congress in 1954 over a rival proposal for the AEC to build six full scale nuclear plants as a fully governmental program. Instead, Westinghouse's Shippingsport PWR became in 1955 the first effort of the Atomic Energy Commission's private industry led Power Reactor Demonstration Program.[465]

In retrospect, it might have been wise for GE in 1955 to have come over to the PWR for civilian as well as military uses. It could then have waged with Westinghouse the same kind of competitive cooperation (or cooperative competition) that served society so well in such technologies as electric railways, turbines, jet engines and (post-Seawolf) nuclear submarines. GE's top nuclear expert, Karl Cohen, advocated this approach in the 1950s, but was overruled Instead in 1954-1957 a GE working group composed of experts in reactor design, chemistry, metallurgy and electric power engineering went looking for other nuclear reactor concepts . [466]

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[464] **GE Monogram August 1955. Karl Cohen Oral History 17 Oct 1986. HoH Collection.MiSci.**

[465] **Bupp, Irwin and Derrian, Jean-Claude. 1978. Light Water.Basic Books. Pp. 35-38.**

[466] **J. B. McClure. Oral History. 30 Dec 1980. HoH Collection. MiSci.**

This led to visits to the AEC's Idaho test site where experiments were being carried out on a range of such ideas. From that collection of concepts, GE chose the Boiling Water Reactor (BWR). It had originally been proposed by Harold Urey, a University of Chicago physical chemist, Manhattan Project participant and Nobel lareate. It had been proved feasible in tests led by a government mechanical engineer Samuel Untermyer, whom GE then hired. Like the PWR, the BWR's coolant was water. The difference was in the plumbing. The PWR used two separated loops of water. One carried heat out of the nuclear reactor. Then, in a heat exchanger, that reactor water heated a separate water loop that made steam for the turbine. The BWR used one loop to do both functions. This made it conceptually simpler, but also introduced drawbacks in materials performance. [467]

Whether one of these types is superior to the other is still being argued in the 21st century. The fact that there were, in 2023, significantly more PWRs than BWRs in the U.S., 63 to 21, suggests that the advantage may lie with the PWR. An internal GE 1978 study supported that suspicion, identifying a persisting performance differential in favor of the PWR. GE technology analyst John Fisher wrote to GE Power Systems technology manager Thomas Lee in 1978 that the study

> examines the possibility that the BWR/PWR performance differential may be diminishing as a result of evolving nuclear design. Unfortunately there is no evidence of such a trend over the ten-year period ending 12/31/77.[468]

Looking beyond that corporate debate, many 21st century experts, think neither of these "light water" reactors was ever the best choice. Some view other less-tried options as potentially superior. These include Canada's "heavy water" reactor, the gas-cooled reactor, and the thorium fueled molten salt reactor.

GE placed its bet on the BWR. In 1958, GE's Annual Report announced a two phase program to accelerate the commercial use of BWR based nuclear power. Phase 1, Operation Sunrise, called for an accelerated development program to achieve economically competitive nuclear power within a decade. The first experimental unit, a small scale 50 MW unit for Pacific Gas & Electric in California, was already under construction. Meanwhile, Phase 2,

[467] **Mahaffey, James. 2009. Atomic Awakening. Pegasus. Pp. 261-264.**

[468] **Fisher to T.H. Lee 4/21/78. John Fisher Papers. 2018-012. MiSci.**

carried out in parallel, aimed at gaining experience on operating other experimental reactors at the GE Nuclear Department's Vallecitos CA headquarters.Both phases aimed toward the 1960 operation of the first full scale BWR. This would be a 180 MW reactor at Dresden IL. It was funded jointly by GE and Commonwealth Edison (the same electric utility that had, under Samuel Insull in 1903, bought GE's first full scale steam turbine). The project got only a relatively small ($20 million) government subsidy. Further plans called for fully privately funded, economically competitive , nuclear electricity by 1965.[469]

Operation Sunrise was controversial. Some GE nuclear technologists thought it moved to fast. That 1965 target required building each next generation reactor before operating the previous generation's model. Better to learn fully about the limitations of each reactor generation, fix the likely to be encountered dislocations of scale, and develop cost-saving production improvements, before moving on to the next level. For example, GE Power Systems executive Glen Warren wrote in 1957 that

> It is unfortunate that political, international, and other non-economic considerations are forcing the technological development of such [nuclear] plants, with resultant high costs and risks at a rate much in excess of the real needs or normal rate of techncal advance.[470]

In parallel with this choice of a reactor type, GE carried out an intensive study of nuclear hazards. "The possible magnitude of public liability arising from nuclear accidents is one of the major problems confronting industrial atomic power development, " that study's 1956 report concluded. In part that problem was addressed politically. In 1957 the federal government passed the Price Anderson Act. It put an upper limit of $60 million on the amount that industry might have to pay in the event of a nuclear accident. For damages beyond that limit, the government would pick up the tab, up to a total of $500 million, a sum described as "high enough to convince, not so high as to scare."As for the cause of such damages, the GE study concluded that "serious damages will be due to the spread of released radioactivity and

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[469] **Cohen, K; Zebroski, E. 1959. Operation Sunrise. Nucleonics. Vol. 17 (now on Internet)**

[470] **G.B. Warren to Robert Paxton 31 Jan 1957. Glen Warren Papers. 94.78.285. MiSci.**

not to explosive effects. " It estimated the probability of such an accident as follows:

> If 1000 reactors are in operation, one of these may be expected to fail so severely as to cause a disaster.

To further reduce that disaster expectation the study added that

> If a reasonable additional expenditure is made to house the reactor in a special building to contain the radioactivity released in a reactor accident, we conclude that the probability of disastrous spread of fission products will be reduced by a factor of 100.

GE adopted the recommendation. The GE experts estimated that this decision reduced the probability of an accident releasing a significant amount of fission products to the atmosphere to somewhere between 1 in 10,000 and one in a million reactor-years. Other U.S. nuclear reactor makers made the same design choice. The containment vessels' iconic spheres, domes, or cubes became the outer structures all U.S.commercial nuclear reactors. This contrasts with the Soviet Union RMBK type reactor which did not have a containment structure. Due to that lack of containment, the 1986 disaster at Chernobyl, Ukraine, led to the release and scattering over a large area of such radioactive elements as plutonium, iodine, strontium and caesium.[471]

While pushing nuclear toward that 1965 commercialization target, GE also explored a more speculative nuclear future. From 1955- 1965, it carried out at its new Research Lab a program experimentally exploring nuclear fusion, the energy source that powers the sun and other stars. This resulted in a GE fusion demonstration at GE's "Progressland" exhibit at the 1964 World's Fair. By then, however, it was clear that GE's "theta pinch" technology, like everyone else's 1950s fusion proposals, was far from practicality. Fusion subsequently receded further into the distance. Indeed, commercial fusion seems further away in the 21st century than it had seemed in the 20th.[472]

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[471] **Weinberg, Alvin.1994. The First Nuclear Era. Springer. P. 174.J.C. Fisher at al. 1956. Nuclear Reactor Hazards. Project Analysis Memo PA-56-4 . John C Fisher Papers Box 2018004. MiSci. .International Atomic Energy Agency . Frequently Asked Chernobyl Questions. On Line. 2023 Wellock, Thomas R. 2017. A Figure of Merit. T&C. 58. 678-721, with the probability estimate referenced above on p. 688.**

[472] **Interview with Willem Westendorp 4/7/76. HoH MiSci**

In summary, for all its public optimism regarding nuclear technology, GE was in an uncomfortable position by 1960 . It seemed to be promising practical, safe, economic nuclear powered electricity in just five years, without further government subsidy. Yet it had no evidence that this challenging and costly goal was actually within reach.

The third major embodiment of GE's 1950s brand of progress was electronics. This held both short range and long range promise. The short range was television. The years 1950-1955 marked TV's rocket-like ascent from luxury to necessity. GE, under its nationally respected electronics czar W.R.G. Baker, followed fast behind TV leader RCA. Baker shifted the GE focus from living room TVs encased in fancy furniture to smaller and more affordable sets movable throughout the house. This helped GE to be one of the dozen or so survivors of the 140 companies that entered television manufacturing after World War 2. GE increased its market share to 16% by the middle of the 1950s.Baker also championed the next innovation, color TV. In 1956 however, as part of the company's decentralization initiative, Baker, his health failing, was replaced by a numbers-focused professional manager. When RCA launched its major color TV initiative in 1956, GE's corporate strategists demurred. That color product , they concluded, was doomed to failure due to its high price, lack of prime time programming, and technical complexity. Initially, this judgment seemed confirmed. The color displayed on RCA's initial 1956 models was unconvincing. The sets frequently went out of adjustment. GE CEO Ralph Cordiner remarked that a purchaser of an RCA color TV needed also to hire a full time engineer. Time Magazine joined in, labeling color TV 1956's "flop of the year." [473]

That apparent flop turned out to be only a pause. RCA's color soon took off, leaving GE with what a manager of the GE television department described as an "uphill battle". As its market share fell due to its tardy entry into color, cutthroat competitive pricing on small black and white sets slashed profits, well before the Japanese came in to administer the coup de grace.[474]

Computers in 1950 stood where TVs had stood in 1930. They worked, but only for dozens of specialists, not for millions of customers. To operate a

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[473] **Fisher, David and Marshal. 1996 Tube; thr Invention of Television. Counterpoint. p. 328**

[474] **Walter A. Peterson Oral History. Sept 1979. HoH Collection. MiSci.**

1950 computer required thousands of fragile and frequently failing vacuum tubes, encased in a collection of cabinets that filled a room. It offered an tiny fraction of the computing power that today can be put on a fingernail sized chip. The computer's scientific uses were highly specialized, its business machine possibilities barely glimpsed, its general consumer use still science fiction. UNIVAC and IBM had been the first movers. GE was one of the first companies to apply a computer to everyday business use, putting a UNIVAC in its Louisville KY appliance plant. As one of the dozen or so U.S. companies with sufficient electronics expertise and available capital to manufacture these complex devices, GE timidly tested the waters.[475]

In 1950 the Schenectady Works built for the company's Aeronautics and Ordnance Systems Department the first GE digital computer. In 1952, Baker's Syracuse electronics department delivered a second to the Air Force. Baker then sent subordinate George Metcalf on the road to explore possible further computer sales to insurance companies. Metcalf immediately received summonses to appear at the offices of two CEOs. IBM's Thomas Watson told Metcalf to stop poaching on his territory. GE's Cordiner concurred. Apparently good relations with equipment customer IBM outweighed GE's slender computer sales prospects. Metcalf was then invited by GE corporate in 1954 to lead a study of electronics futures. The study enthusiastically recommended that GE launch a computer business immediately. The recommendation was rejected. A slight loophole, however, was left open. GE could pursue computation that helped it sell control systems to its industrial customers.[476]

Once again, as so often in GE's history, external events trumped corporate level strategizing. Anticipating a back room overload crisis in the handling of personal checks, the Bank of America sought automation. It hired the Stanford Research Institute, which invented an automatic magnetic method

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[475] **The origin of the GE computer business is described in Oldfield, Homer. 1996. King of the Seven Dwarfd. IEEE Computer Society. supplemented by Sniveley, George. 2007.Tall Tales from the Early Days of the Computer Business. Southwest Museum of Electronics and Computers. Sources for its subsequent history include "Computers: a Case History of Publicizing a New Company Business". Press Relations Seminar 18 Jan 1964. MiSci. Rader, Louis T. Vision for the Business. The Computer Business 1965. Frontiers of Progress. GE Computer Department 1961. and. Something to THINK About. Barron's Magazine. 8 July 1963.**

[476] **Metcalf, George. 1992. Making Waves in the Information Age. Binford and Mort.**

of reading and processing checks. In 1955, the bank sought a manufacturer for this "ERMA" (Electronic Recording Machine, Accounting) system. IBM could have had the contract. It sought, however, more control over the technology than Bank of America was willing to relinquish. This opened the door for lesser contenders, such as GE and RCA.

The GE internal entrepreneur was a relatively low level manager at the Syracuse electronics operation. Homer "Barney" Oldfield was an MIT trained aeronautical engineer. As a marketing manager, he had helped sell that first GE computer to the Air Force. While running a Microwave Lab in Baker's electronics empire, he heard about the ERMA opportunity and went after it.He used two arguments to sell the idea to the skeptical corporate office. One was the large size of the contract, $31 million. The other was that corporate loophole. ERMA was an industrial control system, Oldfield claimed, not a general purpose computer. This was a deception. The Oldfield-Baker intention all along was to enter the general computer business. GE's electronics division won the ERMA contract, executed it successfully, and gained extremely favorable publicity for GE. That, as well as the general market takeoff of the computer industry, brought the corporate office on board. By 1957, GE had created a Computer Department under Oldfield's management. At the department's Phoenix AZ location, a team led by computer engineer Arnold Spielberg (father of future movie director Stephen) developed and put into operation by 1960 the GE-225, GE's first commercial general purpose computer.

So in 1960, GE stood committed to three new industries that had not even existed in 1940: jet engines, nuclear power, and computers. Each industry seemed launched on an exponential growth trajectory. Each appeared likely to someday rival or surpass electrical manufacturing in annual sales. In none of them had GE entry been strategized by the corporate office. GE was pulled into jet engines and nuclear by the military, and pushed into computers by enthusiasm at its own lower levels.

By 1960, each was demanding massive investment in order to even glimpse significant profitability. On which of the three should GE push in more chips and bet its future? Meanwhile, there arose a business no one associated with GE. In a 1959 Time Magazine cover story on GE there was not a single mention of the company's new business that had already

reached profitability; the business of selling advanced materials to industry.[477]

GE 's need for electrical insulating materials had spawned a chemicals business by the 1920s. It was insignificant in the 1930s when GE's research lab got involved. That lab had been pretty quiet on the innovation front since the ca.1910 patents of Langmuir and Coolidge had protected the profitability of the light bulb business.Then, in the 1930s, Research Lab chemist Eugene Rochow invented a better way to make silicones, a then obscure family of materials in the new category called polymers. This, and subsequent wartime government support for work on high temperature electrical insulation for bombers and submarines, gave GE an entry against the dominant silicone maker, Dow Chemical. Quietly, that GE Silicones Business built up a series of niche products that propelled it slowly to 1957 profitability. This included waterproofed films, bathtub sealants, caulkings for window frames, and an expensive but high-performance type of rubber. In the 1960s, boots soled with GE silicone rubber trod on the moon. GE also, however, sold off for a song the rights to its most memorable silicone invention, silly putty.Silicones were a mere drop in GE's sales bucket. Their greater importance was to sell GE on the idea that there was money to be made from advanced materials. With this realization, more successes followed. [478]

In 1950 GE Research Lab scientists had also begun following up on the earlier discussed promising but unsuccessful wartime diamond making project of Harvard Nobel Laureate Percy Bridgman. Two recently hired chemists. Tracy Hall and Bob Wentdorf, and two recently hired physicists, Francis Bundy and Herb Strong, were put to work in a basement lab of the new GE Research Lab.

GE would later portray this ultimately successful four quest as a model of scientific teamwork. For most of the project's four years, that description was correct. The last month or so, however, produced a frenzied dash to the finish line . It turned out that one of the physicists, Herb Strong, had

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[477] **Time Magazine. 1959. Atomic Energy: the Powerhouse. 12 Jan 1959.**

[478] **The history of GE's entry into the silicones and polyer businesses has been told by two GE witness/ participants, Liebhafsky, Herman. 1978. Silicones under the Monogram. Wiley and Coe, Jerome. 2000. Unlikely Victory. American Institute of Chemical Engineers.**

developed the right chemistry for the process. One of the chemists, Tracy Hall had built the right apparatus for applying the needed high pressure. Each kept the details of his finding to himself in the race to be first over that finish line..

Those two partial solutions were brought together by accident. Strong accidentally and unwittingly contaminated his apparatus with a tiny seed diamond used in earlier research. Finding that tiny seed diamond when he examined the result of a test run, he incorrectly (but honestly) believed he had made diamond. This got everyone's attention, including Hall. He now saw the chemistry he should use in his better pressure vessel. Almost immediately he started making small diamond crystals in a process that was reproducible. Meanwhile. Strong could never reproduce his apparent success. Not wanting to air these details, GE management credited the success to a team effort. This led to Hall, his claims to being the inventor denied, to resign and accept a professorship. His request that GE let him use his own invention was denied, He proceeded to invent a second way to make diamond and set up his own business. There was material here for a TV drama-- and indeed Hall's story was later used as an object lesson in the curse of bigness in an episode of the TV series Breaking Bad.

In 1954 GE publicly introduced its process for making industrial diamond, completing a quest at which generations of scientists and engineers had failed for centuries. Unsurprisingly, the success provided a publicity bonanza. More surprisingly, it was rapidly commercialized and soon became profitable business.[479]

A less glamorous and more slowly exploited chemical success ultimately produced far more profit . In 1953 chemist Dan Fox, while experimenting with normally soft polymer type called polyester, accidentally and surprisingly made an exceptionally tough plastic. For some time, "Dan Fox's lollipop" was dismissed as a curiosity. When it was recognized as a potential product, GE learned that Fox had been barely beaten out for the key patent by a German chemist, The GE work was good enough, however, to secure a lucrative cross licensing agreement. The GE version, called

[479] **Hazen, Robert. 1999. The Diamond Makers. Cambridge contains the details of this story as well as other epusodes in a centuries long history of diamond making failure, error, fraud, intrigue, disappointment, and ultimately success (achieved independently and at about the same time as at GE by the Swedish company ASEA).**

Lexan®, got ultimately used on everything from bulletproof glass to compact video disks. It became GE's biggest materials money maker ever. More high performance plastics followed. By 1980, GE sales of advanced materials would be $3 billion a year, equal to GE's total sales in 1959. [480]

Riding the wave of that plastics success was a young Ph.D. chemical engineer working at GE'S Pittsfield MA works.. He had nearly quit GE in his first year there, 1960, when he heard that another new hire had gotten a bigger raise than he had. It took a late night session with his GE management mentor to convince Jack Welch to give GE another chance.

Within a decade, he would not only have moved from engineering to management, but would be widely recognized as the most successful young manager in the company. After leading two polymer innovations to profitable business success, he rose meteorically to the top spot of the plastic business, and soon far beyond.

To organize all those diverse business bets, GE had bet its future on a radical internal change. In 1946 Charlie Wilson had ordered GE to decentralize. He left it to his then assistant, and 1951 successor, Ralph Cordiner, to work out the details.

Cordiner had spent a short 1939- 1942 stint running the Schick Razor Company.That had been the immediate source of his GE nickname, Razor Ralph. But it was the perfect fit that made the name stick. The image of a compact, sharply honed blade, combining high performance and threat, fit the man. Many respected, but more feared, Ralph Cordiner.

He was born in 1900 on a 1200 acre wheat farm in the state of Washington. After graduating from Whittier College, he first sold washing machines, then, in 1923, joined GE. In the 1930s he became assistant to the GE Bridgeport Works top manufacturing man, Charlie Wilson. In that assistant role, except for that brief Schick stint, he followed Wilson to the top (then pulled the ladder up behind him by subsequently banning use of the title assistant in GE). He had contempt for what he saw as GE's disorganized corporate culture, which he described as a "sinecure for mediocrity". Though himself a PYM and Elfun he was not much attracted to the forced camaraderie of

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[480] **The Lexan[R] story is detailed detailed in Wise, George. 1985. Research and Results, on file at Special Collections, Union College Library, Schenectady NY.**

Association Island. In 1959 would give it, Sacred Elm and all, to the YMCA. He especially missed the existence of a GE organization chart, with its implied clear assignment of responsibility . He would tell how he was once appointed to a key consumer products management post, only to run into a colleague who, under a different title, had been assigned the identical set of responsibilities. As Wilson's assistant , Cordiner had planned how to change all this. From 1951 on, as Wilson's successor, he instituted the changes.

The full decentralization, unveiled in 1953, was in many ways the standard Chandler-style Multidivisional form (M-form). GE decentralization pushed day to day management down the hierarchy to the operating level. GE's many hundreds of products were parcelled out among some 100 Business Departments (initially 70, but gradually increasing, by the 1960s to as many as 170 before being cut back). The post of Business Department Manager, formerly nonexistent or insignificant, suddenly became the keystone of the new GE.[481]

That Department Manager now had responsibilities similar to those he would have had it he owned the business. He commanded all the needed specialties: manufacturing, engineering, marketing, finance, legal, and labor and community relations. He had his own factory in his own location. He could make capital expenditures of up to $500,000 without higher level approval. This post of Department Manager suddenly became the grail for ambitious young GE professionals. As one of them, Don Craig, put it: "What he [Cordiner] was talking about -- decentralization, one man responsibility, double your pay-- all this appealed to a young guy."[482]

To a large degree, the Cordiner's program delivered on its promise. Illustrating that success was GE's industrial controls business. It included everything from tiny switches in small factories to giant control panels for running a steel mill or opening and closing the lock gates of the Panama Canal. The control business' organization had mirrored GE's haphazard evolution. Responsibility was diffused, and often conflicting. One organization, under a Vice President of Engineering, designed controls. Another completely separate one under a Vice President of Sales, sold them. A third, under a Works Manager, manufactured them. The salesmen might

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[481] **Cordiner, Ralph. 1956 New Frontiers for Professional Managers. McGraw Hill.**

[482] **Interview with Donald Craig 31 July 1985. HoH**

promise something the engineers could not design, or the manufacturers could not make.By 1950, about as many people worked on controls at the Schenectady Works as made turbine generators. Hundreds of different controls were designed, sold and made. Some were unique designs, customized for for a single sale. All were produced in a manner nobody fully understood. They were shuttled, in various states of incompletion, from location to location among the many buildings of the Schenectady Works, followed by a train of complex, often lost or incomplete, paperwork. As a result of this chaos, GE controls, though well designed, in great demand from industry, and manufactured with good quality, consistently lost money.

Rather than trying to untangle the chaos, Cordiner decentralized it. One vaguely defined business became four sharply defined Business Departments at new GE locations: Appliance Controls at Morris IL, Industry Control at Roanoke VA, Specialty Control at Waynesboro VA, and General Purpose Control at Bloomington IL.By 1960, all of these departments, run by capable and enthusiastic young managers, were still making well designed, eagerly demanded, and good quality controls. They were also, however, all now making money. [483]

By 1956, Cordiner could review his decentralization program and declare it a success. GE was expected to grow in the 1950s more than twice as fast as as the U.S. GDP , which Cordiner expected to increase 40% in the decade 1956-1966.This fast growth GE would now be fully decentralized, with 21 divisions, each headed by a Vice President. Those VPs only lightly supervised the level where the real responsibility lay: the 100 product departments, each headed by a Department Manager.

GE was also high tech, with one out of every 13 of its 250, 000 U.S. employees a scientist or engineer. It would still be overwhelmingly a U.S. company, with only 29,000 overseas employees. Its 200,000 products would be distributed over the entire U.S. economy : 35% consumer, 20% utility, 20% industrial components& materials, 25% user products for industry, 20% defense. Its 138 plants in 107 U.S. cities in 28 states produced in 1956 sales of $3 billion and earnings of $200 million. Its payroll of $1.2 billion meant an average of $4800 per worker.

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[483] **The control ol story is told in W.W. Beardslee, HoH interview 15 Feb 1983.**

In Cordiner's view, the biggest challenges the company faced were not technological, or managerial, but government and labor related: "excessively high taxes"…"growing unchecked union power"…"a fantastically growing federal government" and "the latent suspicion of big business," a suspicion that provided "a tempting target for demagogues " That a challenge of similar proportions might lurk within GE management ranks was not among Cordiner's suspicions.[484]

Decentralization was widely regarded within GE as long overdue. The undercurrent of opposition that rose up against it was not due to the idea, but to how it was done. It was done by creating the cult of the professional manager.

Cordiner assigned the task of creating that cult to a scholarly MIT trained engineer named Harold Smiddy. Smiddy had served in management at several electric utility related companies, including GE 's former financial arm, Electric Bond and Share. Coming to GE in 1948, he briefly managed, with much effectiveness, GE's chemical and air conditioning businesses. In 1953, Cordiner called him to corporate headquarters as chief management consultant. There Smiddy turned Cordiner's vague vision into rigid doctrine.

To implant this new doctrine, GE Department Managers were , from 1956 on, sent back to school. They had to take a three month course at GE's new management institute, created by Smiddy at Crotonville NY .The initial Crotonville course featured lectures not only by by Cordiner and Smiddy, but also by such management experts as Dr. Lillian Gilbreth, Peter Drucker, and Gerard Swope. For homework, each Crotonville attendee received a five volume set of GE "Blue Books", written by Smiddy. They were heavy going. Merely defining the word "manager" required plodding through a swamp of platitudes. A professional manager managed "by blending thought and action...through planning organizing, integrating and measuring...in the balanced use of human and material resources...with due understanding of the skills and knowledge required to manage...with best pace, synchronized flow, timing and turnover", and so on through many tiresome pages. [485]

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[484] **Cordiner, Ralph. 1956 New Frontiers for Professional Managers. McGraw Hill, especially pp. 21, 24, 37, 41 61, 117**

[485] **Zimet, Melvin and Greenwood, Ronald G. 1979. The Evolving Science of Management. American Management Assn. P.188-190,**

Fortunately, an astute student could sum it all up in a few short sentences. One was: "Manage by Objectives". This edict is often credited to Crotonville lecturer Peter Drucker. He was born in Austria and came in the U.S. in the 1940s. He gained a plum assignment as an embedded researcher at the corporate headquarters of General Motors. The result, though rejected by GM, provided the basis for his best selling book The Concept of the Corporation. Cordiner and Smiddy hired him as their chief consultant. This in turn led to his long reign as top U.S business guru. He was still going strong in the 1980s, advising, among others, GE's Jack Welch. Back in the 1950s Drucker and Smiddy were such close collaborators that Management by Objectives might be attributed to both.

That concept is simple to the point of obviousness. Provide managers with a clear set of objectives that are measurable. Evaluate managers' performance by the measurements they record. The management objectives set by GE in the 1950s were 1. Profitability 2. Market position 3. Productivity 4. Product leadership 5. Personnel development 6. Employee attitudes 7. Public Responsibility 8. Balance between short range and long range goals. GE provided this numerical order without explicitly labeling it a priority order. Almost certainly, however, it was one. Professor Ronald Greenwood, a Smiddy acolyte who wrote the leading book on GE decentralization, took great pains and eight pages to deny that profitability was the only thing that mattered. He further explained that profitability was much too complicated a concept to measure by such primitive ratios as profits as a percentage of sales, or profits as a percentage of investment. [486]

In actuality, a GE manager's, life was much simpler. He had one main objective that far overpowered the others. This was gaining membership in the "Seven Twenty Club". The seven was the required percentage of profits to sales. The twenty was the required percentage of profits to investment.[487]

By contrast to that #1 objective profitability, Greenwood dispensed with #7 objective, the "Public Responsibility" in a single page. The GE Blue Book was even more concise. Public Responsibility was "simply...The obligation of the corporation to act as a good citizen within society. " Greenwood noted

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[486] **Greenwood, Ronald G. 1974. Managerial Decentralization. D.C. Heath. P. 61Pp. 61-68**

[487] **Olaf Vea Oral History 24 Oct 1978 HoH. Rothschild, William. 2007. The Secret of GE's Success. McGraw Hill. P.87.**

only one numerical measurement of Public Responsibility: the 16 antitrust cases brought against GE from 1940 to 1960. The last of these, he notes, "gave American business as a whole its worst public relations of the century, perhaps of any century."(More on that case will follow).

The second key element of the Cordiner-Smiddy dogma was that a professional manager could manage anything."When we become students of these principles and these disciplines of Professional Managing, " Cordiner told the first graduating class at Crotonville " it will be entirely possible to change people in diverse areas without in any sense of losing the temper of the operation at any point." This was reduced by Crotonville graduates to more succinct phrasing: a Professional manager could run anything from a pickle factory to a research laboratory.[488]

Reality proved unkind to this assertion. In such businesses as computers and nuclear power, putting management responsibility in the hands of professional managers lacking knowledge of the business and its key technologies proved a mistake. By contrast, success was more often achieved by keeping experts in the business and its key technologies in top management slots.

For example, George Metcalf was among the older of the new Department Managers. He had joined GE back in 1928 after graduating as an engineer from Purdue. He has been mentioned as an early GE champion of computers. Under decentralization he achieved a notable string of management successes. He was one of the four department managers leading a decentralizated control businesses . His was perhaps the most difficult one , the miscellaneous category left over after the more identifiable areas had been assigned, but he led it to profitability. After that, he managed the highly successful and nationally crucial Re-Entry Vehicle Department.

In attributing credit for his management methods , he was tepid in his approval of the Cordiner -Smiddy management gospel. For example, though a Crotonville graduate, the portion of it he dwells on in his memoir is not the

[488] **Cordiner, Ralph. 1956. The Challenge to General Electric. 3 Jan 1956 . Address to Advanced Management Course. Crotonville NY.**

classroom or lecture hall. Instead, it is the students' nightly poker games. These, he said, enabled each aspiring executive to assess the judgment of the people they would soon be competing against for those choice management positions. More generally, Metcalf gave more credit to management mentors from an older generation, such as W.R.G. Baker and Aerospace Division Manager Jim LaPierre. They kept to the spirit more than the letter of decentralization, allowing Metcalf considerable independence. In doing so he drew more on his accumulated experiences in electronics and aerospace than on the gospel of professional management.[489]

A second major management success was Charlie Reed. After getting his Ph.D. in chemical engineering from MIT at 24, Reed spent five years on the faculty, then moved on in 1942 to the GE Research Lab. The Chemical Department quickly commandeered his skills to turn that Rochow silicone invention into a production process . Managing construction of GE's first silicone plant, Reed boldly doubled plant size to reduce future costs. This appeared at first an overreach. Then, however, under early decentralization in 1952, Reed was made Manager of a new Silcones Department. There he focused successfully on finding those earlier mentioned silicone market niches. He stuck with it for five years, bringing the business into the black in 1957. It proved the model for future Reed-managed GE Chemical Business successes. He was no rebel, conforming sufficiently to ascend to a Vice Presidency. He did not, however, embrace the professional management cult, with its narrow focus on this year's numbers. . As he put it, "don't let the bean counters set your strategy. " Nor did he believe in the mythical professional manager who could manage anything. He stuck to areas where his chemical engineering training paid off, seeking the technological edge.[490]

Successful managers in the 1950s did not have to be young, or brought up in new businesses. Glenn Warren was the heir to leadership in the steam turbine business, succeeding, W.L.R. Emmet and Oscar Junggren. Warren was born in Missouri in 1899, the son of the editor of a small-town socialist

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[489] **Metcalf, George. 1992. Making Waves in the Information Age. Binford and Mort.pp. 83-85**

[490] **Reed's story is taken largely from Interview with C.E. Reed, 11 July 1986. Center for the History of Chemistry. Philadelphia PA. And Banholzer, William. 2010. "Charles E. Reed" in National Academy of Engineering Memorial Tributes Vo. 13. pp 205-209.**

newspaper. "I never became a socialist myself," he later wrote. Instead he tried to incorporate " the best socialist ideas" into the "capitalistic system." The included public works projects at times of high unemployment and social security for all citizens. As an engineering student at the University of Wisconsin in 1915-1919 he thought he could invent a gas turbine which would be superior to the then existing steam turbine. He could not. The talents honed by trying, however, earned him get a job in 1919 with the GE Steam Turbine Department. His success as a design engineer led Schenectady Works Manager Charles Evelth to appoint him as a "coach" of the turbine department, the sort of undefined Steinmetz-like "Supreme Court" role that decentralization would eliminate. Holding that role under various job titles from 1922 to 1947 prepared him to become in the 1950s the Turbine Division's top manager. [491]

He recognized the merits of the Cordiner program, writing

> I have had a growing enthusiasm for, and now complete acceptance of our basic concepts and establishment of decentralization.

He had, however, reservations about the specific details.

> Particularly in the areas of marketing and engineering...we might suffer some disadvatages.

The main disadvantages involved the abolition of division staff. These veteran engineers embodied the collective wisdom of the turbine generator business, as Warren himself had done on his way from designer to "coach" to top manager. The department manager could not be expected "to assemble all the expertise he needs", said Warren. Nor could he expect to get the needed turbine-generator related wisdom from the generalist corporate staff. The current decentralization edicts about staff, Warren wrote, subjected new turbine generator department managers to "the old theory that the best way to teach a young person to swim is to throw him into water over his head. " Warren's Manager refused to pass this memo on to Cordiner. Revisiting the memo eight years later, Warren concluded that his concerns had been

[491] **Glen Warren. 1945/ Some Thoughts of an Engineer. 95.78.3; Glen Warren to Clarence Linder. 12 Oct 1955.Glen Warren Papers, MiSci.**

"borne out." The absence of division staff had weakened the technological capabilities of that core GE business. [492]

Lou Rader had joined GE on 1938 with a Ph.D. in electrical engineering from Caltech. He alternated management positions at GE with jobs in academia and other companies. Denied the manager job in the new GE Computer Department in favor of a non-technical professional manager, Rader had taken the top spot at the UNIVAC Division of Sperry Rand. There he did so well that in 1964 GE hired him back as Vice President of its Industrial Electronics Division, overseeing the GE Computer effort.There he gained the confidence of the technical team, and led some of the most successful thrusts of that troubled business, including the early time sharing triumphs, and the ultimately successful development of the GE 600. While doing this Rader found his efforts complicated by his GE superior. Corporate VP Hershner Cross, a man without knowledge of computer business or technology. Cross ordered frequent reorganizations, and overruled Rader by filling key Computer Department positions with people without computer knowledge. Cross's management style was, wrote Homer Oldfield in his GE Computer history, " a stunning demonstration of the GE philosophy at the time that a professional manager with Crotonville credentials could manage anything. " Eventually Rader was moved over to run GE Information Systems, a rare GE Computer success. It would be a marketing expert and believer in the Cordiner professional management creed who would preside over the Computer Depatment's demise. Rader would return to academia, becoming one of the nation's leading authorities at the intersection of technology, education and social change.[493]

GE Aircraft Engines' best manager also defied the bean counters and management science dogma. Even before he arrived at GE, Gerhard Neumann's life story was remarkable. He grew up a Jew in Nazi Germany. He apprenticed at 16 as a motor mechanic, then graduated from technical school.

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[492] **Warren, G.B. Statement with Respect to Division Organization. 12/31/1953. Glen Warren Papers, MiSciWarren, Glen to Prof. Frank Bradshaw. 14 Nov 1961, Warren Papers, MiSci**

[493] **Oldfield, Homer. 1996. King of the Seven Dwarves. IEEE. Pp.168-16, 209-211.**

With war just five months away, in April, 1939, he took a job maintaining aircraft engines in China. There, though officially an an enemy alien, he would provide such valuable service to the Allied side that he was made an American citizen by special Act of Congress . After the war, he drove a jeep from Vietnam to Iran. Soon afterward, he mailed in a job application to a company with which he was barely familiar, called General Electric.[494]

Sent to GE's Lynn MA works, he quickly proved his worth by leading a challenging effort to install a facility for testing jet engine compressors. In 1950, when airflow problems hampered the efficiency of a GE turbojet, he devised a fix called the variable stator. It was a mechanical means of adjusting the angle of previously stationary blades at the engine's input. This solved the problem, won him a major aviation award, and sent him on a rapid rise up the management ladder. In discussing his leadership on the experimental engine applying that variable stator concept, he described management somewhat differently than did the Cordiner-Smiddy Blue Books. "During the assembly of the 12,000 parts that make up a jet engine," he wrote, "all of us were one team: workers, managers, foremen, and engineers, The designers had as many black fingernails and bruised knuckles as the union workers standing next to them. "[495]

When made manager of the Jet Engine Department in 1955, he took pride in the fact that he had risen, he said, "without the of Crotonville rules of management education. " When named the Manager of the GE Flight Propulsion Division in 1961, one of his first actions was, in his words, to "recentralize the division counter to GE's publicly declared philosophy at the time" .As part of that recentralization, he would gather employees, a thousand or more at a time, under a rented circus tent for "Herman the German's camp meetings ." Despite his unique background and accent, his frankness and spontaneity ensured he was understood. Indeed, he turned his uniqueness to advantage, encouraging semi-mythical tales.[496]

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[494] **Neumann's story is in Neumann, Gerhard. 1974. Herman the German. Morrow. and Neumann, Gerhard. A Personal History. Recorded 1975. HoH Collection. MiSci.**

[495] **Neumannn, Gerhard. 1974. Herman the German. Morrow. P.214.**

[496] **Neumann, Gerhard. A Personal History. Recorded 1975. HoH Collection. MiSci.Neumann, Gerhard. 1974. Herman the German. Morrow. p.229**

In one such story he was called on by a corporate boss to use his native tongue to deliver a sales pitch to a German customer. The customer came to the GE boss afterward and complained that he had not understood a word. "Neumann," the boss barked. " I knew you couldn't speak English. I didn't know you couldn't speak German either!“

That appealing Neumann legend was not, however, the whole story. Brian Rowe, an admirer, and a successor as manager of GE Aircraft Engines, later provided some balance.

> Although Gerhard had a great innate sense for leading and motivating people, he never built any close relationships with members of his leadership team. Surprisingly, the ones he seemed not to get along with were the ones who seemed to perform best for him...[he was] a militaristic leader, but he had an amazing personality that enticed people to work for him even if they did not appreciate his style... He had a sign on his office wall reading "feel insecure" ..He had a bit of the old up-from-the-ranks bull-of-the-woods foreman-to-manager style. Sometimes he pitted members of his staff against each other.[497]

As Neumann took command in 1960, GE Aircraft Engines was a long way from competing strongly in the important airline engine market. He was however, the right man to finish that crucial job.

As those examples suggest, some of GE's best managers of the 1960s stuck to the fields they knew best, rejected the Crotonville good-manager-can-manage-anything eclecticism, and defied the bean counters. They placed personal leadership and solid growth ahead of meeting the numbers at all costs.

Also resisting the Cordiner cult was the Schenectady Works. It had reached its all time highest employment of 45,000 in 1945. After a post-war reduction, the Korean war had brought that number back up to 40,000.[498]It

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[497] **Rowe, Brian H. The Power to Fly. Pen and Sword. 2005. Pp. 86-87**

[498] **The 45,000 figure was given by Works Manager J.M.Howell. Works News. 29 June 1945. P. 1.**

operated on three shifts, turning out perhaps the most diverse set of products as any single location in the world. As the control business story indicated, however, Cordiner's decentralization aimed to move many of those businesses out .Those moves ranged from sending the Research Laboratory five miles down the Mohawk River to moving the civilian nuclear power business across the country to California.

A prime destination for these moves was, increasingly, the Southeastern U.S. Some 60 new GE plant locations were added from 1946- 1956. In 1946-1951 one-sixth of these new plants were in Southern or border states. Between 1952 and 1955, that fraction rose to more than one half. "We looked at the Middle South and found the economic climate right for the operation of a General Electric plant, " said Cordiner.[499]

A big part of that right climate was local anti-union sentiment. The CIO's post-war effort to organize unions at the new southern plants, which lasted from 1946 to 1953, was largely a failure. GE did provide a few exceptions. The large GE Appliance Park in Louisville KY and the transformer plant in Rome GA were both unionized. Most GE southern plants, however, began and stayed non-union. By 1960 GE had some 35 non union plants. In the 1960s this would double.[500]

The older fully unionized plants became prime targets for Cordiner decentralization. He expressed an intent to shrink GE employment in Schenectady from 40,000 to 25,000 or less. He put this tactfully to the Schenectady Chamber of Commerce in 1953, calling the Schenectady Works the "seedbed for future products and industry." That was a nice way of saying that as the seeds sprouted, they would be transplanted, grown and harvested elsewhere . Blue collar jobs would follow those transplants. Left in Schenectady would be, increasingly, white collar employees such as researchers, engineers, salesmen and systems specialists.[501]

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[499] **1959 GE Annual Report. Cordiner quote is in Fones-Wolf, Elizabeth and Ken. 2011. Religion, Human Relatons and Union Avoidance. Enterprise and Society. 13. 154-185. p. 162**

[500] **Kochan, Thomas. 1986. The Transformation of American Industrial Relations. Basic Books. P. 46Fones-Wolf, Elizabeth and Ken. 2011. Religion, Human Relations and Union Avoidance. Enterprise and Society.13.154-185.**

[501] **Cordiner, Ralph. 1953. Speech to Schenectady Chamber of Commerce 6 Oct 1953.**

GE's white collar labor relations policies were featured in a 1950s best seller, William H. Whyte's The Organization Man. GE's corps of recruiters, Whyte explained, delivers 1000- 1500 college graduatess, mostly engineers, to the company's Schenectady headquarters. "The most noteworthy feature of the General Electric approach", Whyte wrote ," is the emphasis on the professional manager." New white collar hires are taught "how our business system operates", "effective presentation," and " How to get people to do what you want them to do. " White concluded regarding the aspiring manager that "to get ahead he must cooperate with the others, but he must cooperate better than they do."[502]

As new white collar hires arrived in Schenectady, businesses departed. A.C. Stevens, now manager of the GE Schenectday Relations Department, detailed the long history of business departures from the Schenectady Works: wiring supplies, switchboard and electric locomotives in the 1920s, radio receivers in the 1930s, electronics, refrigerators, and aeronautics and ordnance in the 1940s.[503]

One obvious reason for shrinking Schenectady was the strong union presence. Was, in fact Schenectady a hotbed of anti-company sentiment? How did Schenectady Workers balance union loyalty and company loyalty? Did they maintain union solidarity forever? Did they pragmatically adapt? Or were they Boulwarized into obedience?

Lacking data-based answers, a tentative and imperfect experiment had been tried. The legacy voice of those 1940s and 1950s workers does appear in at least one place that was not stage managed by either union or company. That is in the information their families supplied for their obituaries.The question asked concerned the listing of organizations to which the deceased belonged. These ranged from St. Adalbert's Church to the Pop Warner Football Program to the Order of Odd Fellows to the Polish National Alliance. In this list, did the families list more often union membership, or membership in the GE Quarter Century Club?

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[502] **The Organization Man. 1956 (2002 edition). William H. Whyte. Simon & Schuster (U. PA.) P. 120-125.**

[503] **Works News 25 June 1954, p. 1; 9 July 1954 p. 11.**

The sample picked was obituaries of former GE workers appearing in the Schenectady Gazette in May of 1960, 1970 and 1980. In this collection of 47 obituaries, the GE Quarter Century Club appeared 16 times. A reference of any kind to any union appeared only once.That one appearance was in the obituary of an important IUE union member, its one time Vice-President Bill Hodges. It read " one of the founders of the defunct GE Workers Council, now Local 301, he was a member of the GE QCC..”

In summary, this small exploratory study suggests that any idea that GE workers were radicals, or hostile to the company is at best unsupported by evidence. A more plausible view would look for more a more mixed story. Radicalism occurred in short and only occasional bursts, not as a mainstream attitude.

What did become mainstream for workers’s families was upward social mobility. This was illustrated by the families this book has followed. Most had, in the 1920s and 1930s, six or or more extended family members employed at the GE Schenectady Works. By the 1950s, this had gone down to one or two family members. Examples in the 1950s were Adella Clune, a computer operator for the GE Telecommunications Operation. Joseph Gabriele and Jacob J. Nigirny, sons of semiskilled workers but themselves apprentice program graduates; Vincent Sarnaki, a planner in the Apparatus Department; Joe Mangino, bargaining agent of IUE Local 301; Esther Schwenker, like Kurt Vonnegut a GE technical writer at the Works; and Elbert J. Weller who had carried the family tradition of skilled apprenticeship into a third generation and worked in the GE General Engineering Lab.

Many of those just listed were the last of their family to work for GE. The fading out of these families from the GE roster was not, however, a case of the families themselves fading away. Instead, the younger generation was moving on beyond GE. Some moved into such professions as journalist, or physician. Some launched independent local busineses. The names of the families would appear in the decades ahead on such New York Capital Region businesses as a car dealership, a restaurant, a grocery store, and an electrical supply company. Meanwhile others would move on to similar

carrers as professionals or small business owners in other parts of the country. [504]

In this climate of upward mobility that mixed company loyalty with union organization, at least one GE business was too deeply anchored at Schenectady to move out. That was the turbine generator business. Cordiner viewed it as exhibiting all the evils of the pre-war GE, such as centralization, disorganization and complacency. In his negative verdict of its performance, however, he was not supported by the experts. GE had hired a consulting firm to compare Schenectady to GE's newer single-product factories. The 1952 study of the Schenectady Works' turbine generator business found it "as efficient as any other General Electric plant" in spite of its " lack of system" and "slightly peculiar" style of operation. The consultants did complain, however that " top management, is just too proud of the fact that some employees feel free to chat informally. " [505]

GE's steam turbine generator business did have a problem. It was a technological constraint. Since GE had entered the business at the turn of the 20th century, it had played a leading role in raising turbine efficiency. That efficiency had tripled, from 10% or less in 1900 to just over 30% in 1950.

This had been achieved by steadily increasing the temperature and pressure of the steam. In the process many dislocations of scale were overcome. It was becoming apparent, however, that the conditions of operation of 1950, just over 1000° F temperature and 2400 pounds per square inch pressure were about as high as these numbers would ever get. Nor would increasing the output of a single unit to above one Gigawatt (1000 Megawatts) achieve further cost reductions by economy of scale. "We began to reach diminishing returns, " said engineering manager Charlie Elston. "The cost the boiler and piping overwhelmed the economics. "[506]

So it was not lack of professional management, but technological limits, that limited Steam Turbine improvement. Still, Cordiner interpreted the stasis as Schenectady's resistance to decentralization. Schenectady 's managers had

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[504] **The family stories have been pieced together from the Schenectady County Historical Society Family Files, Schenectady Occupational Directories, U.S. Census records, and the GE Works News.**

[505] **Richardson, Beltous and Henry Co. Inc. 1953. "Field Studies of Employee Relations Atmosphere in Six Plants " .MiSci**

[506] **Charles Elston. Interview 19 July 1984. YoU Collection. MiSci.**

not been converted to Cordiner's views. As A.C. Stevens, the last Schenectady Works Manager, put it tactfully, "the Schenectady Works probably had the greatest difficulty of any works in the company to adapt itself to the changing philosophy that Mr. Cordiner brought to the company." Stevens' predecessor Louis Male-- a former blacksmith, 1911 Socialist, and piecework rate setter-- had been less tactful. There was nothing wrong with decentralization, Male said, that a good Depression wouldn't fix.[507]

In another business remaining at the Schenectady Works, technical leaders also had reservations. Philip Alger, was nicknamed "Mr. Induction Motor" for his leadership in that technical area. He was also a political activist who had given Schenectady its city manager form of government. He believed that just as city governments needed to access expert advice, GE's varied electric motor businesses needed to share common technical principles, as they had done since the days of Steinmetz. His efforts to do this in defiance of the decentralization edict against committees earned the following tribute from his induction motor colleagues.

> With a fine disregard for the rules of organization as expounded at the time but with a fervent wish to accomplish things needed to be done, he preserved the distinctive features of the technical coordinating committee on AC machine development[508]

Despite such localized resistance, at corporate headquarters GE's decade 1950- 1960 seemed to be ending on a high note. For example, although Lemuel Boulware had retired by 1960, his policy scored in that year its greatest ever victory.In negotiations for a new contract in 1960, GE put forth an attractive offer. It included a new Savings and Security program supplementing existing pensions. IUE President Philip Carey sought more. He was quoted as saying that he "owed GE a strike." (He would claim misquotation).

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[507] **Interview with A.C. Stevens. 26 Feb 1975 HoH. MiSci, who quoted the Male remark.**

[508] **Philip Alger File, HoH Oral History Collection. MiSci**

In a vote on strike authorization in September, 1960, Schenectady local 301 overwhelmingly voted no. Leo Jandreau and local president John Shambo took this result to the national union's meeting in New York City. There they were outvoted by the other locals. Taking the national verdict home, Jandreau and Shambo put aside their local opposition to the strike in favor of national solidarity. They convinced IUE 301 to go along. In December, 1960, Schenectady and the rest of GE's union locations went on strike.

The strike ended quickly. Faced with opposition both within and outside the local, after a week Jandreau called the strike at Schenectady off. A nationwide collapse soon followed. From his role as consultant, Boulware could watch his approach vindicated as GE's single and unchanged offer was accepted.

So Ralph Cordiner could point by 1960 to success of both his key policies, Boulwarism and decentralization. In 1959, Cordiner appeared on the cover of Time Magazine, alongside the now familiar symbol of the atom. The story praised GE's leadership in nuclear power and jet engines. It described Cordiner as "a power packed man with restless eyes that are always fixed on the future." Cordiner was judged to have already delivered on the progress that GE had proclaimed five years earlier to be its most important product.[509]

The public face of that progress slogan was Ronald Reagan. He had joined GE in 1952 to host the televised GE Theater. He led it to Sunday evening ratings success. He soon added the second role of Boulwarist-style job salesman. He carried in person the company message to GE locations nationwide.

Did that experience convert him from a New Deal Democrat and union president (of the Screen Actors Guild) to a union busting, big government bashing, Republican? One book credits the direct influence of Boulware and Cordiner. Other interpretations credit the influence of his second marriage, or the big bite taken out of his then $150,000 GE salary by big government income taxes, or to Reagan's dislike of flying, leaving him plenty of time on transcontinental train trips to read economics books and think things out for himself.

[509] **Time Magazine. 1959. Atomic Energy: the Powerhouse. 12 Jan 1959.**

Boulware and Cordiner certainly were both, by the 1960s, conservative Republicans. In 1964, Cordiner would be Finance Chairman for the Presidential campaign of Barry Goldwater. For that cause, Ronald Reagan would give a speech, in a style honed before those hundreds of GE audiences, that marked his transformation from fading movie actor to rising conservative icon. There is little solid evidence, however, that Boulware and Cordiner specifically groomed Reagan for that new political role. Boulware retired in the 1950s. Reagan had little contact with Cordiner. The one notable occasion they met in person was after Reagan inserted in his GE speeches criticism of the Tennessee Valley Authority. Cordiner called in Reagan and got him to remove criticism of that major GE customer from future remarks. In 1962, when the western drama Bonanza beat out GE Theater in the Sunday night TV ratings, GE let Reagan go in a not altogether friendly manner.[510]

In 1960 GE basked in favorable publicity from Cordiner's Time-cover celebrity. This was matched by the reality of the company's first major nuclear plant and first general purpose computer. Even GE's Appliances shared in the excitement, co-starring in the 1959 Moscow "kitchen debate" between Richard Nixon and Nikita Khruschev. [511]

Actually all was not so well. Quietly at first, and then loudly, a long buried secret was surfacing. The secret's essence would later be captured in the 1961 congressional testimony of GE's sixth president, Robert Paxton. He described to Senator Estes Kefauver a 1948 conversation he had with Bill Ginn, a fast-rising GE subordinate..

> MR PAXTON: I had a question from one of my sales managers present who asked if I really meant that they were to have no dealings with competitors... I believe the question came from Mr. Ginn, and he expressed it in a way that I believe I will always remember

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[510] **Evans, Thomas W. 2006.The Education of Ronald Reagan. Columbia U. makes the strongest claim of GE influence on Reagan's politics. Cannon, Lou. 1982. Reagan. G.M. Putnam Sons. Pp. 91-97 and Diggins, John Patrick. 2007. Ronald Reagan. Norton. p. 86 are more typical assessments that put far less emphasis on direct Boulware or Cordiner influence.**

[511] **Safire, William. 2009. The Cold War's Hot Kitchen. New York Times.23 July 2009.**

He said: " I didn't see you wink. "[512]

The wink, Paxton explained was part of what he called a "code of communication." It meant that you were free to ignore GE Policy 20.5, forbidding meeting with competitors to fix prices.

In 1935, Paxton, as a young engineer, had been the recipient of such a wink. In 1948, he surprised Ginn by not winking. Ginn had been regularly winked at by Paxton's predecessor. Paxton was now trying to stamp out a practice he knew to be well established. He did not succeed.

Ginn went on in 1954 to become General Manager of the Turbine Department. In that post, he tried in his turn to convey a newfound allegiance to the company's anti trust policy to his subordinates. He presented the policy in earnest, without a wink. But, as he later conceded, " I didn't sell the thing to the boys well enough, because several of them still went off the reservation, even after my instructions. "

The secret behind the wink emerged in 1959. The Tennessee Valley Authority complained to the Justice Department that it was getting identical bids from different companies on transformers and other equipment. Cordiner had just finished telling a Congressional Committee that GE strictly adhered to the antitrust laws. He assigned both an internal counsel, Gerard Swope, Jr., and an external law firm, to investigate the situation. Were GE employees meeting with competitors to fix prices? The two investigations reported no wrongdoing.

They were mistaken. Actually, GE marketers had indeed been meeting in secret with their counterparts from Westinghouse and other competitors to fix prices. Elaborate codes were used. The goal was to provide each conspirator with prices for bidding on utility contracts. Adherence to those price instructions would parcel out orders among the conspirators. Price fixing was not continuous. It occurred in episodes, punctuated by periods of legitimate competition or even "white sales" -- episodes of viciously competitive price cutting that assured that nobody made any money. Even

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[512] **P.17218 Administered Prices. Hearings of the Subcommittee on Antitrust and Monopoly of the Committee of Judiciary of the U.S.Senate. Hearing no. 27 Price Fixing and Bid Rigging in the Electrical Manufacturing Industry. 1961. U.S.GPO**

when the conspiracy was operating, misreading the codes could lead to mistakes. In all, the effort was as much a comedy of errors as a skillful conspiracy. It was, however, unquestionably a willful and criminal violation of the Sherman Anti Trust Act.

In September, 1959, a Grand Jury convened in Philadelphia. A manager of a small company that made electrical insulators was the first to admit that he had participated in a price fixing cartel. With that confession, the floodgates opened. By November, 1959, one GE Vice President had confessed to price fixing and accused a second. GE was now an alleged participant in four cartels, ranging from switches to steam turbines.By February, 1960, multiple grand juries had indicted 40 companies and 18 individuals for conspiring to fix the prices on 17 products. Whole companies, such as I-T-E Circuit Breakers and Allis Chalmers had chosen to cooperate with the government. GE's corporate not guilty plea was, in the words of a careful student of the story " trampled to death under a parade of grand jury witnesses." GE ultimately pled guilty to the major charges against it Its fine of $475,000 was the largest of any of the 29 companies convicted. Three GE executives, including Bill Ginn, went to jail for 30 days each. The utility customers then sued GE for about a billion dollars. Charlie Wilson came out of retirement to argue that down to the lower hundreds of millions.[513]

Robert Paxton, who had become GE's President in 1958, took leave on grounds of health and never returned. Another Executive Committee member, Arthur Vinson, had been indicted for participation in the conspiracy, but the charges were dropped. Prosecutors had considered also indicting Cordiner, but decided against it. He would retain his CEO role until his 1963 retirement.

The details of this "great price fixing conspiracy" fill several books and thousands of pages of courtroom and congressional testimony. Here concern focuses on just a few main issues. First, how long had price fixing been going on? Price fixing in the electrical manufacturing industry had preceded both the passage of the Sherman Anti Trust Act in 1890 and the creation of General Electric in 1892. Secret market sharing agreements between electric

[513] **Smith, Richard Austin. 1973. Corporations in Crisis. Doubleday. P. 131.**

railway equipment companies Thomson Houston and Edison GE were just the sort of cartels that the Sherman Act had made illegal.

GE had, as mentioned, been created to stabilize competition. Over the company's first generation various means, some of uncertain legality, were explored. These included the GE-Westinghouse Board of Patent Control, Electric Bond and Share, and the secret 1900- 1911 light bulb cartel.

Those other tactics had been discontinued by 1925, either due to Federal prosecution or anticipation of it. Not so for price fixing. In a legal deposition, the President of th I-T-E Circuit Breaker Company testified that at least since the 1930s

> General Electric and Westinghouse, and frequently Allis Chalmers have acted uniformly and cooperated with each other to the disadvantage of their smaller customers on innumerable occasions over many years.

Price Fixing, he said, was not "a few sharp isolated events" but

> a mosaic of incidents stretching in time throughout virtually the entire history of the electrical manufacturing industry and across many product lines.

He went on to detail examples he was familiar with dating back to the 1920s, as well as evidence from his company's corporate records showing how GE's used the Board of Patent Control to eliminate competition back in 1905-1909. [514]

Only a few hints of price fixing appear in surviving GE papers. In June 1929, for example, Swope was told that the purchasing manager of Ford complained of getting six identical bids from electric motor manufacturers. Asking, "if that did not indicate a combine" the Ford man said that his boss Henry Ford was "highly displeased." Swope himself then met with the Ford purchasing manager and, apparently, smoothed out matters. Other instances

[514] **Pp. 2-3, 9-36. Testimony of W.M. Scott, President of I-T-E Circuit Breaker Company In the United States District Court for the Eastern District of Pennsylvania Civil Action No. 29379. 1959. MiSci.**

were in the public record. For example, in 1937, GE and Westinghouse accepted a consent decree to stop fixing prices on turbine generators.[515]

Why did well paid, generally successful, not previously criminally inclined, employees feel the need to break the law? Their explanations boiled down to the belief that the conditions of their industry made it necessary. Those condition were the feast-or -famine nature of demand, the high capital requirements, and manufacturing overcapacity.That feast-or--famine nature of demand made it difficult to maintain a stable labor force, one sufficient to meet the feast of orders and also keep workers profitably occupied during the famine . Unlike light bulbs, such machines as turbine generators were tailored to a particular customers' demands. They could not, the price-fixers argued, be produced at a constant level and stockpiled until needed.

The high capital requirements sometimes drove the weaker companies to operate at a loss rather than passing up orders in difficult times. The resulting income was needed to pay fixed costs and avoid bankruptcy. This led to severe price cutting in tough times. The overcapacity that especially developed after 1945 meant increased frequency of those price-cutting white sales during which nobody made money.

One way to solve these problems, was to break the law. There were, however, alternatives. One had been presented in 1947 by veteran GE turbine generator engineer and manager A. R. Smith. He noted that the turbine generator business at Schenectady was about to move into a brand new building. Covering an area of 16 football fields, Building 273 would be the largest such manufacturing area in the world. It would be for the Schenectady Works the ultimate and last "big shop". It would quadruple steam turbine generator manufacturing capacity from 3 GW to 12 GW. That move offered Turbine-Generator, said Smith, a chance to shake off the "barnacles of tradition." Regarding orders, he said,

> We have always had a feast or famine. When we had a feast we were too busy to do these things. When we had a famine we were too poor.

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[515] **W.D.Cameron to Swope. 5 June 1929. Swope Papers. MiSci. Temporary National Economic Commission. 1939. Investigation of Cncentration of Economic Power. US GPO. Pp. 1736-1737. Federal Trade Commission Annual Report, 1937. P. 59. New York Times 5 April, 1937, p. 29**

"Times are now different, " he argued. Contrary to past practice, it should now be possible to level out the entire business system. Innovations could be systematically incorporated, rather than being added in an ad hoc manner that made every design unique. Those designs could be standardized around a few basic models. In downturns, production could continue, avoiding the layoff of skilled workers. Those machines not immediately ordered could be put in stock. In an experiment with such stock machines, Smith noted that " we have always disposed of them to advantage. "[516]

Though the new building was built and occupied, no such systematic procedure was installed in it. To have done so, patience was required. The Cordiner ethic centered on annual profit measurements did not encourage such patience. It was easier to stick to business as usual, and then do whatever else it took, to stay in business.If that whatever else was violating the letter of the law, so be it. A repeated refrain of the participants was that they were only violating that letter, not the law's spirit. They were acting illegally but not immorally. They were not price gouging. They were merely keeping prices at the level needed for them to go on supplying valuable products, and for them and their competitors to live and let live

This position was expressed most thoroughly by a GE engineering leader and manager not implicated in the conspiracy. Glen Warren accepted the Anti-Trust Laws as "correctly established to protect the public against the excessive profits and monopolization of markets which might follow restrictive agreements". However, he said "the present situation differs." GE did not gain excessive profits from price fixing. Instead, in his experience, it sought only to lessen the burdens under which a highly productive turbine industry labors. Those burdens included over capacity, a recent slowing of the growth in demand, and especially the extreme volatility of the order rate, with annual orders varying by a factor of five over a six year order cycle. This in turn had caused employment fluctuations of more that two to one.These pressures made it very difficult for even the biggest firms to operate. For the smaller ones, survival without market -sharing was perhaps impossible. So price fixing by the large companies, the ones who had "the least to gain" was not profiteering. It was an exercise in survival . The anti-trust laws should distinguish between efforts at excess profiteering by

[516] **Smith, A.R. 1947. Recommendations. Turbine Generator Dinner 14 Feb 1947.. Glen Warren Papers. 95.73.265. On plans for Building 273, see GE 55th annual report 1946.**

monopolization and efforts "to stabilize the market so as to live and let live,". [517].

What was the impact of this law breaking on the public? The hundreds of millions dollars extra in the prices electric utilities paid for equipment showed up as higher prices on consumers' utility bills. The impact should not, however, be overrated. In a detailed economic study of "Pricing in the Electrical Oligopoly" electricity utility economics expert Ralph Sultan concluded that "the conspiracy was impotent." The prices utilities paid for electrical equipment were not much different than they would have been in the absence of the conspiracy. [518]

The price fixing era was also an era of steady improvement in the efficiency of steam turbine generators. This was not due to dramatic breakthroughs. Instead it was due to a steady stream of small improvement. Thanks to that effort , efficiency rose from about 10% in 1900 to over 30% in 1960. This translated directly into falling real cost per kilowatt-hour of electricity produced. Many of those cost reductions were passed on to the consumer. In the decade 1950 -1960, for example, electricity costs to the consumer fell by 25%. It would only be after 1960, when steam turbines had reached their efficiency limit, that electricity prices would begin to rise.That past record of falling consumer electricity price was in large part due to the engineering excellence of the price fixing companies. The Great Electrical Conspiracy is more noteworthy for its exhibit of plutocratic privilege and giant corporation arrogance than for causing actual consumer hardship.

The above downplaying of consumer harm sounds like corporate special pleading. There were, however, economists with no apparent axe to grind who gave theoretical reasons for minimizing the consumer effects of collusion. Concluded economists Chaim Fershtman and Ariel Poles: “”In a market that supports only a small number of firms, we may well be better off encouraging collusion than deterring it.[519]

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[517] **Warren, Glen B. 1961. "A Rational Point of View With Respect to the Anti-Trust Law. 16 Feb 1951. G.B. Warren Papers. 95.78.329. MiSci**

[518] **Sultan, Ralph. 1975. Pricing in the Electrical Oligopoly. Vol.2. Harvard.**

[519] **Fershtman, Chaim and Poles, Ariel. 2000. S Dynamic Oligopoly with Collusion and Price Wars. RAND Journal of Commerce. 31. 207-236.**

How about at the headquarters of that plutocratic privilege? What did Ralph Cordiner and his Executive Committee know, and when did they know it? Officially, the prosecution explicitly exonerated Cordiner and his Executive Committee from any knowledge. Unofficially, however, the reporter who most thoroughly covered the trials expressed skepticism. His account strongly suggests that at least one member of the Executive Committee, Arthur Vinson, participated in the conspiracy and successfully covered up his participation. He adds that the prosecution also considered indicting Cordiner. Its decision not to do so was pragmatic. The prosecutors wanted a quick clean verdict based on guilty pleas. They did not want a long battle over the ambiguous evidence that may or may not have convicted Vinson and Cordiner [520]

At least one pre 1959 GE whistleblower had tried to contact Ralph Cordiner to expose price fixing. Jerry Page was an employee of GE's Switchgear business in 1957 when he sent Cordiner a letter correctly claiming that the GE Switchgear business had fixed prices. Page's management was, however, able to convince Cordiner that the evidence Page sent had a different and innocent explanation, and that Page suffered from psychological problems. The issue was dropped. [521]

Finally, what does the incident say about the Old GE as corporate citizen? It exposed company arrogance, entitlement, and a corporate culture that allowed managers to believe they were above the law. The arrogance operated on two levels. At the operating level, it was the arrogance of treating a clear violation of a major Federal law as if it was on the level of jaywalking. One might argue, as a historical alternative, that the U.S. should have legalized cartelization and price fixing, as some European countries did. A counterfactual retrospective case for a different law is not, however, an excuse for breaking the actual law.

At the top company level, the arrogance was a lack of due diligence regarding pricing.. Cordiner was not alone in this. No GE CEO before him seems to have investigated energetically the possibility of price-fixing. Cordiner was however, on the job when the long-held secret was revealed,

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[520] **Smith, Richard Austin. 1963 Corporations in Crisis. Doubleday**

[521] **Administered Prices p. 16892-4**

The champion of the science of professional management was caught professionally mismanaging.

Critics proposed two alternatives. If Cordiner knew that price fixing was going on, he should have been fired for a cover up. If he did not know, he should have been fired for incompetence. GE's stockholders avoided both of these alternatives. In 1961 they voted, by a 98% majority, to re-elect Cordiner to the GE Board of Directors. The Board proceeded to re-appoint him as its Chairman and the company's CEO. The April, 1961 GE Stockholders Annual Meeting at Syracuse NY was a Cordiner celebration. His expression of willingness to continue as CEO was greeted with wild approval. Speakers expressing disapproval of management were hooted down by shouts of "shut him up!" or " throw him out!". [522]

In celebrating Cordiner, that meeting said little about GE's business performance during Cordiner's first decade. By past standards it was mediocre. 1960 GE sales and earnings were only about 30% higher than in 1950. This contrasted with the company's previous average of more than 100% sales and earnings growth per decade. So ended a decade that had begun with a doubling down on diversification and progress. To answer the questions with which this chapter began.

How did GE's vague 1954 concept of progress get embodied in specific products? The new initiatives of the 1960s that made GE perhaps the world's most diversified company were not the result of strategizing by its top managers. The initiatives that gave meaning to the progress slogan were adaptations to a world of hot war, cold war and big government. GE was pulled into jet engines,nuclear power, and aerospace by the government. It was pushed into computers and advanced materials by its own lower level internal entrepreneurs. In all these areas GE was once again a fast follower, participating in innovation based on ideas brought to it from outside, and adapting to the events and trends of the world at large.

How did GE's decentralization compare to the structural changes of other giant companies? Here too, GE was a follower. Like Du Pont and General Motors before it, GE converted a unified bureaucracy into a collection of decentralized Departments. Everyday decision making was pushed down to

[522] **Glen Warren Papers 95.78.329(6) Misc Related to Anti Trust MiSci. New York Times 30 April 1961.**

the operating level, leaving the top corporate management free to focus on company-wide issues.In this decentralization, GE differed from others in its more rigid definition of professional management. The definition's voluminous rhetoric boiled down to two ideas. One was management by objectives . The other was the claim that a manager who had absorbed the GE dogma could manage anything. The rigid definition proved problematic. The most successful GE managers of the decade achieved good results not because of, but in spite of, that rigid definition.

Meanwhile, the role of corporate headquarters came into question. If it was not strategizing the company's future, or providing useful consulting, or assuring good corporate citizenship, what good was it? Perhaps the only corporate function that emerged from the 1960s with demonstrable value was corporate research, creator of those profitable advanced materials businesses. As for the CEO and his Advisory Committee they had done well to decentralize the company. They had, however, marred that achievement by burdening it with the cult of professional management.

Finally, what was with that wink? It symbolized GE's most embarassing ever episode of bad corporate citizenship. Price fixing was not a single incident, but a long term pattern of behavior. It was both illegal behavior by individuals, and a failure by top management to detect and end that pattern of behavior. The particular characteristics of the electrical manufacturing industry may in part explain that pattern of behavior. Those characteristics do not, however, excuse it.

In conclusion, by 1961 GE's image was seriously tarnished. Its structure, however, was sound, and its prospects were unimpaired. Electricity use was still doubling every decade, and electrical manufacturing was still GE's core business. The possibility of getting back on the company's historical path of doubling its sales and profits in the coming decade still looked promising. To get back on that path, however, GE had a daunting task. It had to turn big progress -- now publicly embodied in aircraft engines, nuclear reactors, computers, and contributions to national defense-- into big profits.

Chapter 12. Turnkey, 1960- 1972

In 1963 GE put a new word into its corporate lexicon. That word was turnkey. In a turnkey project, a contractor takes on full responsibility for designing, planning and building a project. The customer is promised full operation by a fixed date. Just turn the metaphorical key and start it up[523]

GE especially applied that turnkey concept to nuclear power plants. More generally, however, that 1963 turnkey nuclear power plant program symbolized GE's 1960s impatience. It was impatient to see its three big gambles-- aircraft engines, computers, and nuclear reactors-- complete the trip from progress to profitability.To help complete that trip GE had, in the years 1945- 1960, remodeled itself. The signature programs of that remodeling had been Boulwarism in labor relations and decentralization in corporate structure.

The questions this chapter addresses are: how well would GE perform in the 1960s at completing its three key progress-to-profits transitions? How would the company's key post-war changes, Boulwarism and decentralization, perform in the 1960s? What light did this cast on the general evaluation of the benefits and evils of corporate giant size?

On that progress to profits transition, Aircraft Engines had gotten the earliest start. By the 1960s, within GE, it was a company within a company. GE had spent the 1950s remaking itself into a decentralized company of moderate sized departments with single purpose, preferably non-union, factories in small cities or towns. Aircraft Engines had gone the other way, toward a recentralized business, located mainly in two big unionized works on the edge of two big cities, Boston MA and Cincinnati OH.[524]

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[523] **businessnovice.net/definition/turnkey-contract/**

[524] **The following discussion of the 1960s aircraft engine business history draws heavily on General Electric Co. 1979. Seven Decades of Progress. Aero Publishers, Boyne, 1979 Walter and Lopez, Donald. The Jet Age. Smithsonian Press. Garvin,**

By 1960, all aircraft engine makers were converging on an old idea. This was the turbofan. It at last combined the power of the turbojet with the efficiency of the turboprop. The idea had been suggested back in the 1930s. In the next 30 years it was brought along by an international cast. The basic idea was to enclose a turbojet within an open ended cylinder. Use that turbojet's turbine to turn not only the turbojet compressor, but also a fan, also enclosed within the cylinder. The fan acts as a propellor, adding a second means of propulsion. The payoff was achieving three desired properties: the 500-600 mph speed range now expected of commercial airliners, high efficiency, and less noise. Looking forward, engineering issues remained. For example, should the fan be put in front of the compressor near the engine inlet , or in back of the turbine, near the jet output? What should be the "bypass ratio" the ratio of the amount of cooler air propelled by the fan to the amount of hotter air blasted out as a jet?

GE developed its version of the turbofan by following its usual tactic of starting with a Defense Department task. In 1962, this was a $500 million Air Force contract for powering a gigantic new cargo plane, the Lockheed C-5. GE got the contract based on design choices putting the fan behind the turbojet core, and choosing a relatively high bypass ratio of 8:1. GE would build 464 of those engines by the end of the contract in 1971. Could that engine be further adapted to the much more profitable civilian market? Sales there potentially ran into the thousands of engines, with much larger profit margins. A big target was the next model from the now dominant airframe maker Boeing, the 747.

Rival Pratt and Whitney had made different engine choices: putting the fan in front of the turbojet core, and using a bypass ratio of about 5:1. Boeing preferred Pratt & Whitney's engine over GE's. In the airline industry, however, it is the airline, not the airframe maker, that selects the

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Robert. 1998. Starting Something Big. American Institute of Aeronautics and Astronautics,

engine.What happened next is disputed. GE's official history describes it as withdrawing from the contest in deference to Boeing's preference. Joe Sutter, a leading engineer on Boeing's 747 project describes it differently. He says GE tried to sell its engine to a key airline customer, Pan Am, by means of pressure exerted by a GE Board of Directors member who was also on the Pan Am Board. Sutter claims he had to put his reputation on the line to keep Pan Am from making what he believed was a technical mistake.[525]

Whatever the details, by 1967 GE had lost out to Pratt & Whitney on the 747. It was once again on the outside looking in. It would get a big contract for the engine on the proposed supersonic transport (SST). Long before that SST could take to the air, however, a 1971 Senate vote would cancel the program. In 1967 GE faced a decision. Should it retreat to its successful military and business jet engines while betting on an SST leapfrog? Or should take another shot at the subsonic commercial airliner market? The choice was to take another shot. Gerhard Neumann led a new effort that further adapted the GE turbofan. This time GE adopted the Pratt and Whitney choices of a front fan and a more moderate bypass ratio.

This new engine, the GE C5A, did not immediately go on the Boeing 747. Instead, GE executed a pair of flanking movements. Domestically, the C5A engine initially powered Boeing's U.S. rival, the McDonnell-Douglas DC 10. Meanwhile, in a global flanking move , GE joined a joint venture that had originated as a European challenge to U.S. aviation supremacy. This became the airframe company Airbus and the aircraft engine venture Snecma. By 1970 no one yet knew whether these moves would pay off. GE Aircraft Engines and British rival Rolls Royce still lagged far behind the leader, Pratt & Whitney, in much the same way that, in the electric power industry, Westinghouse and Allis Chalmers still lagged far behind GE. It would not be in the 1960s, but in the 1970s, that GE would find out if it could make money selling turbofan engines to the airlines.

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[525] **Sutter, Joe 2006. 747: Creating the World's First Jumbo Jet. Harper Colllins. p. 127**

Meanwhile, the electric power industry would recover in the 1960s from its troubles of the 1950s. The boom and bust nature of utility ordering worked this time to the benefit of the manufacturers. The big electric event of the 1960s was the massive 1965 Northeast U.S. blackout. The event led to a recognition that the low level of turbine-generator orders in the 1950s had reduced utility generation reserves to a dangerously low level. In Schenectady, a manager had anticipated the emerging opportunity. Don Craig was a South Dakota native and a 1932 engineering graduate of that state's university. In the early 1950s, after nearly two decades with GE, he joined that first generation of decentralized department managers, running a turbine parts plant in Somersworth NH.

There his most memorable lesson did not come from Crotonville or the Cordiner-Smiddy Blue Books. It came from a business consultant who was guiding the move of New England textile mills to the South. I can always show them there is a 30% saving from moving a plant south, the consultant told Craig. What I don't tell them, he added, is that with good management, they could get just as big savings here in the North. "That made me think," Craig would later recall. “If you could get everybody involved in this-- the community, labor leaders and GE-- you could get it done.” [526]

In 1962 he got a chance to get it done on that bigger stage. He became Vice President and General Manager of GE’s Turbine-Generator Division at Schenectady. It was the largest division in the company. It was also one of the most troubled. Its problems went beyond resistance to decentralization and price fixing. GE's long undisputed reign over the U.S. electrical equipment market was under challenge from overseas.

The European electrical manufacturers had historically technically equalled, and sometimes surpassed, GE. They had, however been kept out of the U.S. market. This was first done by tariffs, then by agreements, then by the

[526] **Interview with Donald Craig 31 July 1985. HoH**

depression, and then by the war and its devastation. By the 1950s they were recovering. At first their challenge in the U.S. market was small. In some areas, however, such as hydroelectric generators, it soon became significant. This was followed by a wake up call: the 1960 ordering by the TVA of coal-fired turbine generators from the C.A. Parsons Co. of Great Britain. GE lobbyists scurried to Washington to seek more tariff protection. At Schenectady, however, everyone knew that the problem was closer to home. GE's costs were out of control. Many causes contributed. For example, complacency had led to a failure to update procedures or install improved machinery. The focus, however, soon centered on labor costs. Piecework, an old effort to improve productivity, was backfiring.

As mentioned, piecework had begun as a way to reduce manufacturing costs while increasing worker pay. Combining those two goals required more disciplined managerial attention to rate-setting than the Schenectady management was willing to exert. As the company failed to keep rate setting focused on productivity goals, the skilled pieceworkers learned to beat the system. They took advantage of loopholes, such as claiming extra credit on maintenance activities such as sharpening tools. The result was much higher pay without the full expected payoff in improved productivity.

Pieceworkera were about 3000 of Schenectady's 10,000 shop workers. They were earning up to twice as much per year as the day workers --- another split among the labor "us". This time, however, the split worked to the detriment of the managerial "them." A.C. Stevens, the last Works Manager, saw the Schenectady problems as many sided: "the manager who refuses to take the risks ... the engineer who rests on his laurels...the shop man who refuses to accept the fact that he must adapt to changing realities on his job"

It all culminated, Stevens concluded

> in the eternal debate over what the piecework allowance shall be for each job and the dissension which this continually generates. It is not surprising that the system has lost most of its value as a true incentive.[527]

[527] **Interview with A.C. Stevens 31 July 1985. HoH**

Don Craig spent most of his first two years in Schenectady studying the problem. In l963, in the waning days of the Cordiner regime, he had a proposal ready to take down to the Advisory Committee at GE headquarters in New York City. It boiled down to a bargain. In exchange for union acceptance of the end of that lucrative piecework program , GE would put a $25 million investment into Schenectady, ending the decline of the work force number. That decline had already gone from 40,000 in 1950 to 20,000 in 1964, and seemed headed toward 15,000."Quite likely we will have to take a strike", Craig concluded. "But it is still a good idea. "[528]

Craig's presentation was met with silence. He was about to protest the lack of enthusiasm when Vice President Chuck Rieger chimed in. "Don," Rieger said, "That was an enthusiastic reception!" As little as the Advisory Committee cared for Schenectady , they cared even less for missing the boom in utility and industrial orders about to begin as the U.S. economy improved and utility capacity shortfalls became evident.

Craig announced the Make Schenectady Competitive Program on April 13, 1964. Five months of intense confrontation followed. GE took some unilateral actions. For example, In July, 1964, without union approval, it converted all piecework jobs to daywork.

The confrontation was, however, bargaining, not Boulwarism. "They listened," Craig recalls of his conversations with the the union leaders. " They realized it had to happen. " GE also listened . It sweetened its offer of investment in Schenectady to $60 million. It agreed to phase out piecework gradually, and replace it with a hybrid system called day work with measurements.

These changes emerged slowly over five months of intense negotiation. From the company side came a barrage of publicity. Craig, the good cop, held coffee klatches for local clergymen, and made so many TV appearances

[528] **Interview with Donald Craig 31 July 1985. HoH**

that, he said, "my kids started calling me the poor man's Lawrence Welk. "[529]

Unlike in 1946, few Schenectady citizens came out publicly for the union. The Schenectady Chamber of Commerce and Industrial Development Agency came out, unsurprisingly, for GE. All this happened in a slightly overgrown small town where, for example, the son of the manager in the GE motor department was dating the daughter of the union bargaining agent. Meanwhile GE's bad cop, negotiator H.N. Parker, was going head to head with Leo Jandreau. Bluffing accompanied the bargaining. GE let it leak that it was making a study of the feasibility and cost of moving Schenectady turbine operations to "location X" in the South. The union launched court rulings alleging that GE's actions violated the national contract. The national union explored a national strike in sympathy with Schenectady. Neither side followed through. Likely, neither ever intended to.

The impasse dragged on right up to a Sept 30, 1964 deadline, and then a little bit beyond. In the end, Leo Jandreau, a life long Schenectadian as well as a union leader, acted in the balanced best interest of city and union. At 1 AM on September 31 1964 he and Don Craig announced an agreement that he labeled " an honorable settlement " and Craig called "a victory for everyone. " Later, and privately, Craig would add: "if we had a weak union leader instead of Leo we would never have pulled it off. He had the credibility."

It was Jandreau's last act before retiring as IUE 301 bargaining agent. Piecework would disappear but only gradually, tied to seniority. It would be replaced by that day work with measurements system. The company would measure worker performance but would pay all workers a contracted fixed wage varying with skill requirements.

Jandreau left behind a Works and a union local that were making a significant turn upward for the last time. Employment at the Schenectady Works rose from 20,000 in 1964 to 27,000 in 1970. This included 12,000

[529] **Interview with Donald Craig 31 July 1985. HoH**

union members. In 1968 GE had its biggest year so far in turbine manufacturing, shipping 12.2 GW of capacity.

Though becoming more productive, Schenectady remained contentious. Discontent over the pace and details of ending piecework led to walkouts, wildcat strikes, and, in 1966, the long strike that Don Craig had earlier warned about. It lasted 11 weeks. It ended on GE's terms, against the wishes of the union's new bargaining agent John Shambo, by the narrow vote margin of 4475 to 4355. [530]

At the end of those contentious 1960s, Don Craig predicted for 1971 a "reasonably good year" for Schenectady, but added a "warning against complacency. " He noted that "demand for our products still is beyond the capacity of our facilities," and that the reliability and efficiency of GE turbines had earned orders in competition with competitors who offered 35% lower prices. On the other hand, Japan's Hitachi was willing to go to a price 40% below GE's to earn another big U.S. order. [531]

Meanwhile, in labor relations, some of the earlier contention settled down. Joining Leo Jandreau and Schenectady piecework in 1960s retirement was Boulwarism. (Lemuel himself had retired in the 1950s, but continued to consult). In 1964, the National Labor Relations Board declared Boulwarism a violation of the Wagner Act and ordered its discontinuation.[532]

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[530] **The above discussion of 1964- 1970 labor relations is based on Don Craig's HoH oral history, A.C. Steven's HoH oral history, and coverage in the Schenectady Gazette, esp. Feb 13, 1968. P.15. Albany Times Union 31 Dec 1966 p. 1. Bella, Salvatore J. 1962. Boulwarism and Collective Bargaining at GE. Cornell Ph.D. Thesis . esp. Pp. 208-215, 250-267.**

[531] **Works News 12 Sept 1969; 15 Jan 1971.**

[532] **National Labor Relations Board, "GE Company and lU of E, R and MWA, Cases No. 2-CA-7581 et. al., 150 NLRB No. 36, 1964. Phillips-Fein, Kimberly, American Counterrevolutionary. In Lichtenstein, Norman. ed. 2006. American Capitalism. Penn. P.269**

Whether GE acted in accord with this decree was disputed. A New York Times editorial described the subsequent late 1960s union- company clash as "a sense on both the management and union side that they are warriors in an economic holy war over Boulwarism." [533]

As one result, in 1969 a historic reunion occurred. The smaller, once communist, and still feisty UE, and the larger, originally anti-communist, more conservative IUE, agreed to bargain jointly. The bargaining sputtered out in October, 1969. That led to a nation wide 102 day strike by 150,000 union members. It was the last big company-wide strike of the Old GE. It won a 50¢ per hour wage increase, resumption of an earlier discontinued cost of living allowance, and a couple dozen other contract modifications.

So by 1970 GE was faced with a National Labor Relations Board edict that had outlawed Boulwarism, and a unionized labor force that was united to a degree not seen 1950. GE top management dismissed the NLRB rebuke of Boulwarism as a political result, arrived at by the appointees of the Democratic Party, the party of organized labor.

GE top management also participated strongly in new efforts to assert Giant Corporation public influence. A 1971 memo to the U.S. Chamber of Commerce by a prominent lawyer and soon to be Supreme Court Justice Lewis Powell had warned that U.S. capitalism was in grave danger due to attacks not only from left wing political groups , but from such consumer advocates as Ralph Nader. To respond effectively, Giant Corporations needed to unify in both pro capitalist public relations campaigns and political advocacy.

Part of the Giant Corporation response to the Powell Memo was the founding in 1972, led by by CEOs Fred Borch of GE and John Harper of Alcoa, of the Business Roundtable. It has been described as a sort of Senate of Giant Corporations. Members, all of them CEOs, agreed to vote among

[533] **NY Times Nov 22 1969.**

themselves on key political issues, then unite behind the side that won. A prime example was a 1970s political initiative of the Democratic Party the Labor Law Reform Act. It proposed pro-union actions such as repeal of right-to-work provisions of the Taft Hartley Act. GE was not initally opposed to the Labor Law Reform Act, being already union organized. When the Business Roundtable's vote went against that Act, however, GE joined with the majority and lobbied against it. That Business Roundtable lobbying by played an important role in the Labor Law Reform Act's narrow defeat in 1976.

GE and other Roundtable members also embraced the Political Action Committee (PAC) , a way of getting more money into politics. The PAC had been invented in the 1940s by the labor unions. After 1960, it became a capitalist tool. Meanwhile, the spirit of Boulwarism was being injected into the Republican Party by a protege of Lemuel himself, California's new governor Ronald Reagan.[534]

The role of this increased Giant Corporation political effort on the long term decline of unionism in the U.S. is controversial. It happened alongside other influences ranging from globalization to the information revolution. Whatever the detailed causation was, from the 1970s on there was a steady decline of union power in GE. At Schenectady, for example, that 1970 union membership of 12,000 fell by the early 21st century to 600.[535]

Unionism's last stand in GE mainly impacted its older businesses such as turbines, generators and motors, and its old works, such as Schenectady, Erie PA, Lynn MA, and Ft. Wayne IN. Meanwhile, GE was seeking, in newer and less unionized locations from Syracuse NY to Phoenix AZ, to gain leadership in the array of newer businesses based on electronics.

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[534] **Nace, Ted. 2010. Gangs of America. Barret-Kohler. Pp.142-143. Akard, Patrick J. 1992. Corporate Mobilization and Political Power. American Sociological Review. 57. 597-615. Hacker, Jacob and Pierson Paul. 2010. Winner Take All Politics. Simon and Schuster. Pp. 130-140.**

[535] **The 600 number is from Schenectady Gazette 20 Apr 2023 p.1**

The electronics targets ranged from transistors to computers. Most competitors focused on just one segment of this broad exponentially growing electronics marketplace. Examples were Texas Instruments in components, Philco in televisions, TRW in aerospace,and IBM in computers.GE and RCA stood out in their efforts to span the entire range of the new electronics. GE was alone in seeking to achieve this broad electronics span while simultaneously mastering other big technology-business challenges such as jet engines and nuclear reactors.

Was such a stretch possible? Some prominent thinkers said yes. Harvard economists Joseph Schumpeter and John Kenneth Galbraith argued that the synergy provided by giant companies' large professionalized "technostructures" enabled them to dominate not only current manufacturing but also future innovation. To MIT business historian Alfred Chandler, the giants' key advantage was the replacement of the market by the visible hand of top management. In the 1960s GE would provide a test case of this predicted continuation of giant corporation dominance.

In electronics, GE seemed in the 1960s to have both synergy and strategy. The synergy combined a world class Research Lab near Schenectady to explore the frontiers of science with an Electronics Park in Syracuse to follow through on the technology. Then business departments would embody that technology in products.

The strategy element was provided by a new top management that in 1963 succeeded the Cordiner team. The new CEO, Brooklyn-born Fred Borch, had graduated from Case Tech, and spent his career in marketing for GE's consumer businesses. His mantra became "scientific salesmanship."

As president, he endorsed decentralization, but thought it had gone too far. GE' s diversity now lacked an overall strategic vision. To provide one, he beefed up the corporate strategy staff under the leadership of a former marketing subordinate, John McKittrick.

In 1965 that staff assembled a Growth Council, including both inside and outside experts, to recommend targets for the expansion of GE. The Council endorsed the three already identified big gambles commercial jet

engines, computers and nuclear. It further recommended that the company diversify even more widely. Top recommended targets beyond the existing businesses were home entertainment, planned communities, and education systems.

The Growth Council also criticized recent management practices:

> GE's lagging growth was connected with and related to its drastic decentralization program, which, by hindsight, must be judged an administrative success and an entrepreneurial failure.[536]

For the immediate future, however, the key was not entreprenurship. It was how well GE would perform in the growth areas to which it was already committed: nuclear, aircraft engines, electronics and computers.

In electronics components, GE's Syracuse NY Electronics Park was by 1960 a major maker of transistors, the solid state components that were rapidly replacing vacuum tubes. Supporting this solid state transition, the GE Research Lab had built up a strong team of solid state physicists. Some of them, such as LeRoy Apker, Robert Hall and Jerome Tiemann, were also significant inventors.

In television, GE was making up for its late start in color. It continued its emphasis on small sets. It decentralized its production to remote factories that were non union and thus presumably more productive. In the 1960s Japanese competition was still a small cloud on the horizon. For GE a solid #2 position behind RCA seemed within reach.

In the early 1960s computer business, IBM domination was unchallenged. Competitors were derisively dismissed as "the Seven Dwarfs." GE

[536] **John Fisher to Fred Borch. 2 Aug 1965. John Fisher Papers. Box 2018-14. MiSci.**

realistically set as its ambition to become, as a GE pioneer would later title his memoirs, King of the Seven Dwarfs.

This was not a defeatist aspiration, but a sensible and potentially profitable one. After all, GE had learned in businesses ranging from steam turbines to nuclear submarines to aircraft engines that customers want a second source--if only to curb the arrogance and potential profiteering of #1. Moreover, with the antitrust laws in force, a prudent #1 had, at least in the past, kept its #s 2 and 3 healthy, even to the extent of fixing prices with them.

In the mid 1960s there were actually nine dwarves. Far from being their king, GE was in the middle of the pack. Its roughly $40 million in 1963 computer-related sales was not just dwarfed by IBM's $1.2 billion. It was also well behind the $75-$150 million range of Sperry Rand, Control Data and Philco.[537]

Aiming to achieve that #2 position, GE continued its dual effort of both providing alternatives to, and attempting to outmaneuver, IBM. As a global flanking maneuver, it bought controlling shares in two European computer companies, France's Bull and Italy's Olivetti. Meanwhile, In the U.S. it followed fast on a development that appeared by 1965 about to revolutionize the way computers were used.

This was time sharing. In 1960, computer programmers still punched their programs onto stiff paper cards, following the instruction "do not fold, spindle or mutilate". The decks of cards then ran through the computer. It was typical to drop off your program one day, and not get results until the next.

By the early 1960s, increased computer power offered an option. A single computer could be hooked up to a dozen or more typewriter-like terminals. The computer could divide its processing among those users. The speed of

[537] **Fisher, Franklin F. et.al. 1983. IBM and the Data Processing Industry. Praeger. P.65**

the newest computers allowed each user to feel he had personal use of his own computer.[538]

GE had in 1961 already carried out a related idea. Under a Defense Department contract it had time shared computer power among many test instruments at Wernher Von Braun's Huntsville AL rocket facility. In 1962, GE built on that capability to bid on an educational time sharing project. It was funded by federal government's National Science Foundation, and led by Dartmouth College math professor John Kemeny. The obvious first choice, IBM, asked too high a price.This left a competition with NCR and Bendix that GE won. The Kemeny initiative was a computer milestone. It did not just introduce time sharing to academia. It also, via its new simplified and understandable programming language BASIC, vastly widened the community of potential computer users.

The next step was to expand time sharing to full professional and business use. Develop the required more powerful computer operating systems and languages. Set up time sharing centers across the country. Condemn IBM's card chomping dinosaurs to extinction.In pursuit of this goal in 1964, GE entered a joint venture with MIT and Bell Labs. MIT had initiated the effort with its advanced time sharing system, Project MAC. GE would adapt its newest and most powerful computer to time sharing. The three parties would jointly develop the needed operati.ng system, called MULTICS.

So Fred Borch's strategists might well see GE's mid-1960s electronics prospects as bright. Component leadership would flow from GE's world class combination of Schenectady Research Laboratory and Syracuse Electronics Park. In the early 1960s both locations were bigger names in the electronics world than the infant California upstart not yet widely known as Silicon Valley.

With cost reduction and superior components, television could become a reliable cash cow. With superior components and its access to corporate

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[538] **The description here of time sharing and its consequences is taken largely from Campbell- Kelly, Martin and Aspray, William. 1998. Computer. Basic**

cash, GE computers could both provide a solid second source to IBM, and also hit IBM where it wasn't -- on the new frontier of time sharing.

It was a great strategy in theory. Practice proved another matter. In components, new processing methods revived an old idea. It was to produce transistors not just one at a time, but many at a time, all embedded in the electronic circuit that used them. Contrary to the expectation of Schumpeter, Galbraith, and Chandler, this insight was not reduced to practice by the technostructure of a Giant Corporation. It was done at two smaller more nimble companies focused on electronics. At Texas Instruments, Jack Kilby invented one version of the integrated circuit. At Fairchild Semiconductor, Robert Noyce invented another.

Their inventions opened a great opportunity for a fast follower. Why wasn't GE the one to achieve this fast following? Bob Hall, GE's most prominent electronics physicist and inventor, later gave an answer. At Electronics Park in Syracuse, he said, the engineers thought of integrated circuits as a research topic, and waited for the GE Research Lab to take the initiative. At the Research Lab, Hall said, integrated circuits were regarded as a manufacturing improvement and therefore the business of Electronic Park. At this point Hall paused, then added "damn important manufacturing improvement though! " In a later Oral History he added that corporate management

> could see a lot of competition coming from people like Texas Instruments and Raytheon, RCA, Fairchild out in California. Integrated circuits were coming on in a big way, and GE did not have a very strong position. Rather than pour a lot of money into electronics, I think they decided it was better to purchase these electronic transistors and circuits and so on, and not try to compete in semiconductor work. [539]

[539] **Robert N. Hall, personal conversation with author, ca. 1985 and Interview #443, IEEE History Center.**

Hall's later verdict echoed the one presented in 1968 by GE Research Director Arthur Bueche. "Somewhere, somehow," he said,

> our leadership in solid state electronics has dis-integrated... in the old electronics revolution of [discrete component] solid state we did pretty well. But in the 'new [integrated circuit] electronics ' we were, lets face it, for a long time simply asleep at the switch.[540]

Moving up from components to consumer products , GE's never caught up to RCA in color TV. The black and white and small set businesses proved only moderately profitable. First domestic competition kept prices down. Then foreign competition began the process of finishing off the U.S. television industry.

In computers a dominant competitor, IBM, loomed from the start. GE's computer business tried following, but sometimes too fast. For, example, in 1967 too rapid introduction of one computer model, the GE 600, led to an expensive and embarrassing return of the machine by a major customer, Martin Marietta. Forbes Magazine would subsequently label computers as "GE's Edsel". Less attention was later paid to the subsequent fixing of the problems and the emergence of the GE 600 series as a reliable and cost effective machine. The GE flanking movements also did not go as planned. Attempts to merge the GE line with those of Bull and Olivetti proved what GE pioneer Oldfield labeled a "costly diversion."[541]

In time sharing, things initially looked brighter. By 1968, at Dartmouth, a GE computer was serving 200 users simultaneously. GE Research and Bell Labs seemed to be making good progress on the MULTICS operating

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[540] **Bueche, Arthur. 1968. Speech to Division General Managers' Meeting. 22 May 1968. Bueche Papers. MiSci.**

[541] **Oldfield, King of the Seven Dwarfs, p. 186-189**

system needed to make commercial time sharing systems practical. GE had plans for dozens of time sharing centers nationwide.

In 1969, these efforts hit a snag. MULTICS proved difficult to develop. Bell Labs dropped out. (Two Bell computer scientists would develop a simplified version called UNIX. It would prove to be by far the most valuable outcome of the MULTICS effort).

As the giants stumbled, smaller start-ups pioneered a different route to broader computer use. The Digital Equipment Company and others pioneered minicomputers. They were relatively small (initially refrigerator sized rather than room sized) and relatively cheap (tens of thousands rather than hundreds of thousands of dollars). The arrival of integrated circuits gave these economical machines unexpectedly great computing power. Suddenly a subscription to a time sharing utility looked like a bad bargain. It became a 1970s sideshow, not the originally expected future of computing.

In 1969 GE faced a big decision. Should it pour the hundreds of millions of more dollars needed to compete for that King of the Dwarfs crown? The company's losses due to that winter's long strike made such an investment appear even less attractive. The issue was assigned to a team called the Venture Task force and nicknamed "the Three Wise Men". It was made up of strategist John McKittrick, Corporate Counsel Bob Estes , and Vice President of Finance Reg Jones. None was a computer expert. At their recommendation, the GE computer business was in 1970 sold to Honeywell.[542]

Why had GE not been more successful in computers ? Barney Oldfield, first Manager of the GE Computer Department, blamed "micromanagement from corporate headquarters." A non-GE veteran of the computer industry agreed:

> GE had a major problem with the top management of its computer operation. In those days, GE corporate doctrine was that any competent manager could run anything. Management of the

[542] **Oldfield, King of the Seven Dwarfs pp. 170- 199**

> computer division turned over so fast that the engineers could do anything they pleased. Before the [computer] top brass grasped binary arithmetic they were back in upstate New York building turbines.[543]

Another GE computer pioneer, George Snively, had a different story. He denied that GE's computer business was a failure. He argued that accounting for foregone leasing income and other potential earnings , GE Computer was heading for profitability when the plug was pulled. Honeywell got a decade of profits out of the GE effort. GE itself kept its time sharing effort, and for decades afterwards, GE Information Services was a successful business.[544]

Despite such revisionism, the consensus view held that GE's performance across that electronics spectrum was dismal. There were bright spots, such as ERMA, and providing computer power to the Dartmouth time sharing initiative . In total, however, GE's electronics experience provided evidence against the Schumpeter- Galbraith- Chandler theory of continuing giant corporation dominance. Scope, scale, strategy, structure and the visible hand did not enable this particular giant to dominate the electronics future as it had dominated the electric past.

GE could jettison computers in 1970 without losing too much face . Not so nuclear power. Ralph Cordiner put it this way in his 1959 Time cover story. "the atom is the power of the future, and power is the business of General Electric." [545]

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[543] **Dorn, Philip H.1985. "Learning from Lemons". Datamation. 15 Jan 1985.**

[544] **The Rise and Sale of the General Electric Computer Department: A Further Look. 2000. John A. N. Lee, George E. Snively. IEEE Annals of the History of Computing. 1 April 2000**

[545] **Time Magazine. 1959. Atomic Energy: the Powerhouse. 12 Jan 1959. p.75**

In 1963, GE's new CEO Fred Borch decided that it was time to make nuclear reactors profitable. This was not a response to customer demand. The electric utility companies were content in 1963 with coal as a fuel. The three U.S. civilian nuclear power plants operating before 1960 were not utility initiatives, but were all demonstration plants, built with large government subsidy.

In 1960, at Dresden IL, GE and Commonwealth Edison successfully put into operation the first commercial GE BWR. That success did not, however send customers clamoring with orders to GE's door. This was disappointing. More alarming, in 1962, were moves by Westinghouse. It sold a 550 MW nuclear plant to the New England Yankee Power Company, a joint venture of 12 New England utilities, and a 390 MW plant to Southern Calfornia Edison. By participating in an AEC program to speed up the adoption of nuclear, Westinghouse got the government to pay 10% of cost.

GE's response was to do Westinghouse one better. It offered turnkey nuclear plants. Previously, an electric utility that went nuclear managed by itself the efforts of multiple vendors. The utility contracted with equipment manufacturers to supply the turbine, generator and boiler. That utility also contracted separately with a firm of architect -engineers to have the power plant built. To simplify matters for a utility willing to go nuclear, GE offered that turnkey option. For a fixed cost, GE would do everything. As a manufacturer it would supply all the equipment. As architect-engineer, GE would build the plant. All the utility had to do was turn the key to start it up. As George Stathakis, Marketing Manager for the GE Atomic Power Equipment Department, explained, the turnkey alternative

> responds to the expressed desire of some utility company purchasers who desire to place the main construction and financial responsibility with a single organization because of the comparatively new technology involved.

GE offered all this at an attractively low price. For a 300 MW nuclear plant, the price was $45.6 million. For a 1000 MW plant, the price was $103 million. This meant that tripling the capacity would only double the cost.

The 300 MW plant would, GE said, produce electricity for .52¢ per kwhr, the 1000 MW plant for only .38 ¢ per kwhr. [546]

Those predicted figures were based on two principles. The first was economies of scale. Bigger machines should produce output at lower unit costs. This was familiar from the turbine generator business. GE 's first turbine generator had been rated at 5 MW and helped producehelped electricity at a price more than 10¢ per kilowatt-hour. Turbine generators of the 1960s, rated at 500 MW or more , helped produce electricity at a price less than 1¢ per kilowatt-hour.

The second principle was the learning curve. During World War II, shipbuilders had noticed that every time the production numbers of a ship doubled, the cost of producing one fell by a substantial fraction, perhaps 10-20 %. This was due not to a few major inventions, but to the great many small ways engineers, and workers learned to do their jobs better. That learning curve effect was familiar to GE in products ranging from refrigerators to jet engines.

In applying these two principles, GE neglected a third one: dislocations of scale. This had struck its turbine business in 1903 and again in 1919, as detailed in earlier chapters. Increasing scale uncovered problems not seen in the smaller size.

The turnkey faith was a belief that, for nuclear reactors, economies of scale and the learning curve would outweigh dislocations of scale. That faith in the power of scale and learning was not unique to GE. It was widespread across the government-industry nuclear complex. For example, it was not GE but the AEC that predicted a 1962 report that nuclear power was already nearly economically competitive in high fuel cost areas, and could, by the year 2000, supply 50% of U.S. electricity. Westinghouse expressed its similar faith by immediately joining GE in 1963 with its own turnkey

[546] **GE News Bureau 24 Sept 1964. MiSci**

program. Over the three years 1963- 1966 the two companies contracted for a dozen turnkey plants. [547]

There were a few skeptics. Within GE, the company's most distinguished nuclear expert, physical chemist Karl Cohen, did not agree with the turnkey faith. As he put it many years later,

> at the beginning of the commercial nuclear industry, economics comparisons with the fossil fuel power industry were based more on faith than on fact. Until plants were designed and built the capital costs were unknown. [548]

He suggested in 1963 that GE take it slow and deal with the dislocations of scale at each size before moving on to the next. This advice was not taken. In 1966, before that first 550 MW turnkey plant had been completed, GE had contracted to build two. 1065 MW turnkey nuclear plants for the TVA, in the middle of cheap coal country.

Charlie Elston, a leading steam turbine engineer, was experienced in the issues of dislocations of scale. "We learned in the Turbine business," he said, " that when you move so fast that you can't benefit from experience then you are in trouble. " He added that, regarding nuclear

> The executives who were involved on the GE side-- Fred Borch and others from Appliance-- didn't realize that they were dealing with something much bigger than appliances. They swallowed the Boston Consulting Group idea that you gain cost leadership by volume production.[549]

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[547] **Zinn, Walter H. and Pittman Frank. 1964. Nuclear Power U.S.A. McGraw Hill. pp.17, 24**

[548] **Cohen, Karl. 1992. A Promise Unfulfilled. 19th International Conference on the Unity of Science. Soeul, Korea. P. 21**

[549] **Charles Elston. Interview 19 July 1984. HoH Collection. MiSci.**

Looking back from 1977, Jim Young, at one time top manager of the nuclear department, agreed. "We didn't allow reactors to mature enough to make new steps," he said. " cost competitiveness was the emphasis...the whole industry allowed the technology to move too fast. "[550]

As the turnkey program played out, the critics proved correct. Dislocations of scale overpowered economies of scale and the learning curve. Indeed, the learning curve proved negative. Cost overruns on later and bigger projects exceeded those on earlier and smaller ones ones. The bigger plants did not produce cheaper power. In 1966, GE and Westinghouse both discontinued their turnkey programs. The financial bottom line for the programs was a combined loss to GE and Westinghouse of about a billion dollars. GE would confess in its 1966 annual report that

> World -wide site preparation and construction costs have risen very sharply over the levels estimated when the Company undertook most of these turnkey projects. Further losses will be incurred in filling those turnkey orders still on the books.

and in 1967 that

> These orders, important in getting this new industry under way, have been a major factor in keeping this business from being profitable and are no longer being accepted. However, costs to be incurred in construction of these plants will continue to affect earnings adversely.

Despite this financial fiasco, GE declared turnkey a success. As hoped, the nuclear power industry did take off. Orders per year increased from three in 1962 to 38 in 1972. GE and Westinghouse roughly evenly shared most of these sales. The industry seemed launched on a trajectory that would result, by the year 2000, in 1000 U.S. nuclear plants producing half of the nation's electricity.

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[550] **James F. Young Oral History. 1 July 1977. HoH Collection MiSci. Interviews with James F. Young 7/19/84, Charles Elston 9/17/86, Karl P. Cohen 9/17/867**

This claim of a takeoff did not result entirely from the merits of nuclear. It fed on the emerging problems of nuclear's rivals. The main one, coal, faced multiple challenges. The still strong miners union gained substantial wage increases in the 1960s. The Clean Air Act, passed in 1963, made it likely that many coal fired plants would have to add expensive scrubbers to remove such pollutants as sulfur oxides from their exhausts. As for coal 's fossil fuel rivals, oil seemed too dependent on imports, and natural gas too scarce. So despite its as yet unproven economics, the 1970 prospects for nuclear power seemed promising. It still had the strong support of the Federal government. Public opposition, though growing, was as yet scattered and unorganized.

In sum, for GE's big diversifications in the decade 1960-1970, progress has not yet led to profits. Computers had been abandoned. GE's aircraft engines were still seeking a major place on commercial airliners. Nuclear power was becoming popularwith utilities, but still hemorrhaging money.

In that 1960s decade, GE had not limited its diversification to those three big gambles. In addition, top management took the advice of that Growth Council. It launched efforts in the new fields of community development, education, housing, and industrial and personal services. The community development and housing effort was largely an attempt to achieve "spinoff" from the now deemphasized aerospace businesses. For example, GE's missile nose cone department changed its name to "Re-entry and Environmental Systems". It sought to apply aerospace know how to such fields as cleaning up cattle feed lots and producing prefabricated housing. Alas, little learned in the sheltered, highly specialized, gold plated world of military contracting neatly transferred to cow manure and construction.[551]

GE also tried to enter the field of education via a joint venture with Time Magazine. This venture, called General Learning, tried to marry Time's mastery of content with GE's mastery of electronics. It briefly got off the

[551] **Appelbaum, Binyamin. 2023. Why Do We Build Houses in the Same Way That We Did 125 Years Ago? New York Times 18 Dec 2023 describes the 1960s housing technonolgy effort, in which GE was a leading participant.**

ground, but in 1966 collapsed and then faded away. More generally, strategizing growth in trendy new areas did not pay off for the 1960s GE. Branching too far from the Edison Elm, these efforts neither involved the company's technological strengths nor addressed already familiar markets.[552]

What did pay off was the old tactic of fast following the ideas of others in areas closely related to the old GE. For example, GE had been trying since the 1890s to electrify main line railroads. Then, from the 1930s through the 1950s it watched as General Motors sold the railroads a less technically elegant idea more suitable to the railroads' shrunken pocketbooks: the diesel electric locomotive. GE had experimented with diesel locomotives since 1910. In the 1950s it became a follower of GM. It did so in a way that seemed to offer the city of Schenectady an offset to the departure of other GE businesses. Schenectady 's first main industry had been locomotive building. It still in 1950 held the biggest works of the nation's #2 steam locomotive builder, ALCO. That company had by 1950 followed GM into diesels.Why not merge the two local giants, each supplying the technology it knew best? In the 1950s this GE-ALCO diesel electric locomotive effort moved into the #2 position in the declining railroad industry's one growth area.

Sadly for Schenectady, local boosterism and technology nostalgia cut no ice at GE headquarters . The company came to see ALCOs contribution as both low in quality and a drag on GE's high tech image. It cut ALCO loose. It took the whole effort off to its own Transportation Department in Erie PA. There GE introduced in 1961 its own diesel-electric. By 1967 it had sold 1000 of them, and had become a solid #2 to GM. In the 1970s it moved up to #1. The business made money for the rest of the century. In the 21st century, merged with a similar Westinghouse effort, it continues to be a top U.S. locomotive maker.[553]

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[552] **New York Times 20 April 1966**

[553] **Churella, Albert. 1995. Corporate Culture and Marketing in the American Locomotive Industry. Business History Review 65.191-229**

Another old technology, the gas turbine, also came into its own in the 1960s. It had already been an old idea in 1941 when the pioneering efforts of European companies such as Brown Boveri convinced GE to follow. GE installed the first commercial U.S. gas turbine for electricity generation at an Oklahoma utility in 1949. It then struggled for two decades to find a place for this potentially, but not yet actually, high efficiency prime mover. Turning invention into innovation required intensive development efforts in such areas as high temperature alloys and understanding the details of gas turbine thermodynamics and aerodynamics .In addition, the inability of gas turbines to run on coal, the lowest cost fuel, made them less attractive to utilities. Repeatedly in the 1950s and early 1960s GE was on the verge of dropping its gas turbine effort.[554]

It was an apparent diversion that saved the business. As an alternative to the diesel locomotive, GE developed by 1949 a portable gas turbine to drive the electricity generator on an electric locomotive. The Union Pacific Railroad bought and operated 25 units in the 1950s. They proved too expensive to rival the diesel. The development, however,would spark an idea.

Charlie Elston became in the early 1960s the manager of a struggling GE Gas Turbine department. At that time the gas turbines sold to utilities were, like steam turbines, individually designed for each customer. That both increased costs, and caused unacceptably long production times. A utility seeking immediate power additions to deal with potential blackouts or brownouts could not wait.

Elston recognized that the locomotive gas turbines were, by contrast, uniform in design and rapidly producible. This coincided with electric utilities post-1965-blackout need for a rapidly available means of meeting peak power demands. Packaged gas turbines based on that locomotive model met those needs. This proved the turning point in profitability for

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[554] **Howard, Alan. 1949. Two Gas Turbines for Power Generation and other Applications.AIEE Technical Paper 49-114. Gulen, S. Can. 2019. Gas Turbines for Electric Power Generation. Cambridge. Pp. 39-74.**

gas turbines. By the 1970s, offered with power of 50 MW or more, they became a sold and profitable GE business..[555]

Another of GE's little noticed 1960s successes had nothing to do with technological breakthroughs. The old idea behind it had been introduced by Ted Quinn back in the 1930s. The business he created to lend money to consumers to buy refrigerators had evolved by the 1950s into a department called GE Credit.

By then its managers had made a financial discovery. Due to a loophole in U.S. financial regulations, GE could borrow money more cheaply than a bank. By lending out that low-cost money like a bank, at similar interest rates, GE could make more money than could a bank.

GE Credit became an activist lender. It stepped in, for example, to reclaim shipping containers from a bankrupt shipping line, recycle airplanes owned by a busted airline, and assume ownership of the Houston Astrodome. Its profit contribution to GE would take off, from millions dollars in the 1960s to tens of millions in the 1970s to hundreds of millions in the 1980s. It was later renamed GE Finance and trumpeted as a creation of the New GE. Its actual roots in the old GE, and the contributions of its actual creators such as Ted Quinn, and 1960s manager A.W. "Ticker" Clock, were forgotten.

Finally, a big GE success story of the 1960s was that already mentioned advanced materials business. GE had faltered economically and technologically at building nuclear reactors. It had, however, succeeded at building productive, profitable chemical plants for making those advanced materials. Those included a factory for making industrial diamond near Columbus, Ohio, one for making Silicones at Waterford, NY, and one for making the new high performance engineering plastic Lexan® at Mt. Vernon, Indiana.

In conclusion, return to this chapter's initial questions.First, how well would GE perform in the 1960s at completing its three key progress-to-profits

[555] **Bruce Buckland. Interview HoH 25 Feb 1980.**

transitions? A pessimist might depict GE in 1970 as so far going zero for three. None of its three highly visible ventures, had yet shown a profit. Aircraft Engines and Nuclear were still in the red in 1970, while Computers had been abandoned. An optimist might reply that two of the three were on the verge of success. GE turbofan engines were beginning to appear on commercial airliners. The turnkey program, despite its faults, had indeed unleashed a boom in nuclear.

The company's numbers offered a similar mixed message. The optimist could point out that GE's sales had reached $8.7 billion in 1970, compared to $ 4.2 billion in 1960. In other words, after a weak 1950s, GE had resumed its historical pattern of doubling in sales in a decade.The pessimist could reply that the 1960s had been a prosperous decade for the economy as a whole. The U.S. GDP, which had historically grew more slowly than GE sales, in this decade matched GE growth by also doubling. Meanwhile, GE earnings had not even come close to doubling in the decade, increasing only from $200 million in 1960 to $329 million in 1970. “We encountered,” a GE report would conclude in 1979

> A phenomenon affecting most large companies at the time called ‘profitless growth,’ which means a tremendous growth in sales without commenurate growth in earnings.

In the emerging idiom of the financial press, GE risked being downgraded from a "growth engine" to a mere "GDP company", enduring a "profitless prosperity."[556]

This mediocre financial performance suggests an at best guarded answer to this chapter’s nexr question. How would the company's key post-war changes, Boulwarism and decentralization, perform in the 1960s? By the end of that decade GE, its main labor relations strategy of Boulwarism now outlawed, faced a unionized and united labor force. The 1972 creation of the Business Roundtable represented a circling of the Giant Corporation

[556] **Strategic Management for the 1980s. GE, 1979. HoH Collection MiSci. See also Demaree, Allen T. 1970. GE’s Costly Venture into the Future. Fortune. Oct 1970. p. 58**

wagons, under perceived (and greatly exaggerated) attack from labor, the left, consumer advocatesm and the environmental, and anti-nuclear movements. Individually each Giant Corporation's Political Action Committee amped up lobbying effort. In these efforts, GE would be a leader.[557]

In addition to politically thwarting unions , GE had continued to flee them. By 1970 GE had more than 200 plants, mostly small and dedicated to just one product. They were spread over 33 states, with a majority of the additions since 1955 in the South and West. A new development from 1957 to 1961 had been the creation of some 30 overseas plants. In the years after 1960 GE employment outside the U.S would grow to one-third of its total employment.

Decentralization had come to stay. GE was, by the 1960s, too diverse to be recentralized. Though Cordiner's rigid cult of professional management was relaxed, his assertion that a professional manager could manage anything survived. The results were unfortunate. In such businesses as electronic components, computers, and nuclear, management turnover was frequent and disorienting. Symptoms of management unfamiliarity with underlying technology included missing out on integrated circuits, and wrongly assuming nuclear plant scale economies and learning curves.

Three of GE's main management consultants would later described the pressure encouraging short range thinking that was put on Product Department General Managers.Their yearly incentive compensation , not only a big part of pay but a measure of future promotion prospects, was based only on the last's year's performance. This encouraged taking credit

[557] **Nace, Ted. 2010. Gangs of America. Barret-Kohler. Pp.142-143. Akard, Patrick J. 1992. Corporate Mobilization and Political Power. American Sociological Review. 57. 597-615. Jacobs, David C.D. 1999. Business Lobbies and the Power Structure in America. Quorum. P. 16**

for short range successes, and getting out fast. “What was not normal--,” the consultants concluded

> And considered foolhardy by many--was staying on any job for more than three years-- or staying with any business for more than a couple of assignments. Entrenchment-- in fact anything standing in the way of linear upward growth-- was to be avoided. [558]

The Borch administration had revised Cordiner's policies by returning some power to the top. Strategic planning was formalized and made more bureaucratic. The results were unimpressive. In the three big gambles, corporate strategy was inconsistent and unhelpful. In the search for wholly new businesses, the Corporate Growth Council strayed too far from the Edison Elm.

Even GE's sales- doubling success of the sixties owed less to new strategies than to old tactics. Encourage natural branching of the Edison Elm. Follow fast on inventions and innovations begun elsewhere. Find managers dedicated to and knowledgeable about the businesses, and keep them in place. All this was illustrated by such businesses as aircraft engines, advanced materials, diesel electric locomotives, GE Credit, and gas turbines, and by such independent minded managers as Gerhard Neumann, Charlie Reed, and Charlie Elston.

Finally, what light had those dimensions of corporate performance cast on the evaluation of corporate giant size? GE's 1960s experience was not unique. With twenty first century hindsight it is easy to detect signs that once lean and vigorous U.S. giants such as GE, General Motors, Ford, AT&T, Kodak, and soon even IBM were growing flabby and vulnerable. They were about to face hungrier and more agile competirors. These

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[558] **Kane, Donald. Tichy, Noel. Andrews, Eugene. 1987. A Leadership Development Framewok. GE OEN-6. Nov 1987. HoH Collection. MiSci**

included both entrepreneurial U.S. start ups and low wage, high productivity foreign rivals.

Twenty first century hindsight might detect these 1960s trends. Nineteen sixties foresight did not. Business scholars instead doubled down on giant corporation dominance. In 1967 Alfred Chandler published Strategy and Structure, extolling giant corporation efficiency.. John Kenneth Galbraith followed with The New Industrial State. For the giants, said Galbraith, " there is no clear upper limit to the desirable size. "[559]

The most sincere 1960s form of flattery for the giants was, however, not scholarship. It was imitation. The 1960s saw the launching of the conglomerate craze. This was an attempt to achieve instant giant size by buyouts and mergers. Key corporate players included ITT, Textron, LTV, TRW, and Gulf & Western.

General Electric would proclaim itself in the 1970s to be no conglomerate. It was instead, it asserted, a naturally diverse and organic evolution of the Wizard's original electric inspiration. GE further claimed that its recent episode of Boulwarism had put labor back in its proper subordinate place. Meanwhile, GE's recent decentralization gave it the benefits of both department manager initiative and headquarters staffed corporate wisdom.

Standing against GE' s rosy self judgment was that word turnkey. Had the GE 1965 turnkey program jump started the nuclear power business ? In 1970 GE still thought the answer, despite the billions of dollars of losses, was yes. In 2025 that question is better answered with another, rhetorical, question. How many different and perhaps better paths to practical nuclear power (or perhaps to the even better path of bypassing nuclear's deceptive allure altogether) had GE's turnkey impatience helped close off ?

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[559] **Galbraith, John Kenneth. 1967. The New Industrial State. (2007 edition, Princeton U. Press) p. 96**

Chapter 13. Renewal, 1970- 1986

When GE chose a new CEO in 1972, it did not pick someone likely to renew the company. Instead, it chose a man best known for retreating.That new CEO, Reginald Jones, was born in England in 1918, the son of a steel mill foreman. He emigrated to the U.S. as a boy, completed college there, and went on to earn an M.B.A. from the University of Pennsylvania's Wharton Business School. He joined GE in 1939. He completed the company's select Financial Training Program, then rose rapidly, eventually becoming Vice President for Finance. Along the way, he developed a polished appearance and aristocratic manner more suggestive of the landed gentry than of his working class origins.

On one early major assignment he handled the financial aspects of GE's retreat from its mercury turbine project . He learned that as the prospects for the turbines had gone down, the price of mercury had gone up. So much so that money paid for mercury extracted from the decommissioned turbines provided an unexpectedly lucrative consolation prize. Later, after rising in management, he was one of the Three Wise Men who guided GE's 1970 retreat from computers. Again, he found an advantageous financial angle. It involved taking payment in Honeywell stock and then taking advantage of related tax loopholes. Again it eased the sting of business defeat.Jones was not, however, chosen CEO in 1972 for the purpose of supervising more retreats. It was Business Week magazine that explained Jones' selection correctly. Jones, it said "vaulted to the top spot because of his knowledge of strategic planning." [560]

[560] **Business Week. 1972. "GE's Strategy for Faster Growth." July, 1 972.**

Jones would, however, be best remembered in GE not for a planning triumph but for a personnel action. Early in his term, in preparing a CEO succession list, he reached down the organization chart and added the name of a man his Advisory Council thought too young to be CEO. When Jones departed in 1981, he would pick as his successor that late addition to the list, 45 year old Jack Welch. Those two CEOs were, while in office, showered with audulation. The first was touted as as America's most influential Jones, the second as CEO of the century. (Only in the next century would Welch's capsule description be changed to "the man who broke capitalism. ")They were indeed very different leaders. Jones led ethically and cautiously. Welch responded boldly and unconventionally, raising questions about his business and personal ethics. Both, however, did more responding to the economic constraints of the 1970s and 1980s U.S. than crafting Chandlerian strategies

Why, after a century of still robust health, did Welch put an end to the Old GE? How did that ending matter to the wider world? Those are the questions this chapter answers.

In 1972, when Jones took over, times were stormy. National headwinds included the emerging Watergate scandal, a turn of the U.S. economy from a decade of prosperity to a decade of stagflation, the beginnings of an energy crisis, and the winding down of the disastrous and divisive Vietnam War. Like previous wars, Vietnam had offered GE good growing weather. Aircraft Engines and the weapons portion of GE Aerospace had particularly benefitted. Sales of GE's main military turbojet of that era, the J79 , would total 74,000 engines.

Unlike previous wars, however, Vietnam also generated vocal opposition within GE. At the GE Research Lab, for example, there emerged in 1970 a chapter of Scientists Against the War. Among its leaders was one of the company's most distinguished scientists. As an astrophysicist, Ralph Alpher had in the late 1940s been an pioneer of the Big Bang theory of the the universe. At GE's Research Lab In the 1960s he had explored a futuristic energy generation idea called magneto hydrodynamics. Now, in the early 1970s, he stood in protest demonstrations on the traffic circle outside that lab. He appeared on national TV along with other prominent anti-war scientists . He was subsequently summoned before a company VP. There

he did not encounter the expected rebuke. Instead, the two took part in a respectful dove vs. hawk discussion. Neither mind was changed. [561]

As that war limped toward its end, GE Aircraft Engines was finally making its own transition from war to peace. This transition was initially powered by a contract to put GE's CF6 turbofan on one particular highly visible Boeing 747-- the U.S. President's Air Force One. In 1974 KLM Dutch Airways followed by becoming the first airline to select a CF6 for a Boeing 747.By the end of the 1970s, GE CF6 engines were on nearly 400 commercial airliners owned by more than 50 airlines worldwide. GE was pulling even with Pratt & Whitney in the contest for #1 engine supplier. It has taken 30 years to reach commercial airline engine profitability. Only the government funding provided by its military jet engine business had enabled this long stretch of very expensive patience.

GE Nuclear also initially seemed in 1970 to at last be sailing before favorable winds. Annual BWR orders reached double digits by 1972. The arrival of a 1973 storm seemed not to disrupt, but further to propel, nuclear power. That storm was the 1973 oil crisis. The embargo of Middle Eastern oil imports left Americans waiting in long lines outside gas stations. The problem was erroneously depicted not as a specific and temporary oil shortage, but as a general and long term "energy crisis". What could fix that crisis better than clean, convenient, and wholly domestically produced nuclear power?

The answer, quickly and surprisingly, became -- almost anything else. In just a few years, the previous nuclear advance would become first a retreat, then a rout, and finally a moratorium.

Anti-innovations, like innovations, are carried out by a repertory company of scientists, engineers, consultants, customers government regulators, the public, the media and more. The full story of nuclear's anti-innovation is complicated. Neither of the two popular simple answers suffices. Nuclear was not simply murdered by the exaggerations and unscientific "nuclear fear" of environmentalists and anti-capitalists. Nor, however, did nuclear simply commit suicide, betrayed by the cost overruns, exaggerated promises,

[561] **Ralph Alpher Oral History 14 May 1981. HoH Collection MiSci.**

and cover ups of the reactor manufacturers, utility executives, and their captive Federal regulators.[562]

That 1970s retreat from nuclear power was described from the GE perspective in 1982 by the then manager of GE's Nuclear business, Warren Bruggemann. " The oil embargo of 1973,"he said,

> was misread by the nuclear industry, which had expected nuclear energy to be the panacea. But the cost of electricity shot skyward and conservation became a byword.The political climate turned hostile. The bottom of the nuclear market fell out. [563]

A 1984 study by the U.S. Office of Technology Assessment would conclude that nuclear power in the U.S. was " unlikely to be expanded" for at least the rest of the 20th century because nuclear plants

> present too many financial risks as a result of uncertainties in electric demand growth, very high capital costs, operating problems, and increasing regulatory problems.[564]

Much of what happened to nuclear was outside GE's control. For example, in 1971 the Supreme Court ruled that nuclear reactor approval required a full Environmental Impact Statement. This significantly lengthened the time from proposal of a reactor until its operation. Since reactors were built with borrowed money, this extra time translated into higher costs.

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[562] **Sources tracing the fate of nuclear power in the U.S. used as the basis of the following discussion of nuclear power include Mahaffey, James. 2009. Atomic Awakening. Pegasus; Matuzan, George and Walker, J. Samuel. 1984. Controlling the Atom. U.Cal; Campbell, John L. 1988. Collapse of an Industry. Cornell. Duffy, Robert J. 1997. Nuclear Politics in America. Kansas. Bupp, Irwin and Derian, Jean Claude. 1978. Light Water. Basic. Weinberg, Alvin. 1994. The First Nuclear Era. Springer**

[563] **GE Monogram. March-April 1982. Vol. 39. P.2**

[564] **U.S. Office of Technology Assessment. 1984. Nuclear Power in an Age of Uncertainty. OTA-E-216. p. xi.**

Another influence beyond GE's control was the entry into the fray on the anti-nuclear side by knowledgeable scientists. They entered via such organizations as the Union of Concerned Scientists and the Scientists Institute for Public Information.They brought public attention to problems ranging from thermal pollution of rivers and lakes by nuclear plants to the still unsolved problems of reprocessing or storage of spent nuclear fuel

One important issue stemmed from one way a nuclear steam boiler differs from a conventional steam boiler. When a conventional boiler's fire goes out, the fuel quickly cools off. When a nuclear "fire" goes out, the nuclear fuel stays hot much longer. Suppose, for example, that a power plant was struck by an accident such as an earthquake or tsunami and was shut down. Under such condtions, a conventional boiler's fuel would cool off without doing any further damage.

In a nuclear reactor, by contrast, an accident such as an earthquake might cause a break in a pipe that supplied water to cool the nuclear core. In that case, the nuclear fuel might stay hot long enough to melt its way through the steel reactor vessel, and down into the ground. The popular term attached to such an event, initially as a joke, was "the China Syndrome" (that is, melting all the way through the earth to China) . This massive exaggeration provided potent anti-nuclear propaganda, including the title of an anti-nuclear Hollywood movie.

Though the publicity was vastly exaggerated, there was a genuine underlying problem. The melting of a reactor core could cause the release of radioactive materials into the air or water. The possible number of deaths that might result was estimated by responsible expert studies such as the AEC's 1970 Rasmussen Report, to be as high as thousands. The possible dollar costs extended up into the billions. To prevent such consequences, GE had in the 1960s developed the Emergency Core Cooling System (ECCS). In the event of an accident such as a pipe break, the ECCS would flood the nuclear core with water. This would keep the core cool enough to prevent a meltdown.

GE’s proposal of this solution was controversial. Initial experiments on a small scale test reactor at the AEC’s Idaho test facility, supplemented by computer models proved ambiguous. Effective interrogation of the AEC by opponents from the Union of Concerned Scientists fed public suspicion that the Atomic Energy Commission, in its dual role of both nuclear power promotion and nuclear power safety assurance, was allowing the promotion

role to overpower the safety role. This led in 1973 to the splitting off the safety role as a separate agency, the Nuclear Regulatory Commission (NRC). To GE's relief, its ECCS solution, as revised and improved by knowledge gained over many years of small scale experiments and computer simulations, was ultimately accepted in 1973 by that newly created NRC. It would take nearly 40 years for the GE ECCS to get its first full scale live test.[565]

That test followed the 2012 earthquake-caused tsunami that struck Japan. The GE BWRs operating at Fukushima, Japan shut down. The ECCS did initially cool the reactor cores. That ECCS, however, depended on electric power to run its water pumps. The quake and flooding knocked out both the normal electricity supply and the diesel generators supplying emergency power. Only heroic improvisation by local personnel prevented the disaster from spiraling out of control. The damage that did occur has already cost billions of dollars, and will continue to cost billions more. It caused the evacuation of hundreds of square miles of Japan. As for human life, the web site Our World in Data provided in 2023 the following summary

> No one died directly from the disaster... 40 to 50 people were injured as a result of physical injury from the blast, or radiation burns.... one worker has since died from lung cancer... for local populations. there appears to be no increased risk of cancer or other radiation-related health impacts.

Fukushima proved to be the one serious accident encountered by a GE BWR in the first 60 years since the first one went into operation at Dresden IL in 1960. That rate of one accident per some 3000 reactor years years is more than the expected rate of less than one accident per in 10,000 reactor years projected in that Rasmussen Report. On the other hand, the record of extremely low level of death and injury from nuclear power stands in sharp contrast to, for example, the vastly higher level of coal related death and damage.

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[565] **Wellock, Thomas, 2012, Engineeering Uncertainty and Bureaucratic Crisis at the Atomic Energy Commission, 1964-1973. Technology and Culture. 53. 846-884. Dr, Wellock also provided further clarification of the ECCS issue via a personal communication.**

Nuclear 's safety record reflects the dedicated, responsive, and effective effort to assure the safety of nuclear reactors made by GE and its competitors. Where those reactor manufacturers can be criticized is in their rushing this technology into action between 1960 and 1970 before its complex characteristics were fully understood . That impatience led to massive cost overruns as the ECCS and many other environmental and safety fixes were added to licensing requirements. These safety related changes did contribute to the rising capital costs of nuclear power. To at least as great an extent, however, cost increases were imposed by the industry's own misjudgments.

In particular, the economies of scale and learning curve effects expected under the turnkey program never happened. Instead, through the 1970s, diseconomies of scale and insufficient learning continued to raise construction costs. In 1963, GE had claimed its turnkey program would teach it to build nuclear power plants for about $100 per KW. By the mid 1970s, nuclear power plants were costing more than $3000 per KW. Those rising costs helped reverse a seven decade long record of falling U.S. electricity prices. The costs, and liabilities of nuclear reactors drove some utilities to the edge of bankruptcy. It was more this unfavorable nuclear economics than it was nuclear's dangers that killed U.S. nuclear power. The 1979 accident at Three Mile Island only confirmed a moratorium on new orders that had already begun.

Nuclear electric power had by then been revealed as an unnecessary technology. Fossil fuel was abundant and offered cheaper electricity. Only in the late 1980s would a scientifically-based and evidence-supported reason emerge to go nuclear. That reason would be climate change. By then, nuclear had been, whether justly or unjustly, thoroughly discredited. In the early 21st century, solar and wind power would replace it as the currently preferred alternative to fossil fuel. [566]

Meanwhile in the 1970s, GE management was caught unawares by a more general energy related change. This was the deceleration of total U.S. energy use. From 1890 to 1970 total U.S. energy use at least doubled in every decade but the 1930s. By 1970, that era of decadal doubling was over. That energy deceleration was just part of a more general U.S. and world

[566] **Weart, Spencer. The Discovery of Global Warming. Harvard confirms that it was only in the late 1980s that the transition of climate change from hypothesis to knowledge began to influence the public.**

economic deceleration. U.S. economic growth, productivity growth, and increase in use of raw materials, as well as world population growth, all also decelerated . "The 1970s, " wrote economic historian Adam Tooze in 2023 , "is really the moment where much of our modern configuration comes clearly into existence."[567]

GE strategists at first misinterpreted this modern configuration. They viewed the energy deceleration as a temporary dip. In particular, they expected U.S. electricity use to return quickly to its long term decade-doubling trend. Even with the expectation of this return to decade-doubling, there were reasons for alarm. In May, 1972, GE strategic planner John McKittrick explained to the GE Corporate Executive staff that

> Over the past 24 months wer have become increasingly aware that our power generation businesses are facing an entirely new set of conditions which, in the worst set of conditions, has the potential to convert an area of potential company strength into a situation of serious weakness.[568]

This new set of conditions, McKittrick said, included the entry of oil companies into the coal, uranium and nuclear fuel businesses, the need to build progressively larger power generation systems while meeting more stringent demands of environmental and reliability issues, and the "deteriorating trade position of U.S. manufacturers" in the face of foreign competition that had already created a "horrendous amount of excess manufacturing capacity.".

Another GE planner, a corporate gadfly named John Fisher would craft responses to these alarming trends. He had been trained as a metallurgist, but in his GE career he ventured into theories of everything from the mechanics of cancer to the physics of elementary particles. As a manager at GE's Research Lab he had mentored a Nobel Laureate. Now in the early 1970s he worked at GE's California think tank, TEMPO. There, in both an externally published book and in internal company correspondence , he would explain how the company has gotten both ends of the energy situation

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[567] **Adam Tooze. 2023 Speech to Davos International Forum. 15 Feb 2023.**

[568] **McKittrick, John B. to Corporate Executive Staff, Power Generatino Study. 12 M1y 1972. John Fisher Papers, MiSci.**

wrong.On the supply side, there was no general energy crisis. Energy sources were, he said in "abundant supply".[569]

On the demand side, he predicted in advance the coming deceleration in electricity use. Those who listened to him were glad they did. For example, GE Power Systems had initially relied on corporate strategic planning's estimare that electricity use would continue to double every decade. This had led to plans to make a $300 million expansion in its facilities for building generators. However, as Power Systems manager Thomas Lee recalls,

> because of Fisher's analysis, GE did not proceed with the expansion. The postponements and cancellations in the second half of 1974 proved the wisdom of that decision.[570]

As Fisher warned, the next doubling of U.S. electricity use would take not 10 but 25 years.Combined with the growing global competition in electrical manufacturing, this flattening of demand left GE with a big share of that large manufacturing overcapacity about which McKittrick warned . Of all the external trends faced by GE in the 1970s, it was that deceleration of U.S. electricity use and resulting overcapacity that contributed most to the decline and fall of the Old GE.[571]

This misunderstanding of future trends did not arise from lack of studying. Jones had greatly increased GE's strategic planning effort. The businesses and the Corporate components got new homework assignments. Each had to annually fill several thick three-ring binders with the details of an annual strategic plan. These plans were subjected to multiple corporate reviews. The process would culminate at corporate headquarters with a presentation to Jones and his top executives to obtain approval for the component's next year's budget.

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[569] **Fisher, John. 1974. Energy Crises in Perspective. Wiley; Fisher, John. 1974. Prospects for Energy Self Sufficiency in the U, S. NAS Draft 7 Jan 1974 and "Talk to Energy Goals and Environment Onference, 4 Nov 1971. John Fisher Papers. 2018-005. MiSci.**

[570] **Lee, Thomas H., Ball, Ben; Tabors, Richard. 1990. Energy Aftermath. Harvard Business School.**

[571] **Data on this deceleration is in Ayres, Robert and Leslie, and Vladimir Pokrovsky. 2004. On the Efficiency of U.S. Electricity Use Since 1900 International Institute of Applied Systems Analysis Report IR-04-027**

This climactic event was an hour long reading of a fully typed out script by the component manager. It was illustrated by hundreds of slides projected with machine gun staccato and precision from multiple Kodak Carousels, the mechanical predecessors of PowerPoint. Jones and his Advisory Committee would listen in silence, some occasionally dozing off. At the conclusion, discussion was perfunctory. Jones, no technologist, would ask a question, possibly presupplied, about some arcane technology detail. The presenter would appear suitably stumped by the CEO's demonstrated technical chops. Jones would then conclude with a noncommittal promise to give the budget request his serious consideration. [572]

This ritualized months-long planning process caused bureaucracy to balloon, both at the component and the Corporate level. The components created their own strategic planning staffs to prepare the lengthy paperwork, as well as hiring speechwriters and creating visual aids and photography departments to illustrate those elaborate budget reviews.All this had the unfortunate effect of reducing GE's internal communication to ghostwritten incoherence. This was illustrated in the early 1970s when GE created an internal engineering award named after Charles Proteus Steinmetz.

The company's Vice President of R&D was assigned to present the award. Rather than doing so spontaneously, he insisted on a ghost written speech, one that would begin with a Steinmetz anecdote. His speechwriter obligingly dug one up. The anecdote concerned a terrarium in Steinmetz's home laboratory. There he kept his pet iguana. When showing visitors around, Steinmetz would tell how the iguana controlled its body temperature by its running speed. It would run around its cage fast on cold days and slowly on hot days. "So," Steinmetz would say, "if I had a stopwatch and an iguana, I wouldn't need a thermometer. " He'd then add "and if I had a thermometer and an iguana, I wouldn't need a stopwatch! " Most visitors responded with appreciative chuckles. Not so a visiting student. She turned to him and said: " Yes Dr. Steinmetz, and if you had a stopwatch and a thermometer, you wouldn't need that damn iguana! "

That story has been told in full to show its many appearances of that word "iguana." The busy Vice President had not had time to rehearse. In his first

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[572] **I was there, in the projection booth, pushing buttons to advance the Carousels, and observing the occasional dozing off and Jones' brief responses.**

reading, at the actual event, he soon came upon a word with which he was unfamiliar. He gave it his best effort: "Steinmetz had an "eye-goona". " The audience only chuckled. With each repeat of that challenging word, however his attempts at pronunciation strayed further from correctness. This was accompanied by growing audience laughter. He finally finished, red faced and fuming. His mood was not improved when the next speaker turned to him and said " don't worry-- we hired you to run a research laboratory, not a zoo!"[573]

In a similar manner GE's Annual top management meeting, intended for airing important company issues, became instead a mind-numbing parade of clumsily read ghostwritten scripts. This did, however, have the positive effect of making the only two spontaneous presenters stand out. Gerhard Neumann's German accent, and Jack Welch's stutter, did not detract from, but rather humanized, their unscripted remarks. Welch's profanity, and Neumann's reference to big-busted secretaries, would not be accepted today. In the 1970s, however, these were seen as personal touchess, helping GE's two most highly regarded managers spontaneously and convincingly convey important, if sometimes inconvenient, company truths. [574]

To house the corporate portion of that bureaucratic overload, Jones moved GE Headquarters from an older office building at 570 Lexington Avenue in Manhattan to full occupancy of two large multistory brand new buildings on a park-like 68 acre plot in Fairfield CT. Nearby were golf courses suitable for Jack Welch's single-digit handicap. Filling the buildings, the Corporate staff increased from a few hundred to about 2000.

What did this amplified strategic planning effort and bigger bureaucracy bring forth? The only important strategic move Jones made as incumbent was to buy Utah International, a company that mined coal, uranium and iron ore. Its main business was selling coking coal to Japanese and European steel companies, helping them compete with their U.S. rivals. The owner of Utah International , Edmund Littlefield, was a GE Director and became the possessor of the largest individually-owned block of GE stock.

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[573] **I supplied the Steinmetz story to the Vice Presidential speechwriter, who was at the event and told me these details soon afterward.**

[574] **Recordings of these meetings were listened to by lower level company employees, including me. The sharp contrast described above was evident to all of us.**

Utah International was initially profitable for GE. By the early 1980s, however, it has settled in as just another highly cyclical, slow growth, low profit, old economy dinosaur. In 1983, just two years after Jones left office, his successor sold it. Otherwise, Jones' 1970s planning effort, though divesting GE of a few minor businesses, mostly maintained the status quo. As a 1980 GE strategic planner put it, the process produced "the contradiction of a steady state GE and a changing world".

Fortunately for GE, the company's bottom-up entrepreneurship occasionally overcame its top-down strategic somnolence. It did so through GE's century old tactics. Get good ideas from outside and follow fast with diverse technology teams. These tactics had worked for steam turbines in the 1900s, refrigerators in the 1920s, and advanced materials in the 1950s. They would now, in the 1970s work again.

Crucial to this 1970s synergistic success was the GE Research Lab. This was a reawakening for a lab that had slumbered since the glory days of Whitney, Coolidge, and Langmuir. Since moving to a new building well out of sight of the Schenectady Works, it had assumed a pure research emphasis. Though producing good science, this proved of diminished relevance to the needs of most of GE's businesses. For example the lab's physicists achieved in the 1960s notable research results that earned four memberships in the National Academy of Sciences and a 1973 Nobel Prize. Perhaps the best testimony to the lab's quality was that the 1973 Nobel Laureate for Physics, Ivar Giaever, was regarded by his colleagues at the GE Research Lab as only their third best physicist.

That 1973 award contrasted sharply with GE' s other Nobel. The 1932 Laureate, chemist Irving Langmuir, had done his prize winning work in the middle of GE's Schenectady Works. In that industrial setting he had drawn on his scientific insights to contribute mightily to GE businesses. One of his patents helped secure for decades GE's virtual monopoly of light bulbs. One of his papers propelled GE into leadership in the first electronics revolution. His subsequent hundreds of papers and dozens of patents showed a similar mixture of scientific excellence and industrial value. Giaever, by contrast, achieved his major discovery in a suburban laboratory far from the bustle of the Works. Neither his prize winning discovery, superconductive tunneling, nor his subsequent work, were ever picked up by GE businesses.

His winning of the prize was a heartwarming story of a young outsider who made good. He had been educated as a mechanical engineer in his native

Norway. After emigrating to Canada he joined GE. A training program brought him to Schenectady. There a temporary assignment uncovered his interest in and talent for physics. He was a new member of John Fisher's research group at GE's Research Lab, and still working on his Ph.D. at nearby RPI, when he made that prize-winning discovery of superconductive tunneling. When he won the Nobel , his colleagues uniformly (and sincerely) said "it couldn't have happened to a nicer guy." His subsequent career, however, can be summed up in the subtitle he gave to his autobiography: "a Nobel laureate's difficult journey."[575]

More generally, in the quarter century following World War 2, the insights and inventions of GE Research's excellent team of physicists and electronics engineers seldom achieved their intended impact. Fortunately, a string of successes in another field from the 1930s through the 1960s saved the lab's bacon. GE Research's chemists and chemical engineers, though a minority of the lab's staff, collectively had Langmuir-like impact on GE's highly successful advanced materials businesses. Key Research Lab materials innovators and engineers were Eugene Rochow and Charlie Reed in silicones, Tracy Hall, Herb Strong, Francis Bundy and Bob Wentdorf, in man made diamond and its nearly-as-hard GE-developed cousin Borazon®, and Dan Fox, Al Hay, and Edith Boldebuck in plastics. Fox's Lexan® was GE's biggest materials success ever. Boldebuck's discovery that certain plastics could be alloyed like metals made it possible to turn the excellent but hard to process plastic that Hay discovered called PPO into a more processable commercial success called Noryl®. Boldebuck went on to set the GE record for most U.S. patents by a woman.

Now, in the 1970s one more chemical engineer would have the chance to jump start a GE business. This time, however, the target would be outside that field of advanced materials. Instead, the opportunity would for once enable the Research Lab's physicists, electronics engineers and computer experts to outshine their chemical cousins.

The story began in 1969 when Godfrey Hounsfield, an electrical engineer at the British Company EMI, invented CAT Scanning. EMI, whose acronym stood for Electrical Musical Instruments, was until then best known for producing the records of the Beatles. Overnight it became a leader in medical diagnostics. CAT scanning married X-rays and computer power.

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[575] **Giaever, Ivar. 2017. "I am the Smartest Person I Know": a Nobel Laureate's Dufficult Journey, World Scientific.**

Swing an X-Ray tube in a circle around a patient's body, with the X Ray tube on one side and detectors on the other. Take lots of data during that circular swing. Then send that data to a computer. It could reconstruct from that data a detailed image of a cross sectional slice of the patient. The payoff was unprecedented high resolution of the patient's insides, enabling, for example, detection of previously undetectable tumors.

Experts at GE X-Ray were impressed with the ingenuity, but initially did not see it as a business . It seemed a limited research tool, too expensive and specialized to be bought by a typical hospital. Then a flood of EMI orders, soon labeled "CAT fever" , caused GE to take a second look.Taking that look in 1972 was GE X-Ray's recently appointed manager, Walt Robb. He was another of the company's Ph.D. Chemical Engineers. He had started his GE career at its nuclear power lab, KAPL, then moved to the GE Research Lab, then into management. He rose steadily, if quietly. His one splash of publicity was appearing in a photo in Life Magazine, beside an aquarium in which a hamster in an underwater cage survived by breathing oxygen separated from the water by a membrane Walt invented.[576]

People meeting Walt might be misled by his simple, frank, jargon-free speaking style, political conservatism, and occasional malapropisms into underestimating him. Anyone who spent much time with him, however, soon realized that he was perhaps GE's most astute judge of technical and business promise.

Walt's promotion to manager of GE Medical In 1970 was no plum assignment. That business had decades ago parlayed William Coolidge's X-Ray tube into profitable success. There were, however, only a limited number of things you could do with conventional X-Ray apparatus. By 1970 GE had done most of them. The choice now before the business was going into CAT or going into hibernation. It was not really a choice at all. In 1972, Walt concluded that GE should follow EMI. It should, however, do it not by duplicating EMI’s system, or purchasing one of the EMI imitators, but by developing its own version of CAT.[577]

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[576] **Robb, Walter, 2017. Taking Risks. Leon Janssen.**

[577] **The discussion of GE innovations in medical technology that follows relies in part on Morone, Joseph. 1992. Winning in High Tech Markets. Harvard Bysiness School Press. pp. 27- 64, and on the story I told in a report I produced for GE entitled Research and Results.**

He consulted physicists, physicians, electrical engineers, and computer hardware and software experts. From them, he learned that there was more than one way to scan a CAT. One such way especially caught the GE study team's attention. If you replaced the thin, cylindrical "pencil beam" of X-Rays in Hounsfield's scanner with a broader, diverging "fan beam", this theoretically enabled not only a better image but also a a faster scan--reducing that scan time from more than two minutes down to less than ten seconds. This allowed patients to hold their breath and avoid blurring the image by body motion due to breathing.

This fan beam idea was already known to others. Hounsfield had rejected it. Others were trying it. They had not yet succeeded. Here GE, as previously in turbines, refrigerators and aircraft engines, had advantages that rivals lacked. Specifically, GE had lots of money, and lots of people on hand with the needed specialized skills who could be thrown immediately into action. GE Research Labs experts in such fields as electronics hardware and computer software were looking for new projects after GE's recent retreats in their fields. Walt Robb proposed to use them in a crash program at the Research Lab to build a fan beam CAT scanner. In this he had two enthusiastic allies: Research Lab director Arthur Bueche, and Walt's own boss, the Vice-President of the GE Components and Materials Division, Jack Welch.The Research Lab immediately mobilized a crash program. The initially high tension was heightened by continual calls for more speed by Welch and Bueche.

Robb's choice for the CAT scanner team's immediate manager was Rowland "Red" Redington. Round and mustached, cheerful and apple checked, with a frequent barking laugh, Redington looked and sounded more like a small town grocer than the Ph.D. physicist he was. He was skeptical of the creed of professional management. His own management priority was protecting his own technical team from excessive pressure from above.[578]

One episode in the many sided effort stands out . Rey Whetten was a precise, soft spoken expert in the "old electronics" of vacuums, gases, and electronic tubes. He had earlier helped develop an improved TV tube that had lost out in competition with RCA. That was as close as he had previously come to business success.Now he was asked to pinch hit a home

[578] **Interviews with R.W. Redington, A.C.M Chen, and W. Berninger. Oct 1982**

run. His somewhat obsolescing old electronics expertise was, just at that moment, just what GE needed.

The X-rays used in a CAT scanner lose intensity by being absorbed by body features of varying density (flesh, blood, bones, etc). Measuring the remaining intensity provides the data that enables the computer to create an accurate image of a body slice. At this time, in 1976, the best way to measure ordinary light intensity had become the solid state detectors used in the new electronic cameras. An obvious choice for CAT was using similar solid state detectors for X-Rays. Twenty first century CAT scanners indeed use solid state detectors.

In 1973, however, solid state was not quite ready. The old electronics still worked better. Hence the need for Rey Whetten's excellent mastery of those old fashioned skills. He was given a make or break opportunity. "My manager came to me," he said later, "And told me he had put my continuity of service on the line." Rey kept his job. He developed a detector that enclosed the gas Xenon, under high pressure, in many thin chambers side by side. Each chamber acted as a separate detector. It turned the remaining energy of the X-rays into a more collectible and measurable stream of electrons. The outstanding sensitivity, speed and multiplicity of these Xenon detectors enabled faster production of higher resolution scans than achieved by competitors' CAT scanners. [579]

This episode only scratches the surface of an astonishingly complicated, pressure packed crash program. It took dozens of specialized, talented, and dedicated contributors, working long hours under frequent top management harassment, to squeak the project through to success. In 1978 Walt Robb introduced GE's own CAT scanner. It quickly rose to profitability and kept rising. GE not only passed EMI, it ended up buying EMI. By 1988, GE and Siemens shared world leadership in CAT scanner sales.

It has been said that nobody should be regarded as a great technology manager unless he or she creates two huge successes. That requirement eliminates almost all contenders. It does not eliminate Walt Robb and Red Redington. In the early 1980s, they would repeat their 1970s success. Again, it was an inventor elsewhere that got things started. Paul Lauterbur was a physics professor at SUNY Stony Brook when he conceived a remarkable

[579] **Interview with Rey Whetten, 27 Jan 2023**

idea. He showed how a quantum physics based chemical analysis technique called nuclear magnetic resonance could be used to image the human body. (To avoid confusion with bombs and reactors, the word nuclear was soon erased. The sanitized name became Magnetic Resonance Imaging (MRI).)

Once again, GE was slow out of the gate. Once again, Walt Robb was at the helm of GE Medical. Once again he chose for GE to develop its own distinctive device. Once again Arthur Bueche and Jack Welch were enthusiastic allies. Once again Red Redington assembled the needed Research Lab team.

This time, however, the Research Lab did not have all the skills needed. No one at the GE lab had fully mastered MRI. By 1980, that technique had advanced from Lauterbur's conceptual breakthrough to lab prototypes at British universities. There actual, though crude and not medically useful, images were being made. The apparatus was developed with the inexpensive labor of recent physics doctoral recipients. Bueche saw a names of a couple of those postdocs on the author line of scientific papers about MRI. Soon two of them were GE Research Lab employees and on its MRI team.[580]

The two physicists quickly moved to the forefront and led the project to success. Bill Edelstein had grown up in the Schenectady area. A contentious polymath, he described himself as only a so-so Harvard Ph.D physicist. Offered postdocs in either MRI or gravity wave detection, he decided that MRI was more likely to succeed in his lifetime. As a postdoc, he obtained a patent that would prove crucial to practical MRI systems. At GE, he led the development of components such as coils that improved imaging capability. Sadly, in forecasting the progress of physics, he proved a prophet. After making those crucial contributions to GE's MRI development, and seeing MRI become a standard medical technique, he died just a few years before the announcement of the first detection of gravity waves.

Paul Bottomley, a soft spoken Australian, had worked a Britain’s University of Nottingham on MRI as a graduate student, with a future Nobel Prize winning physicist. When the GE team planned its MRI approach, a key decision was how strong a magnet to use. The conventional wisdom was to use only a moderately strong magnet, .8 Tesla in magnetic field strength.

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[580] **Interview with Howard Hart 27 Jan 2023. This section also benefits from many conversations in the 1980s and 1990s with Bill Edelstein.**

Anything much stronger would cost more, yet would not improve, or even might degrade, the image.

In one of his pre-GE papers, Bottomley had challenged that conclusion. A stronger magnet, he argued, could improve images. GE went with his view. It doubled the magnet strength. Its 1.5 Tesla magnet improved images enough to become the industry standard. Due to the efforts of a multidisciplinary R&D team at Schenectady of which Edelstein and Bottomley were the leaders , and an equally effective team in Wisconsin turning the research prototype into a product, GE jumped into the MRI lead. GE Medical Systems became by the late 1980s another GE multi billion dollar high tech growth success story.

Walt Robb, would later complain that his achievement was not honored on a par with Silicon Valley's entrepreneurial superstars. After all, he had built not one but two multibillion dollar high-tech businesses.His achievements were indeed remarkable. His request for that added recognition was, however, a bit excessive. Those Silicon Valley entrepreneurial superstars had hit their home runs from the batter's box. Walt's command of GE's money and its Research Lab talent had enabled him to start, if not on third base, at least on second.

More generally, in medical diagnostics GE was once again just one supporting actor in a improvisational repertory theatre like innovation. GE did not invent either CAT scanning or MRI. Instead it applied "yes-and" ideas. Yes, Hounsfield's invention is genius, and do it with a fan beam. Yes, Lauterbur's invention is genius, and do it with a 1.5 Tesla magnet. GE's medical diagnostics success was a triumph of synergy over strategy. It joined such previous synergistic unstrategized successes as aircraft engines, plastics, and diesel locomotives.

Even more significant was the continuing rise of GE Credit. From 1976 to 1981 its net earnings rose 18% a year, passing the $100 million mark and contributing 7% of the company's total earnings. By 1981 it owned and leased more than 90 jet airliners, 43,000 railroad locomotives and cars, and the largest U.S. fleet of merchant vessels. It was moving beyond industrial financing into consumer and real estate finance and insurance.[581]

[581] **GE Monogram Vol. 58. Mar-Apr 1981**

Leading this expansion was department manager John Stanger. Far from strategizing this expansion, or even supporting it, Jones had tried to shut it down. "The business worried him. He thought we were beginning to take too many risks, " wrote David Dance, the group executive to whom Stanger reported. Dance says Jones told him "to replace Stanger with a more conservative man. " Dance replied that if that was done, Jones would also have to replace him. Jones backed down. Added Dance " he never interfered with me again regarding GE Credit Corporation. "[582]

Those GE Credit earnings were only the smaller part of its contribution to GE. The 1981 tax bill passed early in the first presidential administration of Ronald Reagan allowed corporations to claim increased tax credits for depreciation and other investment -boosting efforts. Such tax benefits claimed by GE Credit reduced GE's corporate tax bill from just over a billion dollars down to $145 million. Forbes Magazine subsequently reported that GE not only “paid not a dime in federal income tax” on 1981-1983 pretax earnings, but even claimed tax refunds of totalling $315 million. A study by investigative reporter Philip M. Stern estimates the total “tax savings” racked up by GE in 1979- 1986 at $4.7 billion.[583]

Skeptics might label tax breaks favorable to GE to be no coincidence. After all, they were engineered by GE's most famous alumnus. There is, however, little if any evidence, that Reagan was GE's stealth presidential candidate. Such evidence as exists points in the opposite direction. Reg Jones had been a key adviser to President Jimmy Carter. At a 1980 GE Management Meeting he confidently predicted Carter's re-election.[584]

As for that tax bill, business journalists reported that the benefits to GE from the 1981 tax bill were so outrageous that the tax bill passed in 1986 to plug some loopholes was known on Capitol Hill as the bill to “get GE”. According to President’s Reagan’s chief of staff, it was Reagan’s anger at

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[582] **Dance, W. David. Memoirs. Privately Printed 2007. Pp. 116-117. Stanger's role is also emphasized in a history of the New GE, Cohen, . 2022. Power Failure. Penguin.**

[583] **Stern, Philip M. 1988. The Best Congress Money Can Buy. Pantheon. p. 289**

[584] **GE Annual Report 1984. King, Ralph. 1988. Last Laugh. Forbes 22 Feb 1988. I was in the audience when Jones made that prediction.**

his former employer's total escape from taxes that convinced the President to back that 1986 tax reform.[585]

Those GE Capital contributions, however obtained, helped Reginald Jones in 1981 to pass GE on in good economic health to his successor. In his nine years at the helm the company's sales had once again doubled, reaching $ 27.4 billion. Earnings also had more than doubled, to $1.65 billion. These were, however, inflation boosted numbers. In real terms, GE , which in its earlier days had grown twice as fast as the U.S. GDP, was now growing at only the same rate as that GDP. It was still a mere GDP company. Its prosperity, no longer profitless, was still judged by Wall Street as insufficiently profitable. That $1.65 billion earnings represented an adequate but unspectacular earnings-to- sales ratio of 6%.

Those figures might, however, be interpreted not as failure, but as maturity. GE had, for 90 years, ridden the electrical wave to achieve greater-than-GDP growth. Now the electrical wave had begun leveling off. So it was reasonable to expect GE also to level off. It could settle into a useful role making those earlier innovations still more efficient, more affordable, and environmentally cleaner. Such a modest, useful role was, however, anathema to both GE management and investors. Wall Street was embracing a view, most prominently expressed by economist Milton Friedman, that a corporation's only social responsibility was to maximize financial return to its shareholders. The old Swope-Young idea of serving the balanced best interests of workers, communities, country, industry, and shareholders had long since been discarded. Responding to this tenor of the times in 1981, Reginald Jones chose as his successor a man who would become fully committed to that stockholder-serving single-responsibility gospel.

Jack Welch was the son of a conductor on the Boston and Maine Railroad and a schoolteacher. It was his mother Grace who most influenced and encouraged him. As he battled a stutter, she assured him that it was only his mind working faster than his mouth. Indeed, that stutter, greatly reduced, would serve as a sort of special effect for his powerful, straight talking,

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[585] **Hector, Gary. 1985. GE Credit Corp Braces for the Tax Reformers. Fortune 5 Aug 1985. King, Ralph. 1988. Last Laugh. Forbes 22 Feb 1988.**

speaking style. Similarly he parlayed modest physical assets into a place of his high school hockey team and excellence as a golfer.

He earned his undergraduate degree at the University of Massachusetts, following up rapidly with a Ph.D. in Chemical Engineering from the University of Illinois and a first job at GE. There he avoided company stereotypes. His rise took place at a relatively obscure GE location, Pittsfield MA, in an unconventional GE business, plastics. There he became GE's most successful young manager by becoming its least sentimental, least conventional, and most brutal opportunist. When his appointment as CEO was announced in 1981 , nearly everybody in GE said that he was the best person for that job. Nobody said "it couldn't have happened to a nicer guy. "

That Jack Welch was a flawed human being was agreed to not only by his detractors but also by his admirers. One of those admirers referred to Welch's "volcanic nature", depicted him as uttering "a string of obscenities so awful I wouldn't want my mother to read them, " and noted how, in Welch's GE, "civility was no longer a virtue, and splatters of career blood began to fleck conference room walls." Those less favorably disposed might put all this less diplomatically. Jack Welch was a foul-mouthed bully.[586]

The admirers might respond that those qualities, however regrettable, were needed to wake the stodgy, plodding mediocrity that was the Old GE. Not even those admirers, however, expected in 1981 that Jack Welch would euthanize that Old GE.The financial press did not know what to expect. Business Week noted Welch's Ph.D. in chemical engineering, his key role in building the plastics business, and his success in overseeing GE's CAT scanning success. Its 1981 story of his accession was headlined "The financial wizards turn back to technology. " [587]

Welch indeed, in his first months as CEO, beefed up company high-tech efforts . His predecessor had already taken such steps. In the waning days of his tenure, in 1981, Jones announced somewhat prematurely, a GE "technological renaissance". In 1981, the year Welch took over, GE, seeking

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[586] **Admirer: Welch's speechwriter, Lane, Bill. 2008. Jacked Up. McGraw Hill. P. 113, 117, 121, Less favorably disposed: Christopher M. Byron. 2004. Testosterone, Inc. Wiley pp. 43, 123, 206**

[587] **"General Electric: the Financial Wizards Turn Back to Technology.". Business Week. 16 Mar 1981.**

to strengthen inadequate microelectronics programs bought an integrated circuits company, Intersil for $180 million. To revive an aging effort In industrial equipment GE bought a computer aided design company, Calma for $350 million. With robotics seeming to emerge as the next big thing in manufacturing GE invested $500 million in a "Factory of the Future" program.

In December, 1981,Welch's made his Wall Street debut in a talk to stock analysts at New York City's Hotel Pierre. A legend grew up later that this was the occasion when he announced the abandonment of the electric past in favor of the financial future.Actually, the talk contained only one strategic imperative. GE's businesses must quickly reach #1 or #2 in their markets or face divestiture. Otherwise, the talk was an energetic blast of vague platitudes.

Within GE, Welch acted more decisively. He decimated the strategic planning overload and cut the planning bureaucracy. Component managers arriving at company headquarters with the usual elaborate presentations found themselves instead subjected to intensive impromptu and often brutal grilling. Their scripts rested unread, their carousels of slides unprojected.[588]

Welch also sharply cut the corporate staff . At Fairfield headquarters it was reduced from over 2000 to less than 500. It soon became apparent that only one of those two new buildings was actually needed. Brutal cuts across the company soon followed. In his first three years, Welch cut 100,000 jobs, about one in every three of GE's U.S. jobs, earning himself that Neutron Jack nickname.

Slimming down the company's bloated middle management and planning bureaucracy was an immediate Welch priority. To at least some department or plant managers, it was a much needed step.For example, John Flock, a chemical engineer, was during the Welch era the manager of GE's plastics plant on Mt. Vernon IN. When he took the job, he had 27 managers reporting to him. Welch reduced that number to four, one for each of the plant's product lines. The demoted managers were not fired, however. They

[588] **I was there also, watching one of those Welch sessions without the distraction of carousel button pushing.**

were but put to work in production With that change the plant became both more productive and more profitable.[589]

Welch's staff reductions also reflected GE's subsequent transition from a manufacturing to a financial giant. That transition, however, was not a pre-planned strategy. It was an adaptation to reality.That reality had begun with a realization that GE's productivity was simply not world class. At a 1979 management meeting, a Vice President who had been appointed GE's " Productivity Czar" pointed out that GE had, with difficulty, increased its annual productivity growth from 1.6% to 4%, The corresponding number for rival Toshiba was, however, 8%.

.In 1981 GE proclaimed its intention to be a full service supplier of automation equipment, including robots. The leader of the effort predicted sales reaching $100 million by 1986 and $600 million by 1990.He presented potential U.S. customers with three choices: automate, emigrate, or evaporate.

Reality, however quickly punctured those claims. GE never became a major player in the ongoing robotic revolution. Instead, the GE effort would itself take only a few years to both emigrate and evaporate.The emigration part became by 1985 a 50-50 merger with the Japanese automation company Fanuc. Those in the know recognized this as not an alliance but a surrender. After 1986, Fanuc would continue its rise to world leadership in robotics and automation. GE' share of the joint venture would evaporate. [590]

These initial setbacks would later in the 1980s be followed by other technology initiatives with similar fates. Two involved two of GE's signature successes of the past. In light bulbs, the 1980s were finally the time to replace the Wizard's now unacceptably inefficient incandescent lamp. Two options had emerged. One, called the Compact Fluorescent

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[589] **Discussion with John Flock 5 Feb 2024**

[590] . **Sources for the GE robotics and numerical control story include James A. Baker, "Robots, A GE Perspective" Presentation to Society of Manufacturing Engineering Executives, Chicago 30 Sept 1981. Business Week, 16 Nov 1981, p. 58F."The Machine Shop Computer Arrives at Last", Business Week, September 13, 1976, 44R; Robert W. Breiken , the NC Story, GE General Management Meeting, 1/15/84, SN, HoH. ; GE Monogram, Winter, 1987, p. 14. Interview with John Cassidy, 7 October 1986. GE Monogram, Winter, 1987, p. 14.**

Lamp (CFL), basically shrunk and twisted the fluorescent lamp to light bulb size.The other was a solid state device called a light emitting diode (LED). A physicist at GE's Advanced Semiconductor Laboratory at Electronics Park, Syracuse NY, Nick Holonyak, had, back in 1962, been one of the original inventors of the LED. GE had not, however, kept up its leadership as LEDs made their painfully slow way from invention to innovation.[591]

By the 1980s, the LED innovation effort stlll required at least a decade of R&D and patience. The CFL was potentially less efficient and shorter lived, but would be ready quicker. GE chose that quicker path. It indeed got on the market quick, in the 1980s. But the lamp had problems in color, cost, and reliability. The product soon sputtered out. Meanwhile, more patient Asian competitors achieved steady improvements in such LED characteristics as color, efficiency, long life and lower cost. It would be that improved LED, absent GE participation, that would light the 21st century. (In the 2020s, many LEDs did bear the GE monogram. They were, however, the made-in-China products of the 2020 purchaser of GE Lighting, an independent company named Savant). [592]

In refrigerators, GE also saw a 1980s need for innovation. A key GE refrigerator component, the compressor, still operated by inefficient reciprocating (back-and-forth) motion. Efficient compressors on everything from aircraft engines to air conditioners were rotary. Rather than buy a rotary compressor, GE decided to make its own. Here both management pressure from above, and too aggressive cost cutting from below, intervened. While adapting a rotary air conditioning compressor to refrigerator use, a designer found a way to make a key part from a cheaper metal. Meanwhile, under pressure from above, reliability testing was rushed and product introduction speeded up. As a result, a million of the new refrigerators were in customers' homes in 1989 when the cheap part started failing. The fiasco would require replacing those million refrigerators at a cost to GE of hundreds of millions of dollars[593].

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[591] **Davis, Amanda. 2022. Remembering LED Pioneer Nick Holonyak IEEE Spectrum. 30 Sept 2022. Online.**

[592] **Kannellus, Michael. 2016. GE's Long Lumpy History in Energy Efficient Lighting. Forbes.com 1 Feb 2016.**

[593] **Magaziner, Ira and Patinkin, Mark. 1989. The Silent War. Random House. Pp.67-100. Meeker William Q. 2015. Pitfalls of Accelerated Testing. National**

Other GE technology efforts of the 1980s did achieve technical success. The most promising one, however, suffered from bad timing. This was extending the gas turbine success of the 1960s into the old idea of combined cycle power generation. The possibilities here were staggering. Burning fuel in a gas turbine at a high enough temperature could, in theory, double the efficiency of power generation, from the 35% of the best steam turbines to as much as 70%. Unfortunately, the technical challenges were as daunting as the goal was attractive. The high temperature needed, 2500° F. or more, would melt the best conventional turbine buckets. Those high temperatures would also produce unacceptable amounts of nitrogen oxides pollutants. The ideal fuel for the system, natural gas, was regarded as too scarce. During the 1970s energy crisis, the U.S. Congress passed a Fuel Use Act that sharply restricted the use of natural gas in electric power generation. [594]

GE did try out the combined cycle idea in the 1960s under the name STAG (Steam Turbine and Gas). The efficiency, however remained below that of steam turbines. The complexity and inability to run on coal fuel were added disadvantages.In 1972, a study by GE's strategic planners of future power generation prospects concluded that

> any serious challenge to steam turbines by gas turbines would cost entirely too much-- development funds that might better be directed, for example, to a catch up program on our nuclear reactors.[595]

GE took that advice. Looking back on this decision later, a leading GE power systems expert, Thomas Lee, viewed that decision as a mistake. Said Lee in 1990

Renewable Energy Laboratory Presentation. 22 Feb 2015. O' Boyle, Thomas. 1990. Chilly Tale. Wall St. Journal. 7 May 1990 , p.7.

[594] **Patel, Sonia, 2019. What Drove the Gas Turbine Technology Leap at GE Over the Past 70 Years? POWER Magazine. 30 Jul 2019, online.OSTI.gov. 1978. P.L. 95-620, "Power Plant and Industrial Fuel Use Act" (1978)."This act prohibits.. the use of natural gas or petroleum as a energy source in any new electric powerplant;"A contemporary view of 1970's combined cycle prospects is Meeting at GPV Services Corp. to discuss the combined cycle. 10 Dec 1971. John Fisher Papers. MiSci.**

[595] **John B. McKitterick to Corporate Executive Staff. 12 May 1972. John Fisher Papers. MiSci.**

> If sufficient effort had been applied to improve the reliability of combined cycle systems, the probability of success would have been very high. But it was not done, and the acceptance of this important technology was therefore delayed.[596]

In 1987, the U.S. Fuel Use Act was repealed. With natural gas subsequently made plentiful by fracking, the efforts of GE and competitors in combined cycles was sharply ramped up. In the 21st century, combined cycle efficiencies of 50% were achieved in commercial natural gas fired combined cycle power plants. With a further R&D program funded by the federal government, that 70% efficiency goal came in sight. Unfortunately, the post 1987 rise of the natural gas fired combined cycle coincided with rising acceptance of the connection between fossil fuel combustion and climate change. By the 2020s, the energy priority had changed from increasing the efficiency of fossil fuel use to phasing out fossil fuel altogether. The combined cycle, despite its technological success, seemed by the 2020s to be transitioning instantly from an ideas whose time has come to an idea whose time had passed. (One shouild add, however that the ability of the gas turbine to run on pure hydrogen offers a ray of future hope, should sufficient supplies of that gas be discovered or economically produced.)

That rise in the understanding of climate change in the 21st century led historians to ask a related question. What did the energy companies know about climate change, and when did they know it? A team of historians led by Natalie Oreskes asked this question about Exxon. They concluded that it "had known since the late 1970s that its fossil fuel products could lead to global warming".[597]

Much depends on the 1970s meaning given to that word "could." Did it mean the energy companies saw climate change as likely, uncertain, possible, or merely speculative? For GE, the answer seems to be somewhere between uncertain and possible. "People knew by the 1970s that CO_2 was increasing," recalled Richard Alben, a physicist then working on energy technology evaluation at GE's Research Lab. "What was not known was the

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[596] **Lee, Thomas H., Ball, Ben; Tabors, Richard. 1990. Energy Aftermath. Harvard Business School. p. 128 , 189.**

[597] **Oreskes, Natalie et. al. 2023. Assessing Exxon's Global Warming Projections. 13 Jan 2023. Online.**

climate effect. In 1980 there was no conclusive evidence of a temperature increase." GE Power Systems offered in 1972 an even more vague projection.

> The long term development and future price of coal is dependent on many ecological and technological developments that are as yet unclear.[598]

In 1986, the possibilites of climate change got sufficient attention from GE Nuclear for one of its managers to write

> Nuclear power has reduced the discharge of CO_2 into the atmosphere by over a billion tons. This may be of vital importance if concerns over the Greenhouse Effect are borne out.[599]

On that subject of climate change, uncertainty continued to prevail at the corporate level throughout the last decade of the old GE. Any idea that GE secretly knew before 1986 that climate change was coming, but suppressed the knowledge to sustain its fossil fuel based profits, gets no support from surviving evidence.

More generally, it was only toward the end of the Old GE that environmental issues got major company attention. The issues had, of course, been there all along. The ultimately most publicized environmental issue did not emerge at a high-tech site. Instead, that issue emerged at a couple of small obscure and minor plants engaged in an old electricity related business.

It all began in the 1930s with an attempt to make electricity distribution safer. In the Universal System, such electrical devices as transformers and capacitors got hot. They were originally cooled with oil. Sometimes the oil caught on fire. So it was considered a laudable step when, starting in the 1930s, efforts began to replace that flammable oil with a non-flammable cooling fluids called polychlorinated biphenyls, or PCBs.[600]

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[598] **Richard Alben. Interview 13 Jan 2023. Malcolm Mc Nelly, Power Systems Operation, to VP H.R. Hill 17 Jan 1972. John C. Fisher Papers. MiSci.**

[599] **R.L. Crowther to Donald R. Mack 13 Dec 1986. GE R&D Center Papers. MiSci.**

[600] **The discussion of PCBs that follows draws on National Research Council. 1979. Polychlorinated Biphenyls. National Academy of Sciences. Toxics on the Hudson.**

To put those PCBs, purchased from Monsanto, into electric power systems devices called capacitors, GE opened plants in 1947 in the towns of Hudson Falls and Ft. Edward NY, on the upper Hudson River not far north of Albany. Scientific research published as early as 1937 had indicated harmful human effects, such as acne, from exposure to PCB's. This was countered in those plants by procedures to keep workers safe. Later company funded studies showed no increase in cancer among those PCB exposed workers.

GE's PCB residues were disposed of by dumping them into the Hudson. There, presumably, they would diffuse, decompose, or disappear into the river bottom.More than a million pounds of PCB's had been so disposed of by the 1960s when long simmering concerns burst into prominence.From Sweden, came evidence that PCB's could accumulate in fish. Then U.S. studies asserted PCBs to be a possible cause of cancer On the Hudson, a citizens' movement led by folk singer Pete Seeger set out to reclaim that scenic river from PCBs and other pollutants. In 1976 the state of New York banned fishing on the upper Hudson. It reached a settlement on PCB's that year with GE and its chief negotiator Jack Welch. Under the resulting consent decree GE, admitting no wrongdoing, would cease dumping PCBs, take further remediation steps, and pay $3 million.

Any hopes that GE had ended the PCB issue by this agreement, or by the closing of the Hudson Falls and Ft. Edward plants, proved premature. In 1984 the Federal government declared a 200-mile stretch of the Hudson River a Superfund site, for which GE was to blame. GE responded wIth intense lobbying, stonewalling, and denials of PCB harm. This extended the issue into the New GE era. Rhetorical PCB fireworks in that era included an angry exchange at the 1998 GE Stockholders' meeting between Neutron

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Und. Cleanupge.org/ . pcbssrticle.html. Schmidt, Charles W. 2001 Of PCBs and the River. Chemical Innovatiopn. 31-48-52. U.S. EPA. 2023.Hudson River PCBs Supeerfund Site. Actions Prior to EP's February 2002 Record of Decision. Epa.gov/hudsonriverpcbs

Jack and Sister Patrcia Daly of the Dominican Order, an activist nicknamed the Stinging Nun.[601]

Welch had retired by 2004 when the issue finally reached a resolution. GE would have to pay for the dredging up of millions of cubic yards of river bottom, to remove over 100,000 pounds of PCBs from a 40 mile stretch of the Hudson. It took six years, at a cost to GE of more than a billion dollars. Decades later, controversy still swirls. How much good (or perhaps even harm) did the dredging do? How clean is the Hudson? What are the long range health effects of PCBs? What did GE know about those effects, and when did it know it? Meanwhile, on the Hudson, and at other PCB impacted locations such as the Housatonic River that flows past GE's Pittsfield MA works, protest and litigation continue.

Back in the 1980s, PCBs may have been GE 's most serious electrical manufacturing related environmental and public relations problem. They were not, however , its most serious economic threat. In 1982 Herman Hill, Vice President of GE Power Systems looked back on the 1970s and proclaimed them his business's "worst decade ever." He added that

> Ten years ago Schenectady shipped 19,000 megawatts of steam generation capacity. Today the available world market calls for only 10,000 megawatts [602]

As these realities had emerged in the 1970s, Reg Jones and his team largely ignored them. As late as 1979, the VP overseeing the nuclear business was still predicting that by the year 2000 the U.S. would have more than 200 nuclear reactors, about half made by GE . In reality, the total number of U.S. nuclear reactors would peak at 108 in 1990 By then almost all of the 46 reactors on GE's books had been cancelled, and GE had stopped taking orders for new ones. [603]

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[601] **The encounter between Welsh and Daly is described in detail in Daly's obituary, NY Times 23 Dec 2022**

[602] **GE Monogram Winter 1983-83.**

[603] **GE Monogram. Mar -Apr 1979. 56.5**

Jack Welch's strength was recognizing these realities. He did not strategize. He adapted. In adapting to the U.S. economy of the 1980s, the wizard that Jack Welch would channel would not be his distant ancestor, technology wizard Thomas Edison. It would be his contemporary, financial wizard Warren Buffett. He was demonstrating a new form of conglomerate. It did not grow from a technological seed, or from a use of acquisition to imitate natural diversification. Instead, Buffet's Berkshire Hathaway grew by shrewd analysis of the long term prospects of possible acquisition targets. This revealed that, counter to the then reigning economic theory called efficient markets, the stock market sometimes significantly undervalued established companies. The job of the new type of CEO was not to strategize. It was to identify and scoop up those undervalued companies before someone else did.

By 1986, Welch had taken up this kind of dealmaking. He would turn GE's more successful manufacturing businesses into collateral and cash sources for this financial wizardry. The less successful businesses he would sell. It was the 1984 sale of GE's housewares business to Black and Decker that announced to the world that the Old GE was on the auction block. As Welch accumulated cash, he promised not to let it burn a hole in his pocket. In 1986 he fulfilled that promise with the purchase of RCA. That old radio and TV giant, originally a GE spinoff, had in the 1970s become a very troubled company. It had diversified too widely and unwisely. Reacting to those troubles, Wall Street had, however, gone too far in driving down its stock price. Welch spotted that undervalued target. In doing so, he had been guided by Wall Street titan Felix Rohatyn. In addition, the recently installed CEO of RCA, Thornton Bradshaw, appears to have preferred a friendly GE buyout to a less friendly takeover engineered on Wall Street. With that support, Welch pounced. The stock market price of RCA in its last days in 1986 was about $50 a share. GE paid $66.50 a share . RCA would turn out to be worth somewhere between $70-$90 per share.[604]

Welch reaped this profit by selling off RCA businesses except for its remaining jewel, NBC. Then, showing that his deal of a century was not a one off, he immediately followed up with the purchase of the long established and well known investment bank, Kidder Peabody. Over the

[604] **Langlois, Richard. 2023.The Corporation and the 20the Century. Princeton p. 454**

rest of his incumbency, the number of GE acquisitions and divestitures swelled into the hundreds.

RCA turned out to be a bargain. NBC , before the GE purchase, had put to work two programming geniuses, Grant Tinker and Brendan Tartikoff. They delivered a string of sensational hits, including The Cosby Show, Frasier, Friends, the Golden Girls, and Seinfeld. NBC suddenly in the late 1980s soared from last to first place in the networks ratings race, and stayed there until the year 2000. It provided GE with a moneymaker, though only a temporary one. New GE-produced shows lacked the magic. In the new century NBC soon joined in the general decline of network TV. As it did, a character who was a thinly disguised version of Jack Welch became the butt of jokes on the NBC sitcom 30 Rock.

The other major acquisition of 1986 was a spectacular failure. Kidder Peabody tanked immediately. Its decline was accelerated by a brash embezzlement by one of its stock-trading superstars. All that, however, was in the future when, in 1986, GE's Annual Report rang out the Old GE and welcomed in the New. In its last year, 1986, the Old GE had sales of $37 billion, and earnings of $4.3 billion. Reading the details of that 1986 Annual Report showed that New GE to be still a work in progress. A listing of the approximate fractional sources of GE earnings indeed showed Financial Services to be spectacularly on the rise, but as yet only achieving a tie for second place. The list read:

Appliances 23%; Aircraft Engines 18%; Financial Services18%, Aerospace 12% ; Power Systems 9%; Materials 8% ; Industrial 4%, Medical 4%, NBC 4%.

To put some color into those 1986 numbers, take a quick and selective tour around that 1986 last-of-the Old GE. It was a mixture of new financial empire, old industrial works and new information businesses. In some cases, it was two of those at once. In Erie PA, for example, a 1900 era brick factory buildings held the increasingly computer controlled processes for making diesel electric locomotives. Down at Daytona, Beach, Florida, behind tall palms, the production machines were computers, and the products were pictures of cloud, sky and earth so realistic that a person sitting in one of the flight simulators produced by GE tfor the Air Force couldn't be quite sure that he was not looking at the real thing. It was, by 1986 standards, the ultimate video game. A lucky visitor might be permitted to play.

Business was brisk also across Florida at St. Petersburg, where GE made the triggers for hydrogen bombs. But it was not so good inland at Orlando. There, past a burnt out orange grove and an abandoned Minute Maid plant, a factory that used to make Christmas tree lights had been remodeled and expanded into a factory of GE's Robotics and Vision Systems business. Its mission was to make robots for those GE-built "factories of the future" that were going to reindustrialize America and fight off the Japanese. But right now that plant was not making any robots. It was uncrating robots made in Japan, paintinq on an orange stripe and slapping on a GE monogram, and shipping them out again. Up north, at Charlottesville, Virginia, at GE's recently created automation laboratory, things were also not going well for the factory of the future . There, two advanced automation projects had also been designed to beat back the Japanese. Now, in 1986, one looked like an overpriced failure, while the other was way over budget and far behind schedule. Rumors were already flying about that coming deal with Fanuc.

From the factory of the future, journey to the the factory of the past. Fort Wayne, IN's GE Works was still surrounded by 19th century buildings, some recycled for 20th century purposes. At the last turn before the plant, a carved stone facade still proclaimed Broadway State bank. The wooden sign beneath however, announced "The Scorpion Lounge - Exotic Dancers-No Cover." The plant itself continued the juxtaposition of past and present. On a red brick wall you could still read, in faded letters, the words "Wood Systems". James J. Wood had brought the manufacture of electric power systems to Fort Wayne back in the 1880s, about when he put the first electric lights on the Statue of Liberty. Not long afterwards, by bringing Marcel Audiffren's invention back from France, he would start the chain of events that would put GE into the refrigerator business .

Things were not going so well on the day of that 1986 visit to Fort Wayne. A major customer had announced that it would buy its electric motors not from its long time supplier GE, but from rival Emerson Electric. Emerson lacked GE's technological strength and proud tradition, but it could produce serviceable motors at a cost too low for GE to match.

A year later, Fort Wayne's electrical workers' union would sign an unprecedented wage giveback aimed at making GE more competitive.

Down at Cincinnati, Ohio, by contrast, things were going very well indeed. GE has just been selected over rival Pratt and Whitney as the winner of the "great engine war", the choice of the main engine builder for the Air Force's main fighter plane. In the spotlessly clean buildings of the GE aircraft engine plant. where the factory floors were so huge you travelled around them in electric golf carts, the mood was buoyant. After four decades of staring up the tail of Pratt and Whitney, GE zooming past into the lead.

Down the Ohio River, in Louisville, Kentucky, things were also going well. A new dishwasher design and its automated assembly line had vaulted GE into the lead of yet another market. Good, too, up in Waukesha, Wisconsin, where GE manufactured its very successful line of CAT scanners. Not so good, however, in Sunnyvale, California, where GE's computer aided design venture, Calma, was drowning in red ink. Not so good either in Raleigh, North Carolina, where the staff of GE's Microelectrics Center was finding it unexpectedly difficult to compete in the new microelectrics era.

Very good, however, in Lynn MA where the one time Thomson Houston Works had become the eastern branch of the aircraft engine empire. Across Massachusetts, at Pittsfield, the best of times and the worst of times stood side by side. The buildings where GE transformers were once made, one of them still bearing the name of 19th century transformer pioneer William Stanley, now stood empty. The people who used to work there, who once occasionally stepped in or rinsed their hands in, a dielectric fluid called PCB, were now wondering what it might have done to their health.[605]

At the same Pittsfield Works, however, the GE Ordnance Systems Department was busy making drive systems for fighting vehicles, and missile launching systems for submarines. Down in the basement, an engineer proudly pointed out a GE-built complex of controls and computers

[605] **Berkshire Eagle 1 Feb 1988**

for launching a Polaris missile. Another ultimate video game, but this time visitors were not invited to play.

Further down the Pittsfield Works, at one Plastics Avenue, the prosperous GE Plastics business was adding a brand new showplace, a Plastics Technology Center, built as much as possible out of GE's highly successful engineering plastics, such as transparent, impact resistant Lexan^{R} resin. People in Lexan^{R} houses, a host told visitors, don't have to worry about throwing stones.

The tour could cross oceans, for example to another plastic plant in Bergen op Zoom Holland, or to a circuit breaker plant in San Juan, Puerto Rico. GE, however, had in 1986 some 300 locations around the world, and this tour is already growing tiresome. So instead, head West over the Berkshires and back to this book's central location, Schenectady. [606]

Walk around town and you could not help hearing, or overhearing, constant talk about 1986's chief topic. Usually the tone was bitter, like that of the woman behind you in line at the Price Chopper supermarket, loudly lamenting her brother's layoff. Sometimes it was matter of fact, like the tone of a grade school student: "my dad used to be a welder for GE. Now he cleans bathrooms." Sometimes it was a little bewildered, like the tone of the middle aged man in the booth behind you in the Flavorland Restaurant, discussing his GE silver bullet: "I've never been unemployed before."

Walk through a sadly declined downtown, its recently flourishing department stores and movie theatres now closed up. Turn onto Erie Boulevard, the filled-in old Erie Canal, where the most prosperous looking building sold pornography. Continue on towards a 168 foot long sign with its 35 feet in diameter GE monogram made out of 1399 25 watt GE light bulbs that marked the entrance to the Works.

The immediate entrance looked like it had for over half a century, with Building 2, the main office building on the left, and on the right,

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[606] **The above hypothetical tour of GE is based on notes taken during an actual tour of GE operations by this book's author as part of a study of GE operations commissioned by the GE Corporate Staff. The following Schenectady observations are based on 1985-1986 notes taken by the author at home in Schenectady.**

Buildings 5 and 37 (the one with the big sign on top} , the buildings that housed the two laboratories founded by Charles Proteus Steinmetz, General Engineering and Research.

You did not have to get much farther down Works Avenue, however, to see signs of Neutron Jack at work. In the building that had held the old Apprentice Training Program, the lathes were silent and the lights were out. After three generations, GE was no longer training any more craftsmen at Schenectady . A little further down , the engineering headquarters of the Large Motor and Generator stood more recently abandoned. In the lobby, a black cloth board held white plastic letters that still spelled out the directory of its late occupants, though all in small letters- perhaps a cost reduction. The visitor resisted with difficulty the temptation to place before the name of a manager named cummings the initials "e.e."

Across the Avenue stood a barren lot littered with rubble and swept by the wind. Had you visited not many months earlier, you would have seen there a classic, now empty, "cathedral shop", as they called those raised-roof natural-light illuminated factory buildings a century ago. Inside,it two rows of great square wooden columns stretched away into the darkness. Between the wooden blocks that made up the floor cracks held the oil, grease, and dirt of a century of making nearly everything from turbines to railway motors to refrigerator parts. A bleak grey light filtered through the rows of dirty windows. Far above, on steel rails, still sat a 10-ton crane. One imagined leaping into the cab, grasping the controls, and swooping the length of the building like a great bat.

That had been Building 10, just before its 1986 demolition. For an earlier visitor, in the spring of 1886, the building had also been empty and abandoned. Then, however, it was also brand new and never yet used. It was a perfect find for the man the visitor was representing, a New York City inventor-industrialist known as the Wizard.

Continue on down Works Avenue and you get to Building 273,the last “big shop”. It still looks as good in 1986 as it did when it was built in 1947 (and will still look good in 2024). Not that it was impressive from the outside. It was squat, boxy, and gray. Go in, go up the elevator, and you might think you were in a very ordinary office building. Walk through a door, and suddenly you are standing on a balcony, overlooking a vast roofed canyon, filled with castings,forgings, machines, and here and there, people.From overhead, high pressure sodium lamps bathe everything in illumination just

the orange side of sunlight. It was not as noisy here, as it had been been back in the 1960s when 25 or 30 turbine-generators were under construction at once. A guide hosting visiting customers reels off some big numbers: a quarter of a mile wide and a fifth of a mile deep….you could put 16 football fields down there, or if you preferred, Yankee Stadium.

The proposal for this last of the Big Shops had arisen after World War 2 when GE was flush with postwar optimism. As GE Power Systems lore portrays it, no detailed studies, no market forecasts, no appropriation requests were needed to build this building. In 1948, the vice president of GE Power Systems drove down to GE's New York City headquarters, rode the elevator up to Charlie Wilson's office, went in and told the president "look, if you're going to stay in this business, we need this building." And Charlie answered, "you've got it."[607]

When that Building opened in1950 it enclosed perhaps the the world's largest manufacturing space under one roof . It enabled GE to quadruple its output of steam turbine generators at Schenectady from 3000 MW/yr in 1946 to 12,500 MW/yr in 1963.Turbine generators made in this building in 1986 were essentially the same as the machines that were made there in that opening year of 1950. The steam turbine generator that had evolved at Schenectady in the first half of the 20th century, under the leadership of William Le Roy Emmet, Billy Madigan, Oscar Junggren, A,R, Smith and Glen Warren, and with the work of hundreds of other enginners and foremen, and thousands of skilled shop workers, proved awfully hard to improve on.

Entering that Building 273 in the year 1986, a visitor first encountered, on nearby balconies, engineers working at computer terminals. On the floor below, the pace was glacial. Many machinists were now mainly observers, watching as numerically controlled machine tools cut grooves into cylindrical 200 ton turbine rotors. A foreman sitting at a U-shaped Formica table would occasionally get up, wander over, and take a look. A quality control man might walk by, recording his measurements. If, however, a visitor tried writing

[607] **Interview with Don Brownhill, GE Power Systems, 9/5/85**.

in his own notebook, he was told to stop. Neither management nor workers liked to see outsiders taking notes.

A visitor walking the length of a couple of those football fields could recognize individual parts: retaining rings the size of washing machines ; a turbine rotor with buckets attached looking like two giant metal Christmas trees stuck tip to tip; a steel generator shell the size and shape of a mobile home. The big steel parts had been molded or forged elsewhere, at locations as far away as Krupp in Germany. The Schenectady Works foundry had been shut down for good back in the 1970s. The workers were mostly, but not all, white men, mainly middle aged or older. Many had put in a decade or more in other GE shops before being entrusted with this crucial task of turbine making. Some had graduated from that recently shut down GE Apprentice Course.

All tasks were not yet, however, automated. Building 273 veterans could be seen using their hands to clean something, adjust something, or bang something into place with what seemed a ubiquitous tool of turbine making, a rubber headed mallet. For example, at a steel table, a curly haired young man filed the edge of a turbine bucket, fitted it into a slot in a turbine wheel, then banged it into place with one of those mallets. The buckets, some as short as a finger, some as long as an arm, were as precisely and aerodynamically shaped as airplane wings. They had been machined the old fashioned way in a building next door. In 1986 no computer controlled machine tool had yet achieved the necessary precision.

In a similarly throwback manner, loops of flat, shiny copper conductors hung from overhead slings, as two grizzled, balding workmen levered those conductors into generator stator grooves with wooden sticks. Nearby, a stout Black man pulled his finger from a tube of white sealant, and carefully applied it to a joint where a cooling water hose would meet a conductor. These tasks were still beyond the capabilities of a 1986 robot. Turbine making had never been done on a Fordian assembly line. In 1986 it was only gradually and incompletely becoming computer controlled and robot assisted. More generally , in some places locally, slowly and incompletely, in others globally, rapidly and decisively, the Old GE was ending, giving way to the New. How did that change look to the world of 1986?

That reaction to the New GE and its leader was highly polarized. From the business press, the New GE got high praise for its skyrocketing market

value. Jack Welch was being elevated into the new and highly select category of businessman-as-media- celebrity, alongside realty tycoon Donald Trump. From workers and citizens at deindustrializing GE locations across the nation came the different response of bitter denunciations of Generous Electric and Neutron Jack. Only a few people expressed a more detached skepticism about the unity and permanence of the New GE. One of them, former ITT chairman and conglomerate builder Harold Geneen put it this way in 1988 : "I haven't studied it, but I would guess that the pieces of GE exceed its market value. "[608]

It would take nearly 40 years for Geneen's offhand guess to become a validated prophecy. It took only 14 years, however, for the New GE to prove to be a bubble. The story of the rise and fall of the New GE story has been told in several recent books. In this story of the Old GE it will only be briefly summarized in the next, and concluding chapter.

This book's narrative portion ends where it began, with reflections on the 1986 deindustrialization of GE. It was three generations in the making. The full 1886- 1986 trajectory of Schenectady GE employment gives some perspective. In Schenectady, industrialization and deindustrialization plotted a nearly symmetrical century long bell curve. It began at zero in 1886, peaked at 45,000 in 1945, and then declined in a roughly mirror image of its rise. Extrapolation of that bell curve in 1986 predicted a return to zero in 2005. That symmetrical picture suggests a long term symmetrical perspective on Schenectady deindustrialization. The Edison Machine Works had come to Schenectady in 1886 to escape crowding, politics, and unions. It began to leave Schenectady, starting in 1946, to escape crowding, politics, and unions. Bad as the year 1986 had been in Schenectady, deindustrialization was not devastation. The three neighboring New York cities of Schenectady, Albany and Troy, though still politically independent, had since 1950 blended into a Metropolitan Area called the Capital District. Over that 1950- 1986 time span 30,000 Capital District jobs were lost at GE. In the Capital District in that same time span 30,000 jobs were added by the New York State Government. (Exemplifying this transition was Leonard John, a grandson of Schenectady GE machinist, union leader, and

[608] **Quoted in Chakrabarty, Subrata. 1988. When Everything's for Sale You Lose Something. Forbes. 12 Dec 1988. pp 34-35**

1911 Socialist Bill Turnbull. In 1950, Leonard was operating a tabulating machine for the New York State government).[609]

Similarly it is too narrow to view deindustrialization as simply an injustice to those illustrative GE families that had labored for three generations at the Schenectady Works. Those families had gotten three generations of upward social mobility. By 1986 some family members had attained non-GE local prominence. Most, however had long since moved on from Schenectady. The greatest employment injustice of deindustrialization was not to these early arrivals. It was to the later arrivals who never got the chance to industralize at all. In particular, deindustrialization was an injustice to the increasing number of Black families arriving in Schenectady during and after World War 2. They were coming in one door as GE was going out the other.

In 1940 Schenectady had been less than 5% Black. By 2020 Schenectady was 20% Black. By then, however, GE was just another employer in the city of Schenectady. It was not mainly discrimination, but rather deindustrialization, that deprived Schenectady 's Black population of the chance to emulate the social mobility boosting GE experience of Schenectady's earlier arriving ethnic groups.

Regarding equal opportunity in the Company as a whole, GE had a better record. It had issued a formal policy forbidding discrimination on the basis of race in 1935. As earlier noted, in 1947 GE CEO Charlie Wison chaired Truman's civil rights commission, a progressive milestone in the road to equal opportunity. In 1948 GE became the first major company to make Howard University a regular stop on its annual engineering recruitment schedule.

Under decentralization in the early 1950s department managers of the new southern plants were allowed to set their own employment policies. Some followed local segregationist norms. Others, particularly in the upper South, sought from the first to integrate, even in the face of opposition. For example, at GE's Appliance Park in Louisville KY, White workers went on strike to protest working with Blacks. Management stuck with equal employment , disciplined, and in some cases fired, strikers, and continued its integration policy.

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[609] **Information in 1950 U.S. Census.**

A new plant at Lynchburg VA was the subject of a detailed study by academics Theodore Purcell and Gerald Cavanaugh. GE opened a factory there 1956. By 1960 it was the headquarters of GE's Communications Systems Division with an employment of 4000. Integration efforts had begun in the 1950s. GE's Black work force at Lynchburg reached 6% of the total work force in 1962 and 17% by 1968. That latter fraction was higher than the Black percentage of the local population.

At first GE insisted on very stringent qualifications for these black employees. For example. 78% of Black hires were high school graduates, versus only 40% of Whites. Expectations were set high. One new Black employee recalled being told "you are the Jackie Robinson of the Microwave Department." As both races settled into mutual acceptance, a stronger effort was made to widen the applicant pool. A joint industry government Community Action Program went into neighborhoods to seek out less obvious candidates.

Much of the success was due to the department manager. He was Lou Rader, encountered earlier as one of the successful and unconventional GE managers of the decentralization era. He not only accelerated equal opportunity hiring at the Lynchburg plant, but also spoke out strongly and publicly against Virginia's "massive resistance" defense of segregation. .[610]

In 1986, minorities made up 11.4% of GE employees, 8.5% of professionals, and 5.6% of managers. In that year, women made up 27.6% of GE employees, 16.5% of professionals, and 8.5% of managers.[611]

The 1986 deindustrialization, with its varied effects on the 300 GE manufacturing locations around the world, had not come out of nowhere. It was implicit in the earlier industrialization of GE. The storms that hit GE ca. 1970 only helped complete the century long process. What were the buffeting external storms that, ca. 1970, hit the Old GE? The most important of those were those 1970 energy and economic decelerations .

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[610] **Purcell, Theodore and Cavanaugh, Gerald. 1972. Blacks in the Industrial World. Free Press. Pp. 101- 120. See also Purcell, Theodore V. and Mulvey, Daniel P. . 1971. The Negro in the Electrical Manufacturing Industry. U. Pennsylvania, p. 3**

[611] **GE Annual Report 1986, p.64.**

The particular deceleration that especially changed GE was the end of the decadal doubling of electricity use in the U.S. GE had ridden a rising wave of electrification since its founding. To double its sales in nearly every decade, all it had to do was to hold 25% of the electrical manufacturing market. The profits from the branching of the Edison Elm came as a bonus. By the 1980s, the electrification wave plateaued. As it did, foreign competitors and U.S. entrepreneurs were outcompeting GE. It would have to find another way to double. The way it found was finance. How did those external trends of the 1979s change GE?

That plateauing of electricity use completed the process of turning GE from a growth engine into a mere GDP company. Add in GE's failures in electronics, computers and nuclear power and you have by 1980 a company ripe for renewal To achieve that renewal, Jack Welch did not strategize. He adapted. In doing so he applied GE's traditional tactic: fast following. This time, however it was not independent inventors or scientific breakthroughs that GE followed fast. It followed the national trend of deindustrialization and the rise of finance. The measure of a company had changed from progress of products to evaluation of net worth-- that is, multiplying its stock price by the number of shares. Jack Welch read this trend accurately, and followed it fast. By the year 2000, GE, thanks largely the booming profits of its financial business, would have a net worth of $500 billion, briefly the highest net worth of any company in the world.

For his role I achieving this performance Jack Welch received in the year 2000 a total compensation of $16.7 million. That was some 250 times as large as the year annual compensation of the typical employee. By contrast, GE CEO Gerard Swope's compensation in the 1930s was about $60,000. That was about 25 times as large as the annual compensation of the typical employee. [612]

How did the end of the Old GE matter to the wider world? Unlike the electrification of America, the financialization of GE probably did not make much difference to the wider world. The financial irresponsibility of the late 20th century probably would have brought on the 2008 financial crisis even without the help of GE Financial Services.

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[612] **Frydman, Carola. 2008. Learning from the Past: Trends in Executive Compensation. CESIFO Working Paper No. 2460. NY Times 6 Sept 2002.**

A positive GE contribution to the nation and the world came from those parts of GE that Jack Welch did not throw overboard. In improving aircraft engines, helping innovate medical diagnostic devices, and developing high-efficiency combined cycle electricity generation, GE continued to make contributions valuable to the general public. Set against this was a negative contribution. GE was an important part of the manufacturer- utility-government complex that bungled the introduction of civilian nuclear power. By the late 1980s, the growing reality of climate change suggested that the world might have a use for carbon-free nuclear power after all. By then, however, nuclear was thoroughly discredited by its own economic woes and the public's opposition.

The New GE would also affect the wider world by helping to erase the old idea that a giant corporation should possess any unifying public purpose beyond maximizing market value-- a public purpose, for example, such as electrifying America. For Jack Welch and his New GE, maximizing market value was all that mattered. In accepting that Wall Street criterion, Welch also, though perhaps unwittingly, put GE back into the Wall Street shackles that Charles Coffin had taken off by 1907. For the rest of the 20th Century, Welch would record an unprecedented winning streak of fulfilling his quarterly profit predictions. Wall Street would cheer, and ask few questions.

In the 21st century, that streak would end. That $500 billion market value would steadily decline. Wall Street would stop cheering. Instead, it would start asking Harold Geneen’s question: why GE?

Chapter 14. Conclusion: Three GEs, 2024

In Schenectady, New York, 2024 was a pretty good year. Population, after bottoming out at about 61,000 in the year 2000, had climbed back to 67,000. Unemployment, after that severe deindustrialization of the 1980s, had stabilized at below 5%. In April, 2024, over at its only recently occupied headquarters in Boston MA, the ailing 141 old General Electric Company finally gave up the ghost of its unified corporate existence. In its last full year of existence, 2023, the company which had been number two among U.S companies in market value as recently as 2003 had fallen to number 71.[613] The end of General Electric caused little excitement in Schenectady . After all, that coming demise had been announced back in 2021. By then, for the city of Schenectady, GE was just another big, but far from gigantic or dominant, employer.

The 2000 or so employees still at the GE Schenectady Works in 2024 now worked for a new, merely big, corporatIon called GE Vernova. That new name for the former GE Power Systems business combined the old initials with a newly invented word combining the ideas “green” and “ new”. Its headquarters were not in Schenectady but in Cambridge MA. Its expected annual revenues of about $30 billion would put it around 140 on the Fortune 500 list.[614]

Giving some substance to its invented name was a story that appeared in local newspapers in November, 2023. A photo showed a group of 200 workers standing beside their recently completed achievement, a 6.1 MW wind turbine. It was the first wind turbine ever built at the Schenectady Works. Its power output, though the largest of any current land-based wind turbine, only slightly exceeded that of the 5 MW "monument to courage" steam turbine that, 120 years earlier, had vaulted GE into the lead in fossil fuel power. Like that earlier technology, the wind turbine idea had come to

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[613] **Galloway, Scott. 2024. The Algebra of Wealth. Penguin. p. 164**

[614] **Albany Times Union (online) 25 July 2024.**

GE from the outside, via purchase from the defunct energy company Enron. As in that earlier episode, GE had followed fast, putting its own stamp on the technology.

How far the wind would carry GE Vernova remained to be seen. [615] As of this writing, in 2025, wind was facing financing challenges as a new national administration threatened to remove subsidies. For GE Vernova, however, a surprising renaissance seemed possible. Due in part fo recent progress in Artificial Intelligence (AI), said the magazine MIT Technology Review in May, 2025, large natural-gas fueled electricity generation plants "are being built around the country to feed electricity to new and planned AI data centers…. the booming power demand from data centers is all but wiping out any prospect that the US will wean itself off natural gas anytime soon." What will turn that natural gas into electricity are gas turbine based turbine-generators, many of which will be made by GE Vernova. It currently has a four-year backlog of orders, leading to a recent rise in its stock price.

Before, however, condemning GE Vernova for selling out the climate future to increase its profits, consider the following. Natural gas emits only half the CO2 of coal per unit of energy. The combined cycle gas and steam turbine-generator , largely developed by the Old GE, is twice as efficient at using that energy to make electricity as a 20th century turbine-generator. So GE has helped reduce by three-fourths the CO2 emitted per kilowatt-hour of electricity.[616]

The rest of the former GE was divided between two other merely big corporations. GE Healthcare, which, included the X-ray, CT, and MRI businesses, and GE Aerospace, mainly making and servicing aircraft engines. GE Aerospace inherited GE Global Research, the successor to that pioneering GE Research Lab founded in 1900. In 2024, its 1500 employees still worked at the 1950s-era laboratory located on the Mohawk River just

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[615] **Albany Times Union 17 Nov 2023.**

[616] **MIT Technology Review, May 2025, Online**

east of the Schenectady city boundary. Meanwhile, other former GE products, some still bearing the GE monogram, had become, for example, the housewares of Black and Decker, the appliances of Haier, the light bulbs of Secant, the silicones of Momentive, and the plastics of SABIC (Saudi Arabia Basic Industries Corporation).

The fate encountered in the 21st century by GE was not exceptional. Instead it was typical one for a member of a now endangered species, the 20th Century Giant Corporation. This book's examples of that species, AT&T, DuPont, Exxon, Ford, General Motors, Proctor and Gamble, U.S. Steel and General Electric had all been born before or just after 1900. All were by 1920 among the nation's 25 biggest industrial corporations. All were still in that top 25 list in the last year of the Old GE, 1986 (though one name, AT&T, now had a new identity). By then, however, a retreat had begin. By the year 2000, three of the nine had departed the top 25. By 2025, only three of the nine-- Exxon, Ford, and GM-- remained in the top 25.

Rather than renewing GE's Giant status, the New GE of 1986- 2024 had been a bubble. That New GE spent 14 years spectacularly inflating, and then 24 years steadily deflating. An ongoing debate seeks to place blame for that deflation. Was it an inevitable consequence of Jack Welch, the man who broke capitalism? Or did Welch's hapless successor Jeff Immelt squander a solid legacy? About that clash of CEO reputations this book will not comment.The view taken here is that the New GE episode merely made more spectacular the natural winding down of a typical 20th Century Giant U.S. Corporation The Old GE had done its job of electrifying America. It had also explored the Edison Elm of potential diversifications. By 1986, those jobs were done.

Here is a very brief summary of that Old GE's history. The ultimate cause of its century of industrial achievement was the electromagnetism discoveries of a small band of early 19th century scientific pioneers led by Michael Faraday. Turning those discoveries, and subsequent inventions, into innovations was a **Wizard.** Although GE honored Thomas Edison as its founder, he never worked for it. Instead, GE was the company Edison did not want to happen.

The Edison **Machine Works** moved to Schenectady 1886 to escape crowding, politics, and unions. In 1892 it was swept into a merger carried out by financiers in order to stabilize prices. This new company was not placed under the control of historian Alfred Chandler's new breed of professional managers. Instead, it was dominated by a team derisively labeled the **Shoemakers** because of CEO Charles Coffin's origins in that business. Instead of initially achieving the financiers' desired stability, Coffin's previous risky financial practices nearly destroyed the new company.

The financiers bailed it out . A chastened Coffin subsequently adopted a set of tactics that the Old GE stuck to for decades They were: 1) Follow fast the inventions of others (As opposed to, for example, inventing things yourself, or avoiding innovation altogether) 2) Raise the capital needed to get bigger from retained earnings, thereby escaping Wall Street's shackles (As opposed to staying small, or permanent subservience to Wall Street). 3) Explore the boundaries of the antitrust and patent laws, even if that exploration occasionally takes you over the boundaries into illegality (As opposed to strictly obeying, or consistently violating, those laws.) 4) Mildly decrease prices at a rate slower than the fall in manufacturing costs (As opposed to keeping constant or raising prices, or, conversely passing on all manufacturing cost savings to the consumer). 5) Help your electric utility customers buy your products (As opposed to not accepting in payment the customer's bonds and stocks) 6) Make structure and organizational decisions by consensus arrived at by committees of upper middle level managers (as opposed to downward dictation from the very top, or listening to voices from middle management or even from the shop floor) 7) Let Works managers deal with labor relations pragmatically (as opposed to recognizing unions, or too blatant anti-unionism).

Those tactics characterized Coffin's tenure, and endured for decades. Epitomizing the engineering force that carried out those tactics was Charles **Proteus** Steinmetz. His middle name appropriately captures the ability of electricity to unlock the protean possibilities of energy. He led GE

technically in its role as a supporting actor in the multi - national, multi-institutional repertory company that, in the 1890s, created the "Universal System" of electricity. A different blend of skills, legal as well as technological, also enabled GE to virtually monopolize the light bulb industry.

GE's 1900- 1915 leaders were **Pragmatists** who achieved armistices with unions, socialists, and government trust-busters. Then, in 1915, the First World War provided GE with **Good Growing Weather.** The end of that war also provided GE with an opportunity to suppress its unions. GE's policy of the 1920s, **Coordinated Cooperation**, evolved out of that wartime experience. It aimed at a pragmatic middle course between what GE viewed as two evils, union-based industrial democracy and government dominance. After a decade's trial, coordinated cooperation had its inadequacies exposed by the 1929 crash and subsequent Great Depression. By then, however, it had prepared GE for constructive acceptance of the three **New Deals** of 1930- 1946: the abortive National Industrial Recovery Act of 1932, the more lasting "Second New Deal" of 1936, and World War 2.

Then, stung by a 1946 strike defeat, GE's new management chose to become anti-union reactionaries rather than remaining pragmatists or cooperationists. This backward social turn contrasted with GE's public face as a paragon of **Progress.** GE's major progress initiatives of the 1950s were aircraft engines, nuclear power and computers. Its major structural changes of that decade were Boulwarism and decentralization. Both strategy and structure were, however, in 1960 eclipsed by the public disclosure of the secret **Wink** that had communicated a price fixing conspiracy to decades of GE participants.

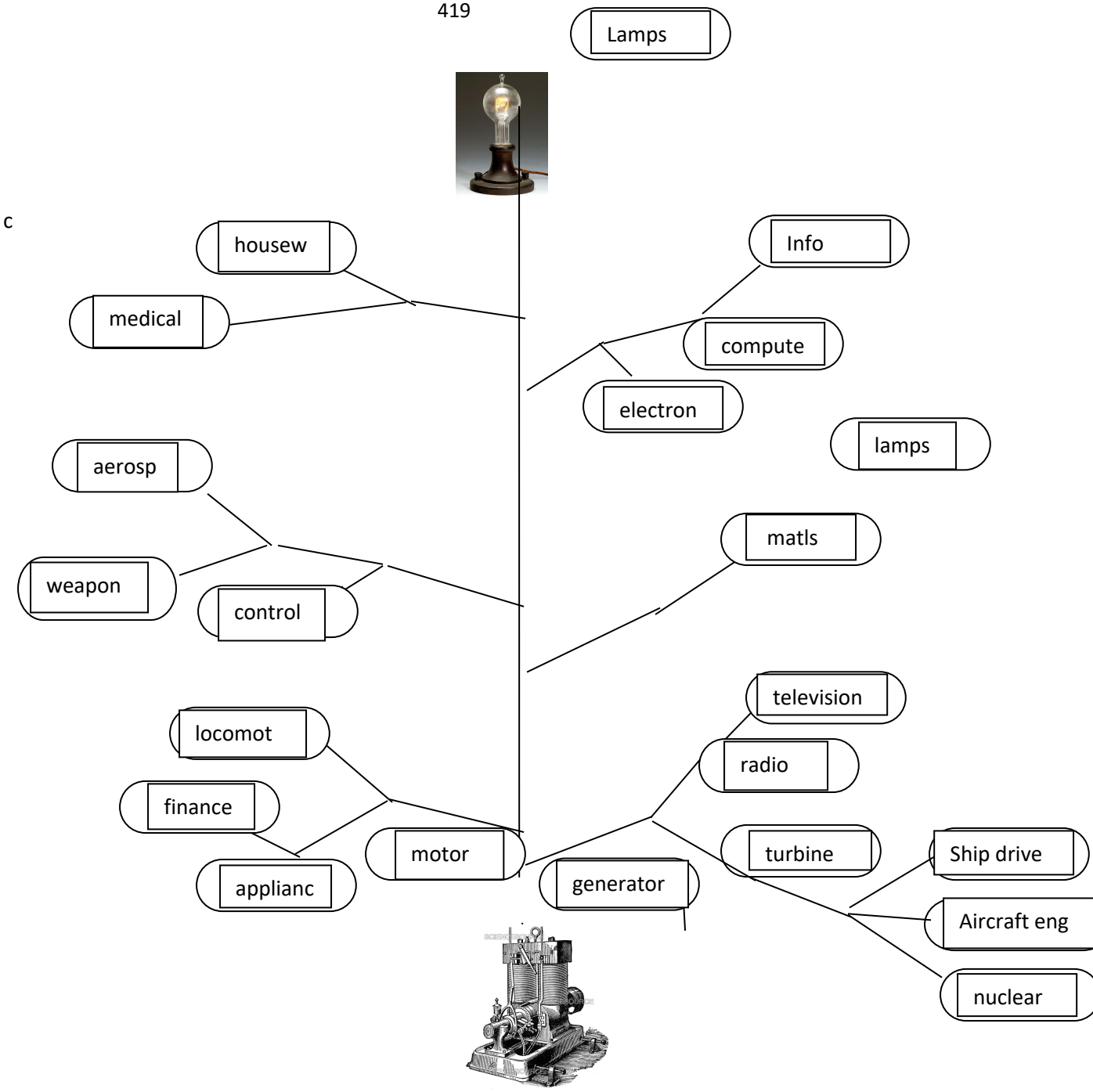
A new 1960s bout of strategizing led to a **Turnkey** project to sell nuclear reactors. It produced a billion dollars of losses, and assisted in the eclipse of nuclear power. Cushioning the consequences of that disaster were the 1970s payoff of the aircraft engines effort, and diversification success in such areas such as advanced materials, diesel electric locomotives and new

medical diagnostics devices. All this might have enabled the Old GE to **Renew** itself. Then, however, an energy use deceleration in the 1970s, misinterpreted as an energy supply crisis, took the company (and the world) by surprise. The response in the 1980s was a dynamic new leader, then a New GE.

That story answers this book's central questions. First, why was the Old GE born? Because the financiers who owned two of the three largest electrical manufacturing companies in 1892 wanted to reduce competition and stabilize prices of an initially narrow range of electrical equipment, principally light bulbs, generators, and street railway motors. That the company so created would become more Generally Electric was only vaguely glimpsed. That it would become perhaps the world's most diversified company was not glimpsed at all.

Why did it thrive for nearly a century? It rode an eight decade long wave of electrification. The doubling per decade of U.S. electrical use in all but one of those decades enabled GE not only to double its sales in most of those decades, but also to assemble the diverse collection of skills that powered the branching out of the Edison Elm of diversification.

Why was it replaced by a New GE? Management feared by 1980 that the Old GE had become a mere GDP company, doomed to permanently endure profitless prosperity. That fear had two causes: the 1970s deceleration of per-person demand for electricity, and increasing competition from foreign giants and domestic entrepreneurs. The GE answer was a new CEO who adapted to the new finance-based realities of the 1970-2000 U.S. By 1980 the Old GE's Edison Elm had reached its ultimate growth



Much of the branching of the Elm is unsurprising . Making generators led to making turbines to power the generators, and later to nuclear reactors to provide steam for the turbines. GE initially made advanced materials to provide insulation, keeping electrons on the wires that carried electric power from the dynamo to the light bulb. Other branchings, however, are surprising. Generators provided GE's entry into radio, since a high speed

alternator (a type of generator) briefly proved to be the best way to produce the radio waves that carried radio signals. GE's financial businesses branched off the appliance business, helping customers buy GE's relatively expensive refrigerator. GE's Medical businesses grew out of the light bulb, as William Coolidge put his light bulb improvements to work to make a better X-ray tube.

Turn now to the more general issue of what light the story of the Old GE might cast on the 20th Century's economic, business, and political history. Begin with the still dominant Chandler interpretation of Giant Corporation emergence. The Old GE's story supports Chandler 's virtual inevitability interpretation. Certain technology - dependent industries were exceptionally well positioned to take advantage in the 1890s of economies of scale and scope. As Chandler pointed out, this happened not just in the U.S., but also in Britain, France Germany, and, later, Japan --all countries with very different political economy systems than the U.S. The rest of Chandler's alleged drivers , however, --professional management, strategy, and the Visible Hand-- get at best equivocal support from the story of the Old GE. It was no technically trained college graduate, but old shoemaker Charles Coffin, who established the tactics to which the company largely stuck.

Strategy later emerged as a bureaucratic exercise with little corporate benefit. The Visible Hand of top management produced such exercises in bluster as the cult of the professional manager who could run a pickle factory or a research lab, the "7-20 club" emphasis on short range profits, and Boulwarism. Meanwhile, such practices as price fixing managed to remain invisible to those Visible Hand professional managers.

GE's exceptional degree of diversification was rarely strategized from the top. Instead, it either welled up from the middle layers, or was brought in from outside. Sometimes the source was an independent inventor (e.g., Reginald Fessenden), sometimes it was a government initiative (e.g.,accepting Great Britain's generous offer of the Whittle jet engine), sometimes a new use for skills needed for an electrical product (e.g, moving from electrical insulation into engineering polymers), sometimes responding

to. the action of new competitors (e.g. CAT scanning and MRI). These diversifications were best managed not by Chandler or Cordiner style professional managers, but by leaders such as Charlie Reed, Gerhard Neumann, Lou Rader, and Glenn Warren. They combined knowledge about the technologies they managed, a willingness to listen, and skepticism of company professional management dogma.

In growing to giant size the Old GE's strengths were neither exceptional efficiency, low cost, nor, despite its pioneering research laboratory, discovery and invention. Instead its main strengths emerged as a participant in collective episodes of innovation. One strength was the capability quickly to assemble teams of diverse specialists. Another was to recognize and overcome dislocations of scale. Early examples drawing on those strengths included steam turbines, improvement of the tungsten filament for the incandescent lamp, the gas filled lamp, the Coolidge X-ray tube, and the domestic version of the Audiffren hermetically sealed refrigerator. Later examples included aircraft engines, silicones, plastics, diamonds, diesel electric locomotives, CAT scanners and MRI machines.

The Old GE story can also illuminate those issues that did not interest Chandler. These include the impact of a Giant Corporation on workers, customers, communities, and citizens.Towards workers**,** the story included, but was more complicated than, mere anti unionism . Even before there was a GE, there was an Edisonian flight to Schenectady to escape unions. At Schenectady, GE sometimes battled with unions it dubbed (or slandered) as radical or communist, such as the 1906 IWW, the 1919 attempt to form a company wide industrial union, or the 1950 UE. These episodes alternated, however, with pragmatic labor peace, such as in 1905- 1919 acceptance of AF L craft unions and the 1936-1945 acceptance of that UE. Even during the 1960s heyday of that most arrogant of the company's labor policies, Boulwarism, GE delivered wages and benefits not all that different from those delivered by more conventional collective bargaining.

In their turn, the workers exhibited nither consistent radicalism, nor consistent conformity. Instead they could, as the occasion warranted, alternate between the two. Prominent examples included Martin Clune who

swung from ordinary metal polisher and Republican Party stalwart to socialist and IWW organizer, and then back to foreman and War Bond sales committee member; Charles Noonan, who went from IWW stalwart to GE Foreman and then back to head of the Socialist Local Schenectady; Bill Turnbull, labor organizer, sewer socialist and also long time GE turbine inspector and first worker board member of the GE Employees Security Investment Fund; and Leo Jandreau, typical GE sklled worker of the 1920s, most likely a communist in the 1930s, and by the 1950s the non ideological bargaining agent of IUE Local 301, totally devoted to the welfare of the workers. More generally, GE workers could vote socialist in 1911 without ever registering for the Socialist Party, follow their co workers out on strike in 1913 or 1915 without carrying a union card, and, in the now legendary strike of 1946, show solidarity not so much for industrial democracy as for two bucks a day. Perhaps for many, membership in a union meant only as much, or as little, as membership in GE's Quarter Century Club.

Particularly tuned to those ambiguous worker attitudes was the coordinated cooperation labor policy of the 1920s. One might dismiss it as mere hypocrisy. To that, a defender might reply that hypocrisy is the tribute that vice pays to virtue. Perhaps the hypocrisy of coordinated cooperation helped prepare Gerard Swope to later adopt a more constructive approach toward workers. His constructive acceptance of the Wagner Act was GE management's finest hour.

Toward customers, GE showed many faces, appropriate to the many types. In selling to electric utilities, the main customers numbered only in the hundreds. Many were engineers, some trained in the GE Test Program. The main Industrial Equipment customers also tended to be also relatively few, mainly oligopolists in such industries as oil, autos, and steel. Defense products has essentially one customer, the Federal government. Only consumer products competed for the millions of ordinary customers. It was in light bulbs, the largest market and the one with broadest cross section of customers, that GE made by far its largest profits, and did the most to limit competition, first by antitrust violation, then by patent monopoly.

More generally however, the Old GE was for most of the 20th century constrained to seek more moderate profits. This was not altruism. The constraints came from customer preference, the threat of government antitrust prosecution, depression, war, cold war, public opinion, and the complexities of technology. As a result of this constrained selfishness, the social rate of return on most of GE's businesses matched or exceeded the company's own private rate of return. Even that most monopolistic business, Lighting, provided such high social returns that lighting products were used by economist William Nordhaus to illustrate the high social benefit of technology-driven productivity.[617]

Towards communities, policies varied from benefit to bullying. The Old GE's role in its largest company community, Schenectady NY, puts the 1980s deindustrialization episode with which this book began into perspective. Far from a surprise departure, that episode was a predictable extrapolation of the century long bell curve of typical U.S. 20th Century Giant Corporation presence . That curve began in 1886 when the Edison Machine Works arrived in Schenectady on the run from New York City's crowding, politics, and unions. It peaked in 1945- 1950, as GE began moving to small locations in the South and West, on the run from Schenectady's crowding, politics and unions. The 1980s only extrapolated the curve. The only real surprise is that the Schenectady curve did not go to zero in the first decade of the 21st century, but leveled off at about 2000.

In between those end points , on the local scale, the Old GE alternately boosted and bullied the community that it had turned into the Electric City. The bullying included about a half dozen threats of departure. Episodes that included such threats ranged from the Kreusi Avenue purchase of the 1890s to the Make Schenectady Competitive campaign of the 1960s.

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[617] **Nordhaus, William D. 1988. Do Real Output and Real Wage Measurements Capture Reality? The History of Lighting Suggests Not. Cowles Foundation Paper No. 957. Nordhaus, William D. 2004. Schumpeterian Profits in the American Economy. NBER Working Paper No. 10433, p.1**

As that century of impact played out, Schenectady families, as illustrated in this book by the Clunes, Cermaks, Nigirnis, Gabrieles, Emspaks, Jandreaus, Manginos, Sarnackis, Schwenkers and Wellers achieved three generations of upward economic and social mobility. Atypical, but illustrating the possibilities, were the Wellers. The first GE Weller, Jake, crossed the Mohawk River in 1888 to join the Edison Machine Works as a laborer. He became a tool and die maker, and stayed for 43 years. His son and three grandsons all graduated from the Apprentice Program, carrying the family deep into the 20th century. From there, two more Apprentice graduates, Jacob's great grandson Keith and great granddaughter Kristie, brought the tradition into the 21st century, rounding off the family's total of 225 years of General Electric employment.[618]

Descendants of these long time families had by the late 20th century moved beyond GE to other professions or enterprises in the vicinity of Schenectady or beyond. Those descendants include Esther Schwencker, head of the Schenectady Library. Dr. James J. Nigirny, a graduate Union College and Albany Medical School practicing medicine in the Capital Region, Raymond Sarnacki, also a college graduate, spending 40 years in the non-GE corporate world, then becoming a citizen-scientist in archaeology for the Smithsonian. Gabriele descendants still run Gabriel's Market in Rotterdam NY. Clune descendants still run the Clune Electrical Supply company in Clifton Park NY. Descendants of Raffaele Mangino who arrived in Schenectady just after 1900 now run a Buick-GMC auto sales business in nearby Ballston Spa NY. The professions of the Cermaks ranged from newspaper reporter to psychologist. Ruth Young Jandreau was in 1986 a leader of many Schenectady County public causes. On the national scene, Frank Emspak, son of Julius, detailed, in a 2022 memoir entitled Troublemaker, his own career as a shop worker, labor organizer, and historian.

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[618] **Jacob I. Weller Family Records, MiSci.Works News 22 June 1925**

For latecomers to Schenectady, however, that deindustrialization was a greater injustice. The growth takeoff of Schenectady's Black community, from 1945 through 1990, coincided with GE's accelerating departure. With it departed the opportunities that had previously been enjoyed by those previous waves of arrivals from Europe. That GE departure from Schenectady, did however, bring some equal racial opportunity to GE destinations such as Louisville KY, Lynchburg VA, and Columbia SC. One way of summarizing this mixed messages of community impact might be that aphorism attributed to economist Joan Robinson. The only thing worse than being exploited by the capitalists is not being exploited by the capitalists.

As national corporate citizen, GE also mixed good and bad. Bursts of good corporate citizenship included the progressive initiatives of 1912 to 1929. such as pensions, life insurance, housing assistance, and unemployment insurance; calm and constructive acceptance of unionization in the 1930s and of civil rights in the 1950s; and service as an arsenal of democracy, helping to win two hot wars, and providing capability that helped deter a cold one from becoming hot.

Bursts of bad corporate citizenship included antitrust violations such as the pre 1911 lighting cartel, misuse of the patents such as the GE-Westinghouse Patent Board and the semantic exaggerations of “Greco-Schenectady” patentability, Boulwarism, the 1950s firing of employees for exercising their constitutional rights, price fixing, the mess left at Hanford WA, and the million pounds of PCBs poured into the Hudson and Housatonic Rivers.

Other a aspects of GE citizenship are harder to grade. For example, should GE's role in the political emergence of Ronald Reagan counts as good or as bad corporate citizenship? Reagan's 10 year GE career was certainly a key turning point not only in his life, but also in national politics. The interpretation , however, that GE leaders Cordiner and Boulware groomed Reagan as a sort of Big Myth Manchurian Candidate goes far beyond the available evidence.

In the end , final judgment of GE as corporate citizen is not just a matter of historical evidence, but also a value judgment. Here is one possible such judgment. Over the Old GE's century, the company's faults did not stop its products from getting better, its wage rates from increasing, its working conditions from getting less exhausting and more safe, its work force families from getting better educated, more diverse,and generationally upwardly mobile, and its technological achievements from helping to make lives longer, healthier, safer, more comfortable and more convenient

The Old GE sometimes did all these things in ways that have justly been criticized. It did so, however, without imposing the full democracy-destroying plutocracy that is depicted in the more extreme Giant Corporation caricatures. In sum, when observing that the Old GE could have done a lot better as a corporate citizen, remember that it also could have done a lot worse. Making profits that were sometines excessive but rarely outrageously obscene kept GE from doing more serious mischief. As the British writer Samuel Johnson put it back in the 18th Century: "men are rarely more harmlessly employed than when they are making money."

To follow up on that thought, go back to that old folk definition of a corporation as a giant immortal artificial person without an ass to kick and a soul to save. How well did that characterize the Old GE? Gigantic it was. Immortal it was not. And it was also not without a target for kicks. The kicks came in the many forms. They ranged in severity from negative publicity to marketplace setbacks to antitrust indictments to courtroom convictions. Sometimes GE learned from painful experience how to anticipate and avoid future kicks. This was especially true for antitrust. For example, after exploring violation of the Sherman Antitrust Act, and suffering a kick in 1911, GE came around to anticipating antitrust effects and preempting them. It did so for example by discarding Electric Bond and Share in the 1920s. On the other hand, its top managers either tacitly accepted or did not inquire into, GE’s most blatant corporate crime, price fixing.

The need for, and the effectiveness of, government antitrust action remains a complicated and contested topic. Few of the 20th century Giant Corporations were broken up or even significantly hampered by antitrust

prosecution. For the Old GE at least, however, repeated antitrust convictions did help install an atmosphere of anticipation and preemption that helped head off more serious violations. As economist George Stigler put it, **"t**he ghost of Senator Sherman is an ex officio member of the board of directors of every large company."[619]

Finally, the Old GE indeed did not have a corporate soul. Its claim to have a unique corporate culture was an exaggerated and inadequate substitute. It treated a small minority, measured in hundreds or a few thousands, of its top management and technical leaders as a privileged aristocracy. It treated the great majority, first tens and then hundred and thousands of its employees as easily replaceable interchangeable parts.

GE was, however, composed of actual people, who did have souls. Perhaps those souls were too often silent. Even when speaking, they were only occasionally listened to . Too often, their voices were drowned out by the barely disguised contempt for democrcy and lack of concern about equality that characterized GE's top management. GE in this regard could echo the poet Wislaya Symborska: "please forgive me, soul, for only having you now and then."

Now and then, however, such souls were heard . Hear them again , with your mind's ear. Hear the voices of the thousand GE women of 1915, leading the thousands of fellow strikers out of the Works, singing:

Put this in your bonnet

With eight hours on it

And don't mind what the bosses say

For when the fight is over

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[619] **Stigler, George. 1950. Monopoly and Oligopoly by Merger. American Economic Review. 40. 23-34. P. 32**

We'll all be in clover

We'll all work eight hours a day

Hear Bill Turnbull, at the depths of the Depression

> Will workers continue to stand by while a wage earner gets $15 a week compared to the company President's $1750 a week, even though he could only wear one suit of clothes and one pair of shoes at a time?

Hear Gerard Swope assert the right of workers to vote about their own representation:

> This is America, and that is the way we do things here!

Hear Leo Jandreau, answering a red hunting congressman:

> I am not an authority on foreign affairs....I am only a fellow who came from the shop, elected as an officer of the union, and try to do my job honestly.

Hear Helen Quirini, answering a corporate labor relations manager who disparaged women workers.

> I answered him." Mr.so-and-so, you know, I have a three year old nephew who could do your job.Because all you do is say "no", and he could do that as well as you do.There was silence in the room, and I was never again afraid to take on anyone.

Finally, whatever you may think of his subdued form of socialism, or his cooperative form of capitalism, hear Charles Proteus Steinmetz:

> Now, personally, I have no fault to find with existing society. It has given me everything I wanted. I have been successful professionally in engineering and have every reason to be personally satisfied, and the only criticism that I can make is that I would be far more satisfied with my advantages if I knew that everyone else could enjoy the same.

"I would be far more satisfied with my advantages if I knew that everyone else could enjoy the same." Not a radical battle cry, strlking fear in the hearts of capitalists cowering in their corner offices. Not a charitable cry toward which those capitalists might be willing to sacrifice a significant share of their salaries, incentive compensation, stock options, or personal perks. Not a business-school justification of corporate giantism rivalling Chandler's Visible Hand .

Though none of the above, that clunky Steinmetz sentence does point toward this book's answer to its main question: Giant Corporations of the 20th century: curse or beautiful;? Giant Corporations' managers were more harmlessly employed making money than they might have been in other efforts, such as politics. Their expressed devotion to progress was indeed hypocritical, but it was a tribute to the virtue of innovation. All this left stockholders, customers, workers, cities holding GE plants, the nation and the world, a little better off being exploited by capitalists than they would have been not being exploited by capitalists,

That comprpmised combination, neither curse nor beauty, did offer halting and incomplete glimpses of Steinmentz's vision. Wages never sufficiently rewarded labor's added value, but did fitfully approach adequacy. Benefits never constituted a full private safety net, but did participate in an incomplete but growing private-public safety net. Non-material advantages that Steinmetz valued--recognition, respect, mutuality, and actual rather than management coordinated cooperation-- were glimpsed less often and less clearly. The Old GE never achieved results in these dimensions that would have , or should have, satisfied Steinmetz. The Old GE did, however, provide glimpses of the possibility that, in cooperation rather than conflict, capitalism and democracy might advance together toward Proteus' modest goal.

Appendix 1: The Old GE by the Numbers

Year	**GE Sales, $-million current $**	**GE Earnings, $-million current $**	**US GDP,, $-billion current $**	**GE ratio of earnings/sales,%**	**US Electric Power use, billion KWH**
1900	**28**	**6**	**21**	**21**	**4**
1910	**71**	**11**	**34**	**15**	**19**
1920	**275**	**39**	**89**	**14**	**51**

1930	**376**	**55**	**92**	**14**	**102**
1940	**411**	**56**	**103**	**13**	**162**
1950	**1960**	**173**	**300**	**8**	**353**
1960	**4197**	**200**	**542**	**4**	**777**
1970	**6726**	**326**	**1073**	**4**	**1512**
1980	**24,959**	**1514**	**2857**	**6**	**2218**
1990	**58414**	**4303**	**5963**	**7**	**2816**

GE Financial Results, constant (year 2000) Dollars (based on Consumer Price Index)

Year	**GE Sales, $-million , $-year 2000**	**GE Earnings, $-million, $-year 2000**	**US GDP,, $-billion, $-year 2000**	**US Electric Power use, billion KWH**
1900	**592**	**123**	**444**	**4**
1910	**1330**	**206**	**636**	**19**
1920	**2630**	**335**	**765**	**51**

1930	**3889**	**567**	**949**	**102**
1940	**5040**	**687**	**1260**	**162**
1950	**14,400**	**1240**	**2790**	**353**
1960	**24,400**	**1160**	**3150**	**777**
1970	**29,800**	**1450**	**4760**	**1512**
1980	**52,200**	**3490**	**5970**	**2218**
1990	**77,000**	**5670**	**7860**	**2816**

Indicators of GE Performance

Year	**Number of shares of GE stock, millions**	**Typical share price for indicated year, $**	**GE Market Value, $-million**	**GE Net Worth, $-million ("capital")**	**GE ratio of earnings to capital, %**	**GE ratio of share price to earnings per share, %**
1900	**.25**	**125**	**31**	**18**	**28**	**4**
1910	**.65**	**160**	**104**	**46**	**13**	**9**
1920	**2**	**140**	**280**	**224**	**18**	**8**
1930	**29**	**75**	**2175**	**403**	**15**	**37**
1940	**30**	**20**	**600**	**368**	**18**	**11**
1950	**30**	**41**	**1230**	**702**	**22**	**6**

1960	**90**	**85**	**7650**	**1513**	**13**	**36**
1970	**90**	**77**	**6930**	**2706**	**12**	**21**
1980	**300**	**58**	**17,400**	**8200**	**14**	**8**
1990	**900**	**60**	**54,000**	**21,680**	**19**	**12**

GE Employment.

Company numbers are mainly from Annual Reports, but estimated pre 1925. Schenectady numbers are mainly from , Buell, Bill. "GE Employment Through the Years". Schenectady Gazette. 21 Sept 2017. The year 1931 marked the lowest employment during the Great Depression

Year	**GE total**		**GE Schenectady**		
1890	**6000**		**3000**		
1900	**20,000**		**10,000**		
1910	**32,000**		**16,400**		
1920	**60,000**		**21,225**		
1930	**78,368**		**25,000**		
1931	**41,560**		**12,000**		
1940	**85,746**		**22,000**		

1950	**183,000**		**32,400**		
1960	**250,621**		**25,000**		
1970	**316,593**		**22,000**		
1980	**285,000**		**24,000**		
1986	**359,000***		**15,000**		

***includes 79,000 from just acquired RCA, most of whom worked for businesses GE soon sold off**

Appendix 2: A Historian Reads the Balance Sheet

In his book The Market Power of Technology (2023. Columbia University Press), Stanford University emeritus professor of economics Mordecai Kurz has some unkind words to say about General Electric, and some unconventional things to say about monopoly. The latter include what monopoly is, how to measure it, what concerns it raises, and what should be done about it. All this makes Kurz's views important for assessing Giant Corporations in general and GE in particular-- however unqualified the

author of this history of GE is to grapple with Kurz's sophisticated mathematical economic models, or even to read a balance sheet.

Like most modern anti-monopolists Kurz does not restrict itself to the narrow definition of monopoly as a single seller serving an entire market. Nor does he identify monopoly with a particular and excessive level of the ratio of company sales to the total market, such as 70%. He does not however, use those rejections to proclaim "I can't define monopoly, but I know it when I see it".

Instead, Kunz sees monopoly not as a binary yes or no but as a measurable matter of degree. He measures a quantity called Monopoly Wealth using information that companies make public in their annual reports or through the press. He then dons his green eyeshade and dives into a venerable accounting document, the balance sheet.

The balance sheet depicts the company in two columns, assets and liabilites. Assets are things that could be turned into cash. These range from real estate, buildings and machinery to inventories, to company holdings of stocks, bonds, and holdings of cash itself. Liabilities are basically what the company owes to others. Subtracting liabilities from assets gives a dollar figure called "Net Worth". (Don't be confused by the fact that on actual balance sheets the accountant then inserts on the liabilities side an item that is called something like "invested capital." It is essentially equal to the net worth. Its purpose is to make the assets and liabilities columns come out equal).

Kurz then computes for the company a number called "Market Value." It is simply the price of one share of a company's stock multiplied by the total number of shares outstanding. He now has all the numbers he needs to define Monopoly Wealth:

Monopoly Wealth = (Market Value - Net Worth) /Market Value

Note that, expressed in % , this number can be above 100%, and also can be negative. A negative Monopoly Wealth means, roughly speaking, that the stock market has found the company to be worth more dead than alive.

Far from being rare, Kurz asserts that in the twentieth century many U.S. companies had negative Monopoly Wealth.

Why is this number an appropriate measure of Monopoly Wealth? Monopoly Wealth so measured is a Wall Street estimate of the value of company characteristics that, though they do not show up on the balance sheet, enable a company to earn far greater profits than it could earn under perfect competition. Those characteristics include creative people, mastery of new technologies, patents, unique procedures, trade secrets, the prestige of the company's logo, and the aggressiveness of the company's business practices. Most of this value does not show up on the balance sheet.

Kurz does not view Monopoly Wealth as typically a violation of the anti trust laws. Indeed he deliberately ignores blatant law violations that increase Market Wealth, such as price fixing. With those, he says, the current antitrust system is capable of dealing. He instead asserts that excessive Monopoly Wealth, even if legally acquired, is harmful to the public. So the possessors of that Monopoly Wealth, even if law abiding, should be targets for government action. All this raises two questions. At what level does Monopoly Wealth become excessive? What are the harms of even legally acquired Monopoly Wealth?

As for the danger level of Monopoly Wealth, Kurz initially looks at 21st century Giant Corporations such as Apple, Alphabet (Google), Meta (Facebook) and Microsoft. Their Monopoly Wealth ranges from 66% to 90%. Kurz views these as clearly dangerous levels. He contrasts them to the mean Monopoly Wealth of all the 21st century U.S. companies that he studied, which is 50%.

The Monopoly Wealth of the Old GE over most of its history is shown in the table below.. (Kurz does not present these numbers in his book., despite the fact that he goes on to make GE the bad example of Monopoly Wealth in the 20th century. The numbers were computed by the author of this book, using Kurz's method.)

GE Monopoly Wealth, 1900-1990

Year	**Number of shares of GE stock, millions**	**Typical share price for indicated year, $**	**GE Market Value, $-million**	**GE Net Worth, $-million**	**GE Monopoly Wealth by Kurz measure, %**
1900	**.25**	**125**	**31**	**18**	**42**
1910	**.65**	**160**	**104**	**46**	**55**
1920	**2**	**140**	**280**	**224**	**20**
1930	**29**	**75**	**2175**	**403**	**81**
1940	**30**	**20**	**600**	**368**	**38**
1950	**30**	**41**	**1230**	**702**	**42**
1960	**90**	**85**	**7650**	**1513**	**80**
1970	**90**	**77**	**6930**	**2706**	**60**
1980	**300**	**58**	**17,400**	**8200**	**52**
1990	**900**	**60**	**54,000**	**21,680**	**59**

Why does Kurz view GE's level of Monopoly Wealth , as dangerous? The two eras he studied , he asserts , had different characteristics. In the first few decades of the 21st century, when U.S. corporations have a mean Monopoly Wealth of 50-60%, a level of 70-90% is dangerous. In the first few decades of the 20th century, when U.S. corporations had a mean Monopoly Wealth of near or even below zero, that GE level of 50% was dangerous.

What, in either the 20th or 21st century, was the harm to the public of excessive Monopoly Wealth? Kurz highlights several harms, including the following. Companies with excessive Monopoly Wealth, even if acquired by good means, such as innovation, often preserve that Monopoly Wealth

by bad means, such as buying up potential competitors. Companies with excessive Monopoly Wealth protect that Wealth by barricading it behind slews of questionably valid patents and other dubiously legal barriers to entry. Companies with excessive Monopoly Wealth slow national economic growth. Companies with excessive Monopoly Wealth make society more unequal. And finally, the harm Kurz illustrates with GE: companies with excessive Monopoly Wealth slow the public adoption of new technologies.

Here the main point is that by joining with its junior partner Westinghouse in the years 1896 - 1930 to dominate the electrical manufacturing industry, GE imposed excessively high equipment prices on electric utility companies. Those high equipment prices led to higher than necessary prices for electric power charged by those utilities to the public. This slowed the annual increase in the number of people who could afford to electrify their homes. This slowing meant that the electrification of 75 % of US urban or rural non-farm homes took the 30 years (from 1899-1929), instead of the 15 years it would have taken in a more competitive economy. Farm electrification was even slower, requiring Federal government help and two more decades to reach that 75% level.

Kurz's justification of these claims is one of the more difficult parts of the book for the general reader to follow. The things that such a reader might expect him to do he does not do. For example he does not apply his earlier definition of Monopoly Wealth to GE, and then relate the resulting figure to too-high electricity prices. Instead he derives a differently defined Monopoly Wealth. Then he inserts GE's so defined Monopoly Wealth into a mathematical model of technology diffusion. The model produces a diffusion constant corresponding to that estimate of a nearly two times too long electricity diffusion.

That procedure must be evaluated by experts who understand Kurz's mathematical models. Even one lacking this expertise can however, raise questions. For example, are there examples of countries achieving that much faster diffusion, or is it an ideal never actually achieved in practice? Did the price of equipment (which was decreasing, not increasing on a per kilowatt

basis) so fully dominate electricity prices, compared to other utility costs such as the purchase of land, the construction of stations and substations, the installation of transmission and distribution lines, and the cost of fuel and labor , that GE and Westinghouse deserve all the blame for the slow diffusion?

So, to conclude, Kurz's approach to Monopoly Wealth is original and convincing. His view that GE possessed the substantial Monopoly Wealth that his definition identified seems valid. His further conclusion that GE substantially retarded U.S. adoption of electricity is, however, more controversial. It remains for other experts to determine if the models he used to address this issue explicate or obfuscate.

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