

TREDEGAR IRON WORKS, RICHMOND, VIRGINIA: A STUDY OF INDUSTRIAL
SURVIVAL, 1873-1892

by

Lee Ann Cafferata
A Dissertation
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of
Doctor of Philosophy
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DEDICATION

To Professor Paula Petrik and in memory of Professor Robert Hawkes (1932-2008) with deepest gratitude.

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ABSTRACT

TREDEGAR IRON WORKS, RICHMOND, VIRGINIA: A STUDY OF INDUSTRIAL SURVIVAL, 1873-1892

Lee Ann Cafferata, Ph.D.

George Mason University, 2016

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Tredegear Iron Works had been the fourth largest iron manufactory in the nation during the antebellum period, the principal supplier of armaments to the Confederacy during the Civil War, and a mainstay of southern economic recovery in the post-War era. With the onset of the Panic of 1873, however, Tredegear faced financial ruin when its railroad markets collapsed. Technological obsolescence threatened as the emergence of the steel industry slowly, but inexorably, eclipsed portions of the iron industry during the 1870s and 1880s.

In order to remain in business during this crisis period, Tredegear followed a path of adaptive evolution rather than dramatic innovation. Instead of revamping product lines and initiating manufacturing processes that

entailed radical technological shifts, the company shored its bottom line through continuing to manufacture traditional iron products with reliable markets and introducing incremental upgrades to plant machinery and manufacturing processes. A tightly-held, family-owned corporation, the values and priorities of its owners, proximity to natural resources, and the circumstances of the social and political framework in which the company functioned propelled these rational business decisions. This corporate persistence enabled the company to emerge from a period of receivership, manage indebtedness, and regain profitability.

I. INTRODUCTION

The remnants of Tredegar Iron Works sprawl on the banks of the James River in Richmond, Virginia, at the terminus of what once was the city's thriving nineteenth century industrial waterfront. An industrial archaeological site, its buildings, brick walls, waterwheels, empty canals and millraces evoke specters of the company's 115 years of operation, of the people who worked there, and of the products they made. Today, the American Civil War Center, a museum, occupies a reconstructed foundry in the complex. Public concerts, fireworks displays, and picnics engage the public in the restored courtyard. Park rangers guide visitors among reconstructed buildings while detailed signage explains striated evolutions of construction, power systems, and manufacturing processes over time.

The archaeological site animates a story of industrial survival. Established in 1838 on the site of former mills, a tanyard, and an early iron enterprise, Tredegar Iron Works had been the fourth largest iron manufactory in the nation during the antebellum period, the principal supplier of armaments to the Confederacy during the Civil War, and a

mainstay of Southern economic recovery in the post-War era. With the onset of the Panic of 1873, however, Tredegar faced financial ruin when its railroad markets collapsed. Technological obsolescence threatened as the emergence of the steel manufacturing slowly, but inexorably, eclipsed portions of the iron industry during the 1870s and 1880s.

In order to remain in business during this crisis period, Tredegar's owner, Joseph Reid Anderson, followed a path of adaptive evolution rather than dramatic innovation. Instead of revamping product lines and initiating manufacturing processes that entailed radical technological shifts, Anderson shored up Tredegar's bottom line through continued manufacture of traditional iron products with reliable markets and he introduced incremental upgrades to plant machinery and manufacturing processes. Anderson maintained the ironworks as a tightly-held, family-owned corporation. His values and priorities, the company's access to raw materials, and the circumstances of the social and political framework in which the company functioned propelled these rational business decisions. Technological persistence enabled the company to emerge from a period of receivership after the Panic, manage indebtedness, and regain profitability. The importance of the iron works as

an exemplary southern manufacturing company remained undiminished throughout the nineteenth century.

Tredegar's situation in the years after the Panic is often classified as failed recovery, concomitantly, the outcome of limited corporate financial resources and short-sighted management because Tredegar did not enter the steel business. The company's direction during the 1870s and 1880s, however, reflected rational decision-making commensurate with the values of the Joseph Reid Anderson, who owned the ironworks, and of his family members who served as corporate officers and members of Tredegar's Board of Directors. The Andersons were conservative businessmen and prominent leaders of Richmond's social and financial community. The importance of their elite position and the role of the company as an economic mainstay of the city influenced risk-averse approaches to business development.

Tredegar epitomized a preponderance of metal manufacturers in the nineteenth century: small to mid-sized companies that continued successfully and exclusively in iron manufacture by adapting traditional technologies to the changing industrial landscape. Tredegar's trajectory during this time period characterized that of family-owned independent iron manufacturers who dominated local economies, society, politics, and culture. Its corporate experience reflected the continuity and prominence

of iron technology during the nineteenth-century industrial revolution in America, confirming that the movement away from iron and into steel production was neither immediate nor universal.

Tredegar had been in operation only four years when Joseph Reid Anderson joined the company as a commercial agent in 1841. He purchased Tredegar in 1843, gradually building the ironworks into a tightly-held, family-controlled enterprise with world-wide markets. In spite of shortages of raw materials, deficiencies of skilled labor, the decimated southern transportation infrastructure, and fiscal confusion within the Confederate government, Tredegar became the principal supplier of armaments to the Confederacy. Even under the exigencies of wartime production, only the R. P. Parrott Company in New York¹ produced more cannon on a national level than Richmond's Tredegar between 1861 and 1865. According to *Scribner's Monthly*, "The Tredegar Iron Works was to the armies of Lee and Johnson, during the war of Secession, what the great forges of Krupp were to the Germans in the contest with France."²

¹ The R.P. Parrott Company was Tredegar's northern avatar. Founded in 1818, The R.P. Parrott Company, also known as the West Point Foundry in Cold Spring, New York, specialized in iron ordinance, gaining lucrative government contracts and an international market before and during the Civil War, as well as manufacturing other cast iron products. See Chapter VI, Tredegar Ironworks and West Point Foundry *infra*.

² Jed Hotchkiss. "New Ways in the Old Dominion," *Scribner's Monthly*, Vol. 5, Issue 2 (Dec. 1872). Making of America, static link, <http://cdl.library.cornell.edu/cgi-bin/moa/moa-cgi?notisid=ABP7664-0005-23>.

By 1873, Tredegar had more than doubled its pre-war capacity in every department and employment climbed to over two thousand workers. These were the boom years. Tredegar rode a crest of profitability and production, marketing to the burgeoning railroads. Over 33,000 miles of new track spread across the country between 1865-1873, and Tredegar based its recovery on manufacturing iron products for those markets. Anderson advertised that the company had customers in every state in the Union as well as in Cuba, South American countries, and the Caribbean.

The *Virginia State Journal* touted Tredegar as the city's flagship iron manufactory. A lengthy article situated Tredegar in the vanguard of iron manufacturing because of the company's technological prowess and the extent of its facilities. The company's prime location among Virginia's vast natural and man-made resources—bituminous coal, limestone beds, port and railroad transportation hubs, and sands and clays for casting and puddling work also contributed to its pre-eminence. "The importance of this large and enterprising company to Richmond," the *Journal* noted, "can hardly be estimated in appreciable results. Besides the large force

they constantly employ, their industry stimulates a hundred others in Richmond and its vicinity.'³

The Panic of 1873 marked a turning point for Tredegar, however. The Panic crushed the company as its customers—predominantly northern railroads—failed with the collapse of the Jay Cooke's financial house.⁴ Major national railroads, Tredegar's principle customers, defaulted on their debts to the company leaving Tredegar, in turn, unable to pay its creditors. Struggling under these dual burdens of debtor and creditor, the ironworks discharged between 600 and 700 workmen in September of 1873. For the next three years, Tredegar's downward spiral continued as profits fell in conjunction with declines in the national iron market and as Tredegar's debtors defaulted on payments.

³ "Richmond Industry." *The Daily State Journal* (Alexandria, Va.) 1868-1874, May 18, 1872," [Mhttp://chroniclingamerica.loc.gov/](http://chroniclingamerica.loc.gov/)

⁴ Tredegar's situation during the Panic of 1873 demonstrated cumulative local effects of this first global depression attributed to industrial capitalism. A major cause of the Panic of 1873 lies with the collapse of the financial house, Jay Cooke and Company. Heavily invested in railroad construction, Cooke's supply of railroad investors evaporated with the tightened money supply induced by the Coinage Act of 1873 that effectively tied the value of the dollar to the amount of gold held in the U.S. Treasury. Access to capital and credit contracted; interest rates rose at dizzying rates; investors turned to gold to pay off debts and investment gambles made now devalued currency. As a result, Jay Cooke & Company was unable to pay loans to outside investors contracted to finance railroad construction. The company declared bankruptcy. The domino effect of the collapse of Jay Cook was far-reaching. Fearing more defaults, banks around the country began calling in loans, causing more firms and investors to default, cutting off the rail industry's cash flow, causing more banks to call in more loans, and so on to cause a major financial depression; the New York Stock Exchange closed for 10 days. Between 1873 and 1879, employment reached a high of 14%, 89 of the nation's 364 railroads went under, and 18,000 businesses failed..

Unable to regain solvency in the aftermath of the Panic, Tredegar entered receivership in 1876, the only recourse that offered the possibility of corporate survival. Appointed receiver by the Chancery Court of Richmond, General Joseph R. Anderson, president of the Tredegar Company, issued in a brief statement explaining that the company “having lost largely by the failure of other parties during the panic of 1873...has been compelled, in consequence of these losses and continued depression of the iron trade, to suspend payment [of corporate debts].”⁵ Newspapers identified the chief villains of Tredegar’s financial woes as the Chesapeake and Ohio, New York & Oswego, and Midland Railroads. According to the terms of receivership, Tredegar instituted stringent credit policies and conscientiously began to repay its debts, emerging from receivership in 1879, as the nation, too, emerged from the long depression.⁶

⁵ “The Tredegar Company Iron Works are suspended.” *Bristol News*, Volume XI, No 22, Bristol, Virginia & Tennessee, Tuesday, January 25, 1876 P. 1.

⁶ Net profits for the period immediately after the Civil War have become bellwether statistics supporting conclusions that Tredegar failed with the Panic of 1873 because its profits did not again reach to those all-time highs. Throughout the nineteenth century, however, both before and after the Civil War, Tredegar’s bottom line followed the course of national business booms and depressions. Nationally, the years between 1868 and 1872 marked a time of prosperity, and during that time Tredegar’s net profits reflected the growth of its principle market: railroads. (See Appendix A: Tredegar Net Profits, 220) Figures between 1873 and 1870 illustrate the exigencies of Tredegar’s post-Panic plight. IN 1874, the company reported net profits of roughly \$25,000 in the midst of receivership and looming debts. In less than a decade, however, during national recovery from the depression, Tredegar’s profits exceeded earlier years for which figures survive during the

Under Anderson, Tredegar maintained technologically sound, but conservative operations. The company continued to propel its facilities with waterpower, replacing waterwheels with hydraulic turbines. It concentrated on manufacturing traditional products essential to railroads such as spikes, car wheels, railroad cars, and bar iron. Although steel had invaded the rail market, rendering iron rails obsolete by 1880s, iron was the better material for these bread-and-butter items for which permanent markets appeared to exist. Anderson focused on expanding and upgrading Tredegar's property, facilities, and power generating capabilities, but never deviated into products or processes that jeopardized the company's stability and profitability.

This dissertation explores Tredegar's technological path in the context of the South and national development, not as a pre-defined failure of recovery, but as a rationale for the direction of the ironworks during in a maelstrom of cultural, social, and economic tension and transition.

antebellum period. Extant records show a range of net profits between \$35,500 and \$103,756.

Across the country, 1880-1882 were years of profitability for metal manufacturers. During 1883, a recession once again led to diminished markets until 1886 when moderate recovery recurred. Rather than representing a failure of recovery, Tredegar was in synch with national economic trends. In a prospectus to a prospective buyer of Tredegar, Joseph Anderson reported net profits between mid-1879 and 1888 as \$1,266,096.69 or an average of \$235,654 per annum representing a nine percent annual growth rate over the original purchase price of the ironworks. Joseph R. Anderson to Archibald Gracie, Esq, September 19, 1889. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

The following chapters discuss this trajectory. Chapter II: Tredegar Ironworks offers counter-arguments to a perception that Tredegar declined and failed in the aftermath of the Panic of 1873. Chapter II: Joseph Reid Anderson: Business Sufficient Unto the Day explores how Anderson's Virginia heritage and personal values of Christian stewardship and southern honor influenced the directions he chose for the company during the economic crises of the 1870s. Chapter III: The Persistence of Iron discusses the significance of Tredegar's traditional product line in the context of contemporary technology and markets. Chapter IV: The Practicality of Waterpower examines how the timing of Tredegar's water rights and the value of its location on the James River influenced technological directions. Chapter V: Conclusion summarizes the context of southern iron industries and the role of Joseph Anderson in Tredegar's survival. Each chapter supports the conclusion that Tredegar's corporate development toward the end of the nineteenth century reflected the perspective "that machines and technical processes are parts of cultural practices that may develop in more than one way. ...it appears fundamentally mistaken to think of... 'the factory' ...as a passive, solid object that undergoes an involuntary transformation when a new technology appears. Rather, every institution is a social space that

incorporates or doesn't incorporate [a new technology] at a certain historical juncture as part of its ongoing development."⁷

TREDEGAR COMPANY RECORDS

In 1919, Archer Anderson, Jr., became the third generation of Anderson's to head Tredegar. The Internal Revenue Service had just reorganized and rewritten Tredegar's balance sheet and challenged the accuracy of Tredegar's records and the valuation of the ironworks. Called upon to defend corporate records, Archer, Jr., explained to the Commissioner of Internal Revenue "We are an old, privately owned and conservatively managed company; ...for the last forty years or more this plant account has been kept on our books as one account, that is buildings, land and water power rights lumped together under one heading not segregated as modern accountants seem to require."⁸ In differentiating between internal and external record-keeping systems, Archer, Jr. explicates the challenges of working with Tredegar records.

The Tredegar Iron Works records housed in the Library of Virginia in Richmond are considered one of the most complete, extant collections of any business, particularly of the nineteenth century. The collection

⁷ *Ibid.*, 62.

⁸ Letter from Archer Anderson, Jr., Prest. The Tredegar Company to Commissioner of Internal Revenue, Washington, D.C., March 3, 1919. A Guide to the Tredegar Iron Works Records, Tredegar Iron Works Records, 1801-1957, Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

documents the history of the company between 1801 and 1957. It fills 596.33 cubic feet organized in 1345 boxes, 490 shelved volumes, seven oversize boxes, numerous blueprints, six oversize map cases, and one rolled tube.⁹ The majority of documents are hardcopies, although the most fragile are available to the researcher only on microfiche. None are digitized. The Library's comprehensive finding aid is more than half an inch thick and comprises several hundred pages.

Besides providing detailed accounts of Tredegar's corporate history, the records themselves offer historical perspectives of business recordkeeping practices. Recordkeeping was not centralized within the company. The Library of Virginia received the collection during the 1950s and organized the materials into broad categories: General accounts, Purchasing and receiving records, Production and labor records, Sales and shipping records, Correspondence, and Anderson family papers. These records include balance books, cashbooks, contract books, correspondence, daybooks, estate accounts, family papers, insurance policies, invoices, journals, ledgers, minute books, patents, payroll ledgers, real estate files, sales books, stock certificates, suit papers, tax returns, vouchers, and war department contracts. Records may overlap.

⁹ A Guide to the Tredegar Iron Works Records, Tredegar Iron Works Records, 1801-1957, Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

Information about a single customer order may appear under correspondence, invoices, contract books, and under several headings of individual shops involved in fulfilling the order.

Organizational methods are inconsistent. The records are both prose (that is minutes, correspondence, and reports) and numeric (financial, inventories, and production records for example) Materials within each of these categories different styles of corporate recordkeeping prevailed over time over time and their organization and methodology likely represent the preferences of individual managers.

The diffusion of information and formatting inconsistencies possibly indicate that informal, internal communication and institutional practices were as germane to operations as the formal organization of written records. Information about specific products or an individual order from a single company, for example, may appear duplicated among correspondence files, contract files, production files, employee records, or in various ledgers and journals for individual machine shops. Labor records between 1873 and 1890 may be listed under the name of an individual worker, under the shop or order to which a workman was assigned, or as a record of total worker-hours for a particular project. As a result, the process of reconstructing, quantifying, and analyzing much of Tredegar's experience requires extensive cross-referencing across diversely formatted

records with the caveat that documents may overlap and totals may be inexact or incomplete.

II. TREDEGAR IRONWORKS

Historians have provided in-depth accounts of the history of Tredegar during the antebellum era and during the Civil War. Studies such as *Virginia Iron in the Slave Era* by Kathleen Bruce published in 1930 was in the vanguard of these accounts, placing Tredegar in the context of the long history of the state's iron industry. Thirty-five years later, *Iron Maker to the Confederacy: Joseph Reid Anderson and the Tredegar Iron Works* detailed the role of the ironworks during the Civil War and focused on Joseph Reid Anderson as a businessman and a staunch Confederate. The work of these historians and others who have written about Tredegar in journals, dissertations, and other monographs include with brief epilogues introducing the narrative of the company during Reconstruction up until the Panic of 1873. These works, by and large, concluded that Tredegar failed to recover from the Panic of 1873 and that its subsequent story is one of decline. Historians have generally declared that the principle factor of that decline was Tredegar's persistence in iron manufacture rather than transitioning to steel during the 1870s. The company's perilous financial status conditioned by the Panic of 1873 shares the blame for the

decision to remain in iron manufacture along with poor planning on the part of company managers.

While it is true that Anderson did not attempt to build Tredegar into a corporate entity on the scale of large steel and railroad companies, the power figures of the industrial landscape during his lifetime, he steered the firm profitably through three major economic depressions during his years at the ironworks. Tredegar continued as a mainstay of Richmond's economy, a principle source of employment, and a significant manufacturer of railroad products. A pejorative conviction of failure after the Panic of 1873 has nonetheless remained engraved in the historic record.

INHERITED PERCEPTIONS OF FAILURE

According to Charles Dew, pre-eminent chronicler of Tredegar's role in supplying armaments to the Confederacy during the Civil War, "Iron gave way to steel in the 1870s and 1880s but the Tredegar Company, shackled with a sizable debt, lacked the capital needed to make this transition,"¹⁰ "The Depression of 1873...stunted the growth of the South's largest industrial plant,"¹¹ Dew, concludes.

¹⁰ In 1860, Tredegar's extensive catalog of manufactures advertised cast steel articles, including tools, axes, switch bars, and a variety of saws and saw blades. Invented in 1751, cast steel is made by heating iron in a crucible container. Stronger than iron, the method for making cast steel in 1860 required adding small amounts of carbon to iron, repeatedly heating the wrought iron and charcoal together in a kiln. Melting allowed the

Other historians echo Dew's statement. In a study of post-Civil War Richmond, historian Michael Chesson repeats Dew's conclusion: "[Tredegar] lacked capital to make the change from iron to steel manufacture..."¹² Lisa Hilleary's dissertation elaborated, "One newspaper believed that a company needed approximately \$300,000 to transition completely to Bessemer converters to produce steel. Anderson could not make this transition. ...While his contracts provided access to raw materials (coal, iron ore), he did not gain enough capital to transition his large company to steel manufacture. ...Anderson's failure to transition the company to steel products resulted in Tredegar's decline..."¹³

The company's documentation in the National Register of Historic Sites affirmed early explanations of Tredegar. "Saddled with a heavy debt, [Tredegar] was unable to make the transition from iron to steel and became a facility primarily of local importance, producing some railroad

addition of alloys to the mixture to strengthen the product. ("[What Is Cast Steel?](http://www.wisegeek.com/what-is-cast-steel.htm)," [wiseGEEK](http://www.wisegeek.com/what-is-cast-steel.htm), accessed July 29, 2015, <http://www.wisegeek.com/what-is-cast-steel.htm>.) The This form of steel production would not have required Tredegar to create radical changes in equipment or production processes. How long and to what extent the ironworks sold these products is not known. The advent of the Civil War and Tredegar's focus on munitions certainly curtailed the manufacture non-war related products. Tredegar Iron Works (Richmond Va.), *An Illustrated and Descriptive Catalogue of Manufactures of Tredegar Iron Works*, Joseph R. Anderson & Co., Richmond, Va (Macfarlane & Fergusson, 1860), 79.

¹¹ Charles Dew, *Ironmaker to the Confederacy*, New Haven: Yale University Press, 1966, 319.

¹² Michael B. Chesson, *Richmond After the War: 1865-1890*. Richmond, Virginia: Virginia State Library, 1981. P. 164.

¹³ Lisa Hilleary. 2009 "Richmond Iron: Tredegar's Role in Southern Industry During the Civil War and Reconstruction." (M.A. thesis) Old Dominion University, ProQuest Dissertations Publishing, (Publication number 1504025). pp 79-81.

iron, ordnance, and horseshoes."¹⁴ Similarly, records of the Historic American Engineering Record of the National Park Service paint a similar picture of decline, "Iron gave way to steel, but the Tredegar, lacking funds, was unable to make the transition. ...the largest industrial plant of the South became a small local concern."¹⁵

Dennis Maher Hallerman, formerly an archivist at the Library of Virginia, who wrote an early finding aid for the Library's massive collection of Tredegar corporate records, also blamed corporate decline on Anderson's decision not to enter the steel market during the post-Civil War period.¹⁶ Hallerman's dissertation examined Tredegar through 1875 and he maintained that Anderson operated Tredegar on a *carpe diem* philosophy. In other words, Anderson lacked long-range planning or vision but seized any available opportunity with the possibility of profit. This

¹⁴ National Register of Historic Places, System ID 71001048, <http://focus.nps.gov/AssetDetail/NRIS/71001048>.

¹⁵ National Park Service, "National Register of Historic Places, Inventory, Nomination Form," Virginia Department of Historic Resources. Historic American Engineering Record, Tredegar Iron Works, U.S. Route 1, along James River, Richmond, Independent City, Virginia. [Library of Congress: <http://www.loc.gov/pictures/item/va1268/>] Convenient for a sweeping narrative, but factually misleading, these documents do not specify dates for various transitions or provide context for the development of metallurgical industries in the South. Birmingham, Alabama, for example, did not begin iron manufacture until 1879. The first open hearth steel manufacture began in 1899. (Langdon White, "The Iron and Steel Industry of Birmingham, Alabama, District, Economic Geography, Vol 4, No. 4, October 1928, p 350)

¹⁶ Dennis Maher Hallerman. 1978, *The Tredegar iron works: 1865-1876*. UR Scholarship Repository: University of Richmond. Dennis Hallerman is also the author of the Library of Virginia Finding Aid, "A Guide to Tredegar Iron Works Minutes, 1876-1879 where he repeats, "As iron gave way to steel in the 1870s and 1880s, Tredegar found it did not have the capital necessary to make the production conversion."

carpe diem business approach, according to Hallerman, was most evident during the rapid period of post-War expansion, when Tredegar failed to utilize profits to reconstruct the facility for the manufacture of steel. "The company's hesitancy to investigate steel production on a trial basis during its boom period," Hallerman continues, "made the effects of the Panic of 1873 harsher and subsequent recovery more difficult.

...Tredegar's reluctance in investigating steel production during its boom period hurt its chances of making a quick recovery after the panic of 1873 as it was locked into iron production, and no capital was available for conversion to steel manufacture."¹⁷

In his often-cited work, however, Hallerman fails to provide specific evidence that Tredegar's management ever explored transforming the iron works into steel manufacture, much less expressed hesitancy, reluctance, or enthusiasm for steel manufacture.¹⁸ In fact, no historian has yet shared specific documents or evidence from Tredegar's vast historic records verifying that Anderson or the company's board had expressed

¹⁷ *Ibid.*, p. 129-30

¹⁸ Hallerman's remarks about Tredegar's failure to begin steel production occupy six pages in his master's thesis. None include footnotes citing instances among Tredegar's extensive corporate records wherein discussions about steel production occurred.

interest in, corresponded about, or even speculated on pursuing steel manufacture.¹⁹

The absence of documentation signals a moot issue, and in her doctoral dissertation, Sally Ann Flocks turns slightly from this inherited construct of the failure to pursue steel manufacture to question whether lack of money prevented Joseph Anderson and Tredegar from entering into steel production. She explores more multi-faceted discussions of Tredegar's development, pointing out that shortages of funds had never stopped Joseph Anderson from moving the iron works into new markets.²⁰ Flock aligns her theory with Hallerman, however, in the belief that Tredegar's single focus on the iron business reflected a *carpe diem* philosophy, a narrow sense of short-term goals in the haste to ride the postwar railroad- building boom to prosperity after the war years. Like other historians, Flock's discussion of Tredegar's failure to enter the steel market becomes speculative in the end. She provides no evidence of

¹⁹ In the process of researching this dissertation, I have explored extant handwritten documents in Correspondence, in Anderson family papers, Administrative records, and Corporate minutes. My original purpose was to locate the records that included information about Tredegar's decision not to enter the steel industry and, thus, to be able to append citations to these assertions. No such records appeared. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

[<http://ead.lib.virginia.edu/vivaxtf/view?docId=lva/vi00494.xml>]

²⁰ Sally Ann Flocks. 1983. "*In the Hands of Others*": *The Development of Dependency by Richmond's Manufacturers on Northern Financiers*." (Doctoral Dissertation). (New Haven: Yale University) 1983

whether, when, or how Joseph Anderson himself considered entering the steel market. It is history built on inference.

Lacking evidence, ongoing discussions regarding Tredegar's failure to enter the steel market become hypotheticals disguised as fact by virtue of their repetition. These hypotheticals sidetrack investigation into factors that shaped Tredegar's technological path between the Panic of 1873 and the death of Joseph Anderson in 1892, masking broader questions about the imperative of technological change. This historiographic interpretation bypasses the nuanced contexts in which technological adaptation occurred in the nineteenth century iron industry. Assumptions about Tredegar's post-Panic failure also deter discussion of other nineteenth-century technological changes and their integration into manufacturing.

WATERPOWER AT THE IRON WORKS

Tredegar's use of waterpower queries the inevitability of adopting new technologies. During the 1870s and 1880s, technological change from waterpower to steam occurred concomitantly with mechanical and chemical advances in metallurgy. "The most striking feature of the power scene in the generation following the Civil War was the accelerating decline of waterpower's role in the national economy," wrote historian

Louis C. Hunter.²¹ The proliferation of steam changed how manufacturing companies operated and where they were located, the speed of urban industrialization, and the rise of large concerns during the 1870s.

At Tredegar, the use of direct-drive, mechanical waterpower continued, not only in the period between the Panic of 1873 and Joseph Anderson's death in 1892, but throughout Tredegar's operational history until 1957. Situated between the banks of the James River and the Kanawha Canal, Tredegar powered its machinery through a complex system of raceways, waterwheels, and turbines. Tredegar's waterpower has been described as the most decentralized waterpower system in the United States and the ironworks itself as one of the very last large-scale American industrial plants to depend almost entirely on turbine-driven mechanical drives.²² To date little discussion of Tredegar's waterpower system occupies the historical record, however.

Tredegar transitioned from the use of waterwheels to turbine-driven waterpower during the 1870s when steam superseded water in industrial use. The possibility of transitioning from waterpower to steam was more attainable for most industries than moving from iron into steel in

²¹ Louis C Hunter *A History of Industrial Power in the United States, 1780-1930 Vol. 1*, (Charlottesville: University Press of Virginia, 1979), 343.

²² Michael S. Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site," (Richmond, Virginia: Raber Associates and The Valentine Museum and the Ethyl Corporation, 1992).68.

metallurgical manufacturing. By 1859, almost 50 percent of all ironworks of all types powered their operations with steam. By 1880, the transition to steam power in the iron and steel industry was almost universal and 96 percent of the horsepower in all branches of the industry derived from steam power.²³

Geography, however, created an opportunity. Statistics for the South, the state of Virginia, and Richmond, the state's manufacturing center and the site of Tredegar Ironworks, ran counter to these national trends. The explanatory notes of the 1880 census elaborated, "...the relative importance of water power has decreased since 1870 in each state in which it was used, except the following: Maine, Massachusetts, Connecticut, North Carolina, and Virginia. These states possessed an abundance of rivers, streams, and lakes. ...in North Carolina, no steam power was used; and in Virginia, the percentage of water power used increased from 77 percent in 1870 to 81 percent in 1880."²⁴

For Anderson, utilizing waterpower reduced his production costs. Tredegar's water leases, mostly established before 1870, were based on fixed fees, immune to increase over time. Local authorities moreover, monitored Tredegar's water consumption irregularly. Waterpower was "a

²³ Louis C. Hunter, *A History of Industrial Power in the United States, 1780-1930 Vol. 1*, (Charlottesville: University of Virginia Press) Vol. 1, 183.

²⁴ U.S. Census Bureau (1880). *Report on the Manufactures of the United States at the Tenth Census*, 3.

bargain, to say the least. ...no water shortages, little if any backwater, and minimal checking on how much water was being used. Tredegar's waterpower was not something that rational company managers would give up for steam power,"²⁵ concluded the authors of an archaeological study of the facility in 1992." In addition, advances to turbine technology enabled Anderson to replace Tredegar's waterwheels with prime movers of greater efficiency and durability. Tredegar optimized the infrastructure its waterpower system during the 1870s and 1880s with the addition of strategically-placed turbines powering individual buildings and machines. Like the decision to remain in iron production, Tredegar's continuing reliance on waterpower stemmed from reasons other than an aversion to technological progress.

Although waterpower was no longer a symbol of state-of-the-art technology by 1873, turbine technology was in its prime. While historians have not yet examined Tredegar's systems in-depth, attention has accrued to the history of turbine technology as well as to the spread of steam power. In his three-volume history of industrial power in the United States, Louis C. Hunter pointed out that the hydraulic turbine proliferated rapidly at the same time that steam power overtook and surpassed

²⁵ Michael S. Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site," (Richmond, Virginia: Raber Associates and The Valentine Museum and the Ethyl Corporation, 1992), 60.j

waterpower in manufacturing. "It may be surmised that...the turbine was introduced as the simplest and often the only available means of meeting the growth needs for power at a given mill," Hunter continued. "In many situations the available power could be increased from 25 to 40 percent by installation of a well-designed turbine, and at less cost and with less dislocation of arrangements than the introduction of auxiliary steam power."²⁶. Historians Jeremy Attack, Fred Bateman, and Thomas Weiss also noted the importance of turbines to the persistence of waterpower. Both Hunter and Attack *et al* challenge the notion of blanket and universal adoption of new technologies. They encourage situational analyses of individual companies, their managers, and the reasons behind corporate decisions determining technological change.

Discussing regional variations in the pace and timing of steam power adoption, Attack, Bateman, and Weiss pointed out that the disadvantages of waterpower—including the fact that it was a non-transportable power source—were of little or no consequence to manufacturers in New England and Richmond, Virginia. These sites, according to the authors, were geographically compact, that is, numerous entities could draw power from a single source of water.

²⁶ Louis C. Hunter, *A History of Industrial Power in the United States, 1780-1930 Vol. 1*, (Charlottesville: University of Virginia Press), 345.

Furthermore, they were linked to comprehensive transportation networks and in proximity to principal markets. Long-term water rights and advances in turbine technology gave them no cost advantage or practical rationale for moving to steam.²⁷

During the nineteenth century, Lowell, Massachusetts, and contiguous New England towns along the Merrimack River exemplified the possibilities of complex waterpower systems. Extensive experimentation to improve turbine efficiency occurred in conjunction with these systems. While the historic record frequently focuses on these locations, Richmond's complex waterpower system has received little attention.²⁸ Tredegar was the largest customer of the James River and Kanawha Canal Company (the principal distributor of water rights in Richmond) with a unique arrangement of multiple turbines strategically and innovatively placed in the ironworks. For Anderson and for Tredegar, transforming and upgrading the traditional technology of waterwheels to

²⁷ Jeremy Atack, Fred Bateman, and Thomas Weiss, "The Regional Diffusion and Adoption of the Steam Engine in American Manufacturing," *The Journal of Economic History* 40, no. 2 (1980): 302, <http://www.jstor.org/stable/2120180>.

²⁸ Robert B. Gordon, "Hydrological Science and the Development of Waterpower for Manufacturing," *Technology and Culture* 26, no. 2 (1985): 204–35. . Terry S. Reynolds, *Stronger than a Hundred Men: A History of the Vertical Water Wheel* (Baltimore: Johns Hopkins University Press, 2002). Atack, Bateman, and Weiss, "The Regional Diffusion and Adoption of the Steam Engine in American Manufacturing," *The Journal of Economic History* 40, no. 2 (1980): 281–308. <http://www.jstor.org/stable/2120180>. Patrick M. Malone, *Waterpower in Lowell: Engineering and Industry in Nineteenth-Century America* (Baltimore, MD, USA: Johns Hopkins University Press, 2009), <http://site.ebrary.com/lib/alltitles/docDetail.action?docID=10363160>.

the installation of efficient and cost-effective turbines signified intelligent management. As Louis C. Hunter confirmed, “The primacy of waterpower during the early stages of American industrialization is an important fact in the history of Western technology refuting the widespread assumption that steam power reduced waterpower to obsolescence.”²⁹

TREDEGAR AND TECHNOLOGY: PERSISTENCE VERSUS INNOVATION

Tredegar remained in iron production, and continued to use waterpower as technological advances in steel production and power generation heralded a new industrial age. For Tredegar, this retention of traditional technologies is conflated with corporate decline. Equating retention of traditional technologies as failure, however, often overlooks the frequency of technological persistence among the majority of small and medium-sized businesses in the nineteenth century. Tredegar’s experience paralleled that of other iron producers during the period of the 1870s and 1880s whose corporate directions were shaped by tightly-held family ownership, access to power sources, proximity to natural resources, and status within their communities. These businesses were frequently major employers and contributors to the economic stability of the cities and towns where they were established. Their owners and

²⁹ Louis C. Hunter, *A History of Industrial Power in the United States, 1780-1930*, (Charlottesville: University of Virginia Press) Vol. 1, 539–540.

managers were among the political, financial, and social leaders in that milieu.

Speculative statements, now canon, about Tredegar and iron manufacture clearly rest on an *if-then* assumption that had money been available, the iron works would have moved into steel manufacturing. These statements, however, inadequately capture the *milieu* of the company and its owners. Joseph Anderson was a business, political, social, and religious leader in Richmond, a member of an established Virginia family whose roots in the Commonwealth dated from the mid-1700s. Most important, he was an independent businessman at the head of a family-owned enterprise that was a major source of employment and revenue for the city of Richmond. Complementary points of view from historians John Ingram and Philip Scranton challenge the received understanding of Tredegar's failure.

Business historian, John Ingham studied similar independent, family-owned iron and steel manufacturers in Pittsburgh during the latter part of the nineteenth century. He contrasts independent businessmen such as Anderson and their companies with the “modern business enterprise” that Alfred Chandler identified as a “multi-unit entity run by professional managerial hierarchies.” The vertically- and horizontally-integrated steel industries and industrialists who led them—men such as Andrew Carnegie

and Charles Schwab—implemented large-scale manufacturing, economies of scale, and formal organizational structures with growing hierarchies of mid-level managers. Family-run, independent ironworks, Ingham states, were the antithesis of the Chandlerian model. Like Tredegar, the independent ironworks in Pittsburgh generally remained with traditional technologies and production methods and, although not exclusively, with localized markets. Like Tredegar, which survived both the Panics of 1873 and 1893, these independent firms remained in business more or less profitably over extended periods of time. Their survival rate, Ingham averred, rested in conscious decisions to remain small and to maintain control and influence over their economic, social, and political environment. “Their goal,” Ingham concluded, “was not to maximize profits and rationalize production as much as it was to maintain business at sufficiently profitable levels to ensure survival, while at the same time not growing so large as to lose their local orientation. ...Of profound importance here is the question of hegemony and control.”³⁰ Like

³⁰ John Ingham was specifically analyzing the success rate of independent iron and steel manufactories in Pittsburgh between 1870 and 1960. His statistics confirmed “a surprising record of survival and continuity over an extended period, a time during which steel technologies changed profoundly, markets altered drastically, and the economy and industry itself were transformed almost beyond recognition.” (109). In 1901, 36 independent iron and steel mills operated in Pittsburgh—as many as existed in 1974. Like Tredegar, these companies remained under family control, focusing on a relatively localized manufacturing base and innovating in the areas of product and markets. Several remained exclusively in iron manufacture, often seeking specialized production

Anderson, the Pittsburgh manufacturers were the “best men” from “first families” who dominated the public culture of their cities, buttressing its cultural and social institutions.³¹ Their longevity, Ingham argued, lay in a *mentalité* that prioritized their status and influence in the community. By maintaining control over corporate finances and decision-making, they avoided dramatic risk-taking that might jeopardize family stability and narrow their social, political, and cultural spheres of influence within their communities.³²

Ingham's observations accord with Philip Scranton, historian of business, technology, and industry. Scranton studied firms engaged in manufacturing both custom and batch products and bulk or mass produced products.³³ Like Ingham, he noted that a common strategy of small- to mid-sized forms involved pursuing moderate innovation in areas

niches. John Ingham, “Iron and Steel in the Pittsburgh Region: The Domain of Small Business,” *Business and Economic History* 20, no. Second Series (1991): 107.

³¹ *Ibid.*, 110.

³² Sally Ann Flocks touches on this perspective, speculating that Joseph Anderson's sense of moral obligation to repay corporate debts without incurring greater liabilities, that his conservative attitude towards financial risk, and that his desire to maintain family control of Tredegar deterred him from moving into steel later in the 1880s as the number of steel manufacturing increased throughout the country. Sally Ann Flocks. 1983. “*In the Hands of Others*”: *The Development of Dependency by Richmond's Manufacturers on Northern Financiers*.” (Doctoral Dissertation_. (New Haven: Yale University) 1983

³³ Scranton defined custom or batch products as locomotives, engines, turbines, and the like, that is, products that were manufactured in response to specific orders. Bulk manufacturers made products in various types or sizes, producing these items in long runs without advance orders and to specifications that remained stable for years. At Tredegar, railroad car production and car wheels fell into the former category; spikes and horseshoes, the latter. Philip Scranton. “Diversity in Diversity: Flexible Production and American Industrialization, 1880-1930.” *The Business History Review*, Vol 5, No. 1 (Spring 1991), 29-31.

of product and markets and minimized aggressive technological adoptions. Instead of radically overturning and replacing existing facilities, long-standing, family-owned firms adopted incremental changes to products and distribution. The key innovation for these firms committed to older iron technologies was to find profitable market niches. "...[T]o that end, they continually sought out markets of a more specialized nature that could be serviced by small production runs of specialty iron..."³⁴

Scranton also points out that nineteenth-century narratives of Chandlerian models encompassed only several hundred firms; companies like Carnegie Steel represented only a fraction of the manufacturing companies that were operational. The Chandlerian model obscures 80 to 90 percent of the nation's industrial concerns. Scranton acknowledged that the managerial and technological trailblazers of emerging mega-corporations appear more exciting to study. He points out, however, "Firms differing in organization and strategy from the 'leaders' were hardly a host of backward sweatshops headed by unimaginative tyrants.

³⁴The open hearth process of steel making superseded the Bessemer method in the late nineteenth century. For small firms, this was a less expensive way of manufacturing steel and a process that did not require radical changes to equipment. In Pittsburgh, the number of open hearth steel makers grew from four in 1884 to eighteen by 1894. A fair number remained with iron. John Ingham, "Iron and Steel in the Pittsburgh Region: The Domain of Small Business," *Business and Economic History* 20, no. Second Series (1991):111.

Indeed, it was the giants who were peculiar and unrepresentative, and the 'others' who constituted the bulk of American production."³⁵

Among his conclusions, Scranton notes that the proprietary firm (of which Tredegar was an example) experienced a greater survival rate after the dislocation of the Civil War and throughout the nineteenth century, in part, because their flexible organizational structure contributed to their ability to meet the exigencies of economic fluctuation and technological innovation. . "Profusion," explained Scranton, "rejected a focus on scaling up manufacture of any one product...and instead fostered the capacity to create diverse outputs to tap into multiple nodes of fluctuating demand."³⁶ At Tredegar, this flexibility enabled the company to focus on niche markets, manufacturing products such as high-quality cold-blast car wheels. (Cold blast furnaces that produced the finest iron for these wheels were in proximity to Tredegar where their manufacture continued until the mid-twentieth century.) Flexibility also promoted diversity. Unlike `steel companies that were essentially one-product industries concentrating on mass-production of rails during the 1870s and 1880s, Tredegar continued to produce multiple product lines as they had from the company's inception. Their processes ranged from

³⁵ Philip Scranton. *Endless Novelty: Specialty Production and American Industrialization, 1865-1925*. Princeton, New Jersey: Princeton University Press, 1997. P. 7.

³⁶ Philip Scranton, "Diversity in Diversity: Flexible Production and American Industrialization, 1880-1930," *The Business History Review* 65, no. 1 (April 1, 1991): 37.

mass production to custom manufacturing. Although Tredegar had been one of the earliest manufacturers of iron rails, the company stopped production in 1870 when prices and demand began to plummet. The ironworks concentrated on items for which there were steady, if fluctuating, markets. Tredegar mass-produced Iron bars, spikes, fishplates, other staples of the railroad industry, and horseshoes. They batch- or custom-produced cars, wheels, pipes, and products made to the specification of individual customers. As an additional strategy, Tredegar maintained a customer base in Richmond and nearby areas, supplying routine products such as iron pipes and custom-made small machines to local institutions and businesses. The theories of classical economist and political scientist, Joseph Schumpeter, and those of economic historian, Paul Strassman, present conflicting perspectives on technological continuity and change through the alembic of creative destruction.

Tredegar's survival challenges theories espoused by classical economist and political scientist Joseph Schumpeter who, inarguably, characterized the late nineteenth century as a period of innovation, occasioned by the application of new technologies to create "new and less costly ways of making old goods."³⁷ Cycles of growth and change,

³⁷ Joseph Alois Schumpeter, *Capitalism, Socialism, and Democracy*, 3d ed (New York: Harper, 1950), 154.

according to Schumpeter, also instigated cycles of creative destruction—that is, innovations in technology and production caused old methods, ideas, corporate structures, physical facilities, and even unsold inventories of products on hand, to become obsolete. While obsolescence is destructive, destroying established industries, invention, creation, and adaptation of new methods lead to growth, to progress, and to wealth. That the new replaces the old is essential to progress. During the nineteenth century, Schumpeter observed, entrepreneurs operated under “conditions that change at any moment under the impact of new commodities and technologies.”

Specifically singling out prototypical technologies of the nineteenth century, Schumpeter pointed to the history of the productive apparatus of the iron and steel industry from the charcoal furnace to our own type of furnace or the history of power production from the overshot water wheel to the modern power plant as examples of creative destruction.³⁸ Certainly Joseph Reid Anderson confronted this dilemma. The charcoal furnace, particularly the cold blast charcoal furnace, and the waterwheel were foundational technologies for Tredegar production. Both enabled Tredegar to produce specialized products at an unrivaled low cost for power production. According to Schumpeter, new technologies, new

³⁸ *Ibid.*, 83.

methods of production, and ultimately, new managerial structures forced entrepreneurs to innovate or to fail. For Tredegar, the opposite was true. Filling a niche product market with items made from ore processed in cold blast charcoal furnaces, a market which lasted well into the twentieth century-, and powering the plant with waterwheels and turbines that channeled water from the James River and Kanawha Canal gave Tredegar a solid base of relatively risk-proof manufactured products. For Anderson, corporate progress and survival required a conservative approach to change.

Economic historian Paul Strassman presented a nuanced alternative to Schumpeter, documenting why innovation is not always progress. Strassman proposed that remaining with established technologies and methodologies is often a better choice than change. Theoretically, investing in new, commercially available technology may enhance a firm's competitive position. Strassman points out, however, that it is not always in a firm's best interests to replace machinery and methods with the latest discoveries and processes. Economic, political, and social factors may justify retaining an obsolete technology. The low cost of existing equipment, the rapidity or lack of speed of change in an industry, and the specific context of an individual business may all factor into decisions to remain with traditional technology. Innovations to the

charcoal blast process and the introduction of the Bessemer method during the nineteenth century could have brought about rapid and massive creative destruction in the metallurgical industries. In fact, the shift in dominance from iron to steel, the gradual replacement of old machinery with new, the slow adoption of innovative methods of producing pig iron, the improvement of Bessemer technology, and then the replacement of Bessemer processes with open hearth manufacture all took place unevenly and over an extended time period. Charcoal blast methods did not become redundant, but remained the most efficient processes for selected products; anthracite and coke-smelted pig iron offered new production methods that diversified the grades and kinds of pig iron without replacing charcoal smelting. Steel companies focused almost exclusively on rail manufacture during the 1870s and 1880s. Simultaneously, the demand for other wrought iron products increased. Old and new methods as well as old and new technologies existed together to meet different market demands. "Innovations lead to net losses among firms committed to older products or methods only if obsolescence occurs with unforeseen rapidity. ...The records of production growth in the United States during the period 1850-1914 indicate that far-reaching novelties in production methods transformed the economy, but that apparently obsolete methods survived and grew

for decades, though at a reduced rates.³⁹ Anderson's experience and that of Tredegar between 1873 and 1893 and the transformation of the iron industry during those years bear out this conclusion.

That Tredegar's course of action during the Panic of 1873 and its aftermath is consistently conflated with failure implies the adoption of new technologies is a bellwether of success. John Staudenmaier, however, has emphasized the need for historians of technology to escape what he has termed, "Whiggism,"⁴⁰ which he defines, in part, as the tendency to equate industrial progress with herculean achievements of size and scale. According to Staudenmaier, the history of technology is frontloaded with stories in which success is conflated with massive growth, with amassing exorbitant profits and expanding productivity levels to astronomical heights.

Staudenmaier proposes exploring the opposite instead, in effect, asking, "How and why do things not happen?" nullifying Whiggism with "historical studies of technological failures." Historians may fail to recognize successes that might accompany decisions about technology that do not conform to the myth of progress. According to Staudemaier,

³⁹ W. Paul Strassmann, "Creative Destruction and Partial Obsolescence in American Economic Development," *The Journal of Economic History* 19, no. 3 (September 1, 1959): 348, <http://www.jstor.org/stable/2115265>.

⁴⁰ John M. Staudenmaier. *Technology's Storytellers: Reweaving the Human Fabric*. (Cambridge, Massachusetts: MIT Press, 1983, 162-201.

the construct that equates technological change with success "... poses a particularly vexing problem for historians [and]...implies a radical disjunction of...technological design from human culture."⁴¹

Susan Douglas, a historian who focuses on the social construction of technology, warns against the opposite extreme: ignoring technological change as a bellwether of progress. The rubric of social construction is layered, according to Douglas who asks, "In our insistence on including all actors and all struggles, had we at times constructed a playing field that was artificially level? Had we underemphasized the role of power—state power, corporate power—in privileging some technical forms over others?"⁴² Pointing to the range between poles of technological determinism and social construction, she reminds that technological change remains on a continuum between the two—if technology is not the primary agent of historical change, neither is it completely subject to the socioeconomic, political, and cultural." She argues, "...the fact remains that technology may still powerfully direct the course of events"⁴³

Socioeconomic, political, and cultural factors certainly influenced how Joseph Reid Anderson negotiated Tredegar's survival. The profit

⁴¹ *Ibid.*,

⁴² Susan J. Douglas. "Some Thoughts on the Question 'How Do New Things Happen?'" . *Technology and Culture*, Vol 51, No. 2, April 2010. Project Muse: http://muse.jhu.edu.mutex.gmu.edu/journals/technology_and_culture/v051/51.2.douglas.html

⁴³ *Ibid.*, xiv.

motive was critical to Anderson's decisions, but perhaps not a predisposing, isolated rational for Tredegar's remaining in iron production. Survival and revival of the local and regional economy after the double blows of Civil War devastation and the Panic of 1873, local politics, and the upending of a traditional social order in Richmond and in the South impeded a stampede toward technological change. Richmond, too, faced unique problems as the South's pre-eminent antebellum industrial city. While other parts of the South turned towards initiating manufacturing and industry, Richmond faced the task of rebuilding.

A study of Tredegar's approach to technological change, then, suggests a layered discourse on the social construction of technology, that is, an adaptation of a synthesis of macro- and micro-level study proposed by Thomas Misa. Macro-level studies, Misa defines, are prone to emphasize technological determinism. At the opposite end, micro-level studies are apt to find more contingent, personal, and multiple societal forces at work in the historical process. Macro-level studies lead to the Chandlerian corporate model predicated on technological determinism, propelled by the market, and carried out by middle managers who oversee the various functions of the large corporation. Tredegar, however, was mid-sized, traditional, family-managed firm with limited mass production. Its technological direction was, in fact, far too contingent on

the forces of external agents and on the personalities and motivations of its leadership to fit into abstractions of the Chandlerian model.

TREDEGAR AS A SOUTHERN INDUSTRY

A study of Tredegar illuminates the process of southern industrialization. Charles Dew argued that “the preeminent position of the Tredegar Iron Works among Southern manufacturing establishments makes the story of this company particularly significant,⁴⁴ His identification of Tredegar as preeminent and his locative Southern descriptor invite further study. Southern industrial development followed a time line and a pattern that differed from that of northern and western regions. Southern historian Michael Gagnon, who focused on textile industries in antebellum Georgia, believed “Historians need to consider how the adaptation of technology and business systems fit local culture. [Southern} industrialists honestly believed they could create a unique southern path to increased industrial activity.⁴⁵ Tredegar’s structure as a mid-sized, family-owned firm

The historiography of individual, large corporations is plentiful, detailing technological development and triumphs of speed and scale across the spectrum of analysis from technological determinism to the

⁴⁴ Charles Dew. *Ironmaker to the Confederacy: Joseph R. Anderson and the Tredegar Iron Works*. (New Haven: Yale University Press, 1966) , 287.

⁴⁵ Michael J. Gagnon. *Transition to an Industrial South: Athens, Georgia, 1830-1870*. (Baton Rouge, Louisiana: Louisiana State University Press, 2012), 205.

social construction of technological progress. Few of these monographs, however, pay attention to the particular situation of southern iron and steel manufacture, despite the prominence of southern states in metallurgical industries. A focus on the technology of a southern industry illuminates generalities about the differentiated South and the trajectory of southern industrial development.

Classic interpretations of southern industrial development painted the south as a backward region in a progressive nation. During the antebellum period, this traditional focus generally posits planter resistance to industrial development and details the chilling effect of a slave economy. In the postbellum era, southern backwardness is built on a concept of the south as a colonial entity, in thrall to northern financiers, hampered by the occupation of reconstruction, frozen by the legacy of slavery, and mired in regional devotion to the "Lost Cause."

More recent visions of southern industrialization lighten the southern burden of backwardness and failure. Historian James Cobb postulates that the evaluation of southern modernization—in this case, industrialization—uses the northern example as the classic and optimal case study, the bellwether of progress. "Consequently" he concludes, "instead of treating the region's experience with modernization as a discrete phenomenon worthy of study in its own historical context and in

all of its complexity, a number of scholars simply concentrated on finding an explanation for the South's divergence from the northern example."⁴⁶ This result, according to southern scholar Ed Ayers, is a tendency to "define southern history by what failed to happen. Our questions are not *why*, but *why not*. [sic]" Ayers argues that "the currents of industrial capitalism, the national state, and new cultural styles ran deeply throughout the New South."⁴⁷

Mega-studies, too, approach the South as if little diversity existed between urban and rural, among states, and within the region's various populations and geographies. In fact, industrial activity varied throughout and within southern states. More recently, case studies of individual corporations and geographic areas, have nuanced these variations in how industrial and technological development occurred in the South. W. David Lewis's massive case study of the Sloss Furnaces in Birmingham, Alabama, shattered assumptions that post-Civil War southern industrial development grew from transplanting northern models of economic growth to the South. He focuses on a single company and concluded,

⁴⁶ James Cobb, "Modernization and the Mind of the South." In *Redefining Southern Culture: Mind and Identity in the Modern South*. Athens, Georgia: University of Georgia Press, 1999. p. 186.

⁴⁷ Ed Ayers, "Narrating the New South.," *The Journal of Southern History*, Vol. 61, No. 3 (Aug., 1995), p. 559.

“...southerners drew upon their own human and financial resources...they industrialized in their own way on their own terms.”⁴⁸

During the period between Panic of 1873 and the death of Joseph Anderson, Tredegar's technological decisions occurred in the context of ideological tensions between the South's past and its future. In 1877, journalist Henry Grady defined the era as a transition from the Old South to the New South, terms that have entered the historic lexicon. The rhetoric of Grady and other Southern boosters emphasized the relationship of this New South to the national industrial mainstream. In the 1880s, Grady wrote, “The industrial growth of the South in the past ten years has been without precedent or parallel. It has been a great revolution, effected in peace.” He then narrowed his focus to the growth of iron industries throughout the region. “We start with iron, which is the base of all industrial progress. In 1880 the South made 212,000 tons of iron. In 1887 she made 845,000 tons—thus quadrupling her output in seven years. But this is small compared to the future.”⁴⁹

Nonetheless, entrenched regional images of a backward, dependent, poverty-stricken, illiterate, disease-ridden region, beset with insurmountable social and economic inequalities conflicted with the

⁴⁸ W. David Lewis. *Sloss Furnaces and the Rise of the Birmingham District: An Industrial Epic*. (Tuscaloosa and London: The University of Alabama Press, 1994), xiv.

⁴⁹ Henry Grady. *The New South*. (New York: Robert Bonner's Sons, 1890), 191.

mythology of boosterism and with the growing cultural emphasis on American nationalism and sectional reunion. "The paradox of the New South involved not just the constant strain between the sanguine New South creed and the representation of the backward South but also the struggle to counterbalance the belief that the South was American in spite of regional characteristics that appeared to mirror conditions in distant lands."⁵⁰

Locally, Richmond lay in the crosshairs between the New South and the Old South and a culture of history and tradition battled the spirit of progress. Civic discourses worked at cross-purposes, simultaneously striving to articulate and commemorate the Confederacy while pushing the ideology of New South rhetoric of growth and development. Because of this mixed vision, according to historian Michael Chesson, Richmond and its dominant antebellum corporation, Tredegar, never regained pre-War industrial pre-eminence. Chesson characterized Richmond between 1865 and 1890 as the "old city of the New South." "Richmond stagnated chiefly because its leaders did not want nineteenth century material progress—not badly enough, not with the alien things that accompanied it," according to Chesson. "The New South creed held that industry and

⁵⁰ Natalie J. Ring. *The Problem South: Region, Empire, and the New Liberal State, 1880-1919*. (Athens and London: The University of Georgia Press), 21.

scientific agriculture promised progress—prosperity, sectional reconciliation, and racial harmony—but it was a progress in which Richmond chose not fully to participate." Chesson argued that Richmond's leaders, caught between the Old South and the New, preferred tradition and the "familiar cadence of decline."⁵¹

To Joseph Anderson and his cohort of upper-class white elite city leaders, the challenge and the mandate of the 1870s and 1880s was not to innovate and to invent, but to rebuild and to reconstruct. For the men of industry, dramatic changes requiring perhaps inter-planetary leaps from old to new technologies threatened corporate survival. Striving for radical changes in social and political norms challenged their positions as leaders in the community and jeopardized their effectiveness in business and commerce. Despite, or perhaps because of, this deeply conservative approach to change Richmond's economy, followed national trends in the fourth quarter of the nineteenth century: that is, severe economic depression following the Panic of 1873; recovery for several years after 1878; an economic boom in the early 1880s; recession from 1882-1888; followed by expansion until the Panic of 1893.⁵²

⁵¹ Michael Chesson, *Richmond after the War, 1865-1890* (Richmond: Virginia State Library, 1981), xiv.

⁵² *Ibid.*, 161-162.

Unquestionably, over time, society, government, the marketplace, and science itself privileged steel production over iron and steam and steam engines over the river and the waterwheel. Steel and power technologies fed the growth of world economies, shaped cities, and transformed communication and transportation. During the two decades after the Panic of 1873, however, Tredegar's technological choices moved in rhythm with the company's identity as a family-owned firm whose managers prioritized community responsibility and valued their leadership status in that community.

III JOSEPH REID ANDERSON: BUSINESS SUFFICIENT UNTO THE DAY

In 1890, the American Society of Mechanical Engineers (ASME) held its annual meeting in Richmond, Virginia. Noting that the society's one thousand members included some of the most prominent and illustrious men in scientific and engineering professions, Richmond's planning committee outlined a sightseeing agenda to impress delegates "not only with the rapid development in the mechanical industries made in this city and in the South generally, but also with the far-famed 'Virginia hospitality.'"⁵³

Tredegar Iron Works and its head, General Joseph Reid Anderson, CSA, were vital to this agenda. Tours for the delegates juxtaposed memorializing the Old South and the Confederacy with the industrial promise of the New South. Anderson and his company exemplified the resilient transition from the antebellum past to the progressive future extolled with the boosterism of New South rhetoric. Southern economic development buttressed Anderson's worldview. Christian stewardship and southern honor expressed in integrity, charity, fairness, and service

⁵³ "The Mechanical Engineers: A Conference to Be Held with Reference to Their Entertainment," *The Richmond Dispatch*, September 28, 1890, Sunday edition..

underpinned his business and personal dealings. The restoration and continuation of traditional social hierarchies and the leadership of elites and framed his political and social priorities.

Journalist Henry Grady had coined the term New South in 1886 in a speech at the annual meeting of the New England Society in Boston when he became the first southerner invited to speak there since the Civil War. In a spellbinding speech considered “in many respects the greatest address of the year,”⁵⁴ Grady emphasized a South that was defeated, but unvanquished, a unique region that, nevertheless, was now dedicated to working in unity with the rest of the nation. He explained to his audience, “The Old South rested everything on slavery and agriculture, unconscious that these could neither give nor maintain healthy growth.” He continued, “There is a New South, not through protest against the Old, but because of new conditions, new adjustments and, if you please, new ideas and aspirations.”⁵⁵ Southern economic and industrial development formed a cornerstone of the goals of this rejuvenated South.

⁵⁴ “An Eloquent Speech: Editor Grady on 'The New South.' The First Southerner at the Dinner of the New England Society Thrills His Bearers and Carriers Of the Honors What He Said. What the New South Means. Things that have been Accomplished. But What of the Negro? What Answer Has New England.” *The Washington Post* (1877-1922), January 9, 1887, sec. General, http://search.proquest.com/mutex.gmu.edu/cv_786252/docview/138144120/abstract/885F0F332B704484PQ/2.

⁵⁵*Ibid.*

Delegates to the Engineering Society meeting first visited Richmond's memorials of the Old South: the recently dedicated monument and statue of the revered General Robert E. Lee; Hollywood Cemetery where the graves lay of nearly 3,000 Confederate soldiers; Chimborazo Hospital where 76,000 wounded Confederates received treatment during the Civil War. This edited presentation of southern devastation and heroism served as a palpable reminder of a tragically divided nation but also spoke of a South beaten, but not bowed.

A visit to Tredegar Iron Works and its head, General Joseph Reid Anderson, CSA, was next on the program. Anderson and his company were living examples of the New South Grady had described: "Crushed by defeat, his very traditions gone...never was restoration swifter."⁵⁶

IDEOLOGICAL FOUNDATIONS

For Joseph Reid Anderson the New South was not wholly new, but on a continuum with the Old South in which he had built one of the largest iron manufactories in the nation. To Anderson, New South ideology corresponded to principles that, by 1890, had shaped his actions throughout his 49 years at Tredegar. These ideals had enabled corporate survival during the Civil War, through financial panics, corporate receivership, and threats of technological obsolescence posed by the

⁵⁶ *Ibid.*

emerging technologies of the steel industry. The broad framework of the New South gospel incorporated the continuity of Anderson's lifelong work toward southern industrialism and economic growth that emphasized state sovereignty and the hegemony of traditional authority. For Southerners, the ideology of the New South also reinforced a distinct southern identity and acknowledged a north-south cultural differentiation. Anderson espoused and embraced both. "The marvelous financial and industrial rehabilitation [of the South] has been the work of southern men—of the generation which fought in the war...They are the people of the south, with the education of the south, the habits, the sentiments, the principles of the south," opined an article reprinted in the *Atlantic Constitution*.⁵⁷ Joseph Reid Anderson was one of those men.

Joseph Reid Anderson spoke to the visiting engineers, memorializing the experiences of Tredegar Iron Works during the Civil War. The arc of his speech was boilerplate New South rhetoric. Like the memorials the delegates had visited, Anderson emphasized the unique wartime experiences of the South; however, he also addressed themes of reconciliation, unity, and a shared future. Anderson had favored secession—although only as a last resort in the face of irreconcilable

⁵⁷ "The New and the Old in the South.," *The Atlanta Constitution* (1881-1945), August 11, 1889, http://search.proquest.com/mutex.gmu.edu/cv_786252/docview/495200321/abstract/68287A80EB3F409BPQ/1.

sectional differences. He had armed the Confederate war effort and led, fraternized with, and supported Confederate political and military leaders in his home and his community. With the end of the Civil War, he turned his attention to rebuilding his iron works, extending his reach once again toward associates and markets outside the South as well as within the region. Even so, as he spoke to the engineers, Anderson ensured that they were aware of the distinct hurdles Tredegar encountered during the Civil War.

“We had to buy a mine and raise our own coal to put in operation, blast furnaces to supply us with iron, to bring corn and bacon for our people from Alabama, to establish shops for making shoes for our people and finally to start two tanyards to supply us with leather,” he told them. “I mention these things as they may be of interest to our friends present who are not aware of the troubles we encountered in those trying times.”⁵⁸

As he continued, Anderson moved away from the Civil War, ignoring divisive topics of the past and the present. He neither mentioned slavery, secession, and reconstruction nor did he address the encroaching growth of large corporations and railroads or the prominence of technology in the national culture, all of which he had witnessed, all of

⁵⁸ Anderson, Joseph R., *History of Tredegar*. Written for the American Society of Mechanical Engineers, Richmond, Virginia, November 12, 1890. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

which had profoundly shaped Tredegar Ironworks after the Civil War. He made no reference to Janus-like internal ideological conflicts within the South that pitted memorializing the Confederate past against the progressive rhetoric of southern development. Instead, Anderson projected visions of national unity: "...let us desire henceforth perpetual friendship and move forward as a band of brothers, seeking only our individual welfare and our country's honors." He reminded his audience of their common history: "Let us remember that we are descended from that race of revolutionary patriots, statesmen and soldiers, men of Massachusetts, Virginia and other colonies who stood shoulder to shoulder in defence [*sic*] of our rights and won for us our liberties; and resolve that we will be found worthy of these noble sires."⁵⁹⁶⁰

Describing Anderson's address as "touching," the representatives of the American Society of Engineers acknowledged that Tredegar had contributed "much to the importance and value of iron industries in the South" and that the region had "entered upon an era of manufacturing prosperity which they richly deserve, and which they are well qualified to

⁵⁹ *Ibid.*

⁶⁰ *Ibid.*

carry forward for the betterment of their own city and State, and the country at large."⁶¹

The Society's perception of Tredegar and its leader was a masterpiece of patronizing understatement. Joseph Anderson was charismatic. The man who engaged the delegation was largely responsible for Tredegar's growth and survival and a key figure in southern industrial development with a national reputation. An intelligent businessman, ambitious, and a conscientious public servant, the force of Anderson's personality and character had inspired confidence in Tredegar's viability even during precarious times and further, had led him to positions of political and social leadership in his city and state. A deep-seated commitment to family, church, community, and region configured that leadership. Ultimately Anderson's ideals ensured that Tredegar remained a closely-held, family-owned business throughout its operation. They also delineated a conservative path of adaptive evolution rather than dramatic corporate innovation for Tredegar's product line and methods of production. Anderson's stewardship of his company during the financial and technological upheavals that intensified with the Panic of 1873 precluded dramatic risk-taking and speculation. The welfare of his

⁶¹ American Society of Mechanical Engineers, *Transactions of the American Society of Mechanical Engineers*, Vol. XII., 37.

family, employees, and a community dependent on Tredegar steered his business decisions.

STEWARDSHIP AND SOUTHERN HONOR

Joseph Reid Anderson was “first and foremost a Virginian,” by heritage and by ideology.⁶² His Virginia roots dated to 1756 when his grandfather,⁶³ then-twenty-three-year-old Robert Anderson immigrated from County Donegal, Ireland, part of a wave of Presbyterian Scots-Irish immigrants constituting an estimated one-third of Ireland's Protestant population during the eighteenth century. Robert settled in Fincastle in Botetourt County. Both he and his son, William, worked together as surveyors, fought in the Revolutionary War, and served as elders and deacons in the Fincastle Presbyterian Church which they had helped to

⁶² This description was first applied to Joseph Bryan, Anderson's social and business peer. It applies equally to Joseph Reid Anderson; the two shared a common culture, a heritage deeply rooted in Virginia, and a commitment to southern economic development. Bryan, an industrialist and philanthropist was the owner of Richmond's prestigious newspaper, *the Times Dispatch*, and a principle investor in the growing metal industries of Alabama. He and Anderson were members of the same elite social clubs in Richmond and the same cultural associations dedicated to preserving the history of Virginia and the South. Bryan rescued the bankrupt firm of Tanner & Delaney Engine Company in 1880 and reorganized it as the Richmond Locomotive Works. It became the South's largest manufacturer of locomotive engines, turning out 300 steam engines in 1887 and employing 800 workers. James M. Lindgren, “‘First and Foremost a Virginian’: Joseph Bryan and the New South Economy,” *The Virginia Magazine of History and Biography* 96, no. 2 (April 1, 1988): 157–80, <http://www.jstor.org/stable/4249007>.

⁶³ Two Anderson descendents, Anna Hobson Freeman and Ellen Graham Anderson, granddaughter of Judge Francis T. Anderson contributed first-person reminiscences to Virginia historical journals. Family histories in this dissertation are drawn from those articles. Anne Hobson Freeman, “A Cool Head in a Warm Climate,” *Virginia Cavalcade* Volume XII, no. 3 (Winter -63 1962): 9–17. Ellen Graham Anderson, “The Four Anderson Brothers,” *Journal of the Roanoke Historical Society* VI, no. One (Summer 1969): 15–29.

establish after passage of the Virginia Statute for Religious Freedom in 1785.⁶⁴ Robert died at 86, "...many years a consistent member of the Presbyterian Church, and appeared much resigned to this dispensation of Divine Providence."

Joseph Reid was born at the family estate in Fincastle in 1813, the ninth of ten children and the youngest of four surviving sons of William and his wife Anna Thomas, a Maryland planter's daughter. The four boys grew up, according to Joseph Reid's grandniece, in "a large stone, two story building, with an immense fireplace and chimney and portholes for firing at Indians and marauders."⁶⁵ While they farmed the land, as did most rural Virginia residents, agriculture was not the family's primary occupation. Law, business, and medicine attracted Anderson and his brothers.

The family influences that directed the careers of Joseph and his brothers were deep and encompassed loyalty to each other, fidelity to church, and a strong work ethic. Whether Joseph Anderson's moral compass was rigorously directed by his Presbyterian father or gently pushed by his Anglican mother, standards of right and wrong behavior

⁶⁴ The Virginia Statute for Religious Freedom, which Thomas Jefferson authored, disestablished the Church of England (Anglican Church) and provided freedom of worship for all religious faiths including Catholic and Jewish as well as other Protestant denominations. Until that time, the Scots-Irish, Presbyterian Anderson men worshiped in the local Anglican church which remained the church of choice for Joseph Reid Anderson's mother.

⁶⁵ Ellen Graham Anderson, "The Four Anderson Brothers." *Journal of the Roanoke Historical Society* VI, no. One (Summer 1969) 18.

were clear. His father was remembered as “scrupulously honest, sensitive of his reputation, and cherishing the pure principles of the gospel, he practiced a charity that seeketh not her own, believing that wealth was not the best inheritance for children.”⁶⁶ The local Presbyterian minister, Reverend Stephen F. Cocke, observed that the William “was not one to govern his children in a tame, timid, and ineffectual way. When he did not influence as a father, he commanded as a master and exacted the highest standards of thrift, industry, exactness, and self-control.”⁶⁷ Joseph Reid’s mother, Anna, approached her children more gently, but equally unequivocally, as a letter to Joseph Reid’s 15-year old brother makes clear. “...it is a great undertaking for your dear father to educate so many sons, and you must do all you can to assist him. Shun all evil. Endeavor to engage our heart in Religion, ...if we have not an interest in Christ, we will be lost.”⁶⁸

Joseph Anderson built his life on this inherited cultural tradition whose values were understood and perpetuated in nineteenth century Virginia. Stewardship and honor were foremost among the principles of

⁶⁶ James M. Holladay, “A Partial History of Fincastle Presbyterian Church” (Whittet & Shepperson, printers, 1902), 83, <http://hdl.loc.gov/loc.gdc/scd0001.00411940160>.

⁶⁷ Anne Hobson Freeman, “A Cool Head in a Warm Climate,” *Virginia Cavalcade* Volume XII, no. 3 (Winter -63 1962), 12.

⁶⁸ Letter from Anne Thomas Anderson to Francis T. Anderson when Francis was 15 years old and a student at Washington College in Lexington, Virginia, September 21, 1823. Reprinted in Ellen Graham Anderson, “The Four Anderson Brothers,” 29.

that tradition. William and Anna impressed values of stewardship on their children centered in the teachings of the church and extending into private and public spheres. As an adult, Joseph Reid Anderson followed their example through a life-long commitment to lay service in St. Paul's Episcopal Church in Richmond. There he began as a member of its original vestry in 1844, holding multiple positions until his death. He was a warden, a lay delegate to diocesan conventions, a board member on local orphanages and homes for the indigent, and a strong financial contributor who often managed improvements to the church's physical structure.⁶⁹ A memorial window in the nave added during the 1890s commemorates his service to St. Paul's. The elite of Richmond and of Virginia worshipped there and his stewardship was also indicative of his position in the community.

⁶⁹ In the Episcopal Church, a warden is the elected lay leader of a congregation and liaises between the parish and the church rector. The warden's specific role varies from parish, but broadly conceived, a warden is the lay partner of the presiding cleric tasked with explaining and implementing the vision and goals of a parish and managing day-to-day operations. St. Paul's became known as the Church of the Confederacy. The Bishop of Virginia had supported Virginia's secession from the Union speaking from St. Paul's pulpit in 1861, "slowly and ultimately" accepting that secession and war were "divine providence." Separated from the national Episcopal Church, southern Episcopalian clergy were required to use the prayer book of the "Confederate" church. As a result of the separation from the national church body, St. Paul's remained the only church in Richmond that did not open for Prayer when General Robert E. Lee surrendered to Federal troops at Appomattox because the Confederate prayer book authorized prayer for "The President of the Confederate States of America and all in civil authority," but no provision for prayer for the "President of the United States and the nation." G. MacLaren Brydon, "Historic Parishes: Saint Paul's Church, Richmond," *Historical Magazine of the Protestant Episcopal Church* 23, no3 (September 1, 1954): 290, <http://www.jstor.org/stable/42972355>.

Anderson's service to St. Paul's and the extension of that service into the community embodied values of stewardship encouraged not only in the nineteenth century Episcopal Church in Virginia but in sermons and writings across Christian denominations. The concept of stewardship preached from the nineteenth century pulpit addressed obligations for safeguarding the people and the resources God had entrusted to each as individuals. These obligations included shepherding the welfare of family, friends, and the greater community as well as exercising wisdom in the use and allocation of material possessions and wealth. Virginia Episcopalians were repeatedly reminded "that as to all our means we are stewards, and will have to give account of our stewardship to God. We are stewards in regard to the support of our families, the conducting of our business, and the support of the work of the church..."⁷⁰

The congregation of St. Paul's during Anderson's lifetime "comprehended probably a larger amount of intelligence and refinement, and a greater proportion of men distinguished for talent and influence, than any congregation in the Union."⁷¹ The business, political,

⁷⁰ Episcopal Church., "Journal of the Annual Convention, Diocese of Virginia.," *Journal of the Proceedings of a Convention of the Protestant Episcopal Church of the Diocese of Virginia*, Journal, 76th-78th (1873 1871): 58, <http://catalog.hathitrust.org/Record/006800826>.

⁷¹ The majority of congregation members of St. Paul's Episcopal Church, constructed in 1845, had formerly attended Richmond's Monumental Church. George Fisher, *History*

and social elite of the city and of the south who worshipped there included a permanent roster of Richmond's business leaders as well as prominent politicians and military leaders. Jefferson Davis, president of the Confederacy,⁷² and General Robert E. Lee, Commander of the Confederate Army of Virginia, both held pews. Anderson's pre-eminent position among these leaders was evident.

Multiple reminiscences, for example, recall Anderson attending the service in St. Paul's on April 2, 1865, a week before Lee surrendered at Appomattox. A church sexton quietly passed a telegram from Robert E. Lee to Jefferson Davis advising evacuation of the Confederate capital. Davis rose, left the church, but immediately returned to collect Joseph Anderson. Within hours the evacuation of the city began. Virginia's capital was ablaze with fires set by her residents and by Confederate troops to prevent assets from falling into Union hands. Forewarned, Anderson placed armed guards around Tredegar, saving the iron works from the surrounding destruction. "Such a scene I never saw before and hope

and Reminiscences of the Monumental Church, Richmond, Va., from 1814 to 1878 (Richmond, Virginia: Richmond, Whittet & Shepperson, 1880), 62.

⁷² According to Joseph Anderson's obituary, the widow and daughter of Jefferson Davis were guests at Anderson's home throughout his lifetime. He was a prime force in movements to create a monument to the former president of the Confederacy. "Joseph R. Anderson: Death of this valuable and beloved citizen of Richmond." *The Richmond Dispatch*, Thursday, September 8, 1892, 3

never to see again...I cannot begin to describe to you the terrors of that day...so that you will understand it," wrote one resident.⁷³

Anderson's exemplification of stewardship intertwined with secular values of southern honor, qualities associated with an emerging urban commercial, financial, and industrial elite to which Anderson and his peers belonged. Anderson and his commercial and social colleagues within St. Paul's as well as in Richmond's political and social circles constituted an upper-middle class of lawyers, doctors, bankers, merchants, manufacturers, and educators—commercial and professional southerners intent on southern economic growth and expanding southern education, culture, and social services. These men of Richmond with whom Anderson shared common ideals and elite status had built the city's industrial base during the antebellum era and directed its revival after the War. They headed industries, banks, and mercantile establishments in Richmond's commercial district and in its industries along the banks of the James River near Tredegar. The city directory was replete with their names that dated to Revolutionary Virginia: Crenshaw, Mayo, Haxall, Maury, Lee, Peyton, Tucker, and Johnston. A common public cause united them: to lessen

⁷³ Elizabeth Wright Weddell, *St. Paul's Church, Richmond, Virginia, Its Historic Years and Memorials*, (Richmond, Va., 1931), 239, 242, 249, <http://hdl.handle.net/2027/mdp.39015065334628>.

southern dependence on the north for raw materials, consumer goods, capital, and culture.

As individuals, southern honor for these men was commensurate with personal financial reliability and independence. In the public sphere, a reputation for impeccable moral character was requisite for standing and influence in this group of leaders. For these men, honor sprang from “probity, principle, or moral rectitude” and constituted “a distinguishing trait in the character of good men.”⁷⁴ Business negotiations stressing financial acumen and a determination to fulfill contractual and financial obligations were integral to this perception of honorable behavior.

Anderson, like his colleagues who formed this nineteenth-century elite of Richmond, had built his community standing through his exemplification of these criteria, that is, for upstanding personal character and rectitude and a public persona identified with integrity. For Anderson, the ideal of

⁷⁴Webster's 1858 American Dictionary of the English Language, The classic work of Bertram Wyatt-Brown, *Southern Honor: Ethics and Behavior in the Old South*, associates southern honor with an antebellum morality code that, in part, obligated men to support their local communities. By mid-nineteenth century, southern commercial communities, like their northern counterparts, had begun to incorporate a reliance on personal reputation into a new credit-rating systems and an emerging national discourse of responsible business practice. This concept of southern honor became a unifying feature of southern national identity. Personal financial independence, integrity, collegiality, and public respect were components of the honor concept for individuals. Regionally, it became associated with southern financial independence and freedom from northern influence. Amanda Mushal, *My Word is My Bond: Honor, Commerce, and Status in the Antebellum South* 2003.University of Virginia, ProQuest Dissertations Publishing, 2010. 3436000.

southern honor would have meant financial probity for Tredegar and freedom from northern financial obligations.

Anderson was not a man given to specific references about these ideals of stewardship and honor that clearly steered his public and private life. His writings give only occasional intimate glimpses into the moral and spiritual foundations that directed his actions. Anderson's prolific correspondence related to the business of Tredegar focuses on the company's daily financial and manufacturing negotiations. Similarly, correspondence collected in private files emphasized family business and monetary concerns. Anderson's response to the early deaths of five of his twelve children, his private response to the potential collapse of his beloved Tredegar, the loss of his first wife, Sara Archer after forty-four years of marriage, and his rapid remarriage to Mary Pegram appear without personal comment in surviving papers. Yet the sense of stewardship and honor with which he approached business, politics, and the affairs of his family and the value to him of an honorable reputation are discernable in the courses of action he chose for Tredegar and in his occasional comments about those directions.

The years of the Panic of 1873 until his death are rife with examples of their impetus, perhaps none more well-documented than the company's struggles to maintain family control, pay corporate debts, and

remain in business during the 1870s. They reflect commitment and responsibility that led *The Richmond Dispatch* to report after his death that Anderson "... loved Richmond and loved her people and took an intense pride in all that gave a good report of her and them."⁷⁵

THE EARLY YEARS: PROLOGUE TO THE PANIC OF 1873

Anderson's business decisions during the critical Panic years solidified a corporate identity that Anderson had formulated in the prewar years, protected during the chaos of the Civil War, and strengthened during the post-War boom. This identity was based on managerial independence, financial integrity, corporate reliability, and public responsibility. Specifically at Tredegar, this corporate identity and the values that shaped it were manifest as family control, a conservative approach to change—whether of products or technology—and a commitment to meeting obligations to creditors. His reputation in his community and within a small cadre of Tredegar investors—mostly northern financiers—as a businessman of integrity and intelligence provided a network of colleagues with whom he could work closely to navigate the repercussions of economic depression. The experience he needed to survive the Panic began early.

⁷⁵ "Joseph R. Anderson: Death of This Valuable and Beloved Citizen of Richmond," *The Richmond Dispatch*, September 8, 1892..

Anderson ran his company within a broad tradition of southern nationalism. As a young engineer, a businessman and manufacturer, and as a political activist and office-holder, Anderson fostered industrial growth and politicked for internal improvements within Virginia and the South—particularly railroads and canals—to strengthen the region's industrial base.

Anderson's granddaughter, Kathleen Bruce, who was a seminal historian of both antebellum Tredegar and the Southern iron industry,⁷⁶ speculated that Anderson's attraction to the challenges of iron manufacture, his love and commitment to Richmond, and his dedication to southern development may have begun in 1838 when he was chosen as a delegate from Staunton to attend a commercial convention in Norfolk, Virginia. Only twenty-five years old, his reputation as an engineer and his personal charisma made him a popular figure in professional and in social circles. At the Norfolk commercial convention, Anderson met men from Richmond who were enthusiastic over the possibility of making the Virginia capital an industrial city. Bruce theorized that "Anderson himself had dreamed dreams of building up the iron business familiar to

⁷⁶ Joseph Reid Anderson was the maternal grandfather of Kathleen Bruce. While she speculates on Anderson's character, her information also came from family reminiscences. *Virginia Iron Manufacture in the Slave Era* was the outgrowth of her doctoral dissertation at Radcliffe College under Edward Charming and Frederick Jackson Turner. Kathleen Bruce, *Virginia Iron Manufacture in the Slave Era* (New York and London: Century Co., 1931), 167, <http://catalog.hathitrust.org/Record/001045275>.

him since his childhood when, mounted on his pony, he accompanied his father, the surveyor, on strenuous rides into the mountain forests...his brother, the future judge,⁷⁷ was [already] being drawn into a partnership to create pig iron, destined to form an important part of the Tredegar Iron Works supply." While family stories of her grandfather undoubtedly informed Bruce's speculation, a historian's objectivity plausibly supports the assertion that the timing was right to expand iron manufacturing in Richmond.

Meeting in commercial conventions throughout the South and exchanging views through the medium of publications such as *DeBow's Review*, Southern entrepreneurs were struggling to develop the industrial infrastructure within a South then heavily dependent on agriculture. The centrality of Richmond's location on the James River and enthusiasm for internal improvements—particularly constructing transportation linkages with connectivity beyond the state--made Richmond a prime location for this nascent movement.

Anderson was at an age and professional juncture when the possibilities of this antebellum vision of the New South offered exciting

⁷⁷ Joseph Reid Anderson's older brother, Francis Thomas Anderson, had graduated from Washington College when he was 19 years old. He studied law independently and was admitted to the Botetourt County Bar two years later. In 1871, he was elected judge of the Supreme Court of Appeals of the State [Virginia] where he served for 12 years. *Lynchburg News*, November 30, 1887.

challenges. His Virginia heritage, combined with West Point training, had “developed and disciplined imagination, judgment, courage, and administrative abilities and lifted him out of provincialism.”⁷⁸

At West Point, Anderson had studied engineering and mathematics, graduating fourth in his class in 1836, and on graduation received his assignment to work in the Engineering Bureau in Washington. He was over six feet and was “proportionally broad of shoulder... He was spirited, full of health and love for his fellow man.” Kathleen Bruce noted that he was not a scholar, despite his academic achievements at West Point. “He had none of the artist’s passion for the form in which he marshaled his thought. When he wrote or when he spoke on public occasion he marched with the soldier’s simplicity and directness to his point. He had, in short, the rounded mind of the civil engineer.”⁷⁹ His leadership positions at West Point served as early indications of qualities he would later apply to developing and managing Tredegar: a great organizing mind and leadership ability. Robert E. Lee, then a lieutenant in the U.S Army had graduated from West Point seven years before Anderson. Lee first met Anderson during Anderson’s assignment to the Engineering Bureau. Impressed, Lee noted,

⁷⁸ Kathleen Bruce, *Virginia Iron Manufacture in the Slave Era* (New York and London: Century Co., 1931), 167, <http://catalog.hathitrust.org/Record/001045275.188>.

⁷⁹ *Ibid.*, 187.

“I have met here a man who seems to me more like George Washington than anyone I have ever known.”

Anderson spent little time as a soldier, however. He left the U.S. Army in 1837 to become an Assistant State Engineer where he worked on construction of the Virginia State Turnpike and promoted railroad construction to connect Virginia's interior with Tidewater ports. Developing Virginia's transportation system continued to preoccupy him throughout his lifetime as a manufacturer and as a politician, particularly because links to the national infrastructure were vital to ensure the flow of raw materials and manufactured products to and from Tredegar.

Joseph Anderson entered the iron industry as commercial agent for Tredegar in 1841 and the next few years marked his entrepreneurial coming-of-age experience. At the start of the decade, Virginia was among the top five iron producers in the nation. While future expansion of the iron industry appeared promising, Tredegar's future was bleak. Frequent shutdowns stemming from inadequate water supplies to power the ironworks had led to involuntary closures. The company never recouped losses from an eight-month shutdown in 1838 when the James River and Kanawha Canal Company had been unable to provide sufficient water power to propel Tredegar's waterwheels. Furthermore, corporate managers had begun expanding plant facilities and

manufacturing products for which they had no advance orders or projected markets. A backlog of inventory clogged storage units. Banks were unwilling to back the faltering company. The company's financial deficiencies totaled \$25,340. Hampered by directors with little knowledge of the iron industry and few business skills and facing a depressed American iron industry, Tredegar was perilously close to failing.

Sorting Tredegar's long list of business problems was Anderson's first experience in negotiating corporate survival. While not all of Tredegar's problems were within the purview of a commercial agent, improvements to the company's bottom line during the next few years were generally accredited to Anderson's business acumen. Tredegar's records would have shown Anderson not only that Tredegar was badly in need of capital, but that its early market was narrow and local. At this point, he began to build a national reputation for financial accountability and for product integrity. Public recognition of his personal character, founded on stewardship and honor, accrued through his response to Tredegar's exigency.

Recognizing Tredegar's potential—waterpower, the proximity of coal as fuel, access to Virginia's vast iron resources, and access to transport for raw materials and finished products—Anderson began to develop those advantages that ultimately became the building blocks of

his long-term success as the head of the ironworks. With Anderson as Commercial Agent, the tottering company showed a surplus of \$14,463.93 within two years. Nevertheless, old debts still weighed down the corporate balance sheet. In 1842, the company failed to satisfactorily fulfill a contract for ordnance with the Federal government. Anderson placed responsibility with a “want of information on the part of the man charged” with cannon manufacture at Tredegar. He also quickly stepped into the breach to restore confidence in the company, just as he later would reassure stockholders and customers during financial crises as the owner of Tredegar. “An error has been committed, but we have paid pretty dearly for it,” he informed the government official who had inspected Tredegar's deficient ordnance. “You may be certain that our recent misfortune will in the end be of great advantage to this establishment—adversity being a good school.” Anderson's reputation grew from his early negotiations of Tredegar's problems. The status of the ironworks, however, became increasingly shaky. The Board of Directors placed the iron works on the market in the fall of 1843.⁸⁰

⁸⁰ Kathleen Bruce provides detailed records of the financial errors of the Tredegar managers and of Anderson's role in strengthening the struggling company. The ordnance contract with the U.S. Department of the Navy called for forty cannon; five had proven defective and the Secretary of the Navy rejected deliver of the entire order. Known as the “Disaster of '43,” the failure not only demolished Tredegar's reputation, but shed negative light on the quality of Virginia iron in general. Kathleen Bruce, *Virginia Iron*

Within two months, Anderson, “a young man without capital of his own, but with personal strength in which the sound bankers of Richmond had come to put their faith, stood ready to take over the company's property and business.”⁸¹ Anderson leased the company for five years at an annual rent of \$8,000. His personal character and reputation in business opened the door.

Until leasing Tredegar, Anderson's role with the ironworks was in sales and public relations. The direct application of his engineering skills to manufacturing iron products lay dormant. With his acquisition of the company, Anderson then stepped in to the production side of the ironworks. His first challenges were to improve the quality and reliability of the company's products. Simultaneously, he needed to restore Tredegar's credibility as a financially sound organization committed to fulfilling contracts at the best price, on time, and with excellent workmanship.

Anderson turned his attention to becoming an expert iron manufacturer, extending his oversight to chemical experiments on metals for arms manufacture, testing various combinations of iron ore and charcoal in iron production. From these experiments, Anderson determined that Virginia's hematite iron ore and bituminous coal mined

Manufacture in the Slave Era (New York and London: Century Co., 1931), 167, <http://catalog.hathitrust.org/Record/001045275>. 176.

⁸¹ *Ibid.*, 176.

near Richmond were the foundational raw materials for the products Tredegar manufactured. He believed that the Cloverdale Iron Furnace managed by his brothers produced a metal that “could not be surpassed in America.” Anderson’s knowledge of Virginia’s raw materials and his understanding of iron products that could and could not be made with Virginia’s them strongly influenced Tredegar’s future manufacturing base.⁸²

For Anderson, patrimony and pragmatism worked hand-in-hand. He viewed Tredegar as an innovative company whose growth was consistent with the goal of southern markets for southern iron. Regional parochialism, however, was contra-indicated in the process of reaching this goal. Building the company required following markets and money. Throughout the nineteenth century, southern markets could not absorb the output of southern iron manufacturers. Anderson, therefore, reached out to potential customers in the North as well as in the South. Customer contacts and relationships with other iron manufacturers helped him establish a national business reputation that would support him later during the Panic of 1873.

⁸² During the 1870s and 1880s, Anderson increasingly turned to the use of scrap iron, that is recycled rails, car wheels, and other railroad equipment, to manufacture many of Tredegar’s products. When scrap iron provided the appropriate quality for selected products such as spikes, there was no reason to use the more expensive pig iron in their manufacture.

Cannon became a major product at Tredegar during these early years, and Anderson joined ranks with prominent northern ironmasters who also focused on munitions, particularly Gouverneur Kemble of New York, Charles Knap of Pittsburgh, and Cyrus Alger of Boston. These four ironmasters, among whom Anderson was probably the youngest, corresponded, met together in Washington, D.C., to discuss special problems, subcontracted each other's orders, exchanged samples of pig iron suitable to different kinds of armaments, and agreed on prices for various products.⁸³ While continuing to improve the quality of Tredegar iron, Anderson also worked to extend the company's markets making personal visits to iron centers in Boston and New York, among other northern cities. Whether these marketing efforts resulted in sales or simply served as public relations efforts to build Anderson's business networks, they served to extend the breadth of his reputation and to increase Tredegar's visibility.

His commitment to southern economic development, and home manufactures—that is, southern manufacturing for a southern market—remained an ideological and a practical priority, however. With the expansion of southern railroads during the 1850s from two thousand rail

⁸³ *Ibid.*, 197.

miles to almost nine thousand, Anderson's southern market grew concomitantly.⁸⁴ He could reach this market with competitive prices and more reasonable transportation costs than northern manufacturers. He cultivated business networks among the individuals and railroad developers in the South, like-minded advocates of southern industrial growth who knew his reputation as a regular delegate to Southern Commercial Conventions. (These were similar to his first such meeting in Norfolk, but widely-publicized and with regional delegates from a spectrum of pro-South ideologies.) He hired commercial representatives in major cities such as New Orleans and focused on Tredegar's southern markets, sending trusted members of his own management team to market the ironwork's products. Anderson's commitment to and dependence on southern industry was clear. "My entire reliance is upon the Southern people for support," he confirmed.⁸⁵

An eight-four page *Catalogue of Manufactures of Tredegar Iron Works* was specifically directed to "friends and patrons in the South" highlight this commitment to promoting southern industry and southern

⁸⁴ Between 1850 and 1860, 22,000 new track miles were laid in America increasing the total mileage from 8,879 in 1850 to 30,626 in 1860. Two-thirds of this growth occurred in northern states. John E. Clark and John Elwood Clark, *Railroads in the Civil War: The Impact of Management on Victory and Defeat* (LSU Press, 2004), 12.

⁸⁵ J.R Anderson to Dr. Stephen Duncan, Natchez, Mississippi, April 27, 1850. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia. .

manufacturing and to building a personal and corporate reputation in that region. Anderson promised present and potential Southern customers that “we shall manufacture and use none but the best material for machinery purposes; nor will we ever sell...machinery that we cannot fully and fairly guarantee as represented, and...we challenge the entire trade to produce an equally reliable article at less than our prices.” Anderson assured his customers that Tredegar was the “only Independent Southern Works [sic] in existence as we manufacture the raw material from which we manufacture our machinery.”⁸⁶

Dozens of corporate and individual customers throughout the South, added their names to Anderson’s brochure as references while others contributed letters endorsing the quality of Tredegar’s products. Speaking of Tredegar’s engines, the President of the Raleigh and Gaston Railroad Company confirmed “the workmanship of the engines to be of superior quality.” Private customer, Col. B.B. Simmes in Louisiana was “...most happy to inform you that my steam saw mill exceeds my most sanguine anticipations. It is the admiration of all.” In a lengthy testament describing each product Tredegar had supplied the railroad—including spikes, iron washers, screw bars, fish plates, and engines—the Chief

⁸⁶ “An Illustrated and Descriptive Catalogue of Manufactures of Tredegar Iron Works, Joseph R. Anderson & Co., Richmond, Va.,” *HathiTrust*, 15, accessed December 30, 2015, <http://hdl.handle.net/2027/umn.31951000947450w?urlappend=%3Bseq=21>.

Engineer of the Norfolk and Petersburg Railroad wrote a testimonial “for the better interest of our Railway Companies who wish to encourage home manufacture, and to obtain an honest equivalent for their money. ...I wish to express my opinion of the superior material and make of the articles which you have furnished this Company. Your [products] are, in my opinion infinitely superior in quality and shape to any other...made elsewhere in the country.” He went on to discuss the tensile strength and durability of the products, the weight-bearing capacities, and the uses to which they were subjected in bridge and track construction. “Such is the pre-eminently superior quality of your iron, that it was by me selected for the construction of my iron bridges, from the fact that it was the only iron that could be found of the tensile strength prescribed by the terms of my contract.

A FAMILY-RUN COMPANY

Financial problems continued to plague Tredegar's new owner instigated, in part, by a competitive glut of imported, low-cost British rails and bar iron on the market following the collapse of the early railway boom of the 1840s. Anderson countered external market fluctuation to the extent that he could through the creation of internal corporate stability by increasingly integrating family control into Tredegar's governance. In Anderson's lexicon, family control meant that an

extended family of Andersons, Archers, and Glasgows filled a majority of positions on the company's board; a majority of management positions running day-to-day manufacturing operations; and assumed primary responsibility and control of financial affairs. Anderson's family control also extended to ownership and management of furnaces and properties that could supply raw materials to the ironworks or serve as sources of capital when needed. This minimized accountability to outside

Two of his brothers, Francis and John had stepped away from their legal practices to manage family-owned furnaces in southwestern Virginia that supplied ore to Tredegar. They then focused on producing and transporting pig iron from the Botetourt "vein of iron" at Cloverdale to Tredegar. Tredegar purchased the entire output of the Cloverdale furnace during the 1850s. Throughout the nineteenth century, the three brothers purchased, operated, leased, closed, and sold multiple furnaces to maintain a supply of iron ore to manufacture Tredegar's products or to provide capital for Tredegar's operations.

Anderson achieved this family control while creating temporary ventures, independent corporations with partners peripheral to Tredegar. These interim alliances enabled him to obtain capital to acquire machinery and manufacture products that increased Tredegar's output and helped him build his business and the reputation of Tredegar

products. As these ventures succeeded and stabilized, Anderson bought out his partners, incorporating these operations into Tredegar's corporate structure. By 1859, Anderson had expanded Tredegar to 12 acres between the James River and the Kanawha Canal that included multiple rolling mills, foundries, and machine shops. Members of the Anderson family received five-sixths of the profits.

Family control became institutionalized after the Civil War.⁸⁷ In 1867, Anderson placed its manufacturing facilities in Richmond under the umbrella of the Tredegar Company, a joint stock company. He placed the furnace and farming properties in August, Alleghany, Botetourt, Goochland and Henrico Counties under the umbrella of J.R. Anderson and Company.

Joseph Anderson held controlling interest in the Tredegar Company, owning 6,950 shares of 10,000 shares of stock. His son, Archer Anderson

⁸⁷ The history of Tredegar during the Civil War is covered in detail in Charles B Dew, *Ironmaker to the Confederacy: Joseph R. Anderson and the Tredegar Iron Works* (New Haven: Yale University Press, 1966). The doctoral thesis of Sally Flock, "In the Hands of Others: The Development of Dependency by Richmond's Manufacturers on Northern Finances" (Doctoral Dissertation, Yale University, 1983), ProQuest Dissertations and Theses Global also explores this era and the period immediately following the Civil War. Flock's research offers insights into the sources of Tredegar's revenue during the post-Civil War period. Dennis Hallerman's master's thesis, drawn primarily from Tredegar's corporate records at the Library of Virginia is particularly helpful in outlining Tredegar's financial chronology. While I disagree with many of Hallerman's conclusions, particularly that Tredegar failed by not entering steel manufacture in the 1870s, Hallerman's research on this period of Tredegar's history presents a particularly useful timeline of corporate history. Dennis Maher Hallerman, "The Tredegar Iron Works: 1865-1876" (University of Richmond, 1978).

became secretary and treasurer of the Tredegar Company, serving as his father's representative until his father's death in 1892. Archer then became president.⁸⁸ Twenty-six years later, at Archer's death in 1918, the lineage continued as Archer's son, Archer, Jr., took over the company. Members of the extended Anderson family filled key management positions throughout the nineteenth century including Head of Tredegar's Rolling Mill Department, Chief Engineer, and Head of the Foundry Department. They filled the company's Board of Directors. Of the five to seven available slots, non-family members occupied only one or two positions.

STEWARDSHIP, HONOR, AND THE PANIC OF 1873

The announcement of the closure of Jay Cooke & Company precipitated runs on Richmond banks. The city's merchants and manufacturers and representatives of commercial associations acted immediately, calling a city-wide meeting of financial and business interests, the largest gathering of its kind ever held in Richmond. This *ad hoc* group issued a quick disclaimer of local responsibility: "The present

⁸⁸ Archer Anderson joined Tredegar as a junior partner in 1861 after a distinguished academic career at the University of Virginia and after studies in Europe. He subsequently joined the Confederate Army, rising to Colonel. After the Civil War, Archer Anderson rejoined Tredegar. Because of his inherited position and his own scholarly proficiencies, he became an orator, a voice of Confederate Civil War history. Perhaps his most publicized speech was his keynote at the unveiling of the General Robert E Lee statue in 1890 in Richmond. After Joseph Reid Anderson's death in 1892, Archer headed Tredegar for twenty-six years until his own death in 1918.

condition of affairs in Richmond has arisen from causes and influences external to the banking and mercantile business thereof, and is in nowise attributed to irregular operations or undue expansion on the part of its banks or merchants." Unanimously, these business groups resolved to abstain from bank runs themselves and to continue to make deposits and to limit themselves to regular and necessary checks and drafts in the course of business.⁸⁹

The effects of the Panic worsened Richmond's already faltering post-War economy. Anderson could concur in hindsight with the Point Pleasant, *West Virginia Weekly Register*, "The experiment of building railroads with borrowed money has been fairly tried, and must now be abandoned as a failure." Richmond might have served as the prototype for a *Chicago Tribune* editorial published one month later, "The panic is over, but the crisis is not...the people have stopped running the banks, but the manufactories have not stopped discharging their hands, the railroads have not recovered their former volume of traffic, the Government is not able to pay its current expenses out of its current receipts, merchants are

⁸⁹ "Richmond Dispatch(Richmond, Va.) 1884-1903, September 25, 1884, Image 1 - Chronicling America - The Library of Congress," accessed August 23, 2010, <http://chroniclingamerica.loc.gov/lccn/sn85038614/1884-09-25/ed-1/seq-1/?words=Tredegar>.

not doing the same business as before."⁹⁰ The public crisis filtered into private lives. Anderson's daughter-in-law wrote to a cousin, "We are tightening our belts and it is more difficult to run a household in these trying times." Sending a forty dollar payment to his daughter's music teacher, Anderson's son, Archer, wrote, "I do this at some inconvenience to myself; for I must tell you that,,since the disastrous panic of last year, my income has shrunk to almost nothing."⁹¹

With the onset of the Panic in September 1873, the New York Stock Exchange closed for ten days. By November, fifty-five railroads had failed, including the Chesapeake & Ohio one of Tredegar's major customers throughout the nineteenth century. In December 1873, in its annual end-of-the-year evaluation of the status of the industry, *Iron Age* reported, "...November and December are ...usually months of dullness and uncertainty, and rarely witness much of either industrial or commercial activity. Recovery from the effects of the panic has, therefore, been slower than it would have been at any other season...As to the immediate future, it is impossible to speak with confidence."⁹² Summarizing the effects

⁹⁰ "Restoration of Confidence.," *Chicago Daily Tribune (1872-1922)*, October 19, 1873, http://search.proquest.com.mutex.gmu.edu/cv_786252/docview/171445274/abstract/35547548213D41FAPQ/12?accountid=14541.

⁹¹ Archer Anderson to Mr. Meerback, October 7, 1874, Richmond, Virginia. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

⁹² "The Lessons of a Year," *Iron Age*, *Iron Age*, 7, no. 52 (December 25, 1873): 2.

of the Panic, the American of Iron and Steel Association concluded, "...no industry in the country was so injuriously affected as the manufacture of iron and steel ...other industries partly revived, but no signs of a revival in the iron trade were apparent."⁹³ Data from the Association revealed that the quantity of iron of all kinds—railroad, bar, and pig—annually required by the railroads was less than one-half the total the amount needed in years past (the report does not define the specific past years under scrutiny), noting that with the collapse of railroads, Panic-induced slowdowns in all business operations that required iron—building construction, agricultural implements, sewing machines, stoves, ranges, heaters, mill machinery—also contributed to the downward trend of the industry. Nationally, the output of iron and steel declined by 45 percent in less than a year.

"Another noticeable bad result [of the Panic] is the general discharge of operatives in locomotive and car factories over the whole country...The Tredegar Works, Richmond; Patterson Railroad Works, New Jersey; Cumming Car Company of Jersey City; and others, have either suspended or discharged operatives by the hundred,"⁹⁴ reported the *Atlanta Constitution*. The *Chicago Daily Tribune* noted, "The Tredegar Iron

⁹³ "Proceedings of the American Iron & Steel Association, and of the Convention of Iron and Steel Makers, Held in Philadelphia, Feb. 4th and 5th, 1874.," *HathiTrust*, 9, accessed August 7, 2015, <http://hdl.handle.net/2027/pst.000057652023?urlappend=%3Bseq=14>.

⁹⁴ "The Financial Situation." *The Atlanta Constitution*, October 4, 1873. 2.

Works Company have discharged between 600 and 700 workmen employed in the car building."⁹⁵

The Panic marked a turning point for Tredegar. For three years, the company struggled to remain afloat. By 1876, profits had fallen more than 90 percent below their pre-Panic highs and Tredegar faced bankruptcy. The company had taken drastic measures in 1873 including floating a \$1,200,000 bond, payable by 1893, at 8 percent per year and secured by a deed of trust on all real estate, fixtures, and other accoutrements of the iron works and of the family-owned furnaces that supplied Tredegar. By 1876, Anderson noted that "the paper of the company has been protested and some of its creditors threatened suit."⁹⁶ Facing a choice between bankruptcy and receivership, Anderson and the Board of Directors agreed "no obstacles should be interposed to the appointment by a proper court of a receiver." Anderson considered receivership of greater advantage to the company's creditors than bankruptcy. This choice appears as a dialectical outcome, that is, the confluence of Anderson's principles of stewardship and honor and his *mentalité* as a

⁹⁵ "Virginia." *Chicago Daily Tribune*, September 26, 1873. 5.

⁹⁶ In 1876, 43 percent of the south's 127 railroad lines were in default of bond coupons or behind in interest payments. At least 25 out of the South's 45 longer railroad lines (over 100 miles) went into receivership at some point during the 1870s. Many of these were Tredegar customers including Virginia-based Chesapeake and Ohio and Virginia Midland. John F. Stover, "Southern Railroad Receivership in the 1870's," *The Virginia Magazine of History and Biography* 63, no. 1 (1955): 41–42, <http://www.jstor.org/stable/4246089>.

businessman. The effect of receivership rather than liquidation was favorable to Richmond's industrial and economic sectors as well as to his creditors. Furthermore, Tredegar would continue to support his family (although in reduced circumstances and with the integration of personal and business properties and accounts) and to provide employment for hundreds of Richmond residents. In January, the Chancery Court of Richmond named Anderson as the company receiver and required that Tredegar conduct its business on a cash business only.⁹⁷

The plant closed briefly, and as it re-opened, Anderson and Tredegar managers promptly contacted customers whose orders they had already promised to fulfill, reassuring them of the company's continued operations. Writing to the agent of the C&O Canal, F. T. Glasgow explained, "The Chancery Court has today appointed Genl Anderson Receiver of the Tredegar Co. and he has taken possession of all the property and operation at the works. We are pleased now to fill your order."⁹⁸ Anderson reached out to past and present customers. "I am operating these works as Receiver and have no agent in New York. I therefore apply to you directly to say that I am prepared to execute your orders...and if you want Fish Plates, Spikes, Wheels and anything in our

⁹⁷ Dennis Maher Hallerman, "The Tredegar Iron Works: 1865-1876," 122-123.

⁹⁸ F.T. Glasgow to J.A. Netherland, Esq, C & O RR, January 18, 1876. Anderson Personal Papers, Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

line, please give me an opportunity, dropping me a line to make an offer. I would take an order today for the 30" broad tread wheels....," Anderson sent many similar letters of reassurance, in his own handwriting under his own signature advising associates of Tredegar's reliability during the weeks following Receivership. Most indicative of his character, he pledged early in 1876 to repay all creditors, "You may rest assured that it will be my effort to pay each creditor all that is possible out of the company assets, and as quickly as possible."

It took three years for the company to recover. In 1879, the Chancery Court lifted receivership when the company issued \$1,000,000 worth of four percent, twenty-year mortgage bonds. The works and the properties were restored to Anderson and the Board of Directors and Tredegar held \$127,000 in working capital. Only a year earlier, Anderson had remained unsure of the company's fate.

"My son Archer has made various efforts to unite all parties in interest upon a safe and practicable plan of reorganizing the Tredegar Company so as to save the whole of a Chancery liquidation, but the indications now are that he will not be successful, he wrote to his early investor and Board member Abiel Abbot Low in January 1878. "...it seems therefore inevitable that the property will be sold by the Court, he

continued."⁹⁹ Anderson assured Lowe that no bad debts had been incurred during receivership, and that "I have conducted the business from a cash basis—the only way I mean ever to do business again if I can control this subject." He further explained that in the event the property was purchased by friends of the company, the opportunity to join in that purchase would be offered to current investors in the same proportion as their investment.¹⁰⁰

A day later, in a confidential letter to John F. Winslow, Tredegar's largest stockholder outside family-owned shares, Anderson outlined the projected outcome if the company were sold. Adding the unpledged assets of the company and property and machinery, Anderson calculated a total fund of \$350,000 to pay off creditors.

⁹⁹ Joseph Anderson to A. A. Lowe, Esq, January 1878, Personal correspondence, 1876. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia. -1879. Abiel Abbot Low, a New York businessman, invested in Tredegar xxxxx and remained a stockholder until his death in 1893, one year after Joseph Reid Anderson. His relationship with the Anderson family was both personal and professional Archer Anderson regularly consulted Low throughout the ups and downs of Tredegar's receivership, recovery, and stabilization. Joseph Reid conferred with Low about financial directions for Tredegar throughout his tenure. His letters to A. A. Low are informational, but he also often approached Low as an authority whose opinion is sought not only for its intelligence, but also in search of or support for various corporate directions that would affect stockholder satisfaction and benefits. Among the exemplary exchanges, Joseph Reid Anderson informed Low of a new venture in Duluth, Minnesota in 1891. Anderson's youngest surviving son, John, was opening an ironworks. Extolling his son's experience and character as well as the business potential, Anderson encouraged Low's investment in this venture. After the death of both Low and Anderson, the Low family continued as stockholders in Tredegar. Correspondence through succeeding generations of each family reflected a mutually caretaking, professional relationship.

¹⁰⁰ *Ibid.*

When Anderson announced official termination of receivership in a letter to stockholders, he exuded poles of triumph and humility, hope and realism. "The Panic of 1874 brought utter ruin upon many of the Iron Mills of the Country and of England...it is some consolation to us that we have our works left—charged it is true, with a heavy debt—but the debt is funded for twenty years at a low rate of interest." Profits had been up between September 1870 and January 1880; net earnings amounted to \$80,518—reason for optimism. Anderson, however, curbed his enthusiasm, referring to the upswing as an abnormal condition of trade, although he acknowledged that such circumstances would allow Tredegar to quickly pay off its debt. "But that is not to be expected. ...we must now only expect our debt to be paid by the earnings we may secure, by economy and good management, in an active competition with other establishments."¹⁰¹

Anderson's sense of Christian stewardship and southern honor undoubtedly underlay efforts to save Tredegar during the long depression of the 1870s. Loyalty to family, personal pride, and recognition of his role and the company's niche in the local and regional economy guided his course. "If when the crisis came the company had gone into liquidation—

¹⁰¹ Minute Book, May 3, 1880. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia

in view of the dilapidation of the words from suspension of business, the heavy constant charges such as rents, taxes, insurance and the like, and the amazing shrinkage of all values through these years, it would probably have ended in the creditors receiving a very minute percentage of their claims and the stockholders nothing," he wrote when receivership ended.

Tredegar remained the largest ironworks in the South during the panic years and the largest single employer in Richmond. In 1872, The *Virginia State Journal* had touted Tredegar as the city's flagship iron manufactory, detailing the history of iron manufacturing and situating Tredegar in the vanguard of its advance. The newspaper praised the ironworks technological prowess, the extent of its facilities, and its prime location among Virginia's vast natural and man-made resources—bituminous coal, port and railroad transportation hubs, and sands and clays for casting and puddling work. The crux of the matter, however, lay in "The importance of this large and enterprising company to Richmond, can hardly be estimated in appreciable results. Besides the large force they constantly employ, their industry stimulates a hundred others in Richmond and its vicinity."¹⁰²

Throughout the subsequent period, trade publications and the press continued to acknowledge the primacy of the iron works, in spite of its

¹⁰² "The Daily State Journal. (Alexandria, Va.) 1868-1874, May 18, 1872."

precarious financial position and while establishments in other sections of the South—primarily Tennessee and Alabama—entered iron manufacture and began to surpass Virginia in annual production. Tredegar's persistence in providing traditional products to the railroad industry and Anderson's conservative approach to technological change enabled survival and continuing prestige of the ironworks during the nineteenth century

IV. THE PERSISTENCE OF IRON

In 1870, Confederate veteran and future mayor of Richmond, Virginia, (1904-1908), Carlton McCarthy, wrote a Richmond guidebook for young people structured as a series of walks around the former capital of the Confederacy.¹⁰³ Tredegar ironworks was the first stop on the tour. McCarthy's description of the rolling mill stressed the power and might of the men and machines that animated Richmond's industrial strength.

He described the puddlers as "stripped to the waist, and when the door of a furnace opened, the glare of the molten metal made them look like demons." The puddlers would haul out "large balls of blazing metal and pass it to others. These would throw it between the rollers and soon the mass would be the desired length and size. These long bars of iron passed through the rollers and back again, looked like huge serpents. ...When a bar of iron was to be cut, it was thrown against a circular saw, and the brilliant sparks flew in every direction."¹⁰⁴

¹⁰³ Carlton McCarthy and McCarthy & Ellyson., *Walks about Richmond*: A Story for Boys, and a Guide to Persons Visiting the City, Desiring to See the Principal Points of Interest, with and Index Showing the Exact Location of Each Point Mentioned (Richmond Va.: McCarthy & Ellyson, 1870).

¹⁰⁴ *Ibid.*, 15–16.

A century later, Elwood Harris, whose father worked at Tredegar between 1895 and World War II, recalled his childhood memories of the rolling mill. It was a quieter building than McCarthy had described. At the time of Elwood's visits (likely between about 1915 and 1925, roughly fifty years after McCarthy's description), puddlers no longer slung balls of molten iron between machine. The snake-like rolls of metal and the heat and fumes of the puddling furnace had disappeared. (Tredegar had terminated puddling operations around 1880.¹⁰⁵) Instead, trays filled with scrap iron, metal bars, rods, and bolts were heated in ovens, and then rolled into long red hot rods and passed to the spike and horseshoe mills. Even though manufacturing techniques and processes had changed between visits, the products that Tredegar manufactured had remained essentially the same over the fifty-year period, as they would throughout Tredegar's history.

After the Civil War, Tredegar resumed manufacturing iron products it had made before the war (with the exception of armaments)—chilled iron wheels, railroad spikes, chairs, axles, fishplates, and railroad cars. Two

¹⁰⁵ In 1868, the Tredegar Proprietors built a new 136 by 60 foot puddling works with 12 single puddling furnaces, on the west side of the west rolling mill, where they had nine puddling furnaces from before the war. They had nine more furnaces in the east rolling mill, some of which, however, they may have already converted to heating furnaces. In 1874, the Tredegar works had a total of 25 puddling furnaces. By 1875, the Tredegar managers were no longer operating the new puddling works. They evidently found it cheaper to buy scrap iron and to or to purchase pig iron from other works than make new iron.

major changes occurred in the company's mass-produced product lines: the addition of horse and mule shoes and a rapid entrance into and exit from iron rail manufacture. Within this framework of product consistency, Tredegar adapted and added equipment and processing techniques to capitalize on efficient, economical, and cost effective manufacture. These changes, too, developed in response to differences in the supply of raw materials. Most notably in the post war era, purchasing and recycling obsolescent iron rails became more cost effective than iron ore for the manufacture of many products.

Tredegar's approach to business was representative of small- to mid-size iron manufacturers operating against a backdrop of industrial change in the latter part of the nineteenth century. These companies remained with product lines that did not convert from iron to steel throughout that era and, like 75 percent of the metallurgical manufacturers during that time, Tredegar's principal manufacturing efforts focused on supplying goods to the railroads where the use of traditional iron products blended with that of new steel rails.

Tredegar's persistence in iron and traditional iron manufactures occurred as geographies of national expansion, the growth of railroads, and the advent and dissemination of technologies for iron and steel manufacture dramatically altered the industrial landscape during the

latter half of the nineteenth century. The transition from iron to steel was gradual, although the long-range outcome was certain. This gradual transition enabled Tredegar to negotiate a niche in the spectrum of innovation and obsolescence.

THE CONTINUITY OF IRON VERSUS THE INNOVATIONS OF STEEL

Between 1873 and 1890, the growth of the iron and steel industries proceeded mutually, although unequally. During those years, the fulcrum between steel and iron production shifted—sometimes dramatically as steel replaced iron in rail fabrication; sometimes less perceptibly as iron persisted as the material of choice for the bulk of existing products. In Tredegar's case, innovation pushed the company out of iron rail manufacturing early during this period of transition while demand continued for railroad peripheral equipment and industrial tools—meat-and-potatoes products that Tredegar manufactured.

Nationally, steel manufacture developed as a metallurgical startup with production levels of about 12,000 tons per annum in 1860 to become a power player by 1890 with an output of 11,412,000 ton. Steel rails constituted roughly 74 percent of the total iron and steel production. Tectonic shifts within the industry were most apparent and most prophetic of future directions as new railroads moved to steel rails when their production began in 1867. Initially, steel rails were almost the only product

of the steel industry and they remained so through the end of the century. By the 1870s, rails accounted for ninety percent of steel production. The impact was monumental. “What mighty changes have been wrought by these steel rails...!” stated a Senate Report in 1877, citing the domino effects of growing steel rail production on the expansion of railroads and the further effect of that expansion on lowering costs of transport and travel for agriculture, business, leisure, and recreation.

However, the wholesale adoption of steel rails, innovative products produced through innovative technologies, did not spawn the “creative destruction” that economist Joseph Schumpeter theorized was the inevitable consequence of rapid dissemination of new technologies—that is, that new modes of production and new products decimate the old order that they replace. The momentum of new technologies, according to Schumpeter, creates obsolescence, killing organizations and institutions of the old order and bringing concomitant financial failure and economic chaos. The advent of steel did not, however, eliminate iron. Instead, iron production, as well as steel, continued and expanded in the latter half of the nineteenth century. During the entire period between 1872 and 1892, the hegemony of steel in rail production rarely extended to other traditional iron products. Production of iron products, other than rails, more

than trebled between 1868 and 1890 with an average annual rate of growth of 7.4 percent.¹⁰⁶

Two principle factors were responsible for the incremental rather than rapid growth of steel rail manufacture. These two factors weighed against entry into steel of firms such as Tredegar and provided options for their survival. For small and mid-sized iron companies, new technology did not equate to greater profits, especially when the corporate identity and personal value systems of the owners were antithetical to the management principles that launched steel enterprises.

First, early steel entrepreneurs and inventors themselves militated against a rapid spread of steel manufacture through the creation of a patent cartel and insistence on institutional accountability and oversight of those who purchased the patents. Second, adoption of the revolutionary Bessemer process, first conceived simultaneously in England in the 1850s by Henry Bessemer and in America by William Kelly, was hampered by early limitations of machinery and chemical processes.

The growing demand for steel rails at the end of the 1860s promised profits and the Bessemer process was the least expensive and most efficient system for supplying railroad demand for these rails. To corner this

¹⁰⁶ James Swank, *History of the Manufacture of Iron in All Ages, and Particularly in the United States from Colonial Times to 1891. Also a Short History of Early Coal Mining in the United States*, 2nd ed. (Philadelphia, Pennsylvania: The American Iron and Steel Association, 1892), 414–415.

growing market, steel corporations employing the Bessemer process inhibited new entries into the industry through the formation of the Bessemer Patent Pool. Entering the steel market required obtaining rights to three patents: the Bessemer, the Kelley, and the Mushet¹⁰⁷ and these early companies purchased and shared the three patents, charging a potential licensee a single sum to obtain them. Further, with the purchase of the license, the patent pool furnished plans for standardized plants, training, and information on the processes and ongoing improvements of the Bessemer method. The pool collected licensing fees and royalties and divided the proceeds among the membership. The license came with a surrender of corporate autonomy: the patent pool required licensed firms to open their account books to ensure the accurate payment of royalties. Strict regulations also governed the flow of information: licensees could share technical knowledge and development among themselves; however, corporate secrecy prevailed. Each was forbidden to communicate anything about its work or business to anyone outside the group of licensees.

This control of information impeded technology transfer and further created a closed circle of informed manufacturers knowledgeable of

¹⁰⁷ .Robert Mushet, a British metallurgist, had invented the chemical processes requisite to overcome inconsistent outputs hindering the quality of steel Henry Bessemer's furnace. Mushet's formulas ensured that carbon and iron mixed thoroughly at the appropriate temperatures and in the right amounts. Add sentence about inventor disputes.

state-of-the art techniques of steel production. Besides the early inventors and developers, Bessemer, Kelley, and Mushet, the mechanical engineer Alexander Lyman Holley, had brought an early iteration of the Bessemer process from England to America in 1867 and had designed and built the first Bessemer plants in America. As a consultant to factory owners and operators, he taught and trained cadres of engineers who departed from the training grounds of Cambria Iron and Steel Works in Johnstown, Pennsylvania, like disciples, to build and expand the first steel plants. Together, these entrepreneurs and engineers were among the forerunners of corporate research departments, and together they rejected, revised, and created subsequent directions in metal manufacture. They talked among themselves and among the members of the patent cartel. Years later, one of them reminisced, "In the early history of the process, ...we met as a band of loving brother engineers....What each of us knew was common to all. ...this fraternal relationship was very important in the exchange of information in a new field."¹⁰⁸ Holley's pupils formed an elite group of industry insiders.

Potential manufacturers were also wary of mechanical barriers to entering steel manufacture: steel technologies were imperfect during the

¹⁰⁸ Elting Morison. *Men, Machines, and Modern Times*. (Cambridge, Massachusetts and London, England: The M.I.T. Press, 1966), 182.

1870s and 1880s. The Bessemer process removed impurities such as carbon and silicon from pig iron through oxidation. Flaws and variations in the rate and extent to which the Bessemer model removed these elements in the blast furnace created inconsistencies in the quality of the output, however. These inconsistencies led to fractures, breakages, and variable strengths in the pig iron produced in Bessemer furnaces. To pinpoint irregularities and stabilize steel production, manufacturers began to institutionalize chemical analysis, examining the output of Bessemer converters and iron from blast furnaces at incremental steps through the production process.

Until 1875, “the fact that iron smelting was a chemical process was not generally accepted.”¹⁰⁹ Until that point, this quality control in the blast furnace generally occurred on a manufacturer-by-manufacturer basis among iron producers. Individual ironworks and their artisans calculated the quality of their output according to the unique characteristics of the raw materials that were available to them and according to the synthesis between those raw materials and the machines used to process them. The mass production environment of steel manufacture rendered this micro-approach to quality control a non-starter.

¹⁰⁹John Birkinbine, “Forty Years of Progress in the Pig Iron Industry, *Iron Age*, January 1, 1896, quoted in William Sisson, “A Revolution in Steel: Mass Production in Pennsylvania, 1867-1901,” *IA. The Journal of the Society for Industrial Archeology* 18, no. 1/2 (January 1, 1992): 81, <http://www.jstor.org/stable/40968251>.

The inhibitory effect of the inventors, engineers, and businessmen in the forefront of the Bessemer process and in the patent pool was clear throughout the era. By 1879, only eleven steel mills were in business. Three had opened in the 1860s. The Cambria Iron and Steel Works in Johnstown, Pennsylvania, and the Union Steel Company, Chicago, Illinois, both opened in 1871. They were followed by the North Chicago Rolling Mill, Chicago, Illinois, in 1872 then by the Joliet Iron and Steel Works, Joliet, Illinois, and the Bethlehem Iron Company, Bethlehem, Pennsylvania, in 1873. Two years later, J. Edgar Thomson Steel Works, opened in Bessemer Station, Pennsylvania, and the Lackawanna Iron and Steel Works in Scranton, Pennsylvania. After a lull, the St. Louis Ore and Steel Company, St. Louis, Missouri, opened in 1878. Even after patent expiration in the 1880s diminished the formal control of the cartel, the corporate structure of these early companies, their adoption of vertical and horizontal integration, economies of scale and their concomitant growth as large industrial firms solidified a competitive barrier to entry that the small manufacturer or industrial outsider could breach only with great difficulty. "There are but eleven Bessemer mills in this country," reported *Iron Age* in 1877. "They own absolutely all the patents essential to the manufacture of their products. ...no other mill can be started in opposition to them."¹¹⁰

¹¹⁰ *Iron Age*, November 8 1877, quoted in Peter Temin, *Iron and Steel in Nineteenth-*

The patent cartel and the gradual evolution of quality control in the steel industry brought unintended beneficial consequences to iron manufacturers such as Tredegar. Despite the demand, steel rails were not overnight sensations but products of an evolutionary adaptation over two decades. This gradual shift, plus the fact that rails were almost the only steel product, helped proprietors of rolling mills that could make high-quality iron rails retain a small share of the market until the 1880s¹¹¹ and further enabled the continuation of industrial and commercial iron products. Concerning iron manufacture as a whole, *Iron Age* commented in 1883 that "iron has stubbornly refused to be forced out of use, and the indications are very favorable to the assumption that the ...car builder, the machinist, the iron founder, and their multitudinous colaborers [sic] will continue to use iron for an indefinite period."¹¹² As a result, the iron and steel industries grew side by side during the last decades of the nineteenth century.

INNOVATION AND TRADITION: RAILS, CAR WHEELS, AND SPIKES

Against this backdrop, Joseph Anderson's continuation in iron manufacture, does not appear shortsighted or as a failure of recovery,

Century America: An Economic Inquiry (M.I.T. Press, Massachusetts Institute of Technology, 1964), 175–76.

¹¹¹ Robert Gordon, *American Iron, 1607-1900* (Baltimore and London: John Hopkins University Press, 1996), 229.

¹¹² *Bulletin*, 17 (September 19, 1883, p. 257). Quoted in Temin, *Iron and Steel in Nineteenth-Century America*, 217.

but as a corporate strategy to ride the wave of his existing product and customer base, maximizing the use of his resources. As a southern company, Tredegar was an unlikely candidate for admission to the tightly-knit industrial fraternity of northern steel manufacturers, the company's growth after the Civil War and the reputation of its president notwithstanding. Southern iron manufacturers such as Tredegar were not among the demographics of the early steel industry and no southern manufacturers purchased the triumvirate of patents from the cartel. No steel manufacture was noted in southern states until James Swank, general manager of the American Iron and Steel Association, reported on the southern iron industry for the trade publication, *Iron Age* in 1888. "The South made some progress in the development of her steel industry, but not much [last year]. Two small Bessemer steel works were completed in the South. ...The works of the Roane Iron Company, at Chattanooga, Tenn., made their first blow on May 7, 1887, and on that day the first Bessemer steel rail ever made in the South outside of Wheeling was successfully rolled at these works. But the manufacture of Bessemer steel by the basic process in the South has not yet been attempted."¹¹³

¹¹³ James Swank, "The Southern Iron Industry," *Chilton's Iron Age*, no. November 15, 1888 (1888): 740, <http://catalog.hathitrust.org/Record/009798831>.

Moreover, transitioning from iron to steel was an all-or-nothing proposition. The profitable manufacture of steel products required large-scale, mass production. The blast furnaces, large machines, and engines requisite for the Bessemer process were power hungry. Even Tredegar's substantial supply of waterpower would have been insufficient to power the new technologies. For Tredegar, moving to steel would have meant virtually razing the existing facilities and systems and rebuilding from scratch.

No known corporate records to date offer any indication of how Anderson viewed the politics of the steel industry or whether he might have weighed the pros and cons of seeking licensing, opening his financial records to outside scrutiny, and rebuilding his plant to conform with the required structures of the Bessemer Steel Association. Clearly, entry into steel manufacture during the 1870s and 1880s required instituting a corporate culture antithetical to Joseph Anderson's family-based management of Tredegar. Buying in to Bessemer's licensing pool would have cost him the family corporate control he had so carefully constructed with corporate reorganization of 1867 that sought investors while limiting their influence on corporate directions.

Iron manufacture is intrinsically a technological process that consolidates principles of chemical, industrial, mechanical, and

metallurgical engineering and science. Tredegar's remaining in iron manufacture seems a result of Joseph Anderson's intelligent recognition (whether tacit or avidly pursued) that the constraints of the Bessemer process were counter-productive and contraindicated, given the company's local and regional orientation, ready access to waterpower, proximity to raw materials, and potential markets. Anderson's sense of stewardship and his responsibilities to family, workers precluded pursuing the financial risks of steel manufacture. Further, the surrender of autonomy required by entering the steel industry during his lifetime encroached on his standing as the unequivocal head of Tredegar and as an elite leader in Richmond's social, political, and economic life.

An exploration of certain iron products that Tredegar continued to manufacture and market offers a perspective on Anderson's devotion to iron production. Anderson took a long view, sticking with products for which he could reasonably expect demand for the foreseeable future. A brief foray into iron rail manufacture before the Panic of 1873 was the only anomaly in this portfolio. It demonstrated a tension between risk-taking and a conservative approach to Tredegar's development and the success of the generally conservative approach to his business decisions that would guide him through near-bankruptcy in the 1870s. Conversely, Tredegar's standard products, exemplified by chilled car wheels and

railroad spikes, were products that appeared to have unlimited market longevity. Each of these items among Tredegar's extensive product base represented a different facet of the company's approach to manufacturing and marketing. While the manufacture of iron rails marked a rapid path to obsolescence, Tredegar's manufacture of chilled car wheels highlights how partially obsolescent methods and techniques remained viable during periods of technological innovation. Spike manufacturing at the ironworks demonstrated an adaptation of marketing and production methods in response to fluctuating demand.

Rail Manufacture at Tredegar

That Tredegar continued to manufacture substantially the same products as it had before the war corresponds to Anderson's value system that juxtaposed risk taking with a conservatism that prioritized his responsibilities to family and community. In 1868, however, the balance between risk-taking and responsibility blurred. Tredegar's re-entry into rail manufacture occurred just as steel rail production began in Pennsylvania between 1867 and 1868.

Anderson's decision to invest in machinery for rail manufacture at Tredegar took place at the start of the company's unprecedented profit boom in the post-Civil War period with the rapid reconstruction and expansion of railroads. When Anderson moved into rails in 1867, the urgent

need to rebuild Southern railroads demolished during the Civil War was clear, and southern railroads had been the mainstays of Tredegar's antebellum market. The simultaneous expansion of the national railway system drove a larger market as national railroad track mileage began an upward course to more than double from approximately 30,000 miles in 1860 to over 70,000 by 1872.

Within a year of corporate reorganization in 1867, Tredegar expanded its facilities and installing both a 2-high rail mill and a 3-high rail mill in the Rolling Mill on the old Armory section of Tredegar's factory compound.¹¹⁴ The decision to invest in the new 2-high and 3-high rail trains to manufacture both rails and chairs¹¹⁵ grew from precedent. Sparked by the early growth of railroads, Tredegar had successfully manufactured

¹¹⁴ On a 2-high rail mill, a heated bar of iron was passed through two rolls to be shaped. Once the iron passed through the rolls, iron workers had to manually circle the iron over the top roll of the mill in order to roll it again. With the 3-high mill, developed in 1857, the bar of iron passed through the two bottom rolls, then reversed to pass through the top rolls of the mill. This process reduced the amount of heat loss to the iron bar and the amount of time necessary to produce a desired shape. The result was greater uniformity and quality. By 1870, the 3-high mill was industry standard. William T. Hogan, *Economic History of the Iron and Steel Industry in the United States*, (Lexington, Mass: Heath, 1972), 40. The 3-high was also useful in efficiently breaking down scrap iron, as Archer Anderson wrote to plant Manager David Eynon with the decision to add the machinery, "The following improvements have been decided on and you may proceed with them at once (1) a three high train for breaking rails, at low heat, in single bars." Archer Anderson to D. Eynon, Manager, May 15, 1869. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

¹¹⁵ A railroad chair is a socket-like fastening made of iron initially used to join adjacent rails end-to-end as well as to attach rails to the ties. Essentially, it is a tightly secured resting place for the rail. No uniform specs existed for rail sizes that varied from railroad to railroad. Customers would submit a pattern section of the rails to be joined from which Tredegar created molds to ensure that the chairs conformed to exact dimensions of each order.

and marketed rails thirty years earlier when Anderson instigated the manufacture of both U-shaped and T-shaped rails in the 1840s and 1850s at the Armory Rolling Mill.¹¹⁶ Historians agree that Anderson was likely the only southern iron manufacturer to enter this market during the antebellum period.¹¹⁷ Contemporary newspaper commentary argues that Tredegar was, in fact, the first to manufacture rails in the nation.

In response to an article in *Miner's Journal* stating that the first railroad iron was manufactured in 1842 by the Great Western Iron Company, a Tredegar stockholder responded that the statement was "erroneous, doubtless unintentionally so. I have no doubt that the first railroad iron made in the United States was manufactured by the Tredegar Iron Works at Richmond Virginia." The author of the letter to the editor offered evidence he considered conclusive: a letter from John Tanner, then secretary of Tredegar, affirming that the first railroad iron "made at these works was featured in ...[1837]." Tanner affirmed that in 1838, Tredegar made a "considerable quantity" for the Richmond, Fredericksburg, and Potomac Railroad Company and other roads in this

¹¹⁶ The Armory Rolling Mill was owned by Anderson's father-in-law and merged with Joseph R. Anderson and Company to create Tredegar Iron Works during the 1867 reorganization.

¹¹⁷ Michael S. Raber, Patrick M. Malone, and Robert B. Gordon. "Historical and Archaeological Assessment: Tredegar Iron Works Site,," Organizational Records Collection, The Library of Virginia, Richmond, Virginia: Raber Associates and The Valentine Museum and the Ethyl Corporation, 1992.

state" and that Tredegar continued to fill similar orders.¹¹⁸ By upgrading his rail manufacturing facilities and re-entering production in the late 1860s, Anderson chose a path characterized as the dominant route of most ironmasters, that of directing energy "to improving the ease of making the existing line of products, which of course also meant increasing the ability to make more exacting progress."¹¹⁹

The antebellum rail models that Tredegar had produced were tentative evolutionary first-steps toward determining rails shapes and weights that could support railroad cars with minimal breakage, lengthy life spans, and maximum ability to absorb shock. Anderson acclaimed the venture. The mill, "erected especially for the manufacture of rails," he wrote, "was engaged in making rails very successfully and held orders for a year ahead."¹²⁰ Early rail production continued for almost two decades until Tredegar turned to providing armaments and munitions to the Confederacy.

¹¹⁸ To the Editor of the Merchants' Magazine and Commercial Review from an unidentified reader, reprinted in *The Enquirer*, Richmond, Virginia, June 1, 1847, Page 1, Column 4.

¹¹⁹ Peter Temin, *Iron and Steel in Nineteenth-Century America, An Economic Inquiry*. (Cambridge, Mass: M.I.T. Press, Massachusetts Institute of Technology, 1964) 103–5.

¹²⁰ Anderson's early correspondence about Tredegar's manufacture of U and T rails demonstrates the motivation of profit in entering new product lines. Kathleen Bruce cites Anderson correspondence in the 1840s. In response to a request from Ripley and Company, Hartford, Connecticut (Tredegar Letter Books) he stated, "I have not as yet made any of the T Rails, but would do so if I could get a price to justify it." Correspondence with various customers about prices, tonnage, and amounts continued throughout the 1850s. Kathleen Bruce, *Virginia Iron Manufacture in the Slave Era* (New York: A. M. Kelley, 1968), 223–4.

In contrast, the rail revival in 1867 was brief. In 1870, Tredegar withdrew from rail production (although throughout the 1870s and 1880s the ironworks still filled occasional orders for T rails such as those designated for carrying small transport vehicles within the grounds of industrial sites).¹²¹ Corporate records give no specific indication of why production halted. An 1871 letter from Archer Anderson to an unknown recipient simply comments, "...we have stopped making rails for the present..."¹²² A closer look at the iron industry at that time, however, indicates that Anderson's stoppage of iron rail production was prescient and pragmatic. Anderson had not begun rail production in the 1840s until he was confident he could do so profitably rather than experimentally.

In 1870, the long-term profitability of iron rails became questionable. Prices for iron rails had already dropped between 1868 and 1870, and Anderson had experienced the effects of competitive challenges of rail markets from northern manufacturers during the antebellum period. As an engineer, and an astute businessman, and by now, an experienced iron producer with extensive contacts within the industry, Anderson undoubtedly recognized the indicators of changing markets. Nationally, production of steel rails, had only begun in 1867,

¹²² Archer Anderson to unidentified recipient, Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia. .

shortly before Anderson re-entered iron rail manufacture.¹²³ Between 1867 when Anderson began production and 1870 when he ended it, the net annual tonnage of steel rails produced in the United States rose from 7,225 to 34,000. In contrast, iron rail production barely rose between 1868 when it stood at 499,489 tons and 1870 when it reached only 586,000 tons.¹²⁴ The hegemony of the steel producers in northern markets and the tottering finances of southern railroads struggling to finance repairs and expansion foretold an unpredictable customer base and shaky bottom line.

The technology of iron rails, too, was falling under scrutiny and discussion in trade publications and other public venues. Increased traffic on the expanding network of railroads in the country and the construction of larger engines and rolling stock already presaged the inevitability of creating stronger, safer, more durable rails. A brief report in the 1872-73 *Bulletin of The American Iron and Steel Association* repeated a question voiced in the industry as early as the 1850s: whether iron rails were sufficiently heavy to bear the weight and strain of locomotives and rolling stock that were becoming increasingly larger and heavier. "There has been but little change in the weight and size of rails since they were first

¹²³ These first rails were rolled first in August at the works of the Pennsylvania Steel Company near Harrisburg, then in September by the Spuyten Duyvil Rolling Mill Company in New York from ingots created at the Bessemer steel works in Troy, New York, then co-owned by John Winslow who later sat on Tredegar's Board of Directors.

¹²⁴ Swank, *History of the Manufacture of Iron in All Ages in the United States*, 440, 462.

introduced, and when the locomotives and rolling stock were much lighter than at present."¹²⁵ Throughout the 1870s, iron manufacturers worked to develop technologies to strengthen iron rails, experimenting with various chemical compositions, sometimes combining old iron with newly-puddled iron; sometimes reconfiguring the amount of phosphorous in the final product to increase strength and flexibility. If Tredegar had continued to manufacture iron rails for even a few years during the 1870s, the effort would have required diverting resources for manpower, research, and experimentation from other Tredegar products with more reliable markets and without predictable possibilities of obsolescence. The rise of steel and declining markets forecasted nebulous profits and markets for iron rails.

Dwindling demand and prices for iron for rails validated Anderson's decision to stop their manufacture. In 1873, 761,062 net tons of rolled iron rails were produced nationally. By 1880, that number fell to 493,762 net tons. By 1883, few iron rails were manufactured, their obsolescence promoted, in part, by the durability of steel rails, whose life span ranged from 20 to 60 years in contrast to the four-year durability of iron rails. Iron, too, was also caught in the downward price spiral. In 1870, iron rail prices

¹²⁵ American Iron and Steel, *The Bulletin of the American Iron and Steel Association*, 4 (American Iron and Steel Association, 1872), 24.

began to sink below those of the previous decade, and they continued to sink with the Panic of 1873. In 1870, the price per ton for iron rails slumped to \$72.24, down from \$83.12 in 1867. By 1878, prices hit a decade low of \$33.75 per ton. By 1880, the price was only 68 percent of the 1870 price, or \$49.25 per ton. In the long term, between 1868 and 1890, the average annual rate of growth for Bessemer steel rails averaged of 26.2 percent while annual iron rail production growth declined at a rate of 17 percent.

By 1890, only 15,000 tons of rolled iron went to rail manufacture, and that, for repair of older tracks still in use and for smaller tracks in mines, light street rails, and industrial complexes. The American Iron and Steel Association reported the iron rail's extinction in the early 1880s, "...steel rails have been steadily sold since 1882 at a lower price than iron rails could be produced, and consequently iron rails have not since been made in this country except for mine railroads or other special purposes."¹²⁶ The reality of the 1877 Senate report was clear, "The resisting and wearing qualities of a steel rail being much superior to those of an iron rail, it is therefore capable of supporting a much heavier weight...and it permits trains to be moved at a greater speed; hence the carrying

¹²⁶ *Ibid.*, 657. National figures on the percentage of steel track nationally in 1890 point to the phasing out of iron rails. Although their manufacture had ended, their use persisted, as long as they were operational. In 1883 when iron rail manufacture ended, only 52.7 percent of the total miles of rail were steel; seven years later, in 1890, 80 percent of railway track was steel. Swank, *History of the Manufacture of Iron in All Ages in the United States*, 441.

capacity of our railroads has been increased many times, and the cost of operating them...has been greatly decreased,"¹²⁷

The 3-high rail mill at Tredegar stood unused for many years after Anderson curtailed iron rail manufacture. Historians of Tredegar have speculated that Anderson's investment in upgrading rail manufacturing helped throw Tredegar into receivership and "suggest[ed] that the Tredegar management may have been out of touch with current trends in the iron industry."¹²⁸ In fact, the decision more likely indicates that Anderson was in touch with and perhaps ahead of industry trends. Certainly, Anderson's decision to expand was a risk, but a calculated one based on experience and current market trends. Anderson wasted no time in extricating himself at the beginning of the decline of iron rails, throwing the weight of his decision on the side of caution and conservatism.

Anderson's bottom line would have been in jeopardy had Tredegar somehow leaped external and internal barriers to begin manufacturing steel rails, as historians often suggest they should have done. Innovation was no guarantee of profit. Prices for steel rails plummeted throughout the

¹²⁷ *Reports of Committees of the Senate of the United States for the First Session of the Fiftieth Congress, 1877-1888*, vol. 2527 (Washington, D.C.: U.S. Government Printing Office, 1888), 654..

¹²⁸ Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site," 41.

1870s as the supply curve rose more rapidly than the demand schedule.¹²⁹

While the production of steel rails increased, their price decreased below that of iron. Decline in railroad construction towards the end of the nineteenth century as well as market saturation further lessened demand. Steel rails had opened the decade at \$106.75 per ton in 1870; sinking to \$68.75 in 1875; diminishing to \$42.25 in 1877; reviving briefly in 1880 to \$67.50 gradually sloping downward and stabilizing at \$31.75 in 1885. By 1890, the average annual sale price for Bessemer steel rails fell below \$26 or \$27 per ton—less than one-sixth their original price in 1867. Coupling lowered prices for steel rails with the costs associated with transitioning an existing ironworks to steel production spelled doom.

Chilled Car Wheels

In a falling market as iron rails began to cede to steel, Tredegar changed gears, offsetting the discontinuation of rail manufacture with continuing and expanded production of items for which a reliable market continued. Chilled car wheels were among those products. Chilled car wheel manufacture illustrated not only the persistence of traditional iron products, but also the persistence of traditional techniques, among them

¹²⁹ Iron, too, was also caught in the downward price spiral. In 1870, iron rail prices had begun to sink below those of the previous decade, and they continued to sink with the Panic of 1873. In 1870, the price per ton for iron rails had already slumped to \$72.24, down from \$83.12 in 1867. By 1878, prices hit a decade low of \$33.75 per ton, rebounding only to \$49.25 by 1880—just 68 percent of the price in 1870.

a cold blast charcoal to produce the pig iron essential for their manufacture. Chilled car wheel manufacture based on pig iron made in cold blast charcoal furnaces entailed iron craft techniques and technology that had changed very little since their inception. Cold blast furnaces produced pig iron with the fewest impurities and greatest tensile strength of any processing technique. Unlike the limited lifespan of some iron products such as rails, chilled iron car wheels made of cold charcoal blast pig iron offered extraordinary durability.

Tredegear had first manufactured chilled wheels for railroad cars in 1844 in their foundries and the ironworks continued their production until 1946. During the twentieth century, chilled car wheels shared market space with wheels made of steel and various alloys in varying proportions. Throughout the 1870s and the 1880s, however, car wheels fabricated of cold blast charcoal pig iron were a superior product whose excellence was unmatched by any other manufacturing method. During this period, car wheels consistently ranked at the top echelons of Tredegear's income-producers and the company maintained and expanded its facilities for car wheel manufacture, designating personnel for research and testing the product line. In the early 1870s, the Tredegear foundries had two air furnaces with a melting capacity of 50 tons in a single heat, a 30-ton cupola, a 20-ton cupola, two 10-ton cupolas, and a 5-ton cupola. In total,

the daily melting capacity stood at 125 tons. Pouring castings for car wheel manufacture took place in three foundry buildings: a pre-Civil War gun foundry, the Confederate foundry where munitions were manufactured during the Civil War, and a Car Wheel Foundry. By 1889, the company added a new car wheel facility by enlarging the old car-wheel foundry and the pre-Civil War gun foundry.¹³⁰

Tredegar manufactured six standardized car wheel diameters: 20", 26", 28", 30", 33" (Tredegar's best seller during the 1870s), and 36". Each of these diameters, generally intended for rolling stock, were produced with broad or narrow tread with options for hollow spokes or rims.¹³¹ Anderson supervised the quality of the raw materials that went into the car wheels as well as the excellence of the final product. "You know the care we take as to the quality of the iron put in wheels," he wrote to his chief engineer, Captain Patrick Derbyshire, in 1875. He continued, "You know how careful we are in preparing the iron, casting, and casting to wheel. And you are aware of the fact that we have gone to the expense of running our own iron Cold Blast Furnace to be sure that we have uniformly a cold blast charcoal iron of ...strength and also of superior chilling process." He pointed out, "the Chesapeake and Ohio has used them for

¹³⁰ Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site," 39.

¹³¹ Tredegar sales ledgers. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

years and would not give them up for any others."¹³² Tredegar guaranteed its wheels for 60,000 miles, although reports from the Richmond and Danville Railroad, regular contractors for Tredegar's chilled car wheels, reported 15 years of constant use—presumably racking up mileage surpassing the guarantee. He encouraged Derbyshire to actively market the wheels, offering a bonus of fifty cents for every wheel for which he succeeded in getting an order.

The importance of the car wheel to Tredegar's product line was paramount. Even as Tredegar moved into receivership, managers immediately emphasized the importance of their manufacture to their customer base: "...as soon as I can get the bonds of the Tredegar Company written up and a statement of our condition made to all the creditors. Then I would be pleased to furnish you the wheels you mention at 3 ¼ cents per pound," wrote Company Treasurer F. T. Glasgow to a West Virginia agent in February 1876.¹³³ "I am operating these works as Receiver," Anderson wrote to another customer, "I would therefore apply

¹³² Letter to Captain P. Derbyshire from Joseph A. Anderson, July 27, 1875. Joseph R. Anderson personal correspondence.

¹³³ F.T. Glasgow to Smith, Esquire, February 14, 1876, Personal Letters of Joseph Anderson, Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

to you direct that I am prepared to execute your orders promptly. ...I would take an order today for 30" broad tread wheels."¹³⁴

Tredegear was well-situated to car wheel manufacture. This product line enabled Anderson to capitalize on natural resources that were abundant in Virginia: brown hematite ore, limestone, timber, and water. While cold blast furnaces produced the ideal pig iron for car wheels, the quality of that pig iron, in turn, depended upon the native composition of the iron ore. Brown hematite had proven best of all ores for the cold blast and Virginia ranked first in the nation in the presence of the ore—38 percent of America's brown hematite lay in Virginia. In the nineteenth century, Virginians mined brown hematite for use within the state; very little of the ore was exported. Virginia was also rich in limestone that lay in proximity to deposits of brown hematite. Limestone was requisite during the blasting process, serving as a fluxing material that caused impurities in the ore to adhere to each other and separate from the pig iron.

The cold blast charcoal iron essential to car wheels was the output of furnaces fueled by wood, a renewable resource and plentiful in the Virginia. Furnaces were generally constructed on forested properties with proximity to rail and water transportation to reduce overhead costs of

¹³⁴ Letter from Joseph R. Anderson to G.W.B. Cushing Esq, Agent D.C & WRR Railroad, New York, February 4, 1876. Tredegear Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

charcoal iron production. These cold blast furnaces dominated the landscape in Virginia throughout the nineteenth century. In 1870, Virginia boasted 23 charcoal blast furnaces with a total of 28 stacks ; 18 of these were cold-blast. By comparison, only five furnaces in the state smelted coke; only one, anthracite.¹³⁵ Charcoal iron was universally considered the most expensive of the triumvirate of fuels used to smelt ore. In Virginia, however, forested lands and other production amenities served as counterweights. In 1874, an out-of-state investor intent on developing ore and coal lands in Virginia calculated that cold-blast charcoal iron could be produced at \$15.05 per ton, three dollars less than hot blast charcoal iron in Virginia, and ten dollars less than the cost of cold-blast charcoal iron produced in Philadelphia.¹³⁶ By 1885, Virginia's 31 charcoal blast furnaces ranked second in the nation, behind only Pennsylvania, and between 1880 and 1890, the state rose from seventeenth to sixth in pig iron production.¹³⁷

¹³⁵ American Iron and Steel Association, *The Ironworks of the United States*: directory of the Furnaces, Rolling Mills, Steel Works, Forges and Bloomaries in Every State /, Centennial ed. (Philadelphia: , 1876), 34, <http://hdl.handle.net/2027/uc2.ark:/13960/t9765cv43>.

¹³⁶ Thomas Dunlap, *Wiley's American Iron Trade Manual of the Leading Iron Industries of the United States*: with a Description of the Iron Ore Regions, Blast Furnaces, Rolling Mills, Bessemer Steel Works, Crucible Steel Works, Car Wheel and Car Works, Locomotive Works, Steam Engine and Machine Works, Iron Bridge Works, Iron Ship Yard, Pipe and Tube Works, and Stove Foundries of the Country, Giving Their Location and Capacity of Product / (New York: , 1874), 533, <http://hdl.handle.net/2027/miun.aet7597.0001.001>.

¹³⁷ Nationally, number of charcoal furnaces gradually diminished between 1870 and 1890, as did the number of furnaces using anthracite while the numbers of furnaces using coke and anthracite grew. In Virginia, the presence of vast bituminous coal fields and

Tredegar had relied on charcoal iron since Anderson had taken over the company, developing family-owned and operated furnaces that sold their entire output to supply pig to the ironworks.¹³⁸ By the end of the Civil War, Tredegar owned six furnaces in Virginia with a total value \$175,000. The company put the furnaces into blast, shut them down, leased, or sold them over the history of the company. In the early 1870s, Anderson's explored into the feasibility of re-opening two of these furnaces, Grace and Rebecca located on 15,000 acres in Botetourt County. Union troops had burned them toward the end of the Civil War, devastating the furnaces and surrounding land. Investigating those properties. William Patton, Anderson's agent, reported that ore was abundant at Grace Furnace, and that the furnace itself, the stack, casting, bridge house, store, stable and dwelling houses were in good

proximity to the larger bituminous resources of West Virginia led to an increase in bituminous furnaces and the gradual cessation of charcoal pig iron production. Between 1880 and 1890, Virginia's production of pig iron increased from 17,906 tons to 392,447 tons, giving the state the highest rate of growth in pig iron production of any southern state and second only to Alabama in tons of pig iron produced. Bulletins of the Twelfth Census of the United States: No. 233-247; Aug. 1, 1900. Preliminary Results as Contained in the Eleventh Census Bulletins, 11th Census, 1890.

¹³⁸ Tredegar used charcoal iron in varying proportions for other products, including horse shoes and mule shoes. Manufacturing with charcoal iron on efficient machinery proved cost effective for the iron works. "In the last few years, the manufacture of horse & mule shoes has been added upon patented machines, invented by an employee of the company. These machines each make fifteen to twenty perfect shoes per minute. The shoes made of the best charcoal iron have been extensively introduced and...the finished shoe costs little more than the Iron formerly cost," Anderson wrote in 1876. Anderson personal letterbook, page 247. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

repair. Forests that supplied fuel for the furnace were gone, however. Patton reported. "There is not one years stock of wood on the whole property, & what is there is...almost inaccessible... " He discouraged rebuilding.¹³⁹

Patton was confident, though, that Rebecca could be rebuilt profitably, "I strongly urge that the Co. start her, believing that Iron can be made as cheap there as at any of these mountain Furnaces now in operation." He estimated the cost of fitting up Rebecca at \$7,410, the cost of labor at \$30 per teamster per month for board and salary, and a delivery cost to nearby transportation at 30 per ton.

Contrary to Patton's opinion, Anderson chose to re-open Grace Furnace first, putting the furnace into blast in 1873. Limestone quarries were within a stone's throw of the furnace, according to another undated report on the property and that proximity coupled with the greater convenience of transporting iron from Grace to Tredegar because of

¹³⁹ In 1883, with a view to either firing up Grace Furnace once again or leasing the property, Anderson hired Jedediah Hotchkiss to conduct a thorough survey of the property. Hotchkiss wrote from his "professional standpoint as a Consulting Mining Engineer and as Editor of a Widely circulated mining and industrial journal "The Virginian." The detailed Hotchkiss report, too, addressed the paucity of wood. Second growth trees expanded the supply of wood for fuel since Anderson took the furnace out of blast nine years earlier, and Hotchkiss stressed the need to protect future growth if the furnace were to become profitable as a charcoal furnace. He concluded that the supply of excellent iron ores and limestone were inexhaustible and that the furnace was "a very valuable property for the cheap manufacture of iron upon a large scale."

proximity to the James River & Kanawha Canal may have tipped the balance.

The health of the iron market had influenced those decisions, as Anderson's actions after the Panic of 1873 revealed. In 1872, Tredegar's orders for cold blast charcoal wheels had totaled more than 10,000 units; in 1873, more than 13,000. Describing 1873 as the year that "brought the only disasters the business has ever suffered," Anderson wrote, "Grace Furnace is just going into blast to produce Car Wheel Iron. Rebecca Furnace will not be put on Blast till trade revives. These furnaces should yield the company in ordinary years a profit of \$10,000 each per annum. There [sic] whole product will be consumed in the Car Wheel Foundry."¹⁴⁰ Trade did not revive in 1874 for Anderson or for the iron industry as a whole. In 1874, orders dropped to 6,729. In the context of the company's precarious financial situation after the panic, Tredegar shut down Grace Furnace in 1876 and did not reopen Rebecca. Purchasing cold charcoal blast pig iron from Virginia furnaces, primarily those in Wythe and Shenandoah counties, or from other Southern furnaces in Tennessee, North Carolina, and Alabama was more cost effective for Tredegar than refurbishing corporate properties.

¹⁴⁰ Letter in Anderson's personal papers journal. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

Consensus in the car wheel industry supported the soundness of Anderson's decision to invest manpower and money into chilled car wheels. Unlike the uncertainties of iron rail manufacture with the advent of steel rails and the production of larger locomotives and rolling stock, the extant technologies of charcoal wheel manufacture were unsurpassed. In the depressed market after the Panic of 1873, car wheel foundries still followed only locomotive and car works in their importance to the railroad industry. The car wheel industry consumed 175,000 tons of pig metal "with a money value for product of over \$17,000,000"¹⁴¹ even during the depressed iron market of 1874 according to a national report on iron industries. Tredegar was among only fifty car wheel companies in the nation at that point, and "the number of wheels cast per annum is stated at between 600,000 and 700,000 with a consumption of 175,000 tons of iron, of which at least one-third is of old wheels re-melted." Explaining the tenacity of the cold blast, iron experts pointed out "it doesn't shrink on the surface, giving greater tenacity and hardness to the wheel. Recently a large number of wheels of different forms and kinds have been tried and

¹⁴¹ Dunlap, *Wiley's American Iron Trade Manual of the Leading Iron Industries of the United States*, 16.

some of them found not to be safe, durable, or economical ...They will not...ever supersede the regular “old fashioned” chilled wheels.”¹⁴²

Nonetheless, in a competitive iron and steel market, the technology of chilled car wheels stood at the center of metallurgical controversy. The essence of the argument pitted old versus new, equating the adoption of innovative technologies with improvement and progress while the retention of prevalent methods fell under the stigma of Luddism. Many argued that charcoal iron was a relic of the past, rendered irrelevant by the hot blast furnace and the use of mineral fuels.¹⁴³ Certainly, advancing iron technologies led to larger, more efficient hot blast furnaces with greater outputs and with better fuel efficiency for coke, anthracite, and other mineral-fueled furnaces.¹⁴⁴ Anderson's cold blast furnaces, which were typical, could produce between 1,500 and 2,000 tons of pig iron annually; the potential output of comparably sized hot blast furnaces more than doubled that figure. In its favor, the hot blast was a more versatile production process and one that continued to evolve into

¹⁴² *Ibid.*, 38.

¹⁴³ Cold blast furnaces were the earliest utilized in the American colonies, transferred with settlers from Europe; hot blast furnaces were first used experimentally between 1802 and 1828.

¹⁴⁴ In Virginia, a typical charcoal blast furnace was about 30 feet tall and 30 feet at the base, tapering to 20 feet wide at the top. Iron ore, charcoal, and limestone were thrown into the open top of the furnace. The smelting process applied heat and a chemical agent (limestone, in the case of Virginia furnaces) to remove oxygen from iron ore, leaving the pig iron. It required pumping air into the furnace at the bottom through the tuyere, a pipe- or tube-like opening common to all furnaces whose size and composition varied according to the furnace type.

increasingly cost-effective methods of mass processing iron. Its speed and volume of production enabled economies of scale that, in turn, enabled mass production requisite for the growth and profitability of the steel industry.

The innovative efficiency of the hot blast furnace was not effective for all iron products, however, and it could not completely displace the utility of cold blast, charcoal-fueled furnaces. Pig iron produced in hot blast furnaces lacked the toughness, uniformity, and flexibility of cold blast charcoal iron. Furthermore, the larger furnaces that were effective for some types of pig iron offered no economies of scale or particular efficiency for production of cold blast charcoal iron that could only be produced in small quantities in a long time frame. “The lower the blast temperature, the better the metal made, but the smaller the tonnage for a given quantity of charcoal and the furnace the iron is made in,” an early twentieth-century report on charcoal iron explained¹⁴⁵.

The manufacture of cold blast charcoal iron depended upon slow cooling and small batch production to ensure the integrity of the product. Well-made, it contained fewer impurities than any other form of pig iron—

¹⁴⁵ Richard Moldenke, *Charcoal Iron*, (Lime Rock, Conn., [c1920]), 38, <http://hdl.handle.net/2027/uva.x004294401>.

particularly, less silicon.¹⁴⁶ Its flexibility, consistency, and strength comprised the perfect material for railroad car wheels that sustained jolts and shocks, supported the weights of railroad cars and their freight, and encountered abrupt changes in weather and climate. Charcoal iron was simply capable of standing more punishment than coke and anthracite fuel of hot blast furnaces. In the post-Civil War railroad boom, car wheels for rolling stock consumed most of the charcoal iron produced in America.

Proponents of each method within the metallurgical industries vehemently debated the pros and cons of cold and hot blasting techniques. Professional associations and trade publications were rife with articles extolling one over the other. Organized in 1880, in part as an advocacy organization, the Association of Charcoal Iron Workers began immediately to defend of charcoal iron and charcoal iron products. The association focused its attention on disseminating the latest advances and techniques among its members, but also on public relations efforts highlighting statistics and arguments supporting the use of charcoal iron, including its use in car wheels. "Sometime ago a statement went the rounds of the metallurgical press to the effect that other wheels than

¹⁴⁶ The removal of carbon is the primary function in the transformation of ore to pig iron. When the silicon content is small, carbon separates slowly from the pig iron during the blasting process, creating small grains of graphite in the pig that promote strength and flexibility. High silicon content has the opposite effect, abetting rapid carbon loss to create iron riddled and weakened with large grains of graphite.

those of chilled iron were superior for railway service. This gave us the opportunity to ask from the various car-wheel makers in the Association their views concerning the peculiar pig-irons best suited for the manufacture of chilled car wheels,"¹⁴⁷ reported an article in the association's journal.

Car wheel manufacturers were emphatic in their responses. "We know of no wheel—when safety and economy are considered—that is equal to a good chilled cast-iron when made with proper care and the proper material. ...We know of no red or brown hematite ores which will not make a better iron when smelted with cold blast," replied representatives of the Lobdell Car Wheel Company of Wilmington, Delaware. "We suppose that a reasonably good wheel could be made of a mixture...of anthracite or coke iron, but a better one can be made of all charcoal iron," answered another. "We know of nothing superior to a *thoroughly first-class* charcoal car wheel," concluded another.¹⁴⁸ Twenty years later, a master cupola furnace consultant, reiterated, "Attempts have been made to produce...an iron from coke or anthracite irons having the characteristics of a cold blast charcoal iron...but

¹⁴⁷ "Journal of the United States Association of Charcoal Iron Workers. [Vol. 3]," 177, accessed April 8, 2011, <http://quod.lib.umich.edu/mutex/gmu.edu/cgi/t/text/pageviewer-idx?c=moajrnl;cc=moajrnl;q1=tredgar;op2=and;op3=and;rgn=pages;idno=ahj4772.0001.003;didno=ahj4772.0001.003;view=image;seq=354;page=root;size=100>.

¹⁴⁸ *Ibid.*, 178–186.

oleomargarine does not possess all the qualities of a good butter, and the imitation cold-blast charcoal iron will ...be found to be deficient in some of the characteristics of the genuine article.¹⁴⁹

Joseph Anderson concurred. Prior to the Panic of 1873, Tredegar briefly tested the manufacture of a wheel mixing Bessemer steel and pig iron. Patented by William Hamilton of the Ramapo Wheel Company in New York, the method was intended to promulgate a less expensive method than chilled charcoal iron. The resultant car wheel was inferior to Tredegar's car wheel. The amount of scrap steel available at that time was limited as well. Steel production was too recent to have generated recyclable scrap. This limited availability raised the cost of the metal higher than that of chilled charcoal pig iron. Anderson dropped the experiment.¹⁵⁰

Anderson's persistence in the manufacture of chilled charcoal iron car wheels was a practical measure. Car wheels faced minimal threat of obsolescence from steel. The technologies of the two were incompatible. Car wheel manufacture enabled Anderson to capitalize on the abundance of resources in Virginia. Railroads had created a demand for

¹⁴⁹ Edward Kirk, *The Cupola Furnace: A Practical Treatise on the Construction and Management of Foundry Cupolas*, 2nd ed. (Philadelphia and London: Henry Carey Baird & Co, Industrial Publishers, 1903), 206.

¹⁵⁰ Joseph R. Anderson to W.G. Hamilton, New York, December 7, 1872. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

steel rail manufacturers, a demand inconsistent with Tredegar's corporate identity. While railroads created the demand for steel, however, they expanded the market for cold blast charcoal iron car wheels as the production of rolling stock burgeoned. Anderson could continue their manufacture through building on and adapting Tredegar's extant technologies and processes without dramatically altering the core of the company's operations.

Railroad Spikes

Like chilled car wheels, iron spikes were among the core products at Tredegar. For the iron works, spikes represented a product with a consistent market and persistent technology. The structure and substance of spikes remained essentially the same throughout the nineteenth century and the machines on which they were produced underwent periodic upgrades and tweaks rather than dramatic change. Unlike car wheels that called for the finest cold blast charcoal iron or rolling stock that called for customization, spikes were made of scrap iron in standardized sizes, and those sizes remained consistent over time. Tredegar's standard spike, for example, was five and a half inches long at 9/16 of an inch thick. This size, the most commonly used among railroads, persisted from the antebellum period throughout Tredegar's manufacture. Spikes lent themselves to mass production; daily factory output was

limited only the numbers and size of spike machinery and the efficiency of the laborers.

Anderson reported on Tredegar's spike manufacturing facilities with both hyperbole and fact. He claimed that in the history of American manufactures the consistent quality of the Tredegar spike could not be matched.¹⁵¹ He boasted of Tredegar's manufacturing capacity: "In the manufacture of spikes...there are three mills and two spike machines to each mill, making sixty tons of spikes daily,"¹⁵² Robert S. Archer, Anderson's brother-in-law, made similar claims, bragging to a customer, "I venture to assert that there is no establishment in this country that can show such a record as Tredegar can." Archer backed up his claim with a description of Tredegar's quality controls. "Our system of Inspection is very rigid. We have a man in the Factory whose business it is to inspect the spikes and see that no bad ones are put into the kegs, and once certainly, & sometimes 2 or 3 times a day a number of spikes (5 or 6 generally) are taken from the pile in the Factory and tested in the Blacksmith shop...and these spikes are brought into the office regularly in the morning where they are examined by a member of our Board." Archer committed to

¹⁵¹ Joseph Anderson to Gest and Atkinson, Cincinnati, May 14, 1870, Tredegar Letter Book, February –May 1870 cited in Dennis Maher Hallerman, "The Tredegar Iron Works: 1865-1876," 60.

¹⁵² Joseph R. Anderson Personal Journal, leaf 247. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia..

sending his customer a small box with spike samples “for distribution to your RR friends.”¹⁵³

Anderson had first explored spike manufacture in 1848, ultimately beginning their production with a machine invented by Tredegar employee Joshua Cary. The essential operation of spike machines entailed feeding heated metal rods into the machine. The rods were then driven, bent, angled, and cut to form spikes of standardized specifications. Sales growth was rapid, and Tredegar leased two additional spike machines for \$12,000 from Porter, Rolfe and Swatt of Pittsburgh which Tredegar then purchased outright in 1868.

In 1871, Anderson turned in-house again, when the manager of Tredegar's rail and chair mill, Welshman David Eynon, obtained a patent for “Improvement to Spike Machines.” Eynon's improvement increased the simultaneous coordination of parts of the machine that controlled the length of the spike at intervals during the production process. Eynon further sought a patent for improvements that regulated the timing, streamlined the production process, and cut down on waste so that reheating iron bars prior to cutting individual spikes was no longer required. His improvements increased the operations and the scope of

¹⁵³ R. S. Archer to Messrs. Gest & Atkinson, Cincinnati, O, September 2, 1871. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

the movable parts that shaped the spikes.¹⁵⁴ In 1871, Eynon also insisted on rerouting Tredegar's system of waterpower, replacing a waterwheel with a turbine to increase the horsepower available to operate the two spike machines that operated on different levels of Tredegar's graduated landscape at that time.¹⁵⁵ With two spike machines in operation receiving turbine-generated waterpower, spike production trebled, although the efficiency of the additional turbine did not increase the amount water needed to propel the machines. "We are now turning out 4 to 450 kegs per day," Robert Archer, Superintendent of the Spike Factory reported.¹⁵⁶ This upswing in manufacture totaled over five thousand tons in 1872. In 1872 at the height of Tredegar's boom years, spike production increased again, adding more than 2,200 tons to an impressive six thousand ton increase in rolled product production at Tredegar. In 1881, Tredegar

¹⁵⁴ The patents obtained by Tredegar employees were assigned to the company and Eynon assigned spike machine improvement patents to Tredegar, although he left the company in 1871. Eynon's improvement was designed for a spike machine originally invented by James Sweet who worked for the Pittsburgh company, Dilworth, Porter, and Company Swett disputed Eynon's patent, claiming that he had first designed the improvements. Anderson agreed to withdraw Eynon's application, allow Swett to apply for the patent on the condition that Tredegar could have royalty-free, unrestricted use. However, a number of people were petitioning for the same patent. The dispute settled with Eynon's receiving the patent with the stipulation that Swett's Pittsburgh company had unrestricted use. David Eynon, David Eynon, US30673 A, issued November 20, 1860, <http://www.google.com/patents/US30673>. Dennis Maher Hallerman, "The Tredegar Iron Works: 1865-1876," 59.

¹⁵⁵ In 1873, Tredegar consolidated the two spike mills on the lower level of the factory grounds.

¹⁵⁶ Robert Anderson, Supt. To unknown recipient, September 2, 1871, Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia, 1934.

again expanded its spike facilities, one of the few investments in new equipment amid the conservative financial management of the post-receivership years.

Experiments to change the shape of the spike head and the shaft had explored the value of flat spikes, oblong spikes, and grooved spikes to see if better friction for inserting the spike and greater ease in extracting the used spike were obtainable. None were as effective as the traditional, plain, hook-headed iron spike with square cross-section that had a reliable holding strength. Iron spikes remained in manufacture well into the twentieth century. Presumably their obsolescence occurred as steel manufacturers moved beyond rails to add products conducive to economies of scale that could be both integrated into large or small steel manufacturing concerns.

Anderson faced two managerial issues with spike manufacture: worker incentives to meet production quotas and cornering the highly competitive market. The daily capacity of Anderson's spike mills stood at 140 kegs per day. Daily output records between 1879 and 1881 show that the output fairly consistently exceeded that total and fell between 140 and 150 kegs daily. Each keg held 200 pounds of spikes that were generally ordered in bulk. An 1881 request from the New York Ontario Western Railway for 6,000 kegs of 5 1/2 x 9/16 spikes was typical. Ordered

on February 11, the railroad requested incremental deliveries in July, August, and September. Even with large and regular orders, the spike market was highly competitive and the prices variable. Anderson developed cooperative strategies with other firms to maintain a profitable seat in the market.

Working in the spike mill was grueling labor. Tredegar's spike mills ran day and night and work stoppages were few, although the factory was usually silent on Sunday; the only official factory closure not due to disasters such as freezing, floods, or fire appears to have been Christmas Day. The night workers, according to the *Richmond Dispatch*, "flit to and fro, wheeling glowing nuggets and drawing long, twisting, and hissing red-hot bars of iron. ...the Tredegar Company employs over 300 brawny and muscular sons of fire and iron—150 of whom work in the spike mill..."¹⁵⁷

Elwood Harris recalled the spike mill at Tredegar he visited as a child. Spike mill workers manned three types of machines enabling Tredegar to produce spikes in different lengths, weights, and widths with the particular shape of the spike head required for various uses on the rails. In the first, long rods were fed into the spike machine, heated half at a time. In one stroke, the machine severed the rod and shaped it into a

¹⁵⁷ "During Dark Hours, The Numbers who work while others sleep." *The Richmond Dispatch*, February 9, 1890.

spike. A second method required heating shorter rods in their entirety and hand-feeding them into a machine with tongs. More automatic, the third fed long rods of iron into one end of the furnace, then removing them on the other where they were fed into the spike machine.

Two-wheeled carts with long handles and made of thick iron plates sat under the spike machines. Full carts were carried over into a work area, poured on an iron-plated floor and cooled with water. Spikes were hand-packaged in 200-pound kegs and the workers rearranged the metal to utilize every space. "Handling these spikes by hand wore the skin off your fingers in half day," Harris explains. "So each packer carried a roll of black tape with which he wrapped his fingers." It was industrial piecework. "The men were very cautious about the accuracy of this work as they were being paid by the piece," Harris continued. Anderson added incentives to speed and accuracy. In July 1886, Anderson offered a premium of \$200 to whichever team of spike workers could turn out the most spikes in four weeks, as long as the winning team met minimum production quotas. A second place team could earn a premium of one hundred dollars. The prize money was to be divided, "pro-rata, according to the pay of the men."

During the 1870s and 1880s, spike prices fluctuated within a gradual decline. Between January and June, 1873, they sold for 4.54 cents per

pound. A year later between January and June of 1874, prices averaged 3.65 cents per pound. By 1875, Tredegar's average price dipped to 1.75 cents per pound. They hovered at that price for the remainder of the decade. In 1880, with the resurgence of the post-Panic economy, price per pound once again broke above 3 cents. By 1889, however, they had fallen even lower, and Anderson was selling spikes at prices between 1.25 cents and 1.94 cents per pound.

Regardless of spike price fluctuation, the sale of spikes remained a cornerstone of Tredegar's sales. At the onset of the Panic of 1873, the depressed iron market had not yet affected sales. Tredegar sold over 82,000 kegs of spikes at an average cost of \$4.43 per pound. The year's sales were \$546,767.59. Although the price per keg averaged less than half 1873 prices, in 1889, Tredegar's spike sales exceeded \$400,000.¹⁵⁸

With spike prices on a downward slope in the 1880s, Anderson intervened in the spike market to promote and regulate sales. He had first attempted to solidify his hold on the market in 1868. Tredegar established a sales office in New York that remained open until 1872. The essential purpose of the New York office was to place the company at the hub of railroad expansion and financial activity, promoting sales through the

¹⁵⁸ Rolling Mill Sales Books, Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

activity of a Tredegar agent. Anderson sought local monopolies for Tredegar's railroad spikes, enlisting agents throughout the country to push the product. Agents worked under a two-pronged deal. Any merchant who sold Tredegar spikes was required to sell only Tredegar spikes, giving Tredegar a solid and unique foothold in the market. In turn, each agent who negotiated such deals received 2.5 percent of any sales of Tredegar spikes.

In 1886, Anderson once again intervened in the market, forming a price pool. From New York, once again, Anderson joined with other spike manufacturers to control the sales price of spikes and the share of spikes that each could place on the market. Eight companies joined Anderson to form the United States Association of Spike Manufacturers: Dilworth Porter, and Co, Pittsburgh, Ames & Co, Massachusetts; Tudor Iron Co., St. Louis; Montour Iron and Steel Co., Danville, Pennsylvania; Sylvester & Co., Boston; Portland R.M., Maine.¹⁵⁹ Anderson was elected president and remained its head at least through decade. Anderson's youngest son, John, held responsibility for overseeing monthly reports from the membership. Membership changed over time, but the basic premise of

¹⁵⁹ Minutes of the Spike Association do not state the location of the firms of the nine members, but only lists company names. These locations are tentatively drawn from the Directory of Iron and Steel Works of the United States. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

the price pool remained that “our only relief from incurring losses through the manufacture of spikes consists in the proper regulation of the product of each spike maker.”¹⁶⁰ Every three months association members set prices for the sale of spikes and on the amount of spikes each could put on the market. Tredegar and Dilworth customarily received the largest allotments, cornering between 55 and 60 percent of the pool with amounts between one and eleven percent roughly divided among the remaining members. Members submitted monthly affidavits of sales and those who exceeded their monthly quota paid money to a general fund; those who fell short received compensation. Arguments frequently occurred among the members over appropriate prices as well as over whether members were providing accurate records of spike sales. The Association hired a general manager in 1887 tasked, in part, with serving as a neutral mediator for internal disputes. Whether the Spike Association affected prices in the overall market is unlikely, Records are incomplete after Joseph Anderson's death in 1892 and the last notation in Association records occurred in 1899.

Rails, chilled car wheels, and spikes representative Tredegar products and of the context of the iron industry in which Anderson made

¹⁶⁰ Correspondence, Series VII, Box 979, November 4, 1880-November 17, 1892. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

decisions about Tredegar's niche in the marketplace. Each is indicative of an approach to business that eschewed dramatic leaps into new technologies when existing methods offered the means to produce quality products for identified markets. These products, too, pragmatically capitalized on the use of available raw materials.

Proponents of hot blast furnaces and mass production denigrated the cold blast. This process, however, had survived from the historical beginnings of iron manufacture, in part, because an equal had not emerged in the course of technological progress. Tredegar's dependence on waterpower, too, lay in the firing line with the proliferation of steam and the advantages it promised to metallurgical industries..

V. THE PRACTICALITY OF WATERPOWER

The James River is Virginia's River. Contained completely within state boundaries, it flows through the heart of downtown Richmond from its source in the Appalachian Mountains in Botetourt County. From the mountains, the James runs for 348 miles to join Virginia's Elizabeth and Nansemond Rivers and drains into the Chesapeake Bay at today's Hampton Roads. The river's fall line, that is, the granite seam between two of the state's major geologic regions, covers a three-mile span where the James drops eighty-four feet dividing the plateaus of Virginia's western Piedmont from the coastal plains of its eastern Tidewater region. Richmond grew at the fall line.

For most of its course, the river's whitecaps and currents promise power. The strength of the James had been a critical factor in establishing Richmond on its northern banks as a trading post in 1737 and as the state capital in 1770. Power generated at the fall line enabled the city's rise as the South's largest industrial center in the antebellum decades. After the Civil War, the strength and abundance of waterpower available from the James was a major selling point attracting business to Richmond and

helping identify the city as one of the most promising industrial cities of the “new South.” City boosters advertised that “great manufactories have resulted from [unsurpassed water-power] such as the Tredegar Iron Works, Old Dominion Iron and Nail Works, Franklin and Manchester Paper Mills, and numerous flouring mills...covering the banks of the canal and river for miles of the city front, all operated by water power.”¹⁶¹

Situated between the banks of the James River and the James River and Kanawha Canal (hereafter JR&K Canal), Tredegar drew on the resources of the river and its regulated flow through the canal to power its machinery. During the latter part of the nineteenth century, the majority of iron and steel industries turned increasingly to steam power to run large furnaces and production facilities. For Tredegar, however, waterpower offered cost advantages and production flexibility that offset any potential advantages from steam. The technologies influencing products that Tredegar manufactured, the layout of its facilities, and its processes of production were contingent on waterpower as a unique and cost-cutting source of energy. Engineering and scientific advances in water turbine hydraulics peaked during the 1870s and 1880s and by the early 1870s, Tredegar had replaced its twenty-nine waterwheels with turbines to power

¹⁶¹ American Grange Bulletin. “Richmond, Virginia.” April 1883, p 182.

the ironworks. This transition placed Tredegar on the cutting edge of waterpower technology.

Tredegar operated perhaps the longest-operating and most decentralized waterpower system in the United States.¹⁶² The ironworks was one of the last large-scale American industrial plants to depend almost entirely on direct mechanical drive from turbines, several of which powered sections of the ironworks from their installation in the 1870s until the company closed almost ninety years later. "Nowhere else in the United States (and perhaps no where else in the world) is there a cluster of so many independent turbines, each linked at one time to a different set of production machinery," concluded a team of industrial archaeologists studying Tredegar in 1992.¹⁶³

THE JAMES RIVER AND KANAWHA CANAL

Tredegar's history was inextricably linked to that of the JR&K Canal. George Washington, whose vision of waterways connecting the nation in networks of trade and commerce, launched the James River Company to build a canal from the James to the Ohio River in 1785. By 1794, a seven-mile-long canal around the fall line formed the beginning of what

¹⁶² Raber, Malone, and Gordon, "Historical and Archaeological Assessment, 68.

¹⁶³ Ibid., 48.

was to become the JR&K Canal.¹⁶⁴ For more than sixty years afterward, various public and quasi-private companies formed and dissolved in efforts to extend the waterways. By 1835, under the JR&K Canal Company, construction started and stopped because of sectional animosities and partisan politics over funding and the placement of roads, locks, and canals access. By 1851, canal construction permanently halted, although the JR&K Canal Company continued to operate the waterway, including a lucrative section eastward along the docks of the James where the bulk of Richmond's imports, exports, and passengers arrived and departed.

To Tredegar's corporate benefit, when canal construction halted in 1851, the JR&K canal terminated at the town of Buchanan in Botetourt County. The 197-mile waterway linked the ironworks to mines, minerals, and furnaces that were sources of Tredegar's raw materials. Tredegar transported pig iron, limestone, and timber from its furnaces and lands in southwest Virginia to Buchanan and from there, to Richmond by canal boat.¹⁶⁵

¹⁶⁴ Louis Manarin and Clifford Dowdey. *The History of Henrico County*. (Charlottesville: University Press of Virginia, 1984), 178.

¹⁶⁵ During the Civil War, poor canal boat service forced Joseph Anderson to purchase nine canal boats and several smaller ones in order to maintain a supply of raw materials from southwestern Virginia to Tredegar to manufacture armaments for the Confederacy. Cloverdale Furnace, owned by Joseph Anderson's brothers, was 17 miles by road to Buchanan. Among other furnaces Tredegar or the Anderson family operated in county,

The canal channeled water from a drop three miles upstream from the city and entered Richmond from the west. Between the canal and the James River, a downward slope of varying incline carried water from the canal and powered multiple industries sequentially. The average width of land—between 450-500 feet between the canal and the river—offered ample space to build the factories that formed Richmond's nineteenth century industrial base. Basins and ponds along the length of the canal in Richmond stored excess water both to control the amount of water flowing to the industries it powered and to hold a reserve for times of draught. The early development of the JR&K Canal expanded trade and provided the power that helped build Richmond as a major southern industrial center. During 1872, mid-way in the life of the canal, the waterway carried almost 175,000 tons of “products of the Forest, of Agriculture, of Mines, of Manufactures, and of Merchandise generally” valued at over seven million dollars.¹⁶⁶ From east to west, the canal served

pig iron from Rebecca Furnace had to be hauled five miles to the canal; Catawba Furnace, 20 miles. Canal boats took three to four days to complete the journey from Buchanan to Richmond. A twelve-foot-wide towpath lay along the canal and nine lift locks raised and lowered boats and cargo a total of 728 feet between Richmond and Buchanan.

¹⁶⁶ This figure does not include a section of the canal that extended between the main dock in Richmond and a southeastern connection to Virginia's Tidewater ports. The business and revenue portion of this portion of the canal exceeded any other portion and provided the principle revenue of the James River and Kanawha Canal company. Of the tonnage, travelling between Richmond and Buchanan, bar, pig, and scrap iron and finished products from iron works accounted for approximately 21,500 tons—far less than food products, coal, or stone, but sufficiently significant to indicate that the

Richmond's principal industries, the Gallego and Haxall flour mills, the Richmond Paper Manufacturing Company, a planing mill, jute-bagging factory, grist mill mills, smaller flour and corn mills and factories, and the Tredegar Iron Works. Also by 1872, smaller mills and Old Dominion Iron and Nail Works, the South's largest nail works on Belle Isle near Tredegar, also drew on the canal for power. "...there is so much fall that the water is or can be used from two to four times before reaching the river," the Richmond Chamber of Commerce boasted in its annual report "from the Gallego Mill being now used four times and at the Tredegar Works twice, having at the last named place a fall of 50 feet between the canal and Haxall & Crenshaw's pond,". The supply of water to power manufacturing was more than ample not only for the companies that were operational, but for industrial expansion. "If ever the banks of the river should be filled up with manufactories," the Chamber of Commerce report continued, "there will still remain sufficient water in the river to propel all the machinery that can be placed on the sites..."

canal still served to some extent to bring in raw materials for iron manufacturers in Richmond. By the end of fiscal year 1872 (September 1872), rail transport superseded the canal. Richmond's four major railroads freighted over 300,000 tons of assorted products in and out of Richmond during that time period. The specific classifications of types of freight are not broken out in consistent categories. "Report on the Trade and Commerce of Richmond, Va., with Other Statistics and Documents.," *Report on the Trade & Commerce of Richmond, Virginia for 1872/73, 1871*, 31–32, <http://catalog.hathitrust.org/Record/008612281>.

James Swain, author of *Reports on Waterpower for the Tenth Census of Manufactures* noted circumstances “peculiar” to the James River and Kanwha Canal. Remarking on the common practice of shutting down canals for repairs or during winter months, Swain reported, “On the JR&K canal, however, the water was not drawn off during the winter and the mills obtained water almost interruptedly. There has sometimes been a little trouble with ice, but it is never serious.”¹⁶⁷ Pointing out that the method of providing waterpower to Richmond was complicated and “...only a very small proportion of the total available power is at present utilized,” Swain concurred with the conclusion of Richmond’s Chamber of Commerce: “There seems to be no technical reason,” he continued, “why Richmond should not be one of the great manufacturing centers of the Atlantic slopes, for it may safely be asserted that so far as water-power goes such advantages are seldom to be found.”¹⁶⁸

The Chamber of Commerce’s wishful thinking was predicated to some extent on the hope of eventual expansion of the Canal based on feasibility studies conducted by the Canal Company’s chief engineer. The Panic of 1873 exacerbated the already-acute indebtedness of the Canal Company, however. Unable to match the speed and cost of rail

¹⁶⁷ United States Census Office 10th census 1880, *Statistics of Power and Machinery Employed in Manufactures: Reports on the Water-Power of the United States* (G.P.O., 1887), 17.

¹⁶⁸ *Ibid.*, 18.

transportation or to effect needed repairs that ran the length of the canal, the waterway fell into decline. In 1880, the Richmond & Alleghany Railroad purchased the works and franchises of the canal company, ending freight and passenger traffic on the waterway. The Richmond & Alleghany closed the towpath and began constructing a railroad in its stead. The General Assembly of Virginia imposed conditions on the railroad. The Richmond & Alleghany was required to maintain the water supply to businesses along its route.¹⁶⁹ "All existing contracts for water privileges along the entire [canal] shall be respected and maintained at rates not exceeding the present rates, except in those cases in which they may be cancelled or altered by agreement, or extinguished by condemnation."¹⁷⁰ In 1890, the Chesapeake & Ohio Railway absorbed the

¹⁶⁹ The original primary purpose of the Canal was navigational. Canal engineers during the 1830s had installed mechanisms that would promote water power use while providing for the needs of boat traffic on the canal. When boat traffic ended on the canal, only 25 percent of the potential water power envisioned in the 1830s was allocated. "The canal company was caught in the position of many American canal operators who tried to balance power and transportation uses. In this case, continuing navigation demands and fiscal imitations precluded the concentration on water power." Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site," 15. When navigation ended on the canal, The Richmond & Alleghany Railroad constructed a route along the canal towpath, a construction project that was less expensive and less arduous than much railroad building because the towpath offered an already-prepared foundation for laying tracks. Within two years, however, the railroad was in the hands of receivers. The Chesapeake & Ohio Railway leased the Richmond & Alleghany, later purchasing the company. The Chesapeake & Ohio, too, was mandated by law to maintain the canal as a conduit of water for power and water purposes for the city of Richmond. Wayland Fuller Dunaway, *History of the James River and Kanawha Company* (New York, Columbia University, 1922), 239–40, <http://archive.org/details/historyofjamesri00dunarich>.

¹⁷⁰ Complaint..._DSC5624

failing Richmond & Alleghany Railroad, also under legal obligation to supply waterpower consistent with the rights allotted to Richmond's businesses. During those decades, Tredegar had already decreased its dependence on the canal as transport for raw materials, first because of the ironworks increasing use of scrap iron rather than pig iron from its own furnaces, and second, because of the cost-effective advantages of rail and steamer transportation for delivering finished products to major cities in the northeast and west. As early as 1874, Anderson noted that the canal connected Tredegar to the iron region of Virginia, but also observed that its relevance as a means of transport paled beside the railroad and Richmond's port. That year, Anderson had completed construction of an internal railway system adding a Richmond and Danville Railroad spur track across Tredegar grounds. The spur track connected with the main line at the eastern and western entryways to the ironworks. Anderson boasted that the Tredegar's own internal narrow gage railroad traversing the property connected directly with this larger railroad system and with "sailing vessels to all Atlantic Ports" at highly competitive rates.¹⁷¹ "We can send a narrow gage car loaded with our products on its own wheels direct from our shops direct to Chicago or St.

¹⁷¹ Tredegar's internal railroad also included autonomous lines running between and within shops to facilitate loading and unloading raw materials, finished products, and products at various phases of manufacture.

Louis," he wrote, "and we can send a 5 ft. car in like manner to New Orleans. ...Six years of experience in distributing our products over the West and Northwest demonstrate that we can cover that whole country in competition with Pittsburgh."¹⁷²

Even though the canal's importance as a navigational route waned, it remained crucial to Tredegar's operations. It served in perpetuity as the source of power for Tredegar, although expansion to the canal, either for commerce or for power never occurred. In 1880, Tredegar was the largest customer of the JR&K Canal Company and drew approximately 400 horsepower from the canal while neighboring industries together used about 1000 horsepower among them.¹⁷³ In spite of

¹⁷² Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia. .

¹⁷³ Many variations in the measurement of waterpower were extant and varied from locality to locality creating challenges for sellers and buyers of water rights during the nineteenth century. Water measurement standardization did not fully occur until the twentieth century. During the last half of the nineteenth century, engineering and census reports and other official materials used horsepower to quantify water and steam power. A horsepower year was the equivalent of one net horsepower delivered under head at mill or factory penstock based on 308 ten-hour working days. Estimates of the amount of horsepower Tredegar drew from the Canal vary among nineteenth century reports, within reports of the ironworks itself, and historical reconstructions during the twentieth century. The 400 hp figure is reported in the Tenth Census. In 1935, in a court case when the Chesapeake and Ohio, then owners of the JR&K challenged Tredegar's use of water from the canal, engineers determined that a reliable estimate of the ironworks inherited water rights was unlikely given the paucity of accurate records, the variability of measurement, the vagueness of terms stated in the water rights, and the challenges of reconstructing and correlating exact circumstances of machines, weather, and Tredegar's production rates. The unavailability of horsepower measurements among the Tredegar records makes it difficult to develop comparative cost and output assessments. Records do exist, however, of the horsepower generated by individual turbines or utilized by selected machinery in the Tredegar complex, horsepower quantifications are generally preceded with the caveat "estimated." Tredegar Iron Works Records, 1801-

the static size and capacity of the Canal, it supplied sufficient power to meet the demands stipulated in the water rights of the companies it served.

WATER AND STEAM: COMPETITIVE OR COMPATIBLE TECHNOLOGIES

During the 1870s and 1880s, Tredegar increased the efficient use of the water it drew from the JR&K Canal, replacing overshot waterwheels with stronger and more powerful turbines, periodically augmenting the numbers of turbines, and adjusting the location of its buildings and pattern of water flow to effectively power different machines. These technological upgrades increased useful horsepower transmitted to its operations without increasing the amount of water utilized to generate that power. The company transitioned from waterwheel to turbine-driven power at a time when steam technologies epitomized technological progress in the national psyche, exciting public imagination and bringing practical solutions to industrial growth. With less fanfare, however, the simultaneous widespread adoption of the turbine in place of waterwheels initiated some of America's most remarkable technological achievements: experiments to standardize and improve turbine efficiency

1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia..

professionalized scientific experimentation in hydraulic engineering.¹⁷⁴

Turbines transformed the mechanics of waterpower production; their diffusion necessitated developing standard models adapted to mass production with reliable measurements of efficiency.

In May 1876, as Tredegar added a tenth water turbine to the ironworks, the Centennial Exhibition opened in Philadelphia.¹⁷⁵ The Corliss Steam Engine was the center of the exhibition filling the thirteen-acre Machinery Hall dedicated to extolling world wide technological inventions and innovations. The Corliss stood 40-feet high, had a 56-foot diameter platform, weighed 200 tons, generated up to 2500 horsepower, and connected to the smaller machines on exhibit in the hall by five miles of shafting. On the opening day of the Centennial, President Ulysses Grant and honorary guest, Brazil's Emperor Dom Pedro, stood before 4,000 dignitaries and powered up the Corliss that in turn started up all the machines in the hall. The crowd roared approval. Awestruck, Walt Whitman later pulled up a chair and for thirty minutes contemplated

¹⁷⁴ Edwin T. Layton, "Scientific Technology, 1845-1900: The Hydraulic Turbine and the Origins of American Industrial Research," *Technology and Culture* 20, no. 1 (1979): 66, doi:10.2307/3103112.

¹⁷⁵ Each state in the Union was invited to create an exhibit for the Centennial celebration. The Virginia legislature voted not to participate, citing poverty. "It was thought the State could not honestly afford an appropriation even for such a purpose. This Commonwealth had been the principal theatre of the recent four-years' war, and in the course of it had been scourged stripped, desolated, and trampled by more than a million of armed men. Our losses and sufferings very far exceeded those of any other state. Virginia declined to incur the cost of taking part in the Centennial because of her poverty, not her will..."

“...the ponderous motions of the greatest machinery man has built.”

Journalist William Dean Howells called the Corliss “an athlete of steel and iron.” The gigantic Corliss at the heart of the Centennial’s technology exhibit represented American progress and power and pride in that strength.¹⁷⁶

The proliferation of steam power and the exaltation of technological progress that it represented occurred in conjunction with the western spread of the population and expansion of industrialism. More than a metaphor for progress, steam liberated industrial development from geographical constraints. Using steam, industries were no longer restricted to building near a fall of water for power. Coupled with the expansion of railroads, factories also no longer needed to build near waterways in order to import raw materials and export their products to market cost-effectively. “...a great advantage in favor of [steam-power] is the fact that steam-power is mobile and may be used wherever fuel

¹⁷⁶ Descriptions of the Corliss Steam Engine and public response at the Centennial Exhibition of 1876 appear in the following publications: “STARTING THE BIG ENGINE.: The Great Corliss Engine Built for the Centennial—Its First Trial.,” *Chicago Daily Tribune* (1872-1922), April 15, 1876, http://search.proquest.com/cv_786252/docview/171626723/abstract/677BF7462C934B00PQ/3. Nathan Rosenberg and Manuel Trajtenberg, “A General-Purpose Technology at Work: The Corliss Steam Engine in the Late-Nineteenth-Century United States,” *The Journal of Economic History* 64, no. 1 (2004): 61–99, <http://www.jstor.org/stable/3874942>. Steven Ujifusa, “The Corliss Engine,” *PhillyHistory Blog*, May 18, 2010, <http://www.phillyhistory.org/blog/index.php/2010/05/the-corliss-engine/>. *All the World’s a Fair: Visions of Empire at American International Expositions, 1876-1916*, Reprint edition (University of Chicago Press, 1987), 216–218.

can be obtained, independently of any particular location. Mills using steam-power may therefore be located in positions most favorable for economical production and for quick disposal of the finished product," according to the *1880 Census of Manufactures*.¹⁷⁷ Between 1870 and 1890, the use of steam power surpassed that of waterpower nationwide; steam generated 96 percent of the six million horsepower produced for manufacturing between 1870 and 1890, and by 1899, steam engines outnumbered waterwheel and turbine use by almost four to one.

Waterpower was not without momentum, however. Rather than threatening obsolescence to waterpower and its ancillary industries, steam increased the choices of motive power available to business and industry. In many geographies and industrial settings, the practicalities of waterpower exceeded those of steam. Addressing the American Society of Mechanical Engineers in 1887, mechanical engineer R.H. Thurston predicted that "the use of steam has increased more rapidly than that of water-power and this change will undoubtedly continue for an indefinite period. Nevertheless, the use of water-power is growing, and will continue to grow so rapidly as to furnish an enormous and extending market..."¹⁷⁸

¹⁷⁷ U.S. Census, 1880: *Statistics of Power and Machinery Employed in Manufactures* by Prof. W. P. Trowbridge, Washington, D.C. xvii.

¹⁷⁸ R.H. Thurston. The Systematic Testing of Turbine Water-Wheels in th United States, *Transactions of the American Society of Mechanical Engineers*, 008, 1887. 361.

Thurston's remarks were accurate. Just as the transition from iron to steel production occurred gradually during the last quarter of the nineteenth century, the spread of steam power, too, was a long-term process occurring at different paces in different industries with regional variations. Even with an overwhelming balance tipped in favor of steam power, the total national horsepower output of water installations doubled between 1850 and 1900.¹⁷⁹

Staying with waterpower or moving to steam varied from industry to industry. The manufacturing processes of the paper and wood pulp industry, for example—pulp grinding and waste disposal—were most efficient and cost-effective on river sites and the industry as a whole continued to draw 60 percent of its power from water as late as 1909. In contrast, iron and steel industries converted from waterpower to steam power rapidly, in part, because waterpower was generally insufficient for economies of scale requisite for profitability in large-scale manufacture. By 1870, 90.82 percent of power usage in iron and steel industries was steam. The terminus of a “rapid and thorough conversion” from water to

¹⁷⁹ Steam power peaked around 1910 when approximately 82 percent of all manufacturing plants in the nation used steam power. However, in 1880, electrical power began to challenge the viability of steam. At the turn of the twentieth century, a number of establishments used steam engines to power electrical generators; the dual technologies kept them off the grid and were cost-effective for small to mid-size establishments. Jeremy Atack, “Fact in Fiction? The Relative Costs of Steam and Water Power: A Simulation Approach” (Faculty Working Paper, University of Illinois, Urbana-Champaign, September 18, 1978), 5–7.

steam in iron and steel occurred by 1880 when almost 96 percent of the power utilized in the industry was steam.¹⁸⁰

The diffusion of steam power in the iron and steel industries corresponded to the urbanization of iron manufacture and the growth of the steel industry. In 1880, the Census Office *Report on Power and Machinery Employed in Manufactures* stated that nationally, the number of water wheels in the nation's iron and steel works declined from 393 to 350. In contrast, steam power flourished over the decade, the number of steam engines operating in the manufacture of iron and steel totaled 3,205; their total horsepower output estimated at 360,741, more than double the figure of 151,001 from 1870.¹⁸¹ Translated to percentages, between 1870 and 1880 the number of steam engines in use throughout the iron and steel industry increased by 134 percent; the numbers of water wheels decreased by roughly 9 percent. The amount of waterpower used in rolling mills alone decreased by 10 percent while steam grew by 140

¹⁸⁰ Shoes and boots represented the only industry that moved roughly as rapidly to steam from waterpower as did the iron and steel industries reaching 96.5 percent by 1880. Nationally by 1880, under 75 percent of the industries classified under agricultural implements, flouring and grist-mill products, paper, woolen, and worsted goods had turned to steam power. U.S. Census, 1880: Summary of the Statistics of Power Used in Manufactures by Herman Hollerith, E.M. (Department of the Interior, Census Office, 1888), 496.

¹⁸¹ U.S. Census 1880: "Report on the Statistics of Steam-Power and Water-power used in the Manufacture of Iron and Steel. (Department of the Interior, Census Office, 1888), 2.

percent. Blast furnaces showed a similar trend as the production of waterpower decreased by 83 percent, while steam grew by 126 percent.

Tredegear's use of waterpower, however, was commensurate with the technologies of industries where waterpower was abundant and cost-effective and whose location provided access to raw materials and markets. In 1880, 66 percent of the nation's waterpower in use was located in the Northeast. The amount of horsepower generated from water continued to increase both in New England and parts of the South into the early twentieth century. In Maine, Massachusetts, Connecticut, and in Virginia, South Carolina and North Carolina as well, waterpower continued as the primary power source.

In 1870 the Census Office "Report of on Power and Machinery Employed in Manufactures" counted 89 establishments in Virginia engaged in some aspect of iron manufacture. Among these, twenty-five utilized steam-power; fifty-eight, waterwheels.¹⁸² During the next ten years, Virginia's use of waterpower in iron and steel industries increased from 77 percent to 81 percent and overall production from 37,836 to 55,782 tons. While a 4 percent increase in the use of waterpower seems insignificant, it

¹⁸² Census statistics do not explain why these figures total 83 establishments, rather than 89 and they give no account of the remaining five establishments.

occurred in spite of a diminished number of manufacturers as a result of closures after the Panic of 1873.¹⁸³

For Tredegar, factors that favored the choice of steam over waterpower for iron and steel manufacturers were not applicable during the nineteenth century. The company owned sufficient low-cost water rights at low cost from the JR&K Canal to power its essential operations and meet production goals. The flow of water was generally consistent and rarely interrupted by weather or drought. Its landscape enabled the company to maximize the efficiency of its system of powering various shops of the ironworks and to expand or alter the pattern of power generation to those facilities. The height of the drop from the canal through Tredegar's raceways to waterwheels or turbines eliminated a problem endemic to waterpower generation, that of backwater.¹⁸⁴

Tredegar was located in an urban center linked by rail and water to interior and coastal markets. Tredegar's business model, moreover, did not

¹⁸³ Geographically, the greatest increase in the use of steam occurred where waterpower resources were either too small or undeveloped to power the growth of an expanding industrial base. In contrast, the *Tenth Census of Manufactures* shows that the drier and more recently populated states, California, Wyoming, and Colorado in the West and Illinois, Indiana, Kansas, Missouri, and Nebraska in the Midwest were among states that relied almost completely on steam power. (Really? United States Census Office 10th Census 1880 and United States Census Office, *Census Reports Tenth Census, June 1, 1880* (U.S. Government Printing Office, 1885), 168.

¹⁸⁴ Backwater is a rise in water levels downstream from a prime mover, e.g. a waterwheel or turbine. This rise, common during heavy rains or flooding, sends water backward into the flow creating a counter-force that impedes the efficiency and cost-effectiveness of power generation.

include product expansion that demanded larger facilities and a commensurate increase of power. With waterpower, Tredegar possessed all the advantages that steam offered to other industries—particularly small to mid-sized iron manufacturers—in other locations.

THE LANDSCAPE OF WATERPOWER

In 1875, Joseph Anderson described his company with particular emphasis on its system of waterpower.¹⁸⁵ Noting that the ironworks stood at the location of Tredegar at the foot of the Falls of James River, he explained the advantages of the ironworks exclusive use water power. “[There is a] rise and fall of fifty-five or six feet under circumstances that combine most of the favorable conditions of that power. First the power is uniform in wet or dry weather. Second, it is free from serious effects of Frost. Third, it is free from backwater and overflow as the maximum perpendicular rise of the river in the Falls is not over six feet.”

The landscape of Tredegar enabled the company to maximize the amount of power it obtained from the water drawn from the canal. The numerous factories, workshops, storage buildings, and administrative offices that comprised the ironworks were built on two levels graduating from the JR&K Canal above the ironworks to the north and the James

¹⁸⁵ Undated paper. Joseph R. Anderson Private Correspondence, 1874-1876. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

River bordering the property on the south side. Industrial archaeologist Robert Gordon has identified this as an ideal layout, both for individual industries and for situations such as Richmond's industrial center in which a series of factories drew water from a shared source. "The land between the canal and the river [becomes] an extended island," he wrote, "on which factories could be placed. Water from the canal entered the factories on the island, dropped through their power-producing wheels or turbines and exited back into the river below."¹⁸⁶ (See Appendix B, 222)

WATER IN PERPETUITY

The early timing of Tredegar's acquisition of water rights and the language of the early nineteenth century that quantified of water to which Tredegar was entitled contributed to the feasibility of Tredegar's persistent use of waterpower. For the most part, Tredegar's water rights had been established early in the nineteenth century, conveyed to Joseph Anderson through previous owners and occupants of the Tredegar site. Although the JR&K Canal Company periodically claimed that Tredegar drew more water from the Canal than permitted, the terms

¹⁸⁶ Robert Gordon was specifically discussing the advantages of the geography of industries along the Merrimack River in Massachusetts. In these locations, industries were constructed on two levels of land between parallel canals on the river. Industries on the upper level drew water from a canal that they passed through their waterwheels and turbines to a raceway that then powered industries and the lower level, falling into the canal below. Robert Gordon, *The Texture of Industry: An Archaeological View of the Industrialization of North America* (Oxford University Press, Incorporated, 1997), 97.

of these early water leases established stable costs that were not subject to rate hikes or and offered reasonable assurance of steady availability of water. Through periodically renegotiating and upgrading the technology and the configuration of waterwheels and turbines, Tredegar maximized the efficiency of its waterpower over time without appreciably exceeding the terms under which it drew water from the canal.

The ironworks was built on land where flour mills, a tanyard, corn mill, a cotton mill, and a small ironworks had existed earlier and whose operators had contracted with the James River Canal Company for the water they needed to power waterwheels. These original owners had negotiated water rights between 1801 and 1828. When Anderson leased, and eventually purchased, the ironworks, water rights from these previous occupants conveyed in instruments of perpetual lease.

Tredegar also obtained water rights through the Armory Rolling Mill established on land contiguous to the Tredegar property, within 100 yards of the Works between the Canal and the James River. Like Tredegar at the time of Anderson's acquisition in 1847, the history of the Armory Rolling Mill was checkered with arguments among investors, manufacturing failure, and a complicated ownership genealogy. Prompted by Anderson's reputation, investors encouraged him to superintend manufacture at the Armory Rolling Mill when he became the head of

Tredegar. Under a ten-year lease that included water rights, the Armory Rolling Mill became the site of Tredegar's early foray into rail manufacture.

Anderson quickly resigned as Superintendent of the Armory Rolling Mill, although he continued to manufacture products in its facilities. In 1848, the superintendent's position passed within the Anderson extended family. Dr. Robert Archer, Anderson's father-in-law, and his son, Robert, Jr. took charge, reorganizing the Armory property as a private company. The Armory Rolling Mill lease joined with Tredegar in 1859 under the umbrella of J. R. Anderson and Company and continued as part of the Tredegar corporate family during post-war reorganization in 1867.

Ownership of the Armory property itself changed hands and subsequent owners added acreage to the tract of land. First privately owned by multiple investors, it became the property of the Confederate government during the Civil War, then of the Commonwealth of Virginia after the War. The Archers continued to hold the lease to the original segment of Armory property, adding to the buildings it contained. The lease included valuable rights to water drawn from the JR&K Canal. Tredegar paid \$1500 per annum to the State of Virginia "free from State

and City taxes" and including "extensive water privileges which...afford ample power for any operations that are carried on."¹⁸⁷

Tredegar's early water rights negotiated prior to the Civil War for both the main site of the ironworks and neighboring property of the Armory Rolling mill conveyed to the company in a typical nineteenth century pattern. "When a site for mill or shop is taken, the requisite power is conveyed to the occupant by an indenture of perpetual lease...The last purchaser takes the same rights in kind as those who have preceded him or those who will come after until the sales shall have reached that safe limit of available power," explained hydraulic engineer James Emerson in an 1878 treatise on waterpower in Mount Holyoke, Massachusetts.¹⁸⁸ According to Emerson, transferring water rights was a boon to both factory and mill owners because the recipient had no associated overhead to maintain dams or canals and could be confident about the permanence and safety of the supply of water. The customary conditions accompanying the conveyance of water rights assumed that the mill or factory owner paid a semi-annual rental to the owner of a canal and "makes his plans and contracts with the assurance that his due allowance

¹⁸⁷ Description obtained from private notebook, probably written circa 1869. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

¹⁸⁸ James Emerson worked in Mt. Holyoke, Massachusetts, testing turbines in order to bring standardized measurement to waterpower and to the machinery required for its efficient generation.

of motive power will always be forthcoming."¹⁸⁹ Tredegar's water rights were guaranteed, regardless of ownership changes in the James River & Kanawha Canal Company and obviated the need for the ironworks to construct and maintain its own dams, canals, or reservoirs. This arrangement, in short, reduced Tredegar's overhead considerably.

Measurement of water allocations authorized in the contracts was problematic, nonetheless. In the early to mid-nineteenth century, waterpower quantification was in its formative phase and far from an exact science.¹⁹⁰ In an effort to quantify water rights, Emerson conducted a survey of waterpower owners to determine how amounts of water were measured and what they cost. Emerson chose the mill-power as the term of measurement. Responses clarified that neither consistent terminology nor consistent standards of measurement were common. Responses were couched in case-by-case definitions of water rights.¹⁹¹ In Manchester, New

¹⁸⁹ James Emerson, *Treatise Relative to the Testing of Water-Wheels and Machinery, with Various Other Matters Pertaining to Hydraulics*. (Springfield: Weaver, Shipman, printers, 1878), 13, <http://catalog.hathitrust.org/Record/001627473>.

¹⁹⁰ Terry Reynolds expends a chapter on the history of water quantification for the vertical waterwheel between 1550 and 1850. Reynolds cites challenges moving from the craftsmanship of early eras to the age of scientific measurement and of adapting mathematics of static objects to the dynamic relationship between power sources in motion and the machines they impacted. Terry Reynolds, *Stronger than a Hundred Men; A History of the Vertical Water Wheel*. (Baltimore: Johns Hopkins University Press, 2002), 196–265.

¹⁹¹ In "Water-power of the United States, The Tenth Census of the United States also relied on definitions of power measurements defined by the lesser or sellers. Mill-power was a common term throughout the northeast, and like the respondents to Emerson's survey, census respondents provided their own definitions of the quantities and variables the

Hampshire, for example, a complex mathematical formula was used to calculate quantities: Managers divided 725 by the number of feet fall minus 1, and arrived “the number of cubic feet per second for a Mill Power.” A New York firm noted, “By one Mill Power is conveyed the right to draw from the nearest race-way or canal 8 ½ cubic feet of water per second, fall of 22 feet.” A Minneapolis firm bypassed the Mill Power measurement to report quantities of “30-cubit feet of water per second, with a head of 22 feet.” The Ousatonic Water Company in Connecticut explained, “Our terms for the rent of water, per year, are \$250 per square foot, 12 hours per day—one square foot being a discharge of five cubic feet per second.” Nearby at Windsor Lock, Connecticut, a business-like overview noted, “Water rented so much per inch yearly, price varying with data of lease...” Emerson concluded, “It will be seen that a Mill-Power is a very indefinite matter,”¹⁹²

Throughout the nineteenth century and well into the twentieth, the accuracy of waterpower allocations was elastic. Their interpretation rested on informal understanding between seller and buyer. Water rights were negotiated in measurements that were indefinite, incomplete, and unquantifiable beyond the time period in which they were negotiated.

measurement represented. United States Census Office 10th census. *Statistics of Power and Machinery Employed in Manufactures: Reports on the Water-Power of the United States*. G.P.O., 1887

¹⁹² Emerson, 14-17.

“The lack of a practical knowledge of hydraulics a generation since caused a looseness in contracts...that has been productive of an immense amount of vexatious and expensive litigation,” Emerson reported. Engineers and experts, according to Emerson, could not agree on common standards. “One great cause for the looseness in contracts has been the difference between the actual and theoretical discharge of water through a an aperture of any size under a given head.”¹⁹³

The inadequacies of water measurements affected an exact quantification of Tredegar's water rights over time. While formal contracts with the James River Company and later, the JR&K Canal Company defined an amount of water the company could draw from the waterway, these agreements generally stipulated that amount in terms of inches of water, sometimes with accompanying measurements of a head.¹⁹⁴ The term, *inches of water*, however, had no definite, established, meaning at the time the grants were agreed upon. Their definition depended on tacit understanding between parties to the agreement that the quantities of granted water were flexible as long as neither party suffered from insufficient power or financial loss. Tredegar's earlier grants amounted to 320 inches, some conveyed with the head measured

¹⁹³ *Ibid.*, 18.

¹⁹⁴ The head is expressed in units of height such as feet or meters. It measures the distance water falls and the subsequent energy generated by the amount of water and distance of the fall.

between three four or five feet, some with no discussion of a head other variables. Allocations to the Armory Rolling Mill property totaled an additional 120 inches.

Discussing the exact quantities of Tredegar's water rights during court testimony in the case of the *Chesapeake & Ohio Railway Co v The Tredegar Company* in 1935,¹⁹⁵ hydraulic engineer, Robert Horton, affirmed that the measurement of inches of water "do not convey or did not convey as of that period a clear meaning of the intent of the parties." Horton frequently had mediated corporate disputes over water rights

¹⁹⁵ Between 1933 and 1936, the case of *Chesapeake & Ohio Railway Co v The Tredegar Co* centered on claims of the Chesapeake & Ohio Railway, then the owners of the James River and Kanawha Canal, that Tredegar had been using more water than that allowed in its various grants. Tredegar was most certainly a money-loser for the railroad because the company paid so little for water rights. The suit had ensued when Tredegar complained to the Railroad that the Canal required repairs and that poor maintenance had lessened the flow of water to the Tredegar site. Tredegar hired a team of attorneys and engineers whose extensive research into the history of water power and of hydraulic machinery constitute a perhaps unparalleled narrative. Testimony focused on the meaning of the original grants, Tredegar's use of water over time, the relationship of Tredegar's production to water power use, and the technology of waterwheels and turbines the ironworks had employed throughout its operations. The case was settled out-of-court. Tredegar's existing water rights were converted to a perpetual grant specifically measured at 175 cubic feet per square inch with the right to purchase more water at an escalating price. Ultimately Tredegar ended up with the same amount of water it had before the Railway initiated the suit, but at a higher cost. The Railway was required to renovate and upgrade the canal and Tredegar shared the cost. In their summary of the court case, Raber, Malone, and Gordon provide a summary of key elements of the case and theorize that although the settlement was costly for Tredegar, it likely cost less than converting to electricity. The records of the court case include a comprehensive examination of histories of waterwheels and waterpower and consolidate Tredegar's records of waterpower usage and the waterwheels and turbines the company used over time. Full documentation of research, depositions, and testimony are among the Tredegar Business Records at the Library of Virginia. Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site," 45–48. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

contracts and had concluded, “ ...I haven’t any doubt at all in my mind but what when [the Tredegar grants] were made, between men who were probably good businessmen and men of horse sense but were not engineers, that they, each of them, had an idea of what the transaction meant and their minds were together.” Practicality and a modicum of self-interest rather than scientific measurement was the essence of the agreement. “I think in their minds,” Horton continued, “was the thought that the buyer was getting enough water...to justify him making an expenditure on the property and I think that the seller had the same mind.” In the absence of standardized measurements, Horton theorized, the buyer proceeded to develop his property, “with the apparent acquiescence of the seller so they then and there practically interpreted what was indefinite.”¹⁹⁶ Another hydraulics expert summed up Horton's historic perspective, testifying “the meaning of the grant [was] fixed by the acts of the parties.”

This informality prevailed between Tredegar and the owners of the JR&K Canal Company as long as it was to the advantage of both. The loose definition of inches of water meant that Tredegar proceeded to draw water and develop a waterpower system generally in the range of

¹⁹⁶ Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

its rights, and the Canal Company acquiesced with Tredegar's use of water through benign neglect. Periodically, however, the Canal Company's precarious financial condition prompted officials to claim Tredegar drew more water from the canal than its leases allowed. These periods of scrutiny intensified as the indebtedness of the Canal Company increased in the 1870s and continued when the Richmond & Alleghany Railroad took control in 1880. Looking at the historical record in 1935, Tredegar's attorneys referred to Tredegar and the Canal Company as parties who were "continually wrangling." The wrangling stemmed from Canal Company complaints that the ironworks drew more water from allowed and occasionally from Tredegar for insufficient water supplies. By 1868, Tredegar's purchased water rights totaled 640 inches. An approximate equivalent in cubic feet per second (cfs)—a measurement usually based on multiple factors, including the size of the aperture through which the water flows, the velocity, and the head—gave Tredegar the right to draw 340 cfs from the canal.

In 1869, however, the Canal Company alleged that for an unspecified number of years Tredegar had exceeded the 340 cfs to which it was entitled. Tredegar agreed, although not to the extent of the Canal Company president Charles Carrington's claim of "three to four fold that

quantity of water for which it paid."¹⁹⁷ The Canal Company acknowledged that the overage had gone unchallenged, in part, because they had failed to maintain accurate records.

In 1868, calculations of a Canal Company engineer had examined the various gates through which water entered the Tredegar property, the placement of waterwheels, the amount of water he thought necessary to run them and other variables and determined that Tredegar specifically exceeded its grants by 73.16 cfs during an indefinite period prior to 1868. Tredegar acknowledged an overage, but placed the amount at about 60 cfs per second in excess of its water rights. The two companies compromised at settlement. Tredegar agreed to purchase a greater amount than the ironworks required and contracted to buy an additional 69.76 cfs effective January 1, 1869.¹⁹⁸ The intent of the new grant was to give Tredegar an ample supply of water for the full operation of the ironworks. With the removal of waterwheels and the judicious placement of turbines along its raceways, the 1869 agreement supplied sufficient water for Tredegar to operate the ironworks at full capacity throughout

¹⁹⁷ Chas S. Carrington to Gen J. R. Anderson, Prest., Richmond, January 25, 1869. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

¹⁹⁸ According to attorneys and engineers preparing the 1935 Chesapeake & Ohio Railway Co v The Tredegar Co. suit, the 1869 grant is the only Tredegar contract specifying cubic feet per second. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

the 1870s and 1880s when orders required Anderson to do so and more than it needed at other times.

Prior to the final settlement of the new lease, Charles Carrington, President of the James River & Kanawha Canal Company, sought to recover revenues the company had lost during Tredegar's post-Civil War excessive use. He asked Anderson to reconsider the terms of the lease the two companies were negotiating, acknowledging that the JR&K Canal Company had no legal right to back payment. "I submit to you whether it is not equitable," he asked Anderson, "that compensation shall be made for so great a benefit so long enjoyed." Carrington's quest epitomized the laissez-faire approach to water rights that endured as long as the interests of neither party were threatened. "Both parties have the leases and know exactly to what the party renting was entitled...It might have been settled by the attention of either party. It was the duty of both but neither thought it proper to give it due attention." He requested that Anderson consider paying half the arrears rather than the entire sum that the Canal Company considered its due. Carrington then requested that Anderson join him before the Canal Company's Board of Directors to indicate a willingness to compromise.

Anderson responded the same day. Prior to 1869, the combined totals of each of Tredegar's water leases amounted to \$2,237.86 annually.

This total included leases Anderson had originally assumed with Tredegar that called for a flat payment of \$1,800 annually for 31.41 cubic feet of water (the equivalent of the 420 inches specified in the lease documents). It also included 7.99 cubic feet for an additional \$437.86 Anderson had negotiated through property transactions with neighboring industries prior to the Civil War.

Tredegar's water charges under the different contracts were established under varied terms. Water rights negotiated prior to 1860 were not for the discharge of water through apertures or openings of any specific dimensions. No costs per unit were cited for the earliest grant conveyed to Tredegar, merely that the lessee "should have the use of one hundred and twenty square inches of water, ...under a pressure of three feet, for the consideration of five hundred dollars, yearly..."¹⁹⁹ An 1828 contract that had passed to Anderson with a portion of the ironworks property included some cost analysis. Indicating that the JR&K Canal Company granted "forever one hundred cubic inches of water under a head and pressure of four feet..." for an annual cost of \$400. Any

¹⁹⁹ Indenture between the President and Directors of the James River Company and Thomas Rutherford of the city of Richmond, July 2, 1812. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

additional purchase of water was guaranteed for four dollars per inch.²⁰⁰

Records of payments to the Canal Company for the Armory Rolling Mill property were more on more specific terms. The charge for 4.59 cubic feet of water per second was \$2 per unit. An additional larger purchase of 160 square inches was equated to 13 cubic feet per second at \$2 per unit. The 1869 the contract between the Canal Company and Tredegar for the additional 69.76 cubic feet does not break out a unit cost, but merely states the total amount of the annual fee: \$4,494.08.²⁰¹

The addition of 69.76 to the company's water rights in 1869 almost doubled Tredegar's existing water agreements. The augmented water rights also almost doubled Tredegar's water bill, adding \$4,494.08 to Tredegar's annual fee.²⁰² As a result of the Canal Company's increased monitoring of usage, Tredegar's annual water fees to the JR&K Canal Company, increased to \$6,731.94 not including the amount paid through the company's lease of the Armory Rolling Mill from the Commonwealth

²⁰⁰ Articles of Agreement between President and Directors of the James River Company, of the one part, and Thomas Green of the other part. June 1828. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

²⁰¹ An 1876 report from a Canal Company engineer computed Tredegar's water rights as 122.3 cubic feet per second at a cost of \$3 for each foot of fall. Attorneys and engineers preparing research for the 1935 case, *Chesapeake & Ohio Railway v The Tredegar Co.*, noted that these figures were never given credence by the James River & Kanawha Canal Company and were an erroneous transposition from inches to cfs. Tredegar's legal experts opinion considered the dollar amount as "ridiculously exorbitant." Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

²⁰² Roswell D. Trimble to Andrew D. Christian, Esq., March 20, 1934.

of Virginia. An additional \$1,280 went to the Canal Company from the Commonwealth of Virginia from whom Tredegar leased the Armory Rolling Mill property.²⁰³ Tredegar's total annual water bill came to \$8011.94. This amount was guaranteed in perpetuity unless the ironworks purchased additional water.

Anderson had apparently hoped to gain additional water rights at better terms and certainly would have preferred to purchase only the amount of water Tredegar was currently using. The Canal Company, however, was seeking to raise old and new water rates wherever possible among its customers. Anderson cautioned, "I am very sure your Company is not going to undo all the encouragement of 30 odd years to start a manufacturing interest in Richmond by cancelling all pledges of the rate we are to pay for water, which is the basis on which every one has invested his money." Anderson denied that the Canal Company had the right to charge more for water at Tredegar than the company currently paid. He offered a compromise, "...but we are willing...to pay for what we are using [in excess of our current contracts] at the top price of \$4 per square inch under a head of 4 ½ feet."

²⁰³ During the Civil War when the State of Virginia leased the Armory site to the Confederate States of America for use during the war, Tredegar paid rent to the Confederacy: \$1750 in 1862, \$1613.73 in two installments during 1863; and \$1760 in two installments in 1864. No payment is on record for 1865. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

His response to Carrington's request for back payments was emphatic. "I had hoped that we had arrived almost to a settlement of the water question...If you are not prepared to compromise on the basis of our leases for the future without going back to the past...I see no prospect of an agreement and doubt the expediency of going before the Board. Our Directors think it is too great a charge and still they are willing to compromise on that. But they are not willing to pay anything for the past," he responded.

Anderson may have hoped for better prices from the JR&K Canal Company in 1869. Whether the rates he paid were competitive is subject to conjecture, given variations among extant methods of measuring and quantifying water rights. As well as concluding that systems of measurement were variable, Emerson's survey had also confirmed that "The prices charged for water-power vary so widely in different sections of the country and the comparative value of such power depends so much on locality, accessibility and other natural conditions..."²⁰⁴

Anderson's earlier prices appear at par or below standard prices for the area. Water rates rose over the decades in the Richmond area. In the 1880 *Water-Power of the United States*, James Swain reported that new

²⁰⁴ Emerson, *Treatise Relative to the Testing of Water-Wheels and Machinery, with Various Other Matters Pertaining to Hydraulics.*, 13.

leases from the City of Manchester across the James River from Tredegar cost \$4 per square inch under a head of three feet, which represented a rate hike from the former \$2.50 per square inch. Leases negotiated prior to the Civil War along the Chesapeake and Ohio Canal in Maryland and Virginia cost \$2.50 per square inch.²⁰⁵ Whatever Anderson's displeasure with the increase in his water bill in 1869, the moderate charges established in the early leases kept the balance of his water costs low.²⁰⁶

In spite of achieving accord on issues of water supply, Carrington and Anderson wrangled about water rights for several years. Throughout 1871 and 1872, Tredegar complained to Carrington about inadequate supplies of water. In 1871, Anderson informed Carrington that the ironworks had suffered for several months from low water in the Canal and he finally felt it necessary to speak up. "I would be faithless to this Company to be silent any longer. Last night the water was lowered so much all of our Puddlers had to stop, thus damaging this Company

²⁰⁵ Costs for waterpower in the nineteenth century were most frequently cited in terms of horsepower.

²⁰⁶ Using 1880 figures from the Tenth Census of Manufactures (etc), Louis Hunter noted that commercial rates for waterpower in Manchester, Virginia, along with sites in New Jersey and southern Ohio were two to three times those of the New England textile centers. (In 1880, Manchester was a separate municipality from Richmond; later, the two cities merged.) The waterpower report stated costs in units of net horsepower per year and placed Manchester's costs in the \$50-\$80 range—two to three times the amount of the highly inexpensive and efficient waterpower systems in towns such as Lowell and Mount Holyoke, mill towns of Massachusetts. Unfortunately, the Census does not include comparable figures for Richmond, and therefore, for Tredegar. Cited in Hunter and Eleutherian Mills-Hagley Foundation (Greenville, *A History of Industrial Power in the United States, 1780-1930 Vol. 1, Vol. 1*, 517, 519.

several hundred dollars and doing great injury to the men."²⁰⁷ A year later, Robert Archer, superintendent of the Armory Rolling Mill, wrote to Carrington explaining that "Our operations of late have been repeatedly embarrassed by an inadequate supply of water, at times we have an abundance but frequently not enough to propel our machinery." The immediate effects of a reduction of ten inches in the canal, according to Archer, "...involved us in great loss." He believed the problem to be one of regulation and requested that Carrington "give the matter your attention."²⁰⁸ According to the Canal Company, the river was low, and they were making all possible effort to keep up the supply of water.

Problems arose again in 1876. During negotiation for back payments seven years earlier, Carrington had reminded Anderson that failure to offer partial payment for water overuse "may interfere with the prosperity of an establishment with which its own prosperity is so nearly connected." In 1876, as Tredegar entered receivership, Anderson handed back the communal responsibility for prosperity. Although Tredegar's financial crisis was of paramount concern, Anderson's concern for those who were dependent upon him—family, workers, creditors, and debtors—

²⁰⁷ Joseph R. Anderson, Prest. To Maj. Chas S. Carrington, Prest. J.R. & K Co. Jan'y 20, 1871.

²⁰⁸ R. S. Archer, Supt. To Mr. Charles S. Carrington, Pres. James R & Ka. Co. Richmond, Oct. 22, 1872. Tredegar Company General Letter Book No. 29, (Sept 27, 1872-Dec. 2 1872) Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

was unmitigated. Anderson informed Carrington that the “dullness of trade and unprofitable nature or it arising from the close competition caused by the great excess of capacity to produce over the demand in the country” made paying the present water rent difficult. “As Receiver I am operating the works on a small scale to give employment to as many of the men as possible and keep them together.” He requested that Carrington reduce Tredegar’s water rent 50 percent “to enable me to keep the works in motion...during the depressed condition of trade.”²⁰⁹ Whether the Canal Company acquiesced is buried in company records.

It seems unlikely, however, that Anderson's letter ignited Carrington's civic conscience, given the Canal Company's concern for his own corporate bottom line. In a public speech he reported that, since 1869, he had continued to direct the Canal Company engineer “to remeasure the water used by the Tredegar company” claiming that Tredegar continued to use water in an unspecified amount “...in excess of the grant. This has and will continue to engage the attention of the JR&K Company until a proper settlement is made.” To Tredegar's legal and financial benefit, however, the Canal Company engineer concluded that “The quantity of water which the operations of the Tredegar Company at

²⁰⁹ Joseph R Anderson, Receiver, to Col. Chas. S. Carrington, Prest. J.R. & Kan. Co, July 21, 1876. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

present require, and which it now uses, is not larger than to which it is entitled under its water grant..."²¹⁰

In 1876, Tredegar extended its lease for ten more years of the Armory property, this time, incorporating the entire State-owned acreage and adding 40 more inches of for a total of 160 water to their entitlement. In 1888, Tredegar purchased the Armory property and "all the water rights and water privileges." Tredegar's water bill for that portion of water rights did not increase, but remained at the \$1,280 the company had paid to the Commonwealth of Virginia under its lease.

With the purchase of the JR&K Canal Company in the 1880s by the Richmond & Alleghany Railroad and the later purchase by the Chesapeake & Ohio Railway in 1890, Tredegar's water usage came under scrutiny periodically. Measurements from the Richmond & Alleghany Railroad during the 1880s were *pro forma*. The company engineer filed one report under the title "Presumed Quantity used by Tredegar" and acknowledged its inaccuracy due to the unreliability of the measuring mechanism with an error factor of minus 14 to plus 32 percent. Readings in 1882, 1889, and 1892 indicated that Tredegar utilized far more water than

²¹⁰ Extract from Report of Colonel T.R.M. Talcott, Consulting Engineer, Exhibit XXX, Court case.

the Canal Company believed it was entitled to take; however, the claims either passed without comment.²¹¹

The 1869 settlement between the Canal Company and Tredegar reverberated in 1883. Decatur Axtell, Manager of the Richmond and Alleghany Railroad who then owned of the Canal, informed Anderson that fluctuations in the flow of water in the canal occurred because of “excessive draught by your works...which largely exceeds the amount to which you are entitled under your various contracts. ...this is not a proper nor equitable condition of affairs” Axtell insisted that Anderson promptly reduce the amount of water Tredegar drew from the canal with the hope that ‘you will exonerate me from any desire to peremptory or unjust and that you will appreciate that I am only moved by the necessities of the case.” Both Axtell canal waterpower engineer, Reuben Shirreffs adamantly insisted that the 1869 settlement grossly had underestimated Tredegar’s water usage and in addition, the increased number of turbines and improved raceways had surely resulted in Tredegar’s taking even more water than that allowed in the settlement.

²¹¹ In spite of the vagaries of translating Tredegar’s various contracts into accurate and standardized measurements, during the 1880s, the Canal Company set Tredegar’s wter rights at 122.36. The measurement had no demonstrable foundation. Although that measurement never attained credence it nonetheless remained the standard by which the Canal Company, when it chose to do so, accused Tredegar of water overdrafts. Court Case, repeated in Raber et al.

Shirreffs attempted to define the meaning of Tredegar's early grants in quantities of square inches. He applied mathematical formulas to possible configurations, theorizing on the size of the openings through which the water fell, the height of the fall, and the placement and size of waterwheels at the time of the grants. Shirreffs mathematical formulas placed the value of Tredegar's alleged excess water usage at \$20,565 per year more than the company's current cost of \$8011.94. Like all previous and later attempts at this quantification, Shirreffs admitted his calculations would not stand up under legal scrutiny. He proposed offering a compromise costing the ironworks an additional \$11,240 per annum and simultaneously freeing up water from the canal that could be sold to other customers.

Anderson replied, "Tredegar does not admit that it draws more water from the canal than it is entitled to, and I think our position was shown to be correct...many years ago," Furthermore, he pointed out that the lower amount of water in the canal had nothing to do with Tredegar's water use, "seeing that the level was so low that we could not draw the small [amount] needed to drive only a part of our machinery required for contract operations." The 1883 claims against Tredegar, like earlier accusations, were found without merit.

Tredegar required no further water purchases during the 1870s and 1880s in order to run the facility. Consensus prevailed that Tredegar's draw of water was within appropriate limits, in spite of fuzzy math. Within the ironworks, attention focused on the purchase and placement of turbines to enhance and efficiently power Tredegar.

TURBINE TECHNOLOGY

Describing the status of waterpower technology in 1887, mechanical engineer James Thurston wrote, "The forms of motor employed in the utilization of the water-power of the United States...are almost universally of the class known as turbines—wheels in which the current is received at one extremity of a bucket-channel and discharged at the other end, traversing the conduit continuously and not with reversal, as in the older and more cumbersome 'vertical' water-wheel." The most significant technological advance to Tredegar's waterpower system occurred in the 1870s when turbines completely replaced waterwheels at the ironworks. Until 1871, Tredegar relied on overshot waterwheels or combinations of waterwheels and turbines to transmit power to its factories. After a brief, failed experiment with turbines in 1847 and 1848 from which he "suffered much by the experiment," the risk-averse Anderson remained with waterwheels until 1861 when improvements to turbine technology met the specifications he required as

a trained engineer.²¹² "The turbine wheel was put in motion this afternoon for the first time," reported a manager of the machine shop in the early 1860s. "It performed very satisfactorily."²¹³ With the transition from waterwheels to turbines and resituating production sites during the 1880s, Tredegar established the basic tenets of its power system: to continue reliance on waterpower and to flexibly determine the most efficient arrangement of buildings, prime movers, and waterways.

The development of the turbine in waterpower generation denoted the transformation of traditional mechanical technology; they were waterwheels re-imagined.²¹⁴ Engineers extolled their advantages. "The first

²¹² Anderson installed two Dripps turbines that he reported required "4 times as much water as an overshot wheel..." According to Anderson, Dripps turbines were wasteful and wrote, "I...must confess that from what I have seen I would not use it for any purpose if the patentee would make a present of it and put it up and attach it gratis." The Dripps turbine hit the market just as noted Lowell engineers, Uriah Boyden and James B. Francis were designing and testing turbines with experiments that became hallmarks of nineteenth century hydraulic technology documented, in part, through Francis's notable work, "Lowell Hydraulic Experiments" published in 1855. Francis's technological expertise enabled the city of Lowell and its mills to operate with waterpower for decades. Of Dripps, little is known. Historian Robert Gordon classifies him as "an obscure figure in American technological history" with the caveat that "Failure, far more common than success, seldom receives the attention it deserves from historians." Studying the Dripps patent drawings, Gordon concluded the turbine was designed with fatal flaws resulting in extraordinary loss of energy even before the stage when the turbine propelled water to transmit power. Turbine performance at the time of Anderson's early experiment was far from optimal. Anderson reintroduced the turbine at Tredegar in 1861, turning to a local manufacturer. By then, turbine technology had advanced and efficacy of the turbine was inarguable. Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site," 57–8.

²¹³ Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

²¹⁴ Layton, "Scientific Technology, 1845-1900," 65. Terry Reynolds. *Stronger than a Hundred Men: A History of the Vertical Water Wheel*. (Baltimore: Johns Hopkins University Press,) 2002. Michael Raber, Patrick M. Malone, and Robert B. Gordon. "Historical and

requisite in a good mill is good motive power and among all hydraulic motors yet discovered none can compete with a good turbine," wrote Robert Grimshaw. In 1882, Grimshaw's listing of the advantages of the turbine over the waterwheel covered several pages in, *The miller, millwright and millfurnisher*. He elaborated that turbines were not affected by ice or backwater; that turbines were less expensive, more cheaply and easily transported and put in place;; that they were suited for all heads and all locations, required less space than waterwheels; and above all, used water more economically to produce greater power.

Any one of these reasons was sufficient for Anderson to consider turbines at Tredegar. The most relevant advantages for his purposes would have been price, flexibility, and efficiency. In the dismal economic climate of the 1870s, Anderson needed the most cost-effective means of delivering power to his various plants. Expansion of Tredegar's production of core products in the 1880s required the most efficient utilization of the water allocated to the ironworks from the Canal Company in order to avoid the expense of further purchases. As James Leffel, a prominent nineteenth century turbine manufacturer, explained in an early catalog, "The best wheel is that which develops the most power

Archaeological Assessment: Tredegar Iron Works Site, " Organizational Records Collection, The Library of Virginia, Richmond, Virginia: Raber Associates and The Valentine Museum and the Ethyl Corporation, 1992

from a given quantity of water...The application of the best wheel adds greatly to the value of the water right."²¹⁵ Tredegar's turbine installations, in short, did not increase the amount of water the company used; they increased the useful power generated from Tredegar's existing water rights.

During the 1870s, Tredegar replaced the last of its waterwheels with turbines and increased the number of turbines along Tredegar's four raceways that channeled water from the Canal down Tredegar's upper and lower levels and back into the James River. By 1891, twelve strategically located turbines powered buildings and machines as far as 500 feet from their locations.²¹⁶ These prime movers were positioned along the lengths of raceways in a complex system of inter-dependent and autonomous linkages to various buildings.

Rather than installing only a few large turbines, Anderson divided the distribution of power among several turbines. Tredegar's two-level layout and this use of multiple prime movers enabled Anderson to control the flow of energy and to decentralize power transmission so that the most power-hungry shops or production sites with variable requirements

²¹⁵ "Illustrated Hand Book of James Leffel's Improve...", 21, accessed February 19, 2016, <https://archive.org/stream/illustratedhandb00jamerich#page/12/mode/2up>.

²¹⁶ By 1920, that number had increased to 16 turbines, according to industrial archaeologists Raber, Malone, and Gordon. Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site," 68.

received ample energy supplies. Anderson explained his system in the early 1870s, "Each (roll) train has its own turbine, and each set of outside machinery its own turbine. This is applying to water power the most advanced practice of steam mills, which is to discard large engines driving a number of trains and machines..."²¹⁷ Decentralization enabled the operations of the ironworks and selected shops to function independently. A breakdown in one department would not halt or affect the operations of another. Expanding on his description of Tredegar's waterpower system in the 1880s, Anderson further explained, "The power is now divided; each train of rolls or set of machines has its own turbine, and consequently each department is perfectly independent as regards power and the results are very satisfactory, the turbines rarely failing, and costing a mere trifle for repairs."²¹⁸

Races on the Tredegar property were identified numerically. Four raceways transected the Tredegar property—two on the original land, two on the Armory Rolling Mill site. Engineers examining the site at different times during the twentieth century concluded that the raceways also enabled Tredegar to maximize the power it obtained from its water rights. Alternative methods such as rope drives or long shafts for distributing

²¹⁷ *Ibid.*, 49.

²¹⁸ Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

water to waterwheels or turbines led to energy loss. Placing prime movers in raceways next to the machinery streamlined power transmission.

Tredegar's second raceway, for example, was the principle conduit from the canal to the river. Power-hungry spike mills, car shops, rolling mill, and foundries lay in proximity to its path with the heaviest power users on the upper level, closest to the canal. (See Appendix D, page 224)

The Pattern Building next to this raceway exemplified the creative and complex engineering on the Tredegar site. Constructed circa 1867 on the lower level of the ironworks, power to three-story building and nearby structures was considered a consummate example of multiple prime movers. Five turbines were installed closely together in the raceway bordering the pattern building. Tredegar's engineers positioned two horizontal turbines above three vertical turbines each of which took in water independently from a 22 foot water drop from the drop of the second [upper] level to their location on the first. Shafts from these five turbines ran in at least three directions to drive machinery in buildings on both sides of the raceway. The shafts entered buildings on more than one floor, including the pattern building while other shafts likely drove spike machinery and brought power to a machine shop and horseshoe forge

shop. Tredegar installed turbines to power individual buildings or sets of machines inside buildings as needed.²¹⁹

Historical explorations of the Tredegar site confirm periodic changes and upgrades throughout the ironworks to improve the efficiency of waterpower not only during the 1870s and 1880s, but also during Tredegar's life cycle. Wheel sites, the locations in the Tredegar raceways that had contained waterwheels replaced by turbines or which were constructed uniquely for turbines, increased from twelve in 1892 to eighteen by 1920. The Number 1 Wheel site was typical.

The Number 1 Wheel site employed a waterwheel until 1847 when the ill-fated Dripps turbine was installed. In 1848, an overshot waterwheel then replaced the Dripps. Enlarged during the Civil War, this replacement functioned until 1863 when a 4 and ½ foot turbine was installed, again replaced by a larger turbine in 1867. In 1869, Anderson ordered a 48" Leffel turbine for Wheel Site 1. Its manufacturers ensured that Tredegar had adequate facilities to install the wheel and provided the company with lithographs illustrating how the wheel worked and its optimal speeds. The Leffel remained in place until 1948 when it was replaced with a

²¹⁹ Testifying during *Chesapeake & Ohio Railway v The Tredegar Company* in 1835, engineer Paul E. Miller broke out a detailed history of each site wheel or turbine site on the property. Raber, Malone, and Gordon summarized Miller's testimony and the associated exhibits in their 1992 Historical and Archaeological Assessment of the ironworks property. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

smaller Leffel turbine. The only recorded repair was a change of case in 1882.

Waterwheel breakages and the cost of repairs undoubtedly spurred Anderson's move to total reliance on turbines. Managers of Tredegar's various shops regularly reported to Anderson about waterwheel inefficiencies and breakages. David Eynon, whose patents led to improvements in Tredegar's spike manufacture, was a Foundry Manager in 1867. Concerned with foundry productivity, he urged Anderson to replace a 54" turbine with a larger model, "begging leave to state some of the many reasons for doing so." Eynon pointed out that the foundry machines had never worked at consistent speeds and that the variations drastically affected the cost of each product unit. Tredegar had also just added the 3-high rail that, Eynon pointed out, will take more power to keep in motion. "By putting in the 60" wheel, we will gain 1/5 more Power, the cost will be small, 30 to 40 dollars will cover all, having only the interest of the Co. in view I hope that the change will be done."

Robert Archer, superintendent of the Armory Rolling Mill, announced in 1869 "The water wheel at the Tredegar is in very bad condition and we will be unable to run the Puddling for the balance of the week...we had better stop the mills for a thorough repair of the wheels." Eynon concurred. "I deemed it my duty to inform you of my

opinion [sic] ...indeed sir it worries me very much. The power is in the head and fall, but the wheel is not constructed to answer it...I wish you sir to consider ...the power is there, all is wanted is to have a machine that will transfer it from the water fall to mill." Also in 1869, General Manager J. F. Tanner told Anderson, "We have had a great deal of trouble with the overshot wheel...and the sooner we get in another wheel there [to run the spike mill] the better,". The wheel running the spike mill required rebuilding and estimated costs were set at \$2,050, including rebuilding shafts to connect the wheel to the spike machines. In 1871, another overshot wheel repair cost was estimated at \$1,120.06

Anderson must have determined that the increased power he could obtain from the use of turbines offset initial installation costs. In 1869, repairs to the waterwheel powering a spike mill, including labor and materials, were estimated at \$2,120. By contrast, Anderson replaced the spike mill waterwheel and an identical nearby water wheel with two turbines, "each wheel to be placed in an iron case and entirely independent of each other." These two turbines powered the spike mill and the car shop and remained in place through 1916. In 1871, Anderson's managers compared costs for repairing overshot wheels powering the carpenter shop to the addition of two turbines. Labor and materials for the turbines totaled \$2,948 including preparing wheel pits ;

the two turbines, \$890. Since turbines themselves were relatively inexpensive and repairs were comparatively few over time, the new installations would pay for themselves more rapidly than waterwheel repairs.

Turbine technology improved rapidly between 1850 and 1880 and Anderson frequently replaced early turbine installations with more efficient models. Anderson replaced turbines he had installed in the mid-1860s within a year or two in favor of the increasingly efficient models then on the market. But like the Leffel turbine, many of Tredegar's turbines installed during the 1870s and 1880s remained in operation for decades.²²⁰

In 1919, Archer Anderson, Jr., the third generation of Andersons to serve as Tredegar's president, notified the Commissioner of Internal Revenue in Washington, DC, "...we are the owners of valuable perpetual water power rights. By this water power owned by us under our rights conveyed to us by deeds practically our whole plant at Richmond is driven..." These water rights, Archer, Jr., explained, served Tredegar's thirty acres of land, ten acres of buildings, and 1200-1500 employees. "For these water rights, we pay yearly \$8011.94." This amount was the same that Tredegar had paid since 1869. According to Archer Anderson, Jr., The

²²⁰ Industrial archaeologists noted that turbines in place by mid-twentieth century reflected obsolescence more than state-of-the art technology. Surviving turbines, however, apparently met Tredegar's waterpower needs.

most moderate figure at which this water power investment could be valued in 1919 would be over \$130,000."²²¹

Under Joseph Anderson, the transition from water wheels to turbines required some initial investment that frequently exceeded the cost of repairing the waterwheels that were in place. Those initial costs would have been recouped over time given the relatively small costs of the turbines themselves, the reduced repair schedule, and their longevity. In spite of periodic challenges from the owners of the JR&K Canal claiming Tredegar exceeded its water rights, shifting to steam was financially ill-advised. The annual cost of Tredegar's water was guaranteed in perpetuity. Tredegar's water rights, negotiated before water measurement was a matter of scientific procedure, virtually ensured that claims against the ironworks for excess water appropriation could not be substantiated. The technology of turbines enabled the company to maximize the amount of power generated from the water rights. Turbine-generated power supplied the company with sufficient power to meet production needs at an unbeatable price legally protected from rate hikes over time.

²²¹ Archer Anderson, Jr., President, to Commissioner of Internal Revenue, Washington, D.C., March 3, 1919. Tredegar Iron Works Records, 1801-1957. Accession 23881, 24808. Business records collection, The Library of Virginia, Richmond, Virginia.

VI. CONCLUSION

Joseph Anderson negotiated Tredegar's path in the two decades after the Panic of 1873 against a national backdrop of an iron and steel sector that was rapidly expanding and the advance of technologies that were restructuring metal manufacturing. The persistence of traditional methods of iron manufacture in the face of dramatic advances in steel production both forced and enabled iron manufacturers like Anderson to balance profitability against risk, traditional production techniques against extensive changes to factories and machines, and the probabilities of known markets versus tentative possibilities.

SOUTHERN IRON

Between 1873 and 1893, the manufacturing center of the United States moved from central Pennsylvania 300 miles west to Ohio. In the South, the geography of iron production also moved westward concomitant with national expansion. This growth opened new sources of raw materials in the South, first in Tennessee, then in Alabama. Virginia, historically the leader of Southern iron manufacturers moved from first to second place as Alabama's nascent industry overtook Virginia as the

South's foremost iron producer.²²² Between 1880 and 1890, the number of iron and steel works operating in Alabama jumped from fourteen to thirty-eight while in Virginia, the number of functioning iron manufacturers declined from forty-four to thirty.²²³ By 1890, the value of Alabama's iron and steel products amounted to \$12,544,227, a staggering 88 percent increase over 1880 production numbers. West Virginia followed with \$10,556,865, a 57 percent increase over 1880 figures.²²⁴ Virginia was third among southern states with the value of iron and steel products totaling \$6,326,084, a 40 percent increase. In all other categories quantified in an 1893 Census Bulletin, "Iron and Steel Industries of the Southern States," Alabama outpaced Virginia in numbers of employees, wages, invested capital, numbers of blast furnaces, and numbers of rolling mills. In the short term, the westward movement of iron manufacture in the South had little effect on Tredegar. The company had experienced and solved problems endemic to new industrial development that other southern states were

²²² Virginia produced 12.8 thousand net tons of rolled iron and steel in 1873. By 1893, that total grew to 37.8 net tons. Alabama, Virginia's closest competitor, produced only 5,000 tons in 1873, but by 1893, the output grew to 27 thousand net tons. Kenneth Warren, *The American Steel Industry, 1850-1970: A Geographical Interpretation*, 68.

²²³ The decline in number of establishments may be an indication that smaller blast furnaces or obsolescent bloomeries went out of production. Many of Virginia's iron production facilities dated to the early eighteenth century or before. The smaller and older the establishment, the more likely the equipment was antiquated or the supply of raw materials was no longer adequate or markets no longer existed, therefore, the less likely it was to remain in production during this period of overall expansion and growth.

²²⁴ According to the Census Bulletin, Virginia's second place ranking in total value of iron and steel products occurred because more products were "worked into higher forms." William Sweet, "Iron and Steel Industries of the Southern States, 1893," 5.

beginning to encounter and Tredegar offered a prototype for that development.

With few exceptions, the leading iron manufacturers in the South, notably Alabama, followed a growth strategy similar to Tredegar's. These establishments manufactured products and entered markets that exploited raw materials native to their own terrain. Northern models of mass production, large facilities, and economies of scale were inappropriate for the South. Southern industries emphasized traditional manufacturing processes during the 1870s and 1880s rather than experimenting with innovative plant machinery or outfitting factories for steel production. These traditional methods took advantage of the proximity of local raw materials, manufacturing products for which southern regional ores were best suited. Like Tredegar's focus on specialized items, such as car wheels that capitalized on the excellence of Virginia's charcoal iron, Alabama's industries, for example, manufactured products suited to iron-poor red hematite mined in the north central section of the state. Birmingham iron manufacturers turned to cast iron for the pipe trade, railroad products, and pig iron.²²⁵ These

²²⁵ Alabama's red hematite required abnormally high temperatures for smelting and the pig iron contained high quantities of impurities. Unlike Virginia, where the ore lent itself to cold blast, Alabama's red hematite produced the best pig iron under high temperatures and in coke furnaces. W. David Lewis, *Sloss Furnaces and the Rise of the Birmingham*

basic techniques were more cost-effective and more conducive to corporate growth and survival than attempting to duplicate the manufacturing models of northern enterprises.²²⁶

Southern iron manufacturers, however, were subject to the prejudices of regionalism that established northern development as normative. Because southern experience did not replicate that of the North, growth and development were often discussed in pejorative or condescending terms. In 1875, the widely-distributed industry journal, *Iron Age*, published arguments and counter-arguments on the merits of iron manufacture in southern states and debate about the business sense and technology of the southern manufacturers. The publication challenged the boosterism of the New South that extolled the potential of the region as a major iron producer. Articles asked why the region's iron industries were not more successful since conditions necessary to the manufacture of cheap iron—contiguous ores and fuels, for example—existed to a

District: an Industrial Epic (Tuscaloosa and London: The University of Alabama Press, 1994), 5.

²²⁶ In writing about the Sloss-Sheffield Company in Birmingham, Alabama, W. David Lewis points to the company's decision by 1920 to specialize in foundry pig iron. By remaining in a traditional field of manufacturing that was free from northern freight-fixing and congruent with the peculiarities of southern ores, the company continued to be a successful enterprise in spite of labor problems hobbling production. This strategy, concludes Lewis, demonstrated that a number of technological changes were not necessary because the company remained true to a characteristically southern style of production and refrained from making steel, for which northern conditions were better suited. W. David Lewis, *Sloss Furnaces and the Rise of the Birmingham District: an Industrial Epic*, (Tuscaloosa and London: The University of Alabama Press, 1994), 482–484.

greater and more perfect extent in the South than elsewhere. "Whatever the possibilities of iron manufacture in the South, there have undoubtedly been too many glowing pictures of what could be done, and too few well-directed and sustained efforts to realize these predictions," postulated one article. "The great trouble with the Southern iron trade is that it has too many talkers and too few hard workers," the article continued.

Acknowledging that prices to manufacture pig iron and costs for transporting southern iron manufactures to northern markets presented hurdles to the growing industry, *Iron Age*, nonetheless, castigated Southern capitalists for failing to invest wisely in their enterprises, failing to build their businesses at a scale that might ensure profitability, albeit at small initial profit margins, and for exaggerating the extent of regional mineral wealth in order to attract investors. Accusing southern manufacturers of sacrificing quality by doing too much, too fast, the periodical concluded, "The great obstacle in the way of the success of Southern undertakings...has been an inordinate desire for large profits with little work. Northern men certainly know better..."²²⁷ The underlying criticism of the South seemed to be simply that it was not following the

²²⁷ "Southern Iron Manufacture," *Iron Age*, 1875.

same pattern as the major northern iron manufacturers, particularly those of Pennsylvania.

Southerners were incensed. Letters flew to the publication arguing against its assertions and statistics the *Iron Age* had printed. Referring to dissenters as “overzealous champions,” the publication published a lengthy rebuttal, “...hoping that the Southern papers which have commented on extracts from our previous articles will do us the favor to publish what follows.”²²⁸ *Iron Age* stood by its previous judgments, but tempered them with excuses for southern backwardness. “We cannot blame the people of the south, impoverished by the events of the last fifteen years and with but little opportunity to mend their broken fortunes for not having built more railroads, opened more mines, built more furnaces, and realized by their own efforts the promise of development ...They might, perhaps, have done more than they have...”²²⁹

The publication was not critical of Virginia in this particular series of articles, but generally singled out developing companies in Tennessee, Alabama, and Georgia for a lack of foresight. Anti-southern bias within the industry was clear. The South was held accountable for failure to deal with problems that were not regional, but national, such as how to control

²²⁸ *Ibid.*

²²⁹ *Ibid.*

manufacturing costs when access to raw materials and transportation to major markets were costly. Despite pejorative opinions that surfaced, at least in some quarters, such conversations did serve to situate the South's growing iron industry prominently within a national conversation. In turn, they advertised the possibilities within a New South, ready and eager to industrialize, and potentially ripe for investment.

TREDEGAR IRONWORKS AND WEST POINT FOUNDRY: A COMPARISON OF DIFFERENT PATHS

Between 1873 and 1892, Joseph Anderson's choice to manufacture traditional iron products with steady demand and no apparent drift toward obsolescence became a determining factor of Tredegar's survival. During this time, Anderson's dominant and charismatic leadership within Tredegar and among the elites of Richmond was also critical to the sustainability of the ironworks.²³⁰ A comparison with West Point Foundry in Cold Springs, New York, demonstrates the viability of Anderson's directions for Tredegar and likelihood of business failure if he had moved differently, particularly during the crisis years of the Panic of 1873.

²³⁰ Anderson conformed to the thesis of Historian Harold Livesay that in in large and small business enterprises "dominant individuals hold the key to enduring success. ...they must function through an organization; therefore, they must know how to build teams, run them, and rebuild them when required. ...they play a role often appreciated only in the failure that attends its absence." West Point Foundry lost that dominant leadership when Gouverneur Kemble and then, his son-in-law Robert Parker Parrott left corporate leadership. Harold C. Livesay, "Entrepreneurial Dominance in Businesses Large and Small, Past and Present," *The Business History Review* 63, no. 1 (April 1, 1989): 4, doi:10.2307/3115424.

Tredegar and West Point Foundry in Cold Springs, New York, were parallel concerns during much of the nineteenth century. Pre-eminent iron manufacturers within the nation and within their regions, both were family-owned companies. Established in 1817, West Point Foundry was older than Tredegar and Gouverneur Kemble, the company's founder and chief, was Anderson's senior. Anderson and Kemble conferred on best practices for iron manufacture during the antebellum period, particularly in meeting standards of the U.S. Department of the Navy. Both companies had purchased pig iron and machinery from each other during those years as well. During the Civil War, West Point Foundry's profits soared as it manufactured Parrott rifles, cannons, and ammunition for the federal government.²³¹ The Foundry's profits are estimated at over \$4,000,000 over the five-year period of the Civil War. While records of Tredegar's war-time profits no longer exist, its pre-eminence as the South's dominant munitions manufacturer is well-documented, and its output was considered second

²³¹ Robert Parker Parrott, (1804-1877) the son-in-law of Gouverneur Kemble, became the Superintendent of West Point Foundry in 1836. A West Point graduate and a civil engineer, Parrott resigned from active duty and remained with the Foundry for 41 years, becoming a lessee and operator in 1839 when Gouverneur Kemble withdrew from active involvement in the ironworks and entered politics. In 1867, Parrott resigned from the Foundry, but continued to develop and patent improvements to munitions until his death ten years later. The Parrott Rifle was made of wrought and cast iron which was difficult to blast at an appropriate strength. Parrott developed methods of reinforcing the rifle to prevent fractures. The Parrott rifles and cannons were manufactured in different sizes and weights applicable to different battlefield conditions. Both Northern and Southern armies utilized these weapons.

in the nation only to that of the West Point Foundry.²³² Both companies depended on water to power their ironworks. After the war, similarities between Tredegar and West Point Foundry continued for a brief time: both ironworks faced decisions about their product lines as contracts for government munitions lessened and as the steel began to dominate iron manufacture. Like Tredegar, the historic record holds that West Point Foundry found itself unable to convert to steel production.²³³

The two companies responded differently to the potential encroachment of steel manufacture on their products and processes. The divergence of their corporate directions at that time emphasizes the rationality of Anderson's trajectory for Tredegar. Tredegar's product line remained linked with products for which ongoing commercial demand persisted in multiple markets. West Point Foundry continued to focus on munitions. Anderson maintained close control of Tredegar by filling key management roles and decision-making positions with nuclear family members. While Anderson outside investors whose opinions Anderson sought joined Tredegar's Board of Directors, corporate control remained with him and with immediate family members. Rather than passing from father to son over several generations as Tredegar had, West Point

²³² See *supra*, note 2.

²³³ Dan Trepal, "The Gun Foundry Recast," *IA. The Journal of the Society for Industrial Archeology* 35, no. 1/2 (January 1, 2009): 78, <http://www.jstor.org/stable/41550366>.

Foundry's family management passed from its founder to Robert Parrott, Kemble's son-in-law who had been deeply involved in the invention and development of munitions. When Parrott left the company in 1867, however, West Point Foundry passed to a board of four nephews of the original owners who leased the ironworks as Paulding, Kemble, & Company. The nephews were neither experts in iron manufacture nor skilled businessmen. Strained by the Panic of 1873, creditors foreclosed the company was foreclosed in 1887 and another ironworks, Cornell Company of New York, took over the property a few years later.

While the absence of consistent, dynamic leadership undoubtedly contributed to West Point Foundry's demise, the production and technological direction of the ironworks in the postwar period stood in stark contrast to Tredegar under Joseph Anderson. The foundry did little to upgrade or improve its facilities. Rather than utilize its furnaces and machinery to manufacture iron products for which there were markets, the Foundry continued to focus on guns and munitions, products rapidly becoming obsolete. Steel technologies for weaponry displaced iron. Guns made of steel were more powerful, durable, and easier to fire than iron. In a quandary, West Point continued to seek government contracts for ordnance but, during the 1870s, these contracts were for converting iron Civil War guns into rifles. Although West Point Foundry's management

explored several avenues for the manufacture of steel guns or as middlemen in steel munitions manufacturing, the lack of technical knowledge and outdated equipment ended in failure. According to industrial historian Dan Trepal, "The gun foundry was conferred obsolescence by the decisions of the 1883 Gun Foundry Board and moved from being the company's largest source of potential profit to a costly albatross around the necks of the owners."²³⁴ Little is known about West Point Foundry between the manufacture of the last gun 1876 and its foreclosure.

The divergent paths of two companies that began as equals in many respects highlight the expertise and wisdom of Anderson's leadership. Managerial flexibility and foresight enabled Tredegar to suspend weapons manufacture, the strength of its antebellum and wartime production, and turn to specialized products for the railroad. Product diversity prior to the war eased this transition. West Point Foundry, too, had manufactured some products other than weapons; waterpower equipment, pipes, steam engines, hardware and machinery for warships were among them. They had diversified to a much lesser extent than Tredegar and to a far more limited market. The company missed one relevant component of survival that Anderson recognized: that of finding

²³⁴ *Ibid.*, 82.

a profitable market niche and developing a product line that tapped into multiple markets.²³⁵

AFTER JOSEPH REID ANDERSON

Hollywood Cemetery lies west of Tredegar and overlooks the James River. Shaded pathways frame the gravesites of a cross-section of national and local politicians and poets, founding fathers, businessmen and soldiers. Presidents James Monroe and John Tyler²³⁶ are buried there. So are Jefferson Davis, J.E.B. Stuart, Fitzhugh Lee, John Randolph, Edgar Allen Poe, and generations of entrepreneurs and early industrialists, peers of Joseph Reid Anderson who built Richmond's cultural and economic heritage: the Valentines, Haxalls, Myers, Harvies, Mayos, Triggs, Glasgows, and Bruces.

The Anderson family plot lies at the apex of a triangle with the wrought-iron enclosed gravesite of President Monroe and the family-plot the circumference of President's Circle. Anderson chose his family burial ground, purchasing the lot in January 1889. He selected an area originally owned by the Commonwealth of Virginia and specifically designated for

²³⁵ See footnote 34 *supra*.

²³⁶ In 1827, The Virginia General Assembly elected John Tyler to the U.S. Senate where he served until 1836. As a Senator,, Tyler endorsed Joseph Reid Anderson's application to West Point in 1830. This was Anderson's second application for a seat at the military academy. It was unsuccessful. Anderson was admitted under the recommendation of the Secretary of War in 1832. Dew, *Ironmaker to the Confederacy*, 6.

prominent Virginians.²³⁷ His site selection underscores the value he placed on his position among the “best men” and “first families” who dominated Richmond’s business, cultural, and political life.²³⁸ His choice reinforces Anderson’s decision to remain, even after his death, a prominent Richmond iron manufacturer. This choice of a final resting place resulted from a confluence of deliberate personal decisions and priorities rather than from poor business choices and technological Luddism.

Anderson’s tombstone, a tall, sandstone monolith, further exemplifies his values. Among the tombs of Richmond’s elite in the bastion of Confederate memory that is Hollywood Cemetery, the inscription makes no mention of Anderson’s graduation from West Point, his rank as Brigadier General, his service to the Confederate government and military, or even his life’s work as the head of Tredegar. His grave marker, instead, memorialized stewardship and honor: “Steadfast Christian Faith, trust in men, public spirit, energy that knew no other rest than varied

²³⁷ The Commonwealth of Virginia had purchased these lots in 1858 and succeeded in having the remains of President James Monroe removed from its original burial site in New York and reinterred at Hollywood Cemetery. The Commonwealth also owned the lot where President Tyler is buried and the Army Corps of Engineers erected his monument years later. The Commonwealth sold the balance of spaces back to the cemetery because further efforts to have other prominent Virginians moved to this section was not successful. Hollywood Cemetery did not pre-assign cemetery sections, but simply enabled their selection and purchase by individuals and families. Email David Gilliam, General Manager of Hollywood Cemetery, to Lee Ann Cafferata, February 3, 2012.

²³⁸ Note 28 *supra*.

activity. These qualities marked his life and won the love of his fellow citizens."

In addition, lines from "Rugby Chapel: November 1857" by Matthew Arnold appear in relief under the inscription. Unattributed and brief, they read "Somewhere, surely afar, in the sounding labour-house vast of being, is practiced that strength, zealous, beneficent, firm!"²³⁹ Arnold's poem is an elegy to his father who "was not only a good man saving his soul by righteousness, but that he carried so many others along with him in his hand, and saved them...along with himself."²⁴⁰ Both inscriptions on Anderson's obelisk recall Christian stewardship and southern honor. Both suggest that his life centered on his conservative, selfless governance of Tredegar directed toward the well-being of his family and the people who worked for him at the ironworks.

By the time Archer Anderson, Joseph Reid Anderson's oldest son, succeeded his father as president of Tredegar in 1892, he had served on the Board of Directors, as the manager of various production facilities, and as the company Secretary and Treasurer since the end of the Civil War. Under Archer Anderson, Tredegar continued as one of the South's

²³⁹ Matthew Arnold, "Rugby Chapel: November 1857." *Peoms of Matthew Arnold, 1840-1867*. London: Oxford University Press), 1909.

²⁴⁰ Letter from Matthew Arnold to his mother, 1855, quoted in Herbet Woodfield Paul, "Matthew Arnold's Letters," *The Forum*, Vol XX, September 1895-February 1896, 628.

larges iron manufacturers. Little change occurred in the ironworks itself, however.

Traditional products such as spikes, chairs, fishplates, and car wheels remained as best sellers. Gradual physical growth accompanied the manufacture of these products. During Archer Anderson's tenure, Tredegar occupied twenty-three acres and a waterpower system of twelve independent turbines situated so that water was used twice. The physical site comprised a rolling mill of 100 tons daily capacity, four foundries with two cupolas with a capacity of 100 tons daily, a car shop with a capacity of 10 cars daily, a horseshoe mill capable of producing 200 kegs daily, four spike mills and a forge producing 60 car-axles daily.²⁴¹

Horseshoe manufacture expanded and Archer Anderson marketed the product enthusiastically. Under Archer, the company added a horseshoe forge and machine shop and multiple horseshoe stock houses.²⁴² He assured customers about the quality of Tredegar's horseshoes, as he had since the 1870s when Tredegar developed its

²⁴¹ "Andrew Morrison, ed., *The City on the James*, Richmond, Virginia. The Chamber of Commerce Book, 1893, 144-145.

²⁴² Tredegar's horseshoe production peaked between 1900 and 1914, then began to show declining sales during the 1920s. Tredegar's third president, Archer Anderson, Jr., admitted that the outlook was "pretty blue," but believed that economic necessity would cause an upswing as farmers and some businesses would return to the use of horses. In 1928, responding to a letter of inquiry about whether Tredegar would sell its horseshow business, Archer, Jr., quoted a figure of \$60,000 per year for nine years. Archer Anderson, Jr., to L. A. McElroy, United States Horse Shoe Company, Erie Pennsylvania, June 14, 1928.

horseshoe manufacturing facilities, "Our shoes are made of the best charcoal iron and have been extensively introduced and given satisfaction."²⁴³

Tredegar once again began manufacturing armaments at the turn of the century, obtaining contracts from the U.S. Army and the U.S. Navy during both the Spanish-American War and World War I. In 1917, one year prior to Archer Anderson's death, the ironworks added a new foundry for munitions production. During World War I when a third generation of Andersons filled the presidency, Archer Anderson, Jr., wisely focused on cast iron shot and shell, products produced in bulk and according to standardized measurements. The war years were lucrative for the ironworks. Between 1910 and 1914, Tredegar's income after expenses and wages totaled \$495,696. Between 1915 and 1919, the company tripled that figure, earning \$1,858,000.²⁴⁴ And so Tredegar continued to the mid-century in much the same fashion that it had for a century

Production ended at the Tredegar site in 1957. Weeds and vines overgrew factory buildings and discarded machines rusted. Vandals crashed her walls. The neglected facilities became "embarrassing white elephants" for the city of Richmond. Politicians, journalists, and urban

²⁴³ Letter from Archer Anderson to unknown recipient, 1887.

²⁴⁴ "1892-1919", Nathan Vernon Madison, *Tredegar Iron Works: Richmond's Foundry on the James* (Charleston, South Carolina: The History Press, 2015).location 2225 of 3703, e-book.

developers acknowledged a dilemma: the factory was “historically too significant to destroy, yet too expensive to restore, and perhaps too dangerous to permit further deterioration.”²⁴⁵

The vacant Tredegar was an industrial archaeologist's dream, however. Historian Robert Vogel wrote in 1969, “A prime example of the need for industrial archaeological work is the former Tredegar Iron Works in Richmond, a bastion of Confederate ordnance production during the Civil War and an industrial complex of major importance in the South before and after.” Tredegar was then an exemplification of the possibilities of industrial archaeology as a viable historical and academic discipline. When Vogel wrote about Tredegar, the field was relatively new in America (although established in Great Britain) and was still somewhat skeptically viewed as an imposter within academia. Vogel argued, “[Tredegar] stands today in near ruinous condition, totally neglected. A careful study of the remaining buildings and their relationships to the site and each other would reveal a great deal about the firm and its development that could not be told from the extant records.”²⁴⁶

Realistically, however, given the tenuous status of industrial archaeology and the scarcity of money for restoration, Vogel saw no immediate

²⁴⁵ George W. Wilbur, “Historic Site Is a Problem,” *The Free Lance-Star*, August 30, 1972.

²⁴⁶ Robert M. Vogel, “On the Real Meaning of Industrial Archaeology,” *Historical Archaeology* 3 (January 1, 1969): 92, <http://www.jstor.org/stable/25615119>.

possibilities for preserving the Tredegar complex. As a compromise, he called for fully studying and recording the extant remains before further deterioration set in. “A ‘dig’ years hence would produce a minute fraction of the evidence concerning building techniques, site development and manufacturing procedures available today” he continued.²⁴⁷

In the ensuing years, Tredegar was, in fact, preserved to some extent, listed on the National Register of Historic Places and classified as a National Historic Landmark.²⁴⁸ In 1972, the Ethyl Corporation, whose offices stand on a hill north of Tredegar above traces of the former James River and Kanawha Canal, bought the property. Almost a decade passed before Ethyl Corporation began intense archaeological examination and analysis conjoining the little-explored narrative of Tredegar's physical development to its technological history. As Properties Manager for Ethyl – Richmond Division, industrial archaeologist and mechanical engineer, Roy E. Johnson, compiled documentation from Tredegar's extensive corporate records, corresponded with and interviewed surviving workers and their families, and studied the crumbling buildings and water races. Johnson's work uncovered layers of industrial development from the property's origins in 1799 as the site of a flourmill and a tannery through its

²⁴⁷ *Ibid.*

²⁴⁸ Cite dates and documents.

final decades. His study pieced together not only the structural components of change over time, but also the specifics of the use of buildings, raceways and railroad tracks during the everyday operations of the ironworks.

One decade later in 1992, Richmond's Valentine Museum and the Ethyl Corporation commissioned industrial archaeologists Michael S. Raber, Patrick M. Malone, and Robert B. Gordon to author *Historical and Archaeological Assessment, Tredegar Iron Works Site, Richmond, Virginia*.²⁴⁹ At that point in Tredegar's tenuous history as a National Historic Landmark, the Valentine Museum (established in 1898 as Richmond's first private museum and dedicated to preserving Richmond's history) proposed building an exhibition space on the site with funding assistance from the National Endowment for the Humanities (NEH). The Ethyl Corporation agreed to make complementary improvements on areas of the property beyond designated boundaries of the National Historic Landmark area. The National Endowment for the Humanities entered into a Memorandum of Agreement with the Valentine museum, the Advisory Council on Historic Preservation, and the Virginia State Historic Preservation Office stipulating an investigation of significant

²⁴⁹ Raber, Patrick M. Malone, and Robert B. Gordon, "Historical and Archaeological Assessment: Tredegar Iron Works Site,."

archaeological resources affected by the project and appropriate recovery of data from these resources.

The Historical and Archaeological Assessment focused on identifying a spatial baseline for developing interpretative components of the proposed exhibition site and identifying the relevance of surviving structures and artifacts. Raber, Malone, and Gordon noted that historical monographs, unpublished theses, magazine and journal articles, and academic course papers informed their report, but explained that these background materials lacked interpretation or analysis of the historic landscape, site development, or industrial processes associated with the iron works. To fill this informational gap, their methodology focused on three components: detailed study of historic context and site development; visual inspection of building, landscape, and waterpower features; and subsurface sampling to interpret the distribution and potential significance of fill deposits and large buried features.²⁵⁰ The well-documented report brings the expertise of each author in industrial archaeology, waterpower, and iron manufacture to multiple conclusions. It also synthesizes the work of previous experts in Tredegar's history and in analysis of Tredegar's water rights and system of waterpower. While

²⁵⁰ Michael S. Raber, Patrick M. Malone, and Robert B. Gordon, *Historical and Archaeological Assessment: Tredegar Iron Works Site*, Organization Records Collection (The Library of Virginia, Richmond, Virginia, n.d.), 1-7.

comprehensively justifying the relevance of the Tredegar site to industrial history, not all components of the report represent Joseph Reid Anderson and Tredegar favorably. The authors conclude that Tredegar's management restrained growth, failing to experiment with steel products and to look to new sources of raw materials. They continue, "...Tredegar managers held back. Instead they searched for market niches where the techniques they had used before the 1870s could still turn a profit. These niche markets faded; so, too, did Tredegar.²⁵¹

The timeline of this conclusion is pertinent. During Joseph Reid Anderson's lifetime, technologies of steel production and of steam power displaced the dominance of traditional methods of iron production and of waterpower. These innovative advances were not universal or rapid and they did not obviate the relevance of either iron or waterpower during the nineteenth century. Innovative technologies and their products co-existed with traditional technologies for decades and their demand would endure well into the twentieth century. The co-existence of old and new led entrepreneurs like Joseph Anderson to rational decision-making based on circumstance rather than to redundancy.

As a southern business with a national reputation, Tredegar's corporate identity straddled business models. Under Joseph Reid

²⁵¹ *Ibid.*, 31.

Anderson, the company neither wanted to⁷ move into the constructs of mega corporations that were developing in the steel and railroad industry nor was a rapid rush to innovative technology advisable. With family members in key positions, a hierarchical organizational structure was neither requisite nor productive. Interpersonal communication, institutional memory, and inherited systems did not lead to reduced profits or to corporate inefficiency in nineteenth century Tredegar.

To classify Tredegar as a company in decline after the Panic of 1873 ignores the fundamental fact that Tredegar continued as a major southern iron manufacturer into the twentieth century. This classification also overlooks Tredegar's correspondence to similar iron manufacturers in all regions of the country. The reputation of the ironworks in the Richmond economy and in southern iron manufacture held during Joseph Reid Anderson's lifetime. Simultaneously, the company maintained an identity as a family-owned business and a Richmond institution led by a family intertwined with the city's history.

Decades after Tredegar's closure, a descendant of a branch of the Anderson family that had migrated North in the nineteenth century, himself an engineer, visited the remnants of the ironworks. Shaking his head at antiquated machinery, rusty waterwheels, disintegrating turbines, and crumbling infrastructures of factory and office, he criticized the

company's failure to commit to innovative technologies from the perspective of presentism. "They were not progressive," he announced. "They were backward."²⁵²

Certainly, decisions of Tredegar's management not to modernize during the twentieth century appear unfathomable from today's vantage. In the last decades of the nineteenth century, however, before the death of Joseph Anderson who had built and steered the company through its formative years, through war, and through economic depression, these seemed plausible directions. The company moved in-step with Anderson's values of stewardship while preserving his prestige role among the elite of his community.

Between the Panic of 1873 and Joseph Reid Anderson's death in 1892, Tredegar's trajectory reflected constraints and attitudes attendant on nineteenth-century iron manufactures, and particularly those influencing iron manufacture in the South. Tredegar's proximity to Virginia's prolific natural resources, the cost-effective abundance of waterpower, and the advantages of Richmond's transportation network were strategic advantages that helped Anderson control his company's overhead. Maintaining these advantages and their concomitant

²⁵² Gilliam, General Manager of Hollywood Cemetery, to Lee Ann Cafferata, February 3, 2012.

²⁵² Note 28 *supra*.

profitability, however, precluded taking on the expenses of radical technological change. They steered the company instead toward corporate technological persistence and Anderson's rational business decisions followed this course.

Anderson's decision, outcomes of his personal value system and an approach to business that emphasized corporate survival, ensured the perpetuation of the ironworks. The day after his death, the Richmond Chamber of Commerce passed a resolution citing the breadth of Anderson's achievements, classifying his death as a public calamity and affirming that Anderson had established one of the most important manufacturing concerns in the South.²⁵³ Extolling Anderson for having advanced the "social, charitable, and material interests of the city" during his lifetime and his influence on the political and economic growth of Richmond and the region, Anderson's newspaper obituary reassuringly concluded, "General Anderson's death will cause no change in the operations of the Tredegar."²⁵⁴ The brief summation at the end of a

²⁵³ *The times*. (Richmond, Va.), 09 Sept. 1892. *Chronicling America: Historic American Newspapers*. Lib. of Congress.

<<http://chroniclingamerica.loc.gov/lccn/sn85034438/1892-09-09/ed-1/seq-2/>>

²⁵⁴ *General Joseph R. Anderson Died Yesterday at Isles of Shoals, N. H.*, *Richmond dispatch*. (Richmond, Va.), 08 Sept. 1892. *Chronicling America: Historic American Newspapers*. Lib. of Congress.

<<http://chroniclingamerica.loc.gov/lccn/sn85038614/1892-09-08/ed-1/seq-3/>>.

lengthy narrative of Anderson's character and achievements
encapsulated his life's work for Tredegar's industrial survival.

APPENDIX A: TREDEGAR NET PROFITS, SELECTED YEARS

Table 1. Tredegar Net Profits, Selected years, 1844-1860

Year	Net Profit (dollars)	Year	Net Profit (dollars)
1844	47,730	1850	45,135
1845	75,669	1851	41,654
1846	98,271	1852	72,834
1847	35,500	1853	61,160
1848	35,500	1859	82,827
1849	42,800	1860	103,756

Table 2. Tredegar Net Profits, 1880-1889

Year	Net Profits (dollars)	Year	Net Profits (dollar)
1880	313,199	1885	40,363
1881	186,009	1886	76,233
1882	252,870	1887	128,949
1883	67,896	1888	98,874
1884	21,240	1889	36,627

APPENDIX B: TREDEGAR, 1877



Figure 1. F.W. Beers. Illustrated Atlas of the City of Richmond, Va., Section Q. (Excerpt), 1877. The Beers Atlas shows the late nineteenth century expansion of Tredegar including the spur track of the Richmond and Danville and Richmond and Petersburg Railways across the property. The railroad lines approximately mark the separation between the upper and lower levels of the ironworks that enabled the company to maximize the power obtained from water rights.

APPENDIX C: TREDEGAR SITE PHOTOGRAPH

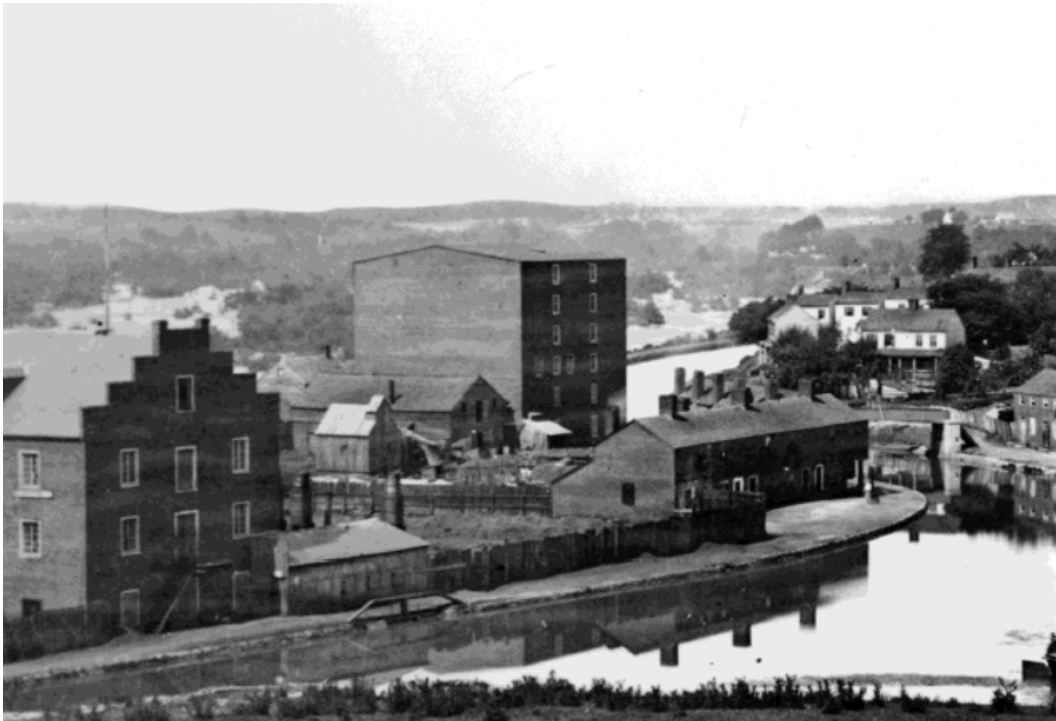


Figure 2: View looking southwest above James River and Kanawha Canal, circa 1865-1870.

APPENDIX D: TREDEGAR PROPERTY MAP

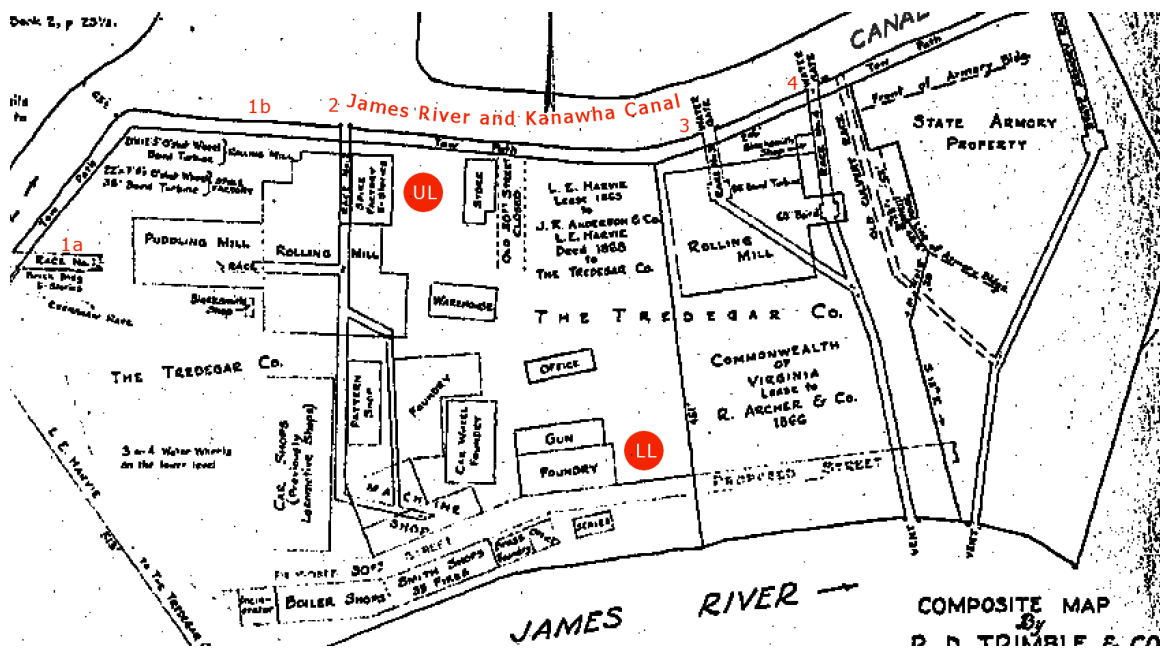


Figure 3: Composite map draw by R.D. Trimble, consulting engineer to Tredegar Company, 1933. Roswell D. Trimble, head of R.D. Trimble & Co., combined information from Tredegar's historic maps in 1933 to clarify the broad spatial arrangement and chronology of sections of the Tredegar property. State Armory property that Tredegar first leased from the Commonwealth of Virginia and purchased in 1886 is in the upper right. Annotations in red indicate the following elements. UL and LL contained in red circles indicate the upper and lower levels between the James River and Kanawha Canal and the James River. Numbered areas show the placement of raceways. Managers moved raceway 1 from the 1a location to the 1b location during the 1880s to more efficiently direct the flow of water to power buildings. Raceway 2 extended from the Canal to

the River and the machines and buildings requiring the most power extended along its track. A spike factory, pattern shop, and machine shop are to the east of Race 2 (top to bottom). Just below the spike factory, Race 2 intersects with a rolling mill.

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BIOGRAPHY

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