Johnson Steel Street Rail Company
(Lorain Steel Company)
(U.S. Steel, Moxham Works)
(Johnstown Corporation)
(Johnson Company)
525 Central Avenue, on Stony Creek River
Johnstown
Cambria County
Pennsylvania

HAER No. PA-271

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

Historic American Engineering Record
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HISTORIC AMERICAN ENGINEERING RECORD

JOHNSON STEEL STREET RAIL COMPANY
(Lorain Steel Company)
(US Steel, Johnstown Works)
(Johnstown Corporation)

HAER No. PA-271

Location:	525 Central Avenue, along Stony Creek, Johnstown, Cambria County, Pennsylvania
Date of Construction:	1887-1911
Builders:	Johnson Steel Street Rail Company (1887-1894), Lorain Steel Company (1894-1901), US Steel Corporation, Lorain Division (1901-1983)
Present Owner:	Johnstown Corporation
Present Use:	Foundry: steel castings, steel shaping and treating
Significance:	Founded by Thomas L. Johnson, who was later Progressive mayor of Cleveland, Ohio, and British-born engineer Arthur J. Moxham, the Johnson Steel Street Rail Company produced the Jaybird rail, patented by Moxham and used extensively in the nation's burgeoning street railways. The Johnstown works was subsequently purchased by US Steel and continued to produce steel shapes and foundry castings until about 1983. Since 1984 the works has been operated by the Johnstown Corporation.
Project Information:	In February 1987, the Historic American Engineering Record (HAER) and the Historic American Buildings Survey (HABS) began a multi-year historical and architectural documentation project in southwestern Pennsylvania. Carried out in conjunction with America's Industrial Heritage Project (AIHP), HAER undertook a comprehensive inventory of Blair, Cambria, Indiana, Fayette and Westmoreland counties as the first step in identifying the region's surviving historic engineering works and industrial resources.

This study of the Johnson Steel Street Rail Company developed from the HAER Inventory of Cambria County and was carried out via a contract with HAER by James Alexander, Jr., professor in the Political Science Department at the University of Pittsburgh, Johnstown. Dr. Alexander's study resulted in this manuscript, which formed the basis for his book Jaybird: A.J. Moxham and the Manufacture of the Johnson Rail (Johnstown, PA; Johnstown Area Heritage Association, 1991).

Historian: James R. Alexander, Jr., 1988

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CHRONOLOGY OF THE JOHNSON STEEL STREET RAIL COMPANY

JOHNSTOWN, PENNSYLVANIA

1883 Johnson Steel Street Rail Company (A.J. Moxham, President) chartered under laws of Kentucky with offices in Louisville, Kentucky. Moxham contracts with Cambria Iron Company to roll experimental girder rail design from steel, and sets up a laying out yard in Conemaugh Borough.

1885 Moxham leases the abandoned Iowa Barbed Wire Mill near the Dell Tannery in Woodvale as first switchworks site.

1887 Company constructs switchworks plant along Maple Avenue in Woodvale Borough.

1888 Moxham designs and constructs a steel foundry and rail rolling mill in the new Town of Moxham. Company rechartered in the Commonwealth of Pennsylvania as the Johnson Company (A.J. Moxham, President). Switchworks remained in Woodvale. Company constructs the Johnstown and Stony Creek Railroad.

1889 The Johnstown Flood destroys the Woodvale switchworks, while Moxham plant uneffected. Salvaged switchworks operations moved to Moxham plant site. A two-story General Office Building is constructed.

1890 Johnson Company rebuilds and electrifies the Johnstown Passenger Railway Company, constructing car barns on the west side of Central Avenue near to the General Office. Third story added to the General Offices. Moxham Fire Company Engine House built.

1891-2 Machine Shop and Laboratory buildings constructed near the General Office.

1893 Fire destroys car barns and Johnson Company rebuilds them across Central Avenue from the switchworks (its current location). A Large Drawing Rooms and Laying Out Floor Building constructed next to General Office.

1894 Johnson Company designs and begins construction of a fully integrated rail plant, with blast furnaces and coke ovens, in Lorain, Ohio. Company officially splits into Johnson Company (Ohio) and Johnson Company (Pennsylvania), with the latter concentrating on switchworks.

1895 Rail mill operations of the Moxham plant moved to the Lorain site. The Johnson Company's subsidiary the Steel Motor Company is moved from Cleveland to the Moxham plant and housed in the old Track Welding Shop Building.

1896 Johnson Company petitions the New York Stock Exchange to list 6% 20-year bonds, listing the value of the capital plant Lorain at $ 3.455 million and the Johnstown plant at $ 1.773 million. R.G. Dun issues negative report on Johnson Company finances.

1898 Johnson Company reorganized as the Lorain Steel Company, with the Johnson Company (Ohio and Pennsylvania) to retain its name until 1899. Lorain Steel itself purchased by Federal Steel Company, with controlling interest in Johnson Company (Johnstown plant) signed over October 17, 1898. Lorain Steel retains its own name.

1899 Johnson Company rechartered as the Lorain Steel Company, a wholly owned subsidiary of Federal Steel.

1901 Lorain Steel merged into the United States Steel Corporation, retaining its identity as separate unit. Moxham plant continues to be known as the Lorain Steel Company.

1902-7 US Steel converts Johnstown plant into a maintenance mill for its other steel and industrial operations, constructing permanent Upper and Lower Shops, a Metallurgical Department, and expanding the Steel Foundry. Plant continues its role as major (international) producer of trackwork for streetcars and railroads.

1922 Second steel foundry (No. 1) constructed for small castings and plant begins production of mining cars.

1935 In an internal reorganization within US Steel, the Moxham plant consolidated into Carnegie-Illinois Steel Corporation and becomes known as its Lorain Division.

1943 A change in designation: the plant becomes known as the Johnstown-Lorain Works of Carnegie-Illinois Steel Corporation.

1948 A second change in designation: the plant becomes known as the Johnstown Works of Carnegie-Illinois Steel Corporation.

1951-3 In an internal reorganization of US Steel, the plant becomes known as the Johnstown Works of US Steel Corporation.

1959 US Steel discontinues production of trackwork. The Johnstown Works becomes devoted entirely to maintenance of other US Steel operations.

1967 US Steel expands the roll capacity of the Johnstown Works with the installation of a 30-ton electric furnace in its No. 2 Foundry.

1984 US Steel Corporation closes Johnstown Works and sells all of its assets to the Johnstown Corporation, which currently operates the plant as a foundry and fabricating complex.

INTRODUCTION

The year was 1869. The aftermath of the Civil War was still the dominating influence throughout most of the country. Late the previous year, Albert Johnson moved his family, his wife Helen and sons Thomas and Albert, back to Louisville, Kentucky where he had relatives. Johnson had always been a fairly nomadic man, moving his family around in search of economic opportunities. Before the War, he moved back and forth between a summer home in Blue Spring, Kentucky where his family had long owned property, and his winter home in Beaver Bayou, Arkansas where he had established a cotton plantation with over one hundred slaves. [1]

When the Civil War started, Johnson's allegiance to his class was apparently stronger than his personal aversion to the institution of slavery, and he organized a company in the Confederate Army in Helena, Arkansas. Appointed a colonel, he would ultimately rise to the rank of brigade commander. In late 1861, he joined General John C. Breckinridge and moved his family to Atlanta. But after a year in Atlanta, Johnson began moving his family northward, and by war's end, had located in them in Staunton, Virginia.[2] Penniless and unemployed, Johnson moved his family to Louisville in 1865. Failing in several enterprises and borrowing from family and friends, he returned to Arkansas in an unsuccessful attempt to reestablish cotton farming with hired freedmen. He then moved on to several unsuccessful enterprises in Evansville, Indiana, and in late 1868, moved back to his brother Jilson's farm near Louisville.[3]

By this time, Johnson's eldest son Thomas was in his fourteenth year and had only one year of formal schooling. In January 1869, a position was secured for him in the Louisville Rolling Mill by Johnson's sister Dullie, who was married to one of the principal owners of the mill, Captain Thomas Coleman.[4] After four months working in the offices of the rolling mill, Tom Johnson was offered a bookkeeping job in the Fourth and Walnut Street office of the Citizens Passenger Railway Company, the smallest of Louisville's three horse-drawn street railways and an enterprise that had recently been acquired by a business partner of Coleman's, Alfred V. du Pont.[5] The next year, du Pont appointed Tom's father to the position of superintendent of the line.[6]

Starting in the street railway business just shy of his fifteenth birthday, Tom Johnson quickly mastered all aspects of the enterprise. Originally assigned to bookkeeping and making change packets for car drivers, he displayed real acumen for not only the intricacies of company balance sheets, but other more technical aspects of the business as well. Elevated to secretary

of the line within the year, Tom assumed the position of superintendent at the age of 19 when his father was appointed chief of police for the City of Louisville in 1873.[7]

By 1873, Tom Johnson had invented and patented an innovative coin fare-box for street railway cars[8] and begun merchandising it by traveling to several midwestern cities. On one such trip to St. Joseph, Missouri, his route brought him through Indianapolis where, attempting to sell fare-boxes to William English, owner of the small, dilapidated Citizens Street Railway Company, he was offered instead majority stock in the company.[9] Using royalties from his fare-box patents and a personal loan from Alfred V. du Pont's younger brother Bidermann, Tom purchased the line from English, rebuilt it, and reorganized its lines and fare structure.[10] He would repay his outstanding personal loans on the line by 1882, and sell the company outright several years later at a 100 per cent profit on his investment.[11]

Johnson thereupon established a successful pattern of purchasing unprofitable, rundown or fragmented horse-drawn street railway lines. While supervising the operations of the Citizens Passenger lines in Louisville for the du Ponts, Johnson had developed a sophisticated understanding of the cost structure of operating street railway lines. He recognized that the basic value of a street railway line was not in its capital stock, but in the location and durability of its right-of-way franchises.[12] After analyzing a line's franchises and revenue potential, he would purchase all of the company's outstanding stock, expand and/or combine existing routes between suburban communities and the downtown center of a major city until through routes were established, reorganize both the line's operations and fare structure, and, more often than not, rebuild the line's trackwork.

When electrification brought the operation of street railways within the financial reach of most modestly-sized cities,[13] Johnson's unique understanding of their operation became even more invaluable. The demand for electrification of existing horsecar (and later cable) systems seemed unlimited, while other smaller communities rushed to build a streetcar line from scratch. At this point, Johnson's understanding of the technical aspects of the design of railway cars and track structure, combined with his understanding of street railways as a business enterprise and object of investment opportunity, solidified his status as innovator as well as entrepreneur.

By the late 1870s, Johnson had designed a girder-based rail section for street railways that he believed would both strengthen and prolong the structural life of street railway rails while providing a more comfortable ride for passengers.[14]

The rail design would both reduce capital costs and generate revenues through expanded ridership. Patented in 1883,[15] the Johnson Rail was to dominate rail design for street railway systems for the next thirty years. Originally designed for horsecar systems, the rail section was so technologically advanced and versatile that when street railways converted to either cable or electric motive power, the section could be easily redesigned.

Although his major fame came from his car fare-box designs and the Johnson girder rail itself (both heavily identified with electrified streetcars), virtually all of Johnson's patented trackwork designs were specifically tailored to cable-powered street railway systems. By the time many major cities were considering or had begun to install cable systems in the mid-1880s,[16] Johnson had designed and patented an impressive amount of specialty cable trackwork, notably yokes, crossings, curves, and frogs, as well as designing braking systems for cable cars and the layout of cable systems themselves.[17] In 1885, he patented a shallow conduit cable system designed to circumvent the costliness of the traditional deep conduit Hallidie system (first introduced in San Francisco in 1873).[18] Unknown to most, the rail and trackwork design for electrified systems commonly associated with the Johnson Company was not developed by Tom Johnson but rather by the Company's staff engineers under the direct supervision of Arthur J. Moxham.

In the spring of 1879, Johnson unsuccessfully bid for a new suburban street railway franchise in Cleveland, Ohio. Failing that, he decided to purchase an existing suburban line in Cleveland, the Brooklyn Street Railroad. Blocked from establishing through routes by franchise holdings of the Mark Hanna-owned West Side Street Railway Company, Johnson successfully sued to use Hanna's right-of-way, thereby connecting his suburban lines by running horsecars over Hanna's track through the downtown Cleveland. The institution of a simple and cheap transfer system made the line extremely popular.[19]

Over the next five years, Johnson expanded his existing lines, developed new routes, secured the first throughline franchise in the City's history in 1883, and culminated his dominance of Cleveland's street railways by gaining a 25-year franchise renewal for the Brooklyn line in 1885.[20] Between 1888 and 1890, all of the Cleveland lines were converted to either cable or electricity.[21] And with electrification, the investment value of Johnson's street railway holdings in Cleveland skyrocked. Until electrification, his investments in street railway companies had proven profitable because he had secured undervalued franchises on potentially valuable routes, had upgraded the systems' capital stock with state-of-the-art equipment, and had reorganized (and

thereby made more efficient) the systems' route and fare structure.

With electrification, the value of such holdings as investments could be magnified dramatically through reduction of operating costs, expansion of ridership on existing routes (which became noticably cleaner, faster, and more reliable), and extension of routes into growing residential sections of cities. To convert existing systems, a company would have to build a power plant and car barns, string wire, purchase new cars and lay all new (heavier) track along existing right-of-ways. All that was needed was a flexible source of capital.

Johnson had several sources of flexible capital. Originally, he parlayed his coin fare-box patents and a personal loan from Bidermann du Pont into an extremely successful investment in Indianapolis. Shortly thereafter he invested in street railways in Cleveland, again using private loans from both Alfred V. and Bidermann du Pont, and the profits from his Indianapolis system. By the mid-1880s, Johnson was realizing significant returns from his railway holdings and the Johnson Steel Street Rail Company, both of which were accompanied by extensive property investments in their respective communities. Johnson became legendary for the railway investments both he and his brother Albert L. Johnson developed in this transition period,[22] and his advice on such investments was highly prized.[23] He was by 1900 an extremely wealthy man.[24]

But Johnson's interests turned to politics, and he became a leading progressive and devotee of Henry George.[25] He was by all accounts a thumping tent speaker and witty master of reparte with audiences at campaign stops.[26] After two fairly undistinguished terms in the U.S. House of Representatives (1891-1895),[27] Johnson emerged as a major political figure in Cleveland, serving four terms (1901-1909) as Mayor.[28] Prior to taking office, he had divested himself of virtually all of his holdings in street railways and the Johnson Company, though he continued to advise his brother and friends on such investments.

Deeply committed to progressivism by this time, Johnson became the champion of the common man being exploited by big capital interests. He pressed successfully for public acquisition of privately-held service franchises, such as streetcar lines, water and electric utilities.[29] A dramatic turnaround from his earlier entrepreneurial days of accumulating capital wealth through acquisition of monopoly franchises, Johnson succeeded in consolidating Cleveland's streetcar lines through municipal ownership.[30]

Johnson's last years were quite difficult. Revered by many around the country as one of the great progressive mayors of his day and financial confidante to some of the major figures in the street railway and steel businesses, Johnson felt compelled to try to resuscitate his brother Albert's investments after the latter's premature death in 1901.[31] After the Panic of 1907, Albert's investments had lost so much value that Johnson began to support them with his own capital.[32] His son Loftin was a constant drain on Johnson's finances, never able to make his own way in the various failed business attempts capitalized by his father.[33] Johnson also continued to support his beloved daughter Elizabeth, who had married disappointingly in 1907, given birth to a daughter, and was divorced a year later.[34]

After his defeat for reelection to a fifth mayoral term in 1909,[35] Johnson returned to the unhappy management of his own financial affairs. Albert's estate had become virtually worthless, taking with it much of Johnson's personal wealth. He and his wife gave up their elaborate home in Cleveland to move into a small apartment in 1910.[36] Thomas Johnson died the next year at the age of 57.[37]

I. THE JOHNSON GIRDER RAIL

By the time Tom Johnson purchased the horse-drawn Citizens Street Railway Company in Indianapolis in 1876, he was intimately familiar with every aspect of the business. Though only 22 years of age, Johnson had personally supervised the operations of the Citizens Passenger Railway Company in Louisville for over three years. Taken over by the du Pont brothers in 1869, the Louisville line was undercapitalized and losing money. Within two years, with Johnson controlling the finances and organizing the routes and fare structure, the line was back on its feet.

But Johnson grew to understand other dimensions of the business as well. He tinkered with different methods for care and feeding of the railway's horses, restructured stables, and instituted series of watering troughs along routes.[38] With the installation of his car fare-boxes, he was able to reorganize how passengers embarked and disembarked from cars, therey allowing cars to keep to more predictable schedules. Johnson most of all came to understand track maintenance.[39] Aside from the stock of horses, track laying was one of the largest capital expenses of a railway line. And while track maintenance, repair and replacement was a relatively small element of a company's operating costs, Johnson recognized that passenger convenience and comfort was primary to building ridership. A rough ride due to poorly-laid track, or service disruption due to track repair, caused potential riders to walk to other lines.

Curiously enough, the average life of a piece of railway trackwork was approximately the same as for a good railway horse or mule.[40] Using a design borrowed from early railroads in the 1830s, street railways constructed their track in fairly crude fashion. The roadbed was dug out by hand and a layer of stone put down. Seven-foot crossties were then set in, approximately every three feet along the route. On top of the crossties were then laid yellow pine beams (called "stringers") that would form the line of the track route. Stone was then filled in to the top of the stringers. And finally, a flat strip of iron (a "strap rail") was spiked directly into the top of the stringer.[41] The flanged wheels of the railway car would ride on the inside edge of the strap rail.

Given the technology of the period, the strap rail spiked onto wooden stringers was the most effective and efficient method of running railways in cities. It was however not without its problems, and the problems proved costly. Made of almost pure (carbon-free or "wrought") iron, strap rails tended to wear unevenly and deteriorate in heavy use circumstances. Redesigning the face of the strap rail to an L-shape increased the wear surface, but did not radically prolong the structural life of the rail which had been estimated at about three to four years.

The roadbed itself was subject to extensive deterioration from both the elements and from other vehicular traffic. Naturally, the wooden crossties and stringers began to decompose in short order, subjected to natural elements as well as a constant dosage of horse manure and urine.[42] Even if the section of strap rail itself were still in good working order, an entire section of road bed had to be re-excavated to replace rotted out crossties and stringers.

Moreover, the presence of other vehicular traffic posed a myriad of problems for railway companies. Freight wagons supplying commercial establishments in a downtown area with everything from produce to finished products quickly adopted the tactic of running one set of their wheels along the strap rail, the smoothest line in an otherwise very uneven "paved" or dirt roadway. Because the strap rail protruded up from the road surface, the wagon wheels would ride up against it, loosening both the spiking and the roadbed balast packed around the stringer. Since the gauge of the railway was too narrow for wagon wheelbases, the opposite set of wagon wheels rode in a set path on the outer side of the opposite railway rail, causing the roadway in both tracks to become pocked as water (in the summer) and ice (in the winter) would settle in the grooves carved by constant use.[43]

The protrusion of the strap rail caused no small measure of civil discontent. City streets were designed as very narrow thoroughfares, built for traffic of small wagons and carriages. In some cities, freight wagons were confined to certain "broader" streets to allow other vehicular traffic to avoid their constant stopping and unloading. The construction of street railways forced wagon and carriage traffic to share the narrow roadways, causing inconveniences to those waiting for horsecars to load and unload passengers (often upon demand) and creating an endless stream of controversy often played out in angry meetings of borough councils. And convenience was not the only measure of the public's displeasure. Crossing the rail head-on or diagonally was a constant and continuous jarring experience that tried both the patience of freight drivers and the comfort of the well-to-do in their frail carriages.[44] Also, wagons and carriages that tracked along the rail had to at some point "turn out", i.e. leave the track to either enter a side street or alleyway or stop before some hotel, merchant establishment, or warehouse. Turning away from the strap rail was difficult enough, given the grooving of the roadway and the diagonal crossing of the other rail. But turning against a protruding rail was extremely difficult, especially for a loaded freight wagon. Naturally, the consequences of these experiences were harsh on the axles, suspensions, and wheels of wagons and carriages, for which railway companies and politicians were considered, in cursed whispers, accountable.

Finally, the trackwork presented a maintenance and repair problem that only technological innovation could address. The structural composition of the iron strap rail and its construction onto wooden stringers encouraged "bending" in the rail between crossties and rail joints, causing a bobbing effect in the ride. This was accentuated when the flanged wheels of the horsecars crossed spiked sections of the rail and rail joints. Aside from the "rough ride" produced by the unevenness of the rail, a significant toll was paid by the running gear of the horsecars themselves.

Railway companies attempted to even out the rail track by adopting an L-faced rail (which allowed spiking away from the track of the flanged wheel) and under-setting rail joints with a 3-4 foot strip of iron set into the stringer. But the constant bending of the rail and the weakness of its composition caused rails to twist, cup and/or protrude unevenly at joints, frequently damaging the wheels or running gears of horsecars as they passed over. Unfortunately, the only method of evening out the track was to constantly replace track sections, an extremely costly enterprise.

Having dealt personally with both the technical and political problems of street railways, Johnson devised a rail section that he hoped would increase wear life, eliminate rail bending, accommodate even jointing, reduce inconveniences to other vehicular traffic, and reduce trackbed deterioration.[45] Such a design would, needless to say, revolutionize street railway track systems. Working on the problem in Indianapolis, Johnson designed a rail section that combined the commonly-used street rail L-face with the strength of a girder section more commonly adopted by railroads. The railroad T-rail design had long been considered too costly for capital-poor street railway companies, and not adaptable for the narrow streets and tight corners of downtown areas of cities.

Johnson's rail section, called a street girder (or later a "Jay-Bird" after its peculiar profile), did in fact accomplish most of these objectives. The girder design, flanges connected by a vertical web, improved so greatly the stiffness of the rail that the rail could be spiked directly onto the crossties without use of stringers. Variations in height of the rail could be achieved by means of a cast iron (and later steel) chair. To increase wear life, Johnson increased the thickness of the section head. Evenness and comfort of ride was improved by splicing the rails together at joints with cast steel splice-plates and by spiking the rails to crossties through the bottom flanges rather than the ride surface of the rail.

But the most interesting improvement of the Johnson rail was how its design accommodated the unique problems associated with laying street railway track on already heavily used, narrow city streets. The offset flange opposite the rail head was purposely made wider to allow wagon and carriage wheels to track easily and precisely without actually riding on the "paving" (or balast) immediately abutting the track. Because the track was standardized at narrow gauge (4' 8 1/2"), grooving on the side opposite the flange used for tracking still occurred. Packing balast around both of the top flanges allowed a lower profile in the street and less of an obstacle to crossing vehicle traffic. The rail head flange itself was purposely rounded on the outer edge to make crossing less of a jar.

Johnson's basic rail section design addressed an intricate set of market problems unique to the street railway business. It reduced track repair and replacement by eliminating stringers, reduced head wear by changing materials, reduced trackbed deterioration by accommodating other vehicular traffic with an offset tracking flange, and dramatically improved the comfort of the ride by rendering rail joints uniform by cast steel splicing. He was confident that the specialty trackwork could be cast in steel using the girder design. But the rails themselves could not be

cast, they had to be rolled. The only question became whether his revolutionary rail section design could be produced at reasonable cost.

II. FAILED FIRST ATTEMPTS: THE BIRMINGHAM AND LOUISVILLE YEARS, 1878-1883

About 1877, Johnson traveled back to Louisville from Indianapolis to explore the production question with Alfred V. du Pont, his mentor in the street railway business, and Arthur J. Moxham, the Assistant Superintendent of du Pont's Louisville Rolling Mill.[46] By this time, Alfred du Pont and his younger brother Bidermann had long since sold out their interests in the du Pont Power Agency they had run in Louisville since the 1850s, and invested their gains in a wide range of enterprises in the Louisville area, including the rolling mill, a paper mill, a street railway line, two separate daily newspapers, a lead mine, a coal mine, and an artesian well company.[47]

The Louisville Rolling Mill had been chartered in 1850 by William Belknap and Thomas C. Coleman, Sr., and was operated largely as a Coleman family business both before and immediately after the Civil War.[48] Coleman had come to the United States from Ireland in 1834, settled in Louisville and became a successful steamboat captain. After purchasing controlling interest in the rolling mill, he organized and managed its operations until his death in 1861.[49]

Coleman married twice and sired fourteen children, five by his first wife in Ireland, and nine by his second wife, Dora Morgan.[50] The most prominent among his sons was Thomas C. ("Captain Tommy") Coleman, Jr., born in Ireland to his first wife in 1824, who succeeded his father as President of the Louisville Rolling Mill Company.[51] In 1849, he married Dulcinea (Dullie) Johnson, daughter of General William Johnson, a prominent farmer and state legislator.[52] It was Captain Tommy who, in 1869, took into his household the fourteen-year-old son of his wife's destitute brother Albert and the fifteen-year-old son of his stepmother's sister Katherine Morgan Moxham. Early in that year, he arranged employment for both Tom Johnson and Arthur Moxham in the offices of the rolling mill.

After the premature death of his father Egbert, Arthur Moxham at the age of fifteen came to the United States from Wales in 1869 to live with his aunt Dora Coleman in Louisville.[53] While Johnson left the rolling mill to work in the offices of the du Pont street railway, Moxham stayed with the mill as bookkeeper, learning the merchant mill business as both an enterprise and as a technical process.[54] By 1877, Moxham had risen to Assistant

Superintendent and had married one of Captain Tommy's daughters Helen Jilson Coleman.[55]

The Johnson rail design presented the du Pont brothers and Captain Tommy a unique opportunity for investment. The du Ponts had bought into the Louisville Rolling Mill Company in 1875, and restructured and refinanced the entire operation as a leasing agent of mill properties in 1877.[56] Already related by marriage and connected in other business dealings around the city,[57] the du Ponts and Colemans had now formed a major business partnership. Together with the du Pont's developing coal interests in nearby Central City,[58] the potential for expansion of the iron rolling business was unavoidable. Ironically, the most immediate expansion came not in their Louisville properties, but in the southern region opened up by the Louisville and Nashville Railroad in 1872.[59]

Lured by the promise of excellent quality coal and valuable price discounts by the Pratt Coal Company in Birmingham, Alabama, Alfred du Pont, Coleman and several other prominent Louisville businessmen financed the organization and construction of the Birmingham Rolling Mill Company, the first significant merchant mill in the southern coal fields.[60] The layout of the mill and its product line (iron bar, sheet, plate and guide mill irons) has been attributed to Moxham.[61] Construction was begun in 1879 and the mill began operations in 1880 with W. B. Caldwell, Jr. as President and Thomas Ward as general manager.[62]

From the outset, the mill proved to be a good investment as a merchant mill for rolling iron products. However, the anticipated conversion to rolling steel products was slowed by the quality of southern ore and the reticence of capital markets to develop properties in the relatively unknown southern market.[63] Moreover, Moxham's efforts to roll the Johnson rail from iron were totally unsuccessful.[64]

Undaunted, Coleman and du Pont organized the Louisville Iron and Steel Company in 1880, with Caldwell as President and Bidermann du Pont as Vice President, and brought Moxham back from Birmingham to reorganize their Louisville Rolling Mill Company's Clay Street plant as a merchant mill to roll iron, tram, and T-rails.[65] Their plan however was more ambitious. They intended to try once more to roll the Johnson rail from iron, and if that failed, to convert to rolling steel rails. And while Moxham was never able to successfully roll a Johnson girder in Louisville, his roll process had become sufficiently refined that the du Ponts incorporated a distinct company to channel capital investment into the production and marketing of steel girder rails. Thus was borne the Johnson Steel Street Rail Company, offices in Louisville, Kentucky.[66]

III. BREAKTHROUGH: CAMBRIA IRON COMPANY AND THE WOODVALE YEARS, 1883-1888

After two frustrating years trying to roll the Johnston rail at the Louisville Iron and Steel, Moxham and Johnson decided to contract the roll process out to an established steel rail producer, of which there were approximately six in the United States. They turned to the Cambria Iron Company, of Johnstown, Pennsylvania. A significant iron and steel producer and innovator since the early 1860s, and producer of the first commercially rolled steel railroad rails in 1871,[67] Cambria Iron had had some experience in rolling girder rail designs out of steel in 1877 for the Clay Street Cable Road in San Francisco.[68] While the roll was not unsuccessful, the production of street girder rails was not a product line that appeared particularly lucrative, and there is no evidence that Cambria Iron pursued the design or the market.

Daniel Morrell of Cambria Iron was approached in March 1883 to see if he were interested adopting the roll process design that Moxham had refined in Louisville for the purpose of rolling steel girder rails.[69] Characteristically a risk taker and a market visionary,[70] Morrell agreed to construct a roll stand using the Moxham designs. After five months of experimentation at Cambria Iron's steel rolling mill, the first successful Johnson girder rail was rolled by June 1883.[71] Moxham moved quickly to patent both the roll designs and the rolling processes,[72] and began to organize a production and distribution apparatus that ultimately would change the face of Johnstown.

Initially the iron castings of specialty trackwork were to be made in Indianapolis, but Moxham was able to contract with John Hannan, operator of the small Fulton Foundry at 726 Centre Street, across from Turners Hall in Conemaugh Borough, to make castings of frogs, switches and curves. He commissioned John McKenna's Machine Shop, two blocks east on Portage Street across from the Gautier Wire Mill, for machine work and hand tools. Railway chairs, tie plates, rods and bolts were secured from Cambria Iron.[73]

With the castings, machine work, and rails contracted, Moxham needed a lay out yard to fit the trackwork before shipping to customers. The yard chosen was a cinder dump on the curve of the Baltimore and Ohio Railroad near Centre and Railroad Streets behind the Hannan Foundry.[74] Several years previous, Daniel Morrell of the Cambria Iron Company had encouraged the Baltimore and Ohio to build a spur from south of Johnstown into the Cambria Iron mill to give him shipping access to southern markets. This spur was now used also to ship rails out of the steel rolling

mill in Millville to the Conemaugh site, where Moxham had erected a temporary roof on four posts, installed a hydraulic jack to bend the rails into precise curves, and pieced the trackwork together.[75]

The Johnson Steel Street Rail Company began actual operations in Johnstown in June of 1883 after Cambria Iron successfully rolled the first girder rail section. Initially Moxham employed five yardmen at the Conemaugh site, where trackwork was cut, bent and fitted by hand. He established a small office on the first floor of the Wehn Building at 421 Main Street (across from the Presbyterian Church), where he employed a clerk and an errand boy. On the second floor, Moxham and his wife Helen furnished a small apartment as their first residence in the city.[76]

In its first year of operation, the Company purchased over 23 tons of steel girder rails from Cambria Iron, in five different sections based on the Johnson Jay-bird design, and the Conemaugh plant site engaged over 30 men fabricating trackwork.[77] Recognizing the market potential of the trackwork, Cambria Iron Company included a display of Moxham's rails, frogs, and crossings in its exhibit at the 1883 National Exposition of Railway Appliances in Chicago.[78] Sales literature was still being compiled and printed in the offices of the Louisville Courier Journal.[79] By the next summer, the Company had established itself as a railway system contractor as well, and for the first time successfully bid on the construction of a new street railway line.[80] In December 1884, the Company displayed its own rail and trackwork designs at the world's exposition in New Orleans.[81]

With the spread of horse-drawn railway systems throughout mid-sized cities in the United States, and the development of cable-powered systems as a realistic alternative, the demand for well-engineered, high quality, durable trackwork was increasing in dramatic fashion. Moxham realized the open site severely restricted his Company's capacity to keep up with orders, and by late 1884 leased an abandoned barbed wire mill on the northern bank of the Conemaugh River in Woodvale from the Cambria Iron Company.[82]

As a principal mill of the Iowa Barbed Wire Company in the 1870s, the facility had been gutted by fire on October 26, 1881 and abandoned.[83] Cambria Iron took over the facility shortly thereafter for purposes of establishing their own wire mill, but by the spring of 1884, they had moved their equipment to one of their western sites. Astride a major spur of Cambria Iron Company's own railroad tracks, the site was ably suited for Moxham's immediate needs for a permanent facility. He abandoned the Conemaugh site in early 1885 and occupied the upstream half of the Woodvale building. The plant site was operational by

March. By the summer of that year, the Company employed over 40 men at the plant site under supervision of foreman Henry O'Shea.[84]

But contracts for constructing street railway systems and the increasing orders for rails and trackwork compelled Moxham to seek expansion. By June 1886, the Company purchased from Cambria Iron Company a two-acre plot of ground in Woodvale on the upstream side of the Johnstown Woolen Mill.[85] Located on Maple Avenue between 5th and 6th Streets, the new site was to accommodate four new buildings, including company offices. By September, track connections and sidings of the Cambria Iron Railroad were completed to the new plant site.[86] The plant site, buildings, offices, railroad connections and layout yard were completed and the previous Woodvale site closed down in early January 1887.[87] The new plant was fully operational by the end of the month.

By June 1887, Moxham was forced to expand the plant's main buildings, forge and general offices[88] and, contemplating manufacturing his own castings and rails, began to look for property on which to locate two blast furnaces and a rolling mill. After originally considering property adjacent to the Cambria Iron Works in Franklin,[89] the Company opted for purchasing the extensive properties of the Von Lunen farm along the Stony Creek River south of Johnstown. By December 1887, the farmland was purchased for $ 65,000 and the necessary rights-of-way to connect the new mill to the Cambria Iron Company via the Cambria and Somerset branch of the Baltimore and Ohio Railroad were secured.[90]

IV. HEYDAY: THE MOXHAM RAIL MILL AND STEEL FOUNDRY, 1888-1895

The Moxham plant site was to occupy almost sixty acres of bottom land on the eastern bank of a sweeping bend in the Stony Creek River, some two and a half miles upstream from Johnstown.[91] Excavations for the foundations of the major buildings were begun in early November 1887 causing no little consternation when an old gravesite, dating back as far as 1811, was uncovered.[92] Beneath the iron and brick structures, where the heaviest machinery was to be located, fourteen foot cement foundations were poured. Four cubic foot cement pads were set down for roof supports.[93]

The basic components of the Moxham mill were completed by August 1888 under the supervision of A.H. Walker.[94] They included the rolling mill with accompanying furnaces and coke ovens, the steel foundry, a pattern and machine shop, a blacksmith shop, a boiler house, and a pump house located on the upper bank to channel

water to the rolling mill. The rolling mill and steel foundry were iron buildings, the boiler house made of brick and the remainder of the structures wood framed. A small mill office was built next to the rail mill near the river bank. By the end of the year, the company was rechartered and the name shortened to the Johnson Company.[95]

To assist in plant construction, a brickworks was established near the Moxham Bridge, completed by mid-summer.[96] Fabrication work, including specialty trackwork and layout, continued at the switchworks in Woodvale. The narrow-gauge railroad spur connecting the plant with both the Woodvale switchworks and the Cambria Iron steel rail mill northwest of Johnstown was completed by early spring 1888.[97]

Connection with the communities to the north was achieved by extension of the Valley Pike, a private toll road that ran from Grubbtown on the western bank of the Stony Creek about a mile south of Johnstown (the site of the Osborne Passenger Station of the B & O Railroad) into Moxham via a newly constructed iron and stone bridge -- later called the Moxham Bridge. A toll gate was erected on the Meadowvale side of the Stony Creek in October 1890 to gain revenues from horses, teams, and foot passengers. The road would run south through the Town of Moxham with the plant laid out on the right side between the road and the river bank and the planned residential community rising up on the left. Within the year, it would be extended across the Stony Creek again (at the Ferndale Bridge) and out toward the village of Benscreek. By 1891, the road was named Central Avenue.[98]

The rail mill itself was an iron truss building, running north to south and measuring 500 x 175 feet, to which was adjoined (on its eastern side) the boiler house containing eighteen 150 horsepower boilers, each with a 32-foot iron chimney, which generated steam for the operation of engines throughout the plant.[99] Moxham initially fueled his mill by burning natural gas, but when supplies proved undependable and costs rose due to increased domestic and public use, Moxham became one of the first steelmakers to substitute an artificial gas. The fuel was produced by the Archer process from heating crude petroleum by burning soft coal brought to the plant from local coal mines.[100] Three gas generators supplied fuel for the six furnaces used to heat the blooms brought in from the blooming mills of both the Cambria Iron Company and plants in the Pittsburgh area.[101]

Blooms weighing up to 1,770 pounds were delivered by a portable crane on tracks to the northern end of the rolling mill, where they were entered into the heating beds fired by five Gagaden regenerative open hearth furnaces by two overhead traveling cranes. Heated blooms were withdrawn from the furnaces by large

tongs suspended from an elevated shaft controlled by ropes and carried on a 200-foot roll train, powered by a Galloway 2,500 horsepower engine, to the middle of the mill. There each bloom was run through a series of eleven to thirteen roll passes, without reheating, producing two lengths (approximately sixty-three feet) of finished girder rail.[102] Water to cool the roll mill was drawn by a pump house on the upstream bank of the Stony Creek and brought by an underground brick flue to the mill.

The rolling process developed for the Moxham mill capitalized on both Moxham's personal expertise from years of designing and operating merchant iron rolling mills and the financial ability to equip the mill with state-of-the-art machinery. The roll mill was set directly in line with the shaft of the roll train. The two-high, reversing type mill, using 26" diameter rolls, was constructed with three stands of housings especially designed for the manufacture of heavy shapes.[103]

The process was originally designed by Moxham for rolling steel rails at the merchant mill of the Louisville Iron and Steel Company but was not rendered operational until Cambria Iron Company agreed to experiment with the roll process (using somewhat smaller roll diameters)[104] in early 1883. Almost five years to the day after Cambria Iron rolled the first successful Johnson girder rail, the Moxham plant successfully rolled its own Johnson rail with little difficulty on May 8, 1888.[105] Within a year's time, the rolling mill produced nearly two dozen different sections of girder rail, not to mention girders, heavy beams, and angles used in the construction of street railway car barns, and slot rails and girders for cable rail systems.

Upon leaving the roll mill, rails were measured and cut by circular saws fed against the rails by hydraulic lifts, then given a slight arch by passing over a series of small rolls, and set on cooling racks where they cooled nearly straight. After cooling, rails were taken to the southern-most end of the facility and straightened precisely by one of eight straightening machines, operated like a die punch with the rail moved back and forth by hand under the head of a working arm.[106]

The steel foundry was completed by early September 1888.[107] Also an iron truss building, the foundry measured 115 x 150 feet running parallel with the rolling mill and boiler house, with a 90 x 55 wing extending to the east. Originally, the foundry was equipped with eight Mitis furnaces (causing it to be known as the Mitis Foundry), two double-drying ovens in the center of the shop, and two hand-powered cranes. The Johnson Company was one of the first steel producers to adopt Mitis furnaces, which lowered the melt time of wrought iron through the addition of small amounts of aluminum. The Mitis process produced castings

that possessed desired strength and hardness, were extremely light, and were easily worked and welded. All castings were completed on the day shift, making five to six casts per day with each cast being approximately 900 pounds. With all six furnaces in operation, the foundry had a daily capacity of 5,400 pounds. The metal was poured with hand shanks into molds for switches, frogs, splice bars and other light mill castings.[108]

On January 1, 1889, the foundry was placed under the supervision of Benjamin J. Watkins, who initiated a number of significant innovations.[109] He was one of the first to develop and construct core ovens for the mill and foundry, and to utilize their capacity, day and night melting was initiated. By the fall of the year, the foundry installed an experimental three-ton Lash open hearth furnace that was immediately converted to accommodate an Archer water-oil gas producer. The ovens were torn down and placed outside the foundry to make room for the installation of Ridgeway balanced steam hydraulic cranes and to allow greater molding room. To accommodate the greater capacity of the Lash furnace, a wood frame annealing and chipping building was constructed just north of the foundry.[110]

To produce rolls and heavy castings, Moxham and Johnson capitalized and built a state-of-the-art iron foundry just upstream from the Moxham plant. The Johnson Foundry Company, financed as a distinct entity from the Johnson Company, was constructed beginning in September 1888 by Riter and Company under the supervision of William Boyd, an experienced foundryman from Pittsburgh, and was operational by April 1889.[111] By the fall of the following year, a machine shop was added to the southern end of the foundry to finish chilled and sand rolls. By the mid-1890s, John McKenna had rebuilt his machine shop, so critical to the early days of the enterprise but swept away by the flood waters in 1889, near the iron foundry at the Ferndale Bridge.

The Great Johnstown Flood of May 31, 1889 devastated everything in its path down the valley of the Little Conemaugh River until it smashed into the hillside at its confluence with the Stony Creek River in Johnstown. The raging waters leveled the communities of East Conemaugh, Woodvale, Conemaugh and Johnstown, killing 2,209 inhabitants in one of the worst natural disasters in American history.[112] Also destroyed in the wake were the entire railroad works of the Pennsylvania Railroad in East Conemaugh, the Gautier Works of Cambria Iron, the switchworks of the Johnson Company, and innumerable small businesses and establishments. Cambria Iron Company, downstream and around a bend from the confluence, received major damage. While the backwash up the Stony Creek wreaked havoc in the communities of Kernville and Meadowvale and wiped out the track of the Johnstown

and Stony Creek Railroad, the Johnson Company's Moxham mill, over two miles upstream, received no damage at all.

Within days of the disaster, Moxham put together a team of over 175 men camped in tents along the eastern bank of the Stony Creek. Organized by Captain W.R. Jones of Braddock and directly supervised by M.W. Wray, they set about to reclaim the major heavy machinery from the Woodvale switchworks, most of which had been buried in the riverbed rather than carried downstream.[113] Records estimate that most of the machinery from the switchworks was salvaged and carried by wagon to the Moxham site, where a rudimentary switchworks and lay out yard was constructed on the southern (upstream) section along Central Avenue.[114] By the end of June, the Company was again filling orders for specialty trackwork, and the team was disbanded by late August.[115]

The relocation of the switchworks to the Moxham plant site forced Moxham to further integrate the Company's functions and rethink the design of the entire plant. Immediately, a 50 x 100 foot General Office building at a new plant entrance was designed along Central Avenue. The two-story Victorian brick building, with its entrance facing off the street, was completed by mid-July 1889.[116] The first floor was comprised of general offices of the Company, while the second floor was used for a drafting area and drawing vault room, in which as many as fifteen draughtsmen designed work for specialty trackwork. A year later, a third story, including three square towers with pyramidal roofs, was completed, housing more drafting rooms and the Company's first laboratory.[117] A public clock was to be added to the eastern tower of the building that same month.[118]

By mid-1891, the plant had a more fully integrated look to it. The switchworks located on the southern half of the plant site had taken on an aire of permanence, with many wood-frame buildings and a large lay out yard. The new switchworks included a pattern shop containing a 100 foot square floor for laying out curves and switches. Next to that, a 125 x 200 foot connected blacksmith shop and machine shop was erected, in which the Company installed several large Thompson electric welding machines. Behind these were constructed a 50 x 125 foot bending room for forming curves and a 40 x 100 foot punch and bolt shop, where materials were sheared to length, shaped by steam-powered drop hammers into tie plates and brace chairs, and punched for spike holes. [119]

Immediately behind this cluster of buildings (known collectively as the switchworks) lay a wood-frame boiler house containing five brick furnaces, one large furnace with a 46-foot iron chimney, and four smaller furnaces with 26-foot iron chimneys. These produced gas by the Archer process to fuel the engines of the

switchworks. Behind that lay a large brick dynamo room, completed in April 1891, to accommodate the new electric welding processes the Company had adopted.[120]

Inside the plant entrance near the General Office, a two-story brick machine shop had been completed by the summer of 1891[121] and plans were initiated for a large two-story engineering building and a laboratory of similar Victorian style. The engineering building, necessary to handle the huge expanse of business for specialty trackwork after 1890, was to be adjacent to the General Office along Central Avenue, ultimately connected by an overhead walkway. It would contain not only large drafting rooms and laying out floor, but also an enlarged drawings vault on the second floor in which all drawings and work orders were carefully recorded and stored. The large laying out floor would envelope the entire first floor and be open to expansive skylight in the roof two stories above. Drafting tables would be located on a second floor balcony that extended around three sides of the building overlooking the enclosed laying out floor below. Begun in early 1893, the engineering building was completed within six months.

Across the entrance from the General Office was constructed a two-story brick laboratory building, completed in 1892. Moxham was an early exponent of the development of improved production processes and new product lines and committed to industrial research since he established the Johnson Company's first laboratory in the General Office Building in 1889. The industrial research conducted in the Company's labs would be instrumental in the development of their innovative productive processes (including early and extensive use of electric welding in the plant and at track construction sites), industrial tools and machinery, and new products, all of which were patented by either Moxham or other company engineers.[122]

V. MARKET INNOVATION AND DOMINANCE

There can be little argument that Johnson Company dominated the street railway business between 1885 and the turn of the century. Its girder rail design was almost universally adopted by horsecar lines, horsecar systems converting to electrification, and most cities installing electrified systems for the first time. Its specialty trackwork including custom designing of crossings, curves, turnouts, frogs, and switches was considered state-of-the-art.

To get a feel for the market dominance of the Johnson Company, one need only consider the sheer number of railway companies, cable roads, horsecar lines, and steam railroads for which the

Company completed orders in its first ten years. While records on orders of rails are fragmentary at best, the Company did maintain extensive and detailed records of its orders on specialty trackwork, all carefully cataloged and shelved in its drawings vault on the second floor of Engineering Building.

Estimating the range of probable orders of rails and trackwork is of course risky, but if a line ordered several pieces of trackwork (e.g. curves and crossings), it may be safely inferred that the line purchased girder rail as well and was probably either replacing existing track or building new routes or route extensions. In the case of a railway line purchasing specialty trackwork over a significant period of time, e.g. two or three years, one can presume the company is replacing trackwork in a manner as to convert to the Johnson girder rail for purposes of electrifying their line. In the case of a railway company purchasing a significant amount of specialty trackwork in a short period of time, one can presume an entire line is being constructed of (or converted to) the Johnson girder.

And as might be expected, the Johnson Company began to construct entire street railway systems, the first in July 1884. Its success as a railway system designer and contractor jumped dramatically in the late 1880s with electrification of street railways all across the country.[123] The Company's rapid growth by the period between 1888 and 1892 was not merely in market size, but more significantly in market share. It had moved quickly to produce the heavier rail sections necessary to accommodate the far heavier electric railway cars, and by 1892 was producing the taller (and more difficult to roll) 7-10" rail in greatest demand.[124] In three short years, the Johnson Company had become the dominant railway contractor and innovator in the United States.

The range of market penetration achieved by the Johnson Company is staggering. Its ledgers of drawings and orders reveal that between 1886 and 1893, it filled orders for specialty trackwork (mostly custom curves and crossings) for over 370 railway companies, cable roads, and elevated systems (both cable and steam).[125] A listing of the street railway companies ordering specialty trackwork during this period is contained in Appendix B. Virtually all of these companies ordered multiple pieces of specialty trackwork, and over half ordered trackwork over a period of three years. The Johnson Company also produced trackwork for many steam railroads and industrial producers of various types. It can be presumed that most companies ordered girder rail from the Johnson Company as well.

With respect to the construction of street railway systems, the Company was responsible as contractor of record for designing

over 94 entire routes, including more than a dozen cable roads, three inclines, and several elevated steam railroads. These are also noted in Appendix B. While this list includes many large and well-known systems, such as the West End Railway in Boston, the Broadway Cable Road in New York City, and the Pike's Peak Cog Rail in Colorado, it more importantly certifies that between 1889 and 1891, the Johnson Company was responsible for the construction of most of the medium and small-sized street railways in the country.

Even these impressive numbers would underestimate the Company's presence in street railway construction during that period. The ledgers also indicate quite clearly that a significant amount of track design and construction was completed on a subcontracting basis to other private companies, mostly electrical manufacturers. The Johnson Company was therefore in fact (if not as contractor of record) responsible for the construction of major street railway lines in Pittsburgh, St. Louis, Baltimore, Charlotte, Wheeling, and Ottawa. Under contract to Thompson-Houston Company alone, the Johnson Company constructed lines in Boston, Atlanta, Cincinnati, Newport, and Denver. In 1894, it was estimated that over 70 per cent of all street railway track material in service in the United States had been furnished by the Johnson Company.[126]

The rapid growth and national market dominance of the Johnson Company can be attributed to a number of factors. First and foremost, the Johnson girder rail design not only addressed most of the pressing market problems associated with street railways in the 1880s, but also was such a technologically advanced design that it easily accommodated the heavier types of rail sections needed for electrified systems. Moreover, it was a flexible enough design to meet the needs of railways of three types of motive power: horse, cable and electricity. It was in short an innovative product brought to production at precisely the right time to meet an emerging market need.

Secondly, and of no less significance, was the contribution of Arthur J. Moxham. An experienced ironmaster and roll engineer, Moxham experimented with roll mill designs for over five years to develop a workable production process for rolling the Johnson girder rail. In the end, Moxham's instinct and experience, together with his perseverence, was a principal factor in bringing the Johnson girder rail to production. The types of technical problems he had to overcome in the production process are discussed at greater length in Appendix D.

Thirdly, Moxham enjoyed unusual access to unfettered pools of private (du Pont) investment capital, at first through the backing of Alfred V. and Bidermann du Pont, and later, after the

death of Alfred du Pont in 1893, through continued investment backing by his heirs, notably Pierre S. du Pont, acting on his own and as guardian of the interests of his seven minor brothers and sisters.[127] This backing was particularly critical in the first six months of 1888, when Moxham constructed the rail mill and steel foundry, and in the summer of 1889, when the switchworks was moved to the Moxham plant site. Expanding market share and high profit margins by 1891 allowed Moxham to expand the mill's engineering capacity and construct the iron foundry.

Also contributing to the Johnson Company's market penetration was one of the most sophisticated marketing systems of its day, developed some two decades before such marketing practices became commonplace among large (modern) corporations.[128] The Company maintained regional offices in nine major cities across the country staffed by qualified personnel who understood the engineering aspects of street rail system design and could work with street railway companies to gather and transmit (by Western Union) to the Moxham plant specific information that allowed the Company to design custom trackwork or systems.[129] Detailed catalogues of Company products, handsomely illustrating and explaining different rail sections and custom trackwork completed for previous clients, were produced and distributed every one or two years.[130]

Finally, the Johnson Company protected their products and production processes through extensive patenting. Virtually every section design of girder, guard, or groove rail, either side- or center-bearing, was covered by a myriad of patents on section design, roll design, and roll process design. Specialty trackwork, such as frogs, switches, curves and crossings, and track construction implements, such as tie-bars, splice-bars, chairs, clips and spikes, were also routinely patented. Also included in the Company's patents were tool designs, machinery, and electric welding processes developed in the Company's industrial research laboratory.[131] By 1895, the Company held patent rights on over 200 designs of products or processes,[132] a complete listing of which is contained in Appendix C.

The Johnson Company intended that its aggressive pursuit of patent rights would foreclose competition in the street rail business. They had a superior product and they knew it. And while the principal protection lay in its patent on the Johnson rail section design itself (a patent claim that Johnson himself considered fairly weak),[133] the Company in effect piggy-backed onto the Johnson patent its own patents on roll and process design in order to cover every possible method of production.[134] For several years the patenting strategy worked perfectly, but with electrification, market demand for street railway trackwork expanded so dramatically that several

other steel producers attempted to break into the market with similar products. As early as 1888, the Company began to actively threaten patent enfringement suits against these interlopers.[135] With the decline in the price of steel rails in the early 1890s and the attempt of larger producers to form a pool to divide up market share, smaller steel producers pressed into the street rail market, forcing the Johnson Company into a series of complicated patent infringement suits.[136] Since the technology of the Moxham rolling processes was fairly common by the mid-1890s, the Company lost many of their suits[137] and other producers began to enter the market more freely.[138]

Yet, even before the Johnson Company lost its first patent infringement case, the patent protections were of lessening importance to the future of the Company. The quality of its product line was already firmly established throughout the country and abroad, and it would remain a dominant rail producer well into the twentieth century. Its name had become synonymous with street rail trackwork. However, the girder rail, the staple of its product line, was now competing directly (at least among railway companies in moderate climate locales) with the groove rail over which the Company held far less patent control.[139]

Moreover, Moxham had long since recognized that no matter how successful the Johnson Company had become in the street rail business, demand for its primary product was subject to seasonal fluctuations (track construction and repair confined to summer months in many regions of the country)[140] and had already peaked with respect to new system construction. While the Company continued its widely accepted lines of rail and specialty trackwork through the 1920s, it began to diversify the production of its steel foundry. By the early 1890s, the foundry undertook production of mill maintenance parts and rolls, and began to experiment with steel alloys.[141]

VI. AUXILLIARY ENTERPRISES: DEVELOPING THE TOWN OF MOXHAM

Because it had integrated the development of plant with its planning of the residential community of Moxham, the Johnson Company was involved in numerous auxilliary enterprises. Many were related to the Company's investment in the development of residential properties, mostly coordinated by Tom Johnson in the name of his brother Albert L. Johnson of Brooklyn, New York.[142] Between 1888 and 1890, they had developed a professionally surveyed plan for an entire community (to be named the Town of Moxham) surrounding the mill. Many of the managerial personnel of the Johnson Company, including Arthur Moxham, ultimately built elegant homes there.[143]

Arthur Moxham himself became involved in other enterprises designed to provide services to those residential properties. He was the moving force behind the incorporation of the Somerset Water Company, designed to develop water supplies from the Von Lunen spring for the anticipated community population of 10,000.[144] And he developed supply routes from the west to pipe in natural gas for both domestic use and street lighting.[145] The residential community was to have all of the modern conveniences.

He also formed the Moxham Steam Fire Engine and Hose Company in February of 1890, which constructed an engine house and stable on Central Avenue south of the General Office by mid-August. The engine house was a 25 x 28 foot brick structure opening directly onto Central Avenue, and housed both a horse cart and a steam engine from the Button Works of Waterford, New York. A small wood-frame stable constructed at the rear of the engine house accommodated seven horses.[146]

Only one major hurdle remained to these elaborate development plans. Isolated over two miles upstream from the established communities in the Johnstown area, the Johnson Company plant site and the planned Town of Moxham were accessible only by horse or foot. If workers residing in the established neighborhoods of Johnstown (mostly surrounding the Cambria Iron Company and its own auxilliary enterprises) were to be drawn to the Company's employ, a more efficient mode of transit had to be provided. And if the Town of Moxham were to be an attractive residential area for plant workers or other townfolk, access to the commercial sections of the Johnstown area was equally important.

The easiest means of achieving these ends would have been to purchase outright the locally-owned Johnstown Passenger Railway Company, the horse-drawn street railway that was built by Cambria Iron Company interests to serve their own mill communities of Cambria City, Millville, Johnstown, Woodvale, Conemaugh and Franklin.[147] The railway could then be extended to the south along the Valley Pike to link up with the Town of Moxham. But local owners resisted both takeover and expansion,[148] and Moxham decided to construct his own rapid transit system.

Chartered January 19, 1888, the Johnstown and Stony Creek Railroad Company established a three-mile rapid transit service from a passenger station built at 400 Bedford Street to the Johnson Company plant entrance.[149] The Bedford Street terminus intersected with the southeastern-most line of the street railway, allowing passengers transit access by horse-car to all other commercial and residential parts of the Johnstown area.

The Johnstown and Stony Creek ran south along the tracks of the B & O Railroad for about a mile, then split off where the B & O

crossed the Stony Creek and instead followed the eastern bank of the river into the Town of Moxham where it formed a loop in front of the plant entrance where the Company had built a platform and a short time later constructed a car shed.[150] The service, three Brill passenger cars pulled by a steam locomotive, ran every half hour from each terminus at a single fare of ten cents. As ridership increased, service ran every fifteen minutes and the fare reduced to five cents each way (three cents for Company employees).[151]

Following the river bed as closely as it did, the Johnstown and Stony Creek Railroad lost much of its track in the Great Flood of 1889, but restored service within three weeks.[152] With the dramatic expansion of the Moxham plant in the year following the flood, the station house near the General Office was moved to the base of Ohio Street.[153] But by that time, the street railway was electrified and had extended passenger service into the downtown section, with connecting lines to most suburban communities. As a rapid transit service, the Johnstown Stony Creek simply could not compete. By May 1891 the railroad had reduced its passenger service to only two runs a day, once in the morning and once in the evening.[154] Half-hour passenger service was restored briefly when the street railway car barns in Moxham were destroyed by fire in early 1893,[155] but the entire service was suspended altogether by 1894. The railroad reverted to hauling materials in and out of the plant.

The demise of the Johnstown Stony Creek as a passenger service was therefore inevitable, not because of flood damage to the trackbed (which had been restored quickly) but because the flood forced the owners of the Johnstown Passenger Railway Company to seriously consider Tom Johnson's standing offer to purchase the street railway. Originally constructed in 1882-83 to link the four company towns of Cambria City, Millville, Conemaugh, and Woodvale, the horse-drawn railway had prospered. It had extended lines into Morrellville, Kernville, Hornerstown, and Franklin, and constructed extensive car barns and stables on Maple Avenue and Ninth Street in Woodvale.[156]

But the Flood of 1889 literally erased the entire railway system. Most of the railway's trackbed was washed away, particularly along the flood path (Franklin, Woodvale and Conemaugh) and in the downtown areas (Johnstown, Kernville, Hornerstown and Millville). Destroyed without a trace were the large car barns and stables in Woodvale, including 15 horse-cars, 76 horses, and 2,000 bales of hay.[157] Basically all that remained of Johnstown's street railway system were the rights-of-way.

To an experienced street railway owner and operator like Tom Johnson, the right-of-way franchises were the most valuable asset

of the Johnstown Passenger Railway Company. He renewed his offer to purchase the line, and after considering dismal prospect of recapitalization, the Directors accepted Johnson's offer in September. The transfer of existing stock was completed by the end of the year.[158]

Given his personal managerial experience in the street railway business and the Johnson Company's sophisticated engineering capacity, Johnson was in a unique position to reconstruct the street railway line after the flood. He moved quickly to secure the necessary changes in municipal ordinances to allow electrification of service in those communities in which he already held franchises,[159] and pressed the newly-consolidated City of Johnstown to construct permanent iron bridges to accommodate streetcar lines.[160] The track system was completely redesigned by the Johnson Company engineering staff and constructed with Johnson girder rail and Johnson specialty trackwork (curves, crossings, frogs, switches, and turnouts) along previous routes.

The biggest change in the railway system was the relocation of its main car barns from the original Woodvale site at Maple Avenue and 9th Street to its new site in Moxham between the Engine House of the Moxham Fire Company and the Johnson Company's General Office on Central Avenue. A large wooden structure, the new car barns fronted over 100 feet along Central Avenue and formed a horseshoe-shaped loop almost 18 feet wide that extended over 100 feet east into the plant itself. The loop covered over 250 feet from the northern entrance to southern exit, and reportedly held up to forty cars, as many as three at a time in its repair shop. A small 15 x 15 foot free-standing railway office was located between the car barns and the General Office.

A second major structure, coal-burning electric power generating plant, was constructed back against the hillside on Baumer Street. The 40 x 60 foot structure was completed by early October, and was connected to local mine shafts in the adjoining hillside.[161] With the completion of the power plant, ten motor cars and ten trailers were readied and regular runs of the new electrified street railway commenced the second week of November 1890.[162] Less than ten years later, service expansion required the railway company to build a second, enlarged power plant on the same site. Constructed of brick along the same style as the car barns, the new Baumer Street power plant was operational by late 1900.[163]

By 1891, Johnson had restored and electrified service from its Central Avenue car barns along the old Valley Pike route through Kernville to a downtown loop and from there out to the

communities near the Cambria Iron Company steel works (Millville, Cambria City and Morrellville). By 1893, service to the devastated comunities of Conemaugh and Woodvale was restored. In that same year however, the Central Avenue car barns (with most of the rolling stock inside) were completely destroyed by an early morning fire.[164] Johnson immediately purchased properties across Central Avenue for the construction of new facilities, this time elaborate state-of-the-art brick structures including two huge car barns, a separate repair shop, and a large office-conductor's house. These structures, centered around Bond Street on the southern end of Central Avenue, would become as recognizable a feature of the Moxham as the Johnson Company plant itself.

Within the next three years, the Johnstown Passenger Railway Company expanded its branch lines in dramatic fashion. To the west, it pushed across the Coopersdale Bridge into the Borough of Coopersdale, constructing a car barn and loop at its northern limit. To the east, it pressed up the Little Conemaugh into and through Franklin Borough. South of Johnstown, it developed exploratory lines into Dale and Hornerstown, though its main north-south route remained the Valley Pike. And together with developers promising a recreational park and racetrack, the street railway extended its Franklin Street line to Roxbury Avenue, eventually constructing a station and loop at Roxbury Park.[165]

VII. THE BIG GAMBLE: BUILDING THE LORAIN WORKS, 1894-1897

The period 1890-1893 marked the Johnson Company's apex as an independent business enterprise. For almost a decade, it had so completely dominated the national market that the Johnson Company name had become synonymous with street railway rails and specialty trackwork. It had supplied track materials to virtually all newly-constructed electrified street railways and their electric department had constructed close to one hundred railway systems. The Company had expanded horizontally into all dimensions of the street railway business as well, producing single and double trucks, regular and special purpose car bodies, and electric motors. In the six-year period between 1886 and 1891, the Company had built and been forced to expand two large mills. Between 1890 and 1893, the Company's net profits exceeded $ 2.1 million dollars and, on a capital investment of $ 2.75 million, the Company paid out an average of $ 528,000 a year in dividends.[166]

The year 1893 proved to be a watershed for most industrial enterprises, particularly the country's steel companies and railroads. The steel rail market had blossomed in the late 1860s

with the dramatic expansion of the nation's railroads and the more successful rail companies capitalized on the trend by enlarging and integrating their production capacities. When railroad construction slowed by the late 1870s, the overcapacity in steel rail production became obvious. From the largest integrated plants in Chicago, Pittsburgh and Johnstown, to the many local mills on both sides of the Alleghenies, steel producers faced a vastly more competitive market in which profit margins were small. Fluctuations in steel prices, including two large drops in the 1880s, brought profit margins dangerously close to zero, jeopardizing the huge capital investments that had been made in the initial integration period of the early 1870s. The Panic of 1893 pushed many such enterprises to the financial brink.[167]

While the Johnson Company was not directly impacted by the dramatic drop in steel prices or the drop in rail demand, it was certainly not immune to the effects of the Panic. At first, the Company's liquid position allowed it to continue accepting orders from street railway companies that backed their purchases with bonds rather than cash. In turn, Johnson Company was able to maintain a liquid position by persuading its employees to accept bond certificates drawn on a local bank in lieu of cash wages, certificates which were accepted at local stores. Because the Johnson Company could afford to wait until the bonds appreciated in value (after the railway lines were completed), it realized an increased profit margin. In this manner, the Company was able to run its plant at near capacity by accepting orders on a delayed payment basis, while less liquid steel plants operated at reduced capacity or closed down operations for lack of cash-backed orders.[168]

Of far greater importance, the larger steel companies attempted for the second time to form a rail pool to control prices, a move that forced several idle rail mills such as Pennsylvania Steel to consider moving into the street rail and trackwork market.[169] In 1891, the Johnson Company initiated a series of patent infringement suits against several smaller mills that had begun producing variations of the Johnson girder or its other patented trackwork.[170] While the Company experienced some initial success, a series of major losses in 1893 and 1894 forced it to share the street rail market with a number of major steel producers.[171]

The drop in steel prices and the prospect of increased competition compelled Moxham to more carefully consider his vulnerability to the steel pool. The Company still relied on Cambria Iron for its Bessemer blooms, a dependence to which he became more sensitive in the constricting market of the early 1890s. The cost of blooms, which came in odd shapes of variable quality, increased the Company's materials and manufacturing

costs. In earlier years, these costs were absorbed easily because of Johnson's extremely high profit margin, particularly in specialty trackwork. By 1893 however, it was clear to Moxham that while the specialty trackwork dimension of the enterprise continued to be quite profitable, the rail dimension was approaching no profit margin at all.[172]

In terms of production management, Moxham had already done all he could to improve efficiencies at the mill. The plant was skillfully organized, financed, and equipped. He had standardized production, improved product quality, and developed new products and production processes. He had expanded the Company's reach into virtually every aspect of the street railway business. And as we have seen, he attempted to control his competition through aggressive defense of the Company's extensive patent holdings. His only remaining option for effecting savings in the rail mill was to produce his own blooms, and this would require increased capitalization of the Company.[173]

As early as 1891, the Johnson Company had considered constructing their own blast furnaces and coke ovens. Moxham had gone to the extent of surveying (and in some cases obtaining) rights-of-way to build a railroad spur from the plant to the Pennsylvania Railroad lines east of Johnstown, and purchasing properties in Ferndale as a potential site for additional sidings.[174] But the nature of the Company's position in the market and its high profit margin allowed it to defer increased capitalization. By 1893 however, Moxham believed that vertical integration was necessary to preserve market share and pressed the possibility of connection with the PRR in earnest. The railroad demurred and began to resurvey the routes, while at the same time, the Johnstown City Council began to raise concerns about the prospective rights-of-way.[175]

Despite the intensity of the local politicing surrounding access to the Pennsylvania Railroad and rumors about the amount of basic steel business that would be lost by PRR's principal customer Cambria Iron if Johnson made its own steel, these were not among Moxham's most critical considerations. Of far greater significance were the lack of expansion space at the Moxham site in Johnstown, and the steel industry's growing reliance on the Great Lakes ore fields.[176] The latter proved to be the most compelling factor, and while Moxham pursued the Johnstown options into early 1894, he also surveyed potential plant sites along Lake Erie at Youngstown, Cleveland and Lorain.[177] In March 1894, he convened a stockholders meeting seeking an additional $2 million in capitalization for the construction of a integrated steel mill.[178] The next month, he confirmed what had been widely rumored in Johnstown for weeks -- the purchase of six square miles (3,700 acres) of land in Lorain, Ohio at the mouth of the

Black River. He also formally announced the formation of a new company, the Johnson Company of Ohio, of which the Moxham plant would be a subsidiary.[179]

Construction of the Lorain plant proceeded without delay, and the Company began to dismantle its rail mill in January 1895.[180] Many of the Company's principal management and engineering personnel, along with the Company's main offices, relocated to Lorain by March.[181] The Moxham plant was to remain as the principal switchworks of the Johnson Company, completing fabrication and foundry work for the Company's well-established street railway business. It was placed under the supervision of Thomas Coleman du Pont, Bidermann's eldest son, who had been brought in from Louisville in 1894 to be General Manager as Moxham planned the Company's move to Lorain.[182]

Integration of Johnson Company operations to include basic steelmaking was well-considered but ill-timed. Steel prices and rail demand did not support Moxham's persistent expressions of market optimism.[183] The Lorain plant completed reconstruction of the rail mill, but construction plans for coke ovens and blast furnaces awaited more capital. Moxham's reliance on profits from the Johnstown plant for operating capital was weakened by that plant's continued practice of accepting orders based on railway companies' bond issues. The only way to generate short-term capital was to either discount those bonds (and lose all profit from them) or borrow on the short-term market.[184] The Company opted for the latter approach, first through a series of personal notes drawn against the value of Johnson Company stock,[185] and later through a series of bonds sold on the New York Stock Exchange directly.[186]

Still relying on external sources for Bessemer blooms, Moxham attempted to magnify the potentially large profit margin available through the Company's subsidiary, the Steel Motor Company. The enterprise was started in 1891 as a small engine repair business to support Tom Johnson's street railways in Cleveland. It was converted to the manufacture of electric motors for Johnson's railway lines and later for the general market after the mergers in 1892 left the electric motor market in the hands of two integrated companies: General Electric and Westinghouse. By 1894, it was formally chartered as the Steel Motor Company and became a subsidiary of the Johnson Company.[187]

To shore up lost plant value and sagging housing investments in Moxham, the Johnson Company moved the Steel Motor Company from Cleveland into Johnstown in 1896, effectively transferring over 200 jobs back into the Moxham plant.[188] At that point, Coleman brought in Frederick W. Taylor as a consulting engineer to reorganize and expand plant operations in Johnstown, particularly

to introduce systematic accounting and storekeeping methods in the electric motor factory, the switchworks and the foundry. But while Taylor's initial programs transformed the Steel Motor Works into the most profitable aspect of the Johnson Company's holdings within a year, his subsequent efforts were, by mid-summer 1896, cut back by the Company's overall financial stringencies.[189]

VIII. THE MORGAN MERGERS AND ABSORPTION INTO THE UNITED STATES STEEL CORPORATION

The Lorain gamble was the right move attempted at an unfortunate time. Defensive integration to stabilize market share would prove to be the appropriate strategy in the steel industry, but Moxham lacked both the capital and the industrial base from which to accomplish his goal of establishing the totally integrated steel plant at Lorain. As history would show, the truly successful steel integrations were some three or four years away, and were accomplished by large steel makers integrating forward into fabrication, rather than steel fabricators moving backward into basic steel making.

Unable to complete the Lorain coke ovens and blast furnaces for lack of capital, and having gleened all of the capital out of his Company's other operations, Moxham decided to refinance the Company altogether through the formation of the Lorain Steel Company in April 1898. Capitalized at $ 14 million, including a new issue of 5% gold bonds, Lorain Steel was to purchase all of the Johnson Company's assets. The Johnson Company would retain its name and control over its operations until December 31, 1898, by which time the increased capital would allow completion of the Lorain plant. Moxham officially retired from the Board of Directors and as President of the Johnson Company, and assumed the Presidency of Lorain Steel.[190]

Virtually all of the Company's major stockholders agreed to the plan, with the exception of Pierre du Pont who, by that summer, still harbored reservations. It was about that time that J. P. Morgan approached Tom Johnson about the prospect of including the Johnson Company in the merger of five companies that would result in the formation of the Federal Steel Company. Originally designed by Elbert Gary and financed by J.P. Morgan & Co. as a holding company allowing Illinois Steel to acquire controlling interest in the Minnesota Iron Company, the Federal Steel merger expanded to include the Elgin, Joliet and Eastern Railroad, and the Johnson Company's Lorain rail mill and Johnstown switchworks and foundry.[191] The deal was quickly approved by the stockholders of the Johnson Company, but Johnson felt that profit could still be made from its street railway and land development interests in Lorain and these properties were not included in the sale.[192]

By November 1898, the sale was completed and the Johnson Company proceeded to transfer its plants and the Steel Motor Company to Moxham's newly-formed Lorain Steel Company. On December 31, 1898, the two Johnson Company steel fabricating plants officially became the property of Lorain Steel, whose stock was wholly owned by Federal Steel. The Johnson Company name was officially changed to Lorain Steel on May 22, 1899. Within the next year, the construction of the blast furnaces and coke ovens at the Lorain plant was begun and Federal Steel showed a substantial profit.

But the competition among the large steel manufacturers only escalated further, as Andrew Carnegie absorbed ore properties in the Mesabi range and began to plan the construction of a major tube plant at Conneaut, Ohio that could successfully undermine the newly-merged (1899) and Morgan-financed ($ 80 million) National Tube Company. Within the year, Morgan discretely approached Charles Schwab, the chief executive officer of Carnegie Steel, about the prospect of purchasing all of Carnegie's steel holdings. By early February 1901, Carnegie agreed to sell for $ 480 million, and the United States Steel Corporation was formed. Included in the giant holding company (and each retaining its previous name) were three large steel makers (Carnegie, Federal and National) and six large fabricating companies.[193]

While the Johnson Company mill in Johnstown continued its principal role as an internationally-prominent fabricator of railroad and street railway trackwork, its steel foundry capacity was expanded so that it could serve as a maintenance mill for other mills in the U.S. Steel orbit. Between 1902 and 1907, large, permanent brick bays replaced the wooden structures of the old switchworks (which became known as the Upper Shops) and the boiler room and electrical department capacity was enlarged. A new set of bays (the Lower Shops) was constructed toward the northern end of the plant along Central Avenue to accommodate the milling of machine parts and rolls. The steel foundry was expanded to allow larger and a more diversified range of castings. And a new Metallurgical Department was constructed near the foundry to handle the range of industrial laboratory work demanded by the mill's broadened product line. By 1907, the plant employed over 1,300 men.[194]

The plant's maintenance role continued to expand in the first two decades of the twentieth century as the demand for street railway and interurban trackwork first leveled off and then inevitably declined.[195] After World War I, an electric foundry was constructed behind the Upper Shops and the plant began to manufacture mining cars. And while its product line did not materially change after the 1920s, the plant's designation within U.S. Steel did change. In 1935, Carnegie Steel, Illinois Steel

and Lorain Steel were consolidated within U.S. Steel to form the Carnegie-Illinois Steel Corporation, with the Johnstown plant named as its Lorain Division. In 1948, Carnegie-Illinois officially retired from the manufacture of steel rails and changed the Johnstown plant's designation to the Johnstown Works. Even during the 1950s, the Johnstown Works was considered one of the foremost suppliers of specialty trackwork for street railways, railroads, and industrial and mining operations. But with the terminal decline of street railways after World War II, the specialty trackwork that had been the trademark of the Johnson enterprise since the mid-1880s had little future. Consequently, on November 30, 1959, U.S. Steel announced it was ceasing its trackwork operations altogether and concentrated the production of the Johnstown Works on rolls and other castings to service its other mills. In fact, an expansion in the plant's roll capacity was completed in the late 1960s with the installation of a new electric furnace in its No. 2 (the old Steel) Foundry.

With the decline in international competitiveness of the American steel industry in the 1970s, U.S. Steel followed the pattern of other big steel producers and trimmed down their operations. In some plants, only product lines were trimmed as previously diversified mills became specialized (mini-mills) in their operations. In others, the entire mill itself was closed down. In 1984, the choice was pressed on the Johnstown Works, and after intricate negotations and financial arrangements which included federal, state and local government officials, the Johnstown plant was sold by U.S. Steel to the Johnstown Corporation, an independent enterprise which now operates the plant site as a steel foundry and fabrication facility.

1.Eugene C. Murdock, "Life of Tom L. Johnson", Ph.D. dissertation, Columbia University (October, 1951), 4-5.

2.Ibid., 5-7; Tom L. Johnson, My Story with Elizabeth J, Hauser (New York, 1911), 2-5; Michael Massouh, "Tom Loftin Johnson; Engineer-Entrepreneur, 1869-1900," Ph.D. dissertation, Case Western Reserve University (September 1970), 4-5; N.D. Baker, "Tom Loftin Johnson," 122-124 in Dictionary of American Biography vol. V, ed. Dumas Malone (New York, 1964).

3.Johnson, My Story, 5-7; Murdock, "Life of Tom L. Johnson," 8-10.

4.Murdock, "Life of Tom L. Johnson," 11; Massouh, "Tom Loftin Johnson," 6 note 9; and "Thomas C. Coleman," in Josiah Stoddard Johnston, editor, Memorial History of Louisville From Its First Settlement to the Year 1896 I (Chicago, n.d.), 639. For an extended discussion of the genealogical relations of the various principals,

see Appendix A.

5.Murdock, "Life of Tom L. Johnson," 11-12; Massouh, "Tom Loftin Johnson," 6-7; and Johnson, My Story, 9-11. By 1869, Louisville had three street railway companies: the Louisville City Railway Company (formed in 1864), the Central Passenger Railroad Company (1865), and the Citizen's Passenger Railway Company (1866). Each maintained a number of routes known by their distinctive names (such as the Fourth Street and Walnut Street line of the Central Passenger Railroad Company), but were all regarded as branches of the original companies. In 1869, A.V. du Pont purchased majority share in the Central Passenger Railroad Company, and his brother Bidermann du Pont took over its management. Johnston, Memorial History of Louisville I, 327-328.

6.Johnson, My Story, 11.

7.Ibid., 11-13; Massouh, and "Tom Loftin Johnson," 10-12. The 1874 Louisville City Directory lists Thomas L. Johnson as the superintendent of the Central Passenger Railway Company of 701 Walnut Street. In June 1872, the Louisville City Railway Company purchased the lines of the Citizen's Passenger Railway Company, together constituting the larger of the remaining two rival street railways in Louisville. Johnston, Memorial History of Louisville, 327. The Central Passenger Railway had been expanded under Johnson but never to the point of being lucrative. In 1875 Bidermann du Pont tried unsuccessfully to sell the line, and instead recapitalized it further and continued the rivalry. Raymond F. Pisney, "The Louisville Agency of E.I. Du Pont De Nemours and Company, 1831-1887," Master's thesis, University of Delaware (June 1965), 65; and Sarah R. Yates and Karen R. Gray, "Business Conflicts in the Mayoralty of Paul Booker Reed, 1885-1887," The Filson Club History Quarterly, 61 (July 1987): 310-314. The du Ponts' investment in the line would eventually pay off when the two antagonistic lines were consolidated in June 1890 under the name of the Louisville Railway Company, with the du Ponts retaining significant shares. Johnston, Memorial History of Louisville I, 327-328.

8.The fare-box design around which Johnson formed a manufacturing company was a glass-faced, coin-operated, registering box patented under U.S. Patent Number 143,698, Tom L. Johnson, Louisville, Kentucky (filed October 4, 1873, patent issued October 14, 1873). This design was an improvement of the basic fare-box design patented the year before under U.S. Patent Number 132,535 (patent issued October 29, 1872) which was totally enclosed and could register counterfeit tokens or coins. Until this time, horse-drawn

railway companies equipped their drivers with change packets for passengers embarking the horsecars without the exact fare. Because of the low profit margin of railways and the small size of the cars, the employment of a second person to take tickets and make change (later called a conductor) was impractical. Instead, companies laboriously counted the day's receipts and made up the next day's change packets at night -- Tom Johnson's original duties at Central Passenger Railway. Johnson's fare-box allowed exact accounting of receipts (and keeping drivers honest), precise registering of number of passengers using each line at various hours, and eliminated change packets. The information generated by the registering mechanisms of the fare-box allowed Johnson to restructure fares and routes to accommodate the most patronized and profitable lines. Massouh, "Tom Loftin Johnson," 32-40; Johnson, My Story, 10-11; "Tom L. Johnson's Improved Fare Box," Street Railway Gazette I (July 1886): 216; John Stephenson, "The Evolution of the Fare Box Car," Street Railway Journal IV (March 1888): 61-62; and Michael Massouh, "Innovations in Street Railways Before Electric Traction: Tom L. Johnson's Contributions," Technology and Culture 18 (April 1977): 205-209. The patent rights to the fare box were ultimately sold to the St. Louis Car Company in May 1888. "St. Louis," Street Railway Journal IV (June 1888): 167-168.

9.Johnson, My Story, 11-16; Massouh, "Tom Loftin Johnson," 73-77; and Murdock, "Life of Tom L. Johnson," 12-13.

10.The line was purchased with a $ 30,000 loan from Bidermann du Pont, and Johnson appointed his father Albert W. Johnson its President. Johnson, My Story, 10, 14; Massouh, "Tom Loftin Johnson," 111-112; Murdock, "Life of Tom L. Johnson," 14-15.

11.Johnson sold out his interest in the Indianapolis line for $ 800,000 when other investors and municipal officials opposed electrification of the line in 1888. Murdock, "Life of Tom L. Johnson," 15; Massouh, "Tom Loftin Johnson," 38; and "Indianapolis, Indiana," Street Railway Journal IV (May 1888): 132.

12.For background in street railway franchises, including detailed discussion of specific major railway, elevated and subway lines, see Delos F. Wilcox, Municipal Franchises 2 vols. (Rochester, 1910).

13.For a detailed historical and technical account of the transition to electrified traction, see Harold C. Passer, The Electrical Manufacturers, 1875-1900 (Cambridge, 1953); and Robert Luce, Electric Railways and Electric Transmission of Power (Boston,

1886), 31-67. More general sources in the transition include James B. Walker, Fifty Years of Rapid Transit, 1864-1917 (New York, 1918); John A. Miller, Fares Please! From Horse Carts to Streamliners (New York, 1941); and Joel A. Tarr, Transportation Innovation and Changing Spatial Patterns: Pittsburgh, 1850-1910 (Pittsburgh, 1972)._

14.Murdock, "Life of Tom L. Johnson," 22-23. Although Massouh ("Tom Loftin Johnson," 50 note 5) argues the Johnson designed the girder rail in the early 1880s, based presumably on its patent application date (note 15 below), most evidence points to his completing the designs before 1878, when he initially traveled to Birmingham, Alabama to discuss the design with Arthur Moxham, as described in chapter one.

15.U.S. Patent Number 272,554, Tom L. Johnson, Indianapolis, Indiana (filed September 11, 1882, patent issued February 20, 1883). Years later, Johnson would admit that his (and Moxham's) patents were somewhat weak of claim, but nonetheless succeeded in dissuading other steel producers from entering the street rail market. Johnson's patent is not unlike an iron girder-type street rail patented by Sidney A. Beers in 1859 - U.S. Patent Number 23,891 (patent issued May 10, 1859), Brooklyn, New York - but there is no evidence that Beers ever attempted to manufacture the rail. As Moxham learned some twenty years later, the girder design could not be rolled from cast or other iron (discussed in Appendix D), and while casting specialty trackwork (curves, crossings, etc.) from iron was not unusual, casting straight rail sections would have been prohibitively expensive.

16.Cable systems became operational in 1873 when Andrew Hallidie constructed the first system of the Clay Street Railroad. Extremely costly to construct and difficult to maintain, cable systems were better adapted to steeper grades than horsecars. Though cable systems were in hindsight "magnificently impractical and obsolete almost as soon as they were built," they enjoyed a brief period of attractiveness between 1885 and 1888 when electrified traction became operational. Cable systems continued to be attractive to cities which resisted installation of overhead wires, and several major cities adopted cable for their downtown section and electrified service to their residential suburbs. For an overview of cable technology and the history of its application, see George W. Middleton's "A Century of Cable Cars," American Heritage (April/May 1985): 90-101; and The Cable Car in America 2nd rev. ed. (San Diego, 1982).

17.This is not to say Johnson ignored trackwork for horsecar systems or the burgeoning electrified traction field. He patented a horsecar turntable that was very well received (U.S. Patent Number 184,527, Tom L. Johnson, Louisville, Kentucky, issued January 31, 1872), and was posthumously awarded a series of patents for a high-speed electric railway he had been experimenting with since 1905: U.S. Patent Numbers 1,090,213 (issued March 17, 1914), 1,123,305 and 1,123,306 (both issued January 5, 1915). For discussion of the latter, see Massouh, "Tom Loftin Johnson," 66-68.

18.U.S. Patent Number 310,184, Tom L. Johnson, Cleveland, Ohio (filed July 22, 1884, patent issued January 6, 1885). Johnson also patented a double ("ladder") cable for his shallow conduit system which he patented as well: U.S. Patent Number 310,285, Tom L. Johnson, Cleveland, Ohio (filed August 16, 1884, patent issued January 6, 1885). For the technical aspects of these patents, see Massouh, "Tom Loftin Johnson," 53-60; and Massouh, "Innovations in Street Railways Before Electric Traction," 212-215.

19.Massouh, "Tom Loftin Johnson," 77-84; Massouh, "Innovations in Street Railways Before Electric Traction," 209-212; Johnson, My Story, 17-23; and Murdock, "Life of Tom L. Johnson," 18-25. Prior to suing Hanna for use of his right-of-way, Johnson connected his suburban lines with transfer passes on an omnibus (horse-drawn coach) line he established through downtown Cleveland.

20.Massouh, "Tom Loftin Johnson," 124-125; Murdock, "Life of Tom L. Johnson," 20-21.

21.Johnson consolidated his line with two other systems not owned by Hanna in 1893, resulting in his controlling 60 per cent of Cleveland's street railways. Having originally invested $ 8,000 in the Brooklyn Street line, he ultimately sold all of his Cleveland railway properties in 1895 for several million dollars. Murdock, "Life of Tom L. Johnson," 21-22; and Robert H. Bremner, "The Civic Revival in Ohio; Reformed Businessman: Tom L. Johnson," American Journal of Economics and Sociology 8
(April 1949): 304-305.

22.Johnson first took his father and brother into the management of the Indianapolis line, then both went with him to manage his Cleveland lines. By the mid-1880s, his brother Albert had invested in several lines in New York City and moved permanently to Brooklyn with Johnson's mother and father. Using New York as home base, Albert L. Johnson invested widely in speculative railway and

interurban lines, the briefly famous Brooklyn Bridge Cable Road and the Citizens Street Railway in Detroit. The latter, purchased with R.T. Wilson in 1894, precipitated a legendary franchise battle between progressive Mayor Hazen Pingree and Tom Johnson, 20 per cent owner in the line whom Albert had persuaded to manage the line until it was on its feet financially. Johnson partially attributed his interest in progressivism to this period. Johnson, My Story, 91-97; Massouh, "Tom Loftin Johnson," 17-18; Melvin G. Holli, Reform in Detroit (New York, 1969), 102-123; New York Times July 3, 1901.

23.Johnson's investment advice was always highly speculative, and he had a good track record of success with his personal holdings. There is some evidence that Johnson advised Alfred V. du Pont on street railway investments, having shown the financier the significant returns that were possible through manipulated capitalization of smaller suburban lines. A.V. was convinced of Johnson's business acumen and prevailed upon Johnson to advise his ward Pierre S. du Pont through his financial and entrepreneurial apprenticeship. There is more evidence that Johnson served as a principal financial advisor to Pierre du Pont and to Bidermann du Pont's eldest son Thomas Coleman du Pont. As revealed by their private correspondance, Pierre was a cautious investor, often staying with the investment portfolios (particularly the Johnson Company stock shares and bonds) left him by Alfred du Pont. When he did dabble in street railway stocks (such as the Dallas Street Railway), his objective was purely interest income rather than company growth. Thomas Coleman on the other hand was an inveterate risk taker in both his business affairs and his investments, much more the kindred spirit of Tom Johnson and (later) Arthur Moxham. Following Johnson's leads, Thomas Coleman spent close to twenty years investing in and personally managing street railways. Alfred D. Chandler, Jr. and Stephen Salsbury, Pierre S. du Pont and the Making of the Modern Corporation (New York, 1970), 24-28.

24.Johnson's wealth around the turn of the century was estimated between five and ten million dollars; New York Times, January 2, 1910; Cleveland Plain Dealer, March 20, 1901. A measure of the scale of his wealth can be taken from some of his investments. Most of his railway companies (in which he held all outstanding shares) paid 8 to 15 per cent dividends, and his Johnson Company stock increased in value 20 % per year in the period 1890-1893. He sold his Indianapolis railway in 1889 for a profit of $500,000, his Johnstown railway in 1901 for a profit of approximately $ 400,000, and his Nassau Electric Railroad Company in 1898 for a profit of over $ 2 million. See Massouh, "Tom Loftin Johnson," 190-192.

25.Murdock, "Life of Tom L. Johnson," 26-36; Johnson, My Story, 48-58; Baker, "Tom Loftin Johnson," 122-124; and Bremner, "Civil Revival in Ohio; Reformed Businessman: Tom L. Johnson," 299-309. Moxham also was a convert to Henry George, founding and serving as President of the Henry George Club in Johnstown. On at least one occasion, George was the featured speaker at a meeting hall at the Johnson Company plant. Johnstown Tribune, December 31, 1889.

26.Murdock, "Life of Tom L. Johnson," 437-442.

27.Ibid., 37-51; Johnson, My Story, 59-81; Gordon R. Rawlinson, "Tom Johnson and His Congressional Years," Master's thesis, Ohio State University (1958).

28.Massouh, "Tom Loftin Johnson," 202-217; Murdock, "Life of Tom L. Johnson," 68-395; Johnson, My Story, 108-276.

29.Robert H. Bremner, "The Civil Revival in Ohio; Municipal Ownership and Economic Privilege," Journal of Economics and Sociology 9 (July 1950): 477-482.

30.The historical account of consolidation of Cleveland street railways is detailed in Johnson, My Story, 221-249; and Robert H. Bremner, "The Civil Revival in Ohio; The Street Railway Controversy in Cleveland," Journal of Economics and Sociology 10 (January 1951): 185-206.

31.New York Times, July 3, 1901, November 20, 1908; Murdock, "Life of Tom L. Johnson," 433-435.

32.Most of the decline in Albert Johnson's estate was caused by the collapse of his investments in the Lehigh Valley Traction Company, which was foreclosed and reorganized by 1905; see New York Times, November 20, 1908; Johnson to Pierre S. du Pont, May 9, 1901; August 12, 1904; August 29, 1904; Pierre S. du Pont to Johnson, June 26, 1905; Papers of Pierre S. du Pont, file 339, box 227, Hagley Library, Wilmington, Delaware.

33.Murdock, "Life of Tom L. Johnson," 432. Loftin's first business enterprise, backed by Tom Johnson, was to become involved in his uncle Albert's Lehigh Valley syndicate with an initial investment of $ 100,000; Johnson to Pierre S. du Pont, May 9, 1901, Papers of Pierre S. du Pont, file 339, box 227, Hagley Library, Wilmington,

Delaware. Loftin's attempt to claim Cleveland residence after the death of his father in order to avoid paying property taxes in New York failed when Cleveland officials certified that he had not lived in the city for over three years, New York Times, January 20, 1912.

34.Murdock, "Life of Tom L. Johnson," 430-432.

35.Ibid., 413-429; New York Times, January 2, 1910.

36.Murdock, "Life of Tom L. Johnson," 437-438. The extent of Johnson's loss of fortune and its true causes are subject to interpretation. His losses due to the foreclosure of the Lehigh Valley properties were estimated by company officials as less significant than reported by Johnson himself, and Albert's widow had remarried comfortably in 1907; New York Times, November 20, 1908. It is more likely that his wealth was depleted by his family obligations and the decline in the value of his remaining Lorain property holdings after the Johnson Company was sold to Federal Steel in 1898. For amplification on this, see Chapter VIII, note 3. At the time of his death however, Johnson's estate was valued at over a half million dollars, including real estate in New York and stock and bonds held in the New Jersey & Pennsylvania Traction Company. New York Times, May 23, 1911; January 20, 1914.

37.New York Times, April 10, 1911.

38.Massouh, "Tom Loftin Johnson," 91.

39.Johnson outlined the problems of street railway track in an extended preface to each of the Company's early catalogs, drawn primarily from his Street Railway Construction (Louisville, 1883).

40.Estimates vary as to the average working life of a street railway horse or mule, but many were said to last four years. Each would work a four-hour shift, most often twice a day, with six shifts being the norm. Iron strap rails were estimated to last three or four years, with the principal cause of failure being a curling or deterioration at the joints.

41.Massouh, "Tom Loftin Johnson," 42-48. See also Bertram Baxter, Industrial Archaeology: Stone Blocks and Iron Rails (New York, 1967), 37-58; and Peter Temin, Iron and Steel in Nineteenth-Century

America, An Economic Inquiry (Cambridge, 1964), 45-49. For elaboration on the composition of wrought iron rails, see Appendix D.

42.For a graphic description, see Joel A. Tarr, "Urban Pollution - Many Long Years Ago," American Heritage 22 (October 1971), 65-69, 106.

43.Mason D. Platt and C.A. Alden, Street-Railway Roadbed (New York, 1898), 20-23; Clay McShane, "Transforming the Use of Urban Space: A Look at the Revolution in Street Pavements, 1880-1929," Journal of Urban History V (May 1979), 285-286.

44.One of the main reasons why the standard steam railroad T-rail was not adapted for use in cities was that it protruded so far above street level as to cause obstruction; Massouh, "Tom Loftin Johnson," 46. Johnson did patent a double-flanged street T-rail, U.S. Patent No. 292,655 (filed February 20, 1883, patent issued January 29, 1884), Indianapolis, Indiana, as a form of a two-sided girder that could be turned around when one side became worn. It was however not well adopted.

45.Analyses of these claims is contained in Appendix D.

46.Johnson developed his girder rail design during his Indianapolis years, which began in 1876 and extended into the early 1880s when he permanently relocated to Cleveland. His trips back to Louisville during that time would have been to consult with A.V. and Bidermann du Pont, his financial backers, while there is evidence he also traveled later to Birmingham, Alabama in all probability to consult with Moxham about production of the rail design. Since Moxham was in Birmingham roughly between 1878 and late 1879 (see below footnotes 15, 16 and 20), Johnson's exploration of technical prospects for production of the rail can be dated to the 1877-1879 period.

47.Raymond Pisney, "The Louisville Agency of E.I. Du Pont De Nemours and Company, 1831-1887," Masters thesis, University of Delaware (June 1965): 63-67; Melville O. Briney, "When Central Park was Hospitable du Pont Square," Louisville Times, January 12, 1950. A.V. du Pont (at age 21, a graduate of the University of Pennsylvania at age 18) and his cousin Charles I. du Pont II had purchased the du Pont powder agency in Louisville (which included partial interest in a paper mill) from Isaac Cromie in 1854 with family and company money. A.V. and his younger brother Bidermann

(age 17) moved into one of Louisville's more exclusive downtown hotels the Galt House, where Alfred would maintain residence for the next forty years. In 1859, Charles moved back to Delaware and the agency was reorganized as the A.V. du Pont Company, with A.V.'s younger brother Bidermann as partner. By 1873, the du Ponts had opened an artesian well company and spa, and purchased controlling interest in the paper mill, in one of the two daily newspapers, a street railway line and a lead mine, and bought into the Louisville Iron Foundry. That same year, the brothers dissolved their partnership in the powder agency and sold it (with the paper mill and artesian well company) to Alexis I. du Pont.

48.Stockholder Record Book, Louisville Rolling Mill Company, 1850-1887 (hereafter referred to as SRB). The Company was chartered February 28, 1850, listing Thomas C. Coleman as President, and William B. Belknap and Thomas C. Coleman, Jr. as managers. Prior to its rechartering in 1873, the Company was almost entirely family-owned.

49.Ibid.; Johnston, Memorial History of Louisville I, 639. See also William T. Hogan, Economic History of the Iron and Steel Industry in the United States I (Lexington, MA: Heath, 1971), 64.

50.For the Coleman lineage, see Appendix A.

51.Johnston, Memorial History of Louisville I, 639.

52.Ibid.; see Appendix A.

53.John H. Frederick, "Arthur James Moxham," in Dumas Malone, ed., Dictionary of American Biography, VII (New York, 1964), 301.

54.Louisville Courier July 4, 1876. While Moxham was identified as a bookkeeper with the Company at the time of his engagement to Helen Coleman, it is clear he had become technically proficient with the mill's rolling processes as well, as evidenced by his design of rolling processes and machinery patented shortly thereafter: Patent No. 193540 (filed December 5, 1876, patent issued July 24, 1877), Arthur J. Moxham, process for reconverting wrought-iron scrap into merchantable iron; Patent No. 192653 (filed March 3, 1877, patent issued July 3, 1877), Arthur J. Moxham, small highspeed bending or coiling machine for hot iron; Patent No.

210049 (filed May 24, 1878, patent issued November 19, 1878), Arthur J. Moxham, process for producing from cast iron a more homogeneous wrought-iron with greater tensile strength and greater specific gravity. During the early periods of manufacturing in the United States, it was the rule rather than the exception that true ironmasters developed as apprentices in iron foundries and rolling mills; see for example Monte A. Calvert, The Mechanical Engineer in America, 1830-1910 (Baltimore, 1967), 3-40.

55.Frederick, "Arthur James Moxham," 301; Caron's City Directory of Louisville 1877.

56.SRB. By 1877, the Louisville Rolling Mill Company had become a holding company that leased its two mill properties (its original Brook Street mill and its acquired Clay Street mill) to other merchant mill companies organized by the Coleman family. The Clay Street mill was the original property holding of the Kentucky Rolling Mill Company (major stockholders J. Morgan Coleman, Barry Coleman, and A.V. du Pont), which in 1875 bought 1,000 shares of the Louisville Rolling Mill Company.

57.Bidermann du Pont had married Thomas C. Coleman, Jr.'s sister Ellen Susan Coleman in 1861, and she bore him seven children. See Appendix A. Among the more interesting connections is the fact that Coleman bought and renovated the Galt House, which was managed for many years by Coleman's son Jilson and in which A.V. du Pont resided all the years he lived in Louisville.

58.Massouh, "Tom Loftin Johnson," 178 note 102.

59.Ethel Armes, The Story of Coal and Iron in Alabama (Birmingham, 1910), 238-254.

60.Ibid., 283-284. Johnston implies that the Birmingham Rolling Mill Company was in fact the relocated operations of the Louisville Rolling Mill Company which would have abandoned its Brook Street mill site, stating "Prior to that time [circa 1880] there were two large rolling mills here. One removed to Birmingham, Alabama, the modern wonder of the iron trade, and there remains here but one rolling mill, making boiler iron, plate and bar iron of superior repute," Memorial History of Louisville I, 279. This would be consistent with the fact that at approximately the same time the Louisville Rolling Mill Company leased its Brook Street mill to the Coleman Rolling Mill Company, SRB, December 16, 1879. It should be

noted that there were six rolling mills operating in Alabama before and during the Civil War, but all were destroyed. Lacking skilled labor and necessary capital, the re-emergence of iron rolling mills was delayed until the mid-1870's. Hogan, Economic History of the Iron and Steel Industry in the United States II, 73-74.

61.Frederick, "Arthur James Moxham," 301; Armes, The Story of Coal and Iron in Alabama, 284.

62.Armes, The Story of Coal and Iron in Alabama, 284. Caldwell was a young geological scientist with significant education and training in the United States and Europe, who had conducted studies of coal and iron deposits in Kentucky while an appointed mineralogist of the Kentucky State Geological Survey in the mid-1870s. In 1878, he married Mary Norton, daughter of George W. Norton a noted banker and financier in Louisville, and became part of the Coleman-du Pont team that established the Birmingham Rolling Mill Company. His expertise would have been invaluable in assessing the quality of Pratt coal deposits and the southern region's iron ore. He would return with Moxham to Louisville in 1879 to organize and become President of the Louisville Iron and Steel Company (below, footnote 20), but died prematurely (at age 29) in 1880. Johnston, Memorial History of Louisville II, 480-481. Thomas Ward had married Coleman's daughter Dora in 1878, and stayed with the Birmingham mill until late into the 1880s. See Appendix A.

63.Based on location factors alone, Birmingham should have enjoyed a transportation cost advantage until the Great Lakes ore fields were integrated into the big steel producers in the early 1890s. Instead, the causes of the southern region's lack of market share can be attributed to ore prices, rather than coal/coke costs or location of market demand as one might expect. Ann K. Harper, The Location of the United States Steel Industry, 1879-1919 (New York, 1977); and Hogan, Economic History of the Iron and Steel Industry in the United States I, 201. Until the mid-1890s, no real national market for risk capital for expansion purposes existed, and entrepreneurs had to fall back on private capital or borrow short-term against immediate earnings. The latter option was less available to both southern and western regions because of structural barriers to banking growth, a restriction that hampered southern iron and steel development through the turn of the century. Thomas R. Navin and Marian V. Sears, "The Rise of a Market for Industrial Securities, 1887-1902," Journal of Economic History 29 (Fall 1955): 107-110, 128; Lance E. Davis, "The Investment Market, 1870-1914: The Evolution of a National Market," Journal of Economic History 25 (September 1965): 359; Alfred D. Chandler, Jr., "The Beginnings of 'Big Business' in American Industry,"

Business History Review 33 (Spring 1959): 14-17; Richard E. Sylla, The American Capital Market 1846-1914; A Study in the Effects of Public Policy on Economic Development (New York, 1975); and Daniel Creamer, Sergei Dobrovolsky, and Israel Borenstein, Capital in Manufacturing and Mining, Its Formation and Financing (Princeton, 1960), 3-37. Access to Coleman and du Pont capital made borrowing on the short-term market unnecessary. The Birmingham Rolling Mill remained a merchant mill through 1886 when it was integrated into DeBardeleben Coal and Iron Company, a huge conglomerate of coal mines, merchant mills, and new blast furnaces which the following year became the first southern entry into the Bessemer Group. Armes, The Story of Coal and Iron in Alabama, 283-359.

64.Platt and Alden, Street-Railway Roadbed, p. 8. The technical reasons why the Johnson rail could not be rolled from iron are discussed in Appendix D.

65.The Clay Street mill was leased by the Louisville Rolling Mill Company to the Louisville Iron and Steel Company for a year with option to purchase, SRB, July 3, 1879. The property was ultimately sold to the Ewald Iron Company of St. Louis, SRB, March 31, 1886, and the Louisville Rolling Mill Company formally dissolved the next year. Egbert Moxham's unpublished memoir "Rosemary" indicates that Arthur Moxham continued to live in Birmingham until October 1881, after the birth of Egbert, when he moved his family back to Louisville and returned to Birmingham alone. By 1882 Moxham resigned from the Birmingham Rolling Mill and returned to Louisville to work in the Louisville Iron and Steel Company permanently.

66.The Johnson Steel Street Rail Company was chartered under the laws of the State of Kentucky March 7, 1883, John E. Gable, History of Cambria, County, Pennsylvania, I (Topeka, 1926), 269.

67.The rise of the Cambria Iron Company as one of the first innovative steel producers in the United States is well-documented. See for example: Victor S. Clark, History of Manufactures in the United States, Vol. II, 1860-1893 (New York, 1929); Hogan, Economic History of the Iron and Steel Industry in the United States, I, 94-95; James M. Swank, History of the Manufacture of Iron in All Ages, and Particularly in the United States from Colonial Times to 1891 2nd edition (Philadelphia, 1892); Peter Temin, Iron and Steel in Nineteenth-Century America, An Economic Inquiry 15-60; and Thomas J. Misa, "Science, Technology and Industrial Structure: Steelmaking in America, 1870-1925," Ph.D. dissertation, University of Pennsylvania, 1987. More focused accounts include Storey, History of Cambria County, I, 400-447; John N. Boucher, The

Cambria Iron Company (Harrisburg, 1888); Richard A. Burkert, "Iron and Steelmaking in the Conemaugh Valley," in Karl Berger, editor, Johnstown: The Story of a Unique Valley (Johnstown, 1984), 255-315; Sharon Brown, Historic Resource Study Cambria Iron Company (Washington, D.C., 1988); Robert John Hunter, "Biography of Daniel J. Morrell, Ironmaster," Master's thesis, University of Pittsburgh (1954); and Ewa Morawska, For Bread With Butter; The Life-Worlds of East Central Europeans in Johnstown, Pennsylvania, 1890-1940 (Cambridge, 1985).

68.Mason D. Platt and C.A. Alden, Street-Railway Roadbed, 6.

69.Ibid., 7-8; Michael Massouh, "Technology and Managerial Innovation: The Johnson Company, 1883-1889," Business History Review, 50 (Spring 1976): 50.

70.Morrell was not an ironmaster in the traditional sense, i.e. he had not apprenticed at either a machine shop or iron foundry. He was in fact a dry goods merchant by experience with the Martin, Morrell and Company in Philadelphia. Morrell had come to Johnstown initially in 1854 to look after credit vouchers which had been paid to his company in stock by the Cambria Iron Company. Through the many years he remained in Johnstown, Morrell's decisions were particularly courageous (some would say risky) and well-attuned to emerging markets. The decision to convert the Cambria Iron steel rail mill to experiment with the Moxham roll process was a clearly a visionary one, and one extremely profitable to both parties. Elements of Morrell's market vision are described in Hunter, "Biography of Daniel J. Morrell, Ironmaster."

71.Johnstown Tribune, June 9, 1884. For discussion of advances in rolling technology during this period, see Hogan, Economic History of the Iron and Steel Industry in the United States I, 38-45.

72.U.S. Patent Number 292759, Arthur J. Moxham and John R. Tranter, Louisville, Kentucky (filed November 23, 1883; patent issued January 1, 1884); U.S. Patent Number 303036, Arthur J. Moxham, Louisville, Kentucky (filed November 26, 1883, patent issued August 5, 1884). See Appendix D.

73.Johnstown Tribune, June 9, 1884; Storey, History of Cambria County, II, 473; Gable, History of Cambria County, I, 270; and Burkert, "Iron and Steelmaking in the Conemaugh Valley", 286-287.

74.The precise location of the first lay out yard is difficult to ascertain. All sources agree it was on a contiguous part of the old canal basin (i.e. Conemaugh Borough) to the John Hannan Foundry, which itself was on Centre Street. And it must have been located near the point where the B & O spur crossed the intersection of Centre and Clinton Streets and curved south past the future location of the Pennsylvania Railroad freight station (the so-called warehouse district), across Railroad Street and down toward Bedford Street. Therefore, the most likely location is on the curve in the track, on the interior of the block bordered by Railroad, Centre and Clinton Streets. One source even cites the yard as being on Jackson Street, which might point to the western siding of the track at the curve where Jackson meets Railroad Street. See Gable, History of Cambria County, I, 270; Storey, History of Cambria County, II, 474; Burkert, "Iron and Steelmaking in the Conemaugh Valley," 286-287; and Bessie Morgan Porter, A History of Moxham (Johnstown, Pa: s.n, 1976).

75.Burkert, "Iron and Steelmaking in the Conemaugh Valley", 286-287; "Historical Sketch," 2-3; Johnstown Democrat, December 18, 1899.

76.Storey, History of Cambria County, II, 473; Johnstown Tribune, June 9, 1884; Johnstown Democrat, December 18, 1899; "Historical Sketch," 1, Egbert Moxham, "Rosemary" (unpublished memoir, 1956), 14.

77.Johnstown Tribune, June 9, 1884. Within the first year, the Company was reported to command over 10% of the street rail market; Bulletin of The American Iron and Steel Association XVIII (June 18, 1884): 49._

78.Johnstown Tribune, May 7, 1883.

79.Johnson Steel Street Rail Company, Catalog No. 4 (n.d., Circa 1885), frontpiece.

80.The first railway line that the Johnson Steel Street Rail Company contracted for was with the East Liberty and Wilkinsburg Street Railway Company, Johnstown Tribune, July 25, 1884. Drawings and orders for trackwork for this contract do not appear in the Company's ledgers because the first ledger starts with order no. 136 (1886).

81.Johnstown Tribune, December 3, 1884.

82.Storey, History of Cambria County, II, 474; Gable, History of Cambria County, I, 270; "Historical Sketch," 3; Johnstown Democrat, December 18, 1899.

83.Storey, History of Cambria County, II, 471.

84.Storey, History of Cambria County, II, 474.

85.Ibid.; Johnstown Tribune, June 17, 1886; July 23, 1886; and Johnstown Democrat, December 18, 1899.

86.Johnstown Tribune, September 19, 1886.

87.Johnstown Tribune, January 10, 1887; January 20, 1887.

88.Johnstown Tribune, June 23, 1887.

89.Johnstown Tribune, August 24, 1887; October 13, 1887.

90.Johnstown Tribune, December 12, 1887; Gable, History of Cambria County, I, 270; Storey, History of Cambria County, II, 474. On the original plan, 95 acres were purchased by the Johnson Steel Street Rail Company for $ 40,000 for the plant site, and 94+ acres were purchased by Albert L. Johnson of Cleveland, Ohio for $ 25,250 for the development of residential properties that would ultimately comprise the Town of Moxham. Storey, History of Cambria County, I, 310.

91.Although 95 acres were originally purchased for the plant site, only sixty acres were used in the original plant constructed in 1888. The current plant site, including the iron foundry, is 60.3 acres.

92.Johnstown Tribune, December 12, 1887; December 29, 1887.

93.Johnstown Tribune, November 19, 1887.

94.Johnstown Tribune, May 14, 1888. Fairly detailed descriptions of the plant site in its first two years are contained in: Johnstown Tribune, May 7, 1888; Frank Younkin, "The Steel Foundry, A Historical Sketch of the Foundry, Its Products and Processes," mimeo in vertical file (1938); and "How the Johnson Girder Rail and Other Track Appliances are Made," Street Railway Journal 6 (June 1890): 296-7, 310.

95.The company was rechartered under the Laws of Pennsylvania at simply the Johnson Company on October 12, 1888. Johnstown Tribune, October 13, 1888. It was chartered again April 13, 1893; Storey, History of Cambria County, II: 474.

96.Johnstown Tribune, August 4, 1888. The brickworks were closed down in 1890 and disposed of at a constable's sale, Johnstown Tribune, October 17, 1890.

97.Johnstown Tribune, May 8, 1888.

98.There is little doubt that the Valley Pike Company, responsible for the pike from Grubbtown to Benscreek, including the Moxham and Ferndale Bridges, was a subsidiary operation of the Johnson Company; Johnstown Tribune, March 3, March 17, May 14, June 2, June 4, June 23, July 23, September 22, October 9, November 10, 1888; September 26, 1890. The Company's chief engineer A.H. Walker was named to head the Valley Pike construction after the rail mill and steel foundry were completed, Johnstown Tribune, May 14, 1888. As late as 1899, Tom Johnson was elected President of the Board of Directors of the Valley Pike Company, the Moxham and Ferndale Bridge Company, and the Stonycreek Bridge Company. Johnstown Tribune, April 14, 1899.

99.Johnstown Tribune, May 7, 1888; "How the Johnson Girder Rail and Other Track Appliances are Made," 296.

100.Johnstown Tribune, November 2, November 18, 1889; Younkin, "History of the Steel Foundry," 1. Coal was brought from the Ingleside Coal Company which A.J. Moxham purchased in 1891 via the Cambria and Somerset spur of the Baltimore and Ohio Railroad. Johnstown Tribune, November 17, 1890; June 16, 1891. Natural gas was the dominant fuel for practically every iron and steel mill in the Pittsburgh area by 1885. By 1886, it was introduced into the Cambria Iron Works in Johnstown. But its employment varied with accessibility, and conversions to natural gas slackened by 1889 due

to diminished supply and the diversion of supply to domestic uses. While many works returned to coal, several changed to producer gas made from coal. The Johnson Company was one of the first to convert to an oil-gas fuel. See Clark, History of Manufacturers in the United States, Vol. II, 1860-1893, 252-253.

101.Massouh, "Tom Loftin Johnson," 146.

102."How the Johnson Girder Rail and Other Track Appliances are Made," 297. Open hearth furnace technology was relatively new at the time it was adopted by Moxham in both the roll mill and the steel foundry. It only became operational and economical by the late 1870s, and the Cambria Iron Company was one of the first to adopt it successfully; see Burket, "Iron and Steel Making in the Conemaugh Valley," 293-295; W. T. Wellman, "The Early History of Open-Hearth Steel Manufacture in the United States," ASME Transactions 23 (1902): 78-98; Misa, "Science, Technology, and Industrial Structure: Steelmaking in America, 1870-1925," 206-236; and Temin, Iron and Steel in Nineteenth-Century America, 139-141.

103."How the Johnson Girder Rail and Other Track Appliances are Made," 297.

104.Moxham's U.S. Patent No. 292,759 rolling process called for 16" rolls. For discussion of the difference, see Appendix D.

105.Johnstown Tribune, May 8, 1888.

106."How the Johnson Girder Rail and Other Track Appliances are Made," 297.

107.Johnstown Tribune, September 12, 1888. Before the steel foundry was operational, the Johnson Company secured its steel castings from other foundries, such as the Johnstown Steel and Iron Casting Company works near Sheridan Station, Johnstown Tribune, February 9, 1888.

108.Younkin, "History of the Steel Foundry;" "How the Johnson Girder Rail and Other Track Appliances are Made," 310; and Michael Massouh, "Technology and Managerial Innovation: The Johnson Company, 1883-1898," 54, note 21. At that time (1887-1888), Lash furnaces, produced by the Carbon Steel Company, were state-of-the-

art open hearth furnaces fueled by natural gas. See Misa, "Science, Technology and Industrial Structure: Steelmaking in America, 1870-1925," 226-228; and H. M. Howe, The Metallurgy of Iron and Steel I (4th ed., Philadelphia, 1891), 296-310.

109. Younkin, "History of the Steel Foundry," 2. Born in Wales, Watkins came to the United States at age 11 and was apprenticed at the Cambria Foundry, rising steadily until he became superintendent by the age of 32. After working briefly with Sharon Steel, he took over the Johnson Company's steel foundry in 1889 until he retired in 1895. His son W.J. Watkins, a trained chemist, became head of the open hearth furnace at the Johnson Company. Storey, History of Cambria County, III, 554-557.

110. Ibid.

111. Johnstown Tribune, July 18, September 12, December 6, 1888; December 7, 1889. The machine shop to the iron foundry was completed and operational by late 1890; Johnstown Tribune, October 8, 1890.

112. Storey, History of Cambria County, I, 457-508; David McCulloch, The Johnstown Flood (New York, 1967); Nathan David Shappee, "A History of Johnstown and the Great Flood of 1889," Ph.D. dissertation, University of Pittsburgh (1940); and Johnson, My Story, 34-44. Both Moxham and Johnson played significant roles on the Flood Relief Committee in the months following the disaster. Moxham chaired the committee and coordinated all of its efforts. Johnson was placed in charge of removing debris and chaired the Board of Inquiry that certified losses for purposes of allocating aid. Employees of the Johnson Company were deputized to prevent looting in the downtown area. McCulloch, The Johnstown Flood, 190-191. For a personal account of Moxham's role in the flood recovery, see Moxham, "Rosemary", 15-28.

113. While the original team of men numbered 175 in June, it swelled to over 300 by July and August. Johnstown Tribune, June 20, August 10, August 22, 1889; Street Railway Journal 5 (July 1889): 207.

114. Johnstown Tribune, June 19, 1889.

115. "Historical Sketch," 4-5.

116.Johnstown Tribune, July 9, July 26, 1889.

117.Johnstown Tribune, October 11, 1890.

118.Johnstown Tribune, October 21, 1890. There is however no evidence the clock was ever actually installed.

119."How the Johnson Girder Rail and Other Track Appliances are Made," 297.

120.Johnstown Tribune, April 7, 1891.

121.The machine shop was partly operational by the following fall, Johnstown Tribune, September 15, 1891.

122.Massouh, "Technology and Managerial Innovation," 54-55.

123.The Johnson Company's specialty trackwork order ledgers indicate that two street railway systems were constructed in 1886, six in 1887, and four in 1888 when electrification first became operational. The next three years, Company constructed 74 systems as primary contractor (25 systems in 1889, 30 systems in 1890, and 19 systems in 1891) and at least 11 systems as a subcontractor.

124.Platt and Alden, 13-17.

125.The Johnson Company, Ledger Book of Drawings and Orders, vols. I-III, nos. 138-16,000 (July 9, 1886 - May 17, 1893). The first recorded drawing (no. 138, July 9, 1886) would have referred to specialty trackwork completed while the Company was still located in the Iowa mill in Woodvale, before they moved to the large switchworks along Maple Avenue between Fifth and Sixth Streets. That specialty trackwork records prior to May 31, 1889 still exist is quite amazing, since the Woodvale switchworks was entirely destroyed by the Flood of 1889. Since the General Office Building (containing the first drawings vault) was not built until July of 1889, these records would have to have been stored at the first mill office of the Moxham plant (west of the rail mill). Records of the drawings for the first three years were probably lost in the Flood.

126."Financial Plan of the Johnson Company of Ohio" (Description of Subordinate Companies: The Johnson Company of Pennsylvania), Arthur J. Moxham to Pierre S. du Pont, June 26, 1894, p. 6, The Papers of Pierre S. du Pont, File 26, Box 34 (1), Manuscript Department, Hagley Library, Wilmington, Delaware. For more elaborate estimate of the Johnson Company's market share, see Massouh, "Technology and Managerial Innovation," 48 note 5.

127.Alfred V. du Pont's estate was valued at $ 2.2 million, including 7,250 shares of Johnson Company stock valued at $ 1,087,500 and $ 206,904 in Johnson Company bonds. It also included $ 142,960 worth of stock and bonds in the Johnstown Passenger Railway Company. Half of the estate, co-administered by Tom L. Johnson and Thomas Coleman du Pont, went to Alfred's mother Margaretta Lammot du Pont with the understanding she would distribute it among his brother Bidermann and Alfred's three wards: Thomas Coleman, Alfred I., and Pierre S. duPont Bidermann du Pont himself had received 725 shares of Johnson Company stock (valued at $ 108,750) and over $ 6,000 in bonds. The net result was that each of the four beneficiaries became major stockholders in the Johnson Company. Pierre S. du Pont's tie to the Company was even stronger, since he was responsible for managing over a half million dollars in investments held in trust for his seven minor brothers and sisters, close to $ 200,000 of which was in the form of Johnson Company stock. Papers of Pierre S. du Pont, File 412, Box 367, Estate of Alfred V. du Pont (July 1, 1893). See also Chandler and Salsbury, Pierre S. Du Pont and the Making of the Modern Corporation, 26-27.

128.Massouh, "Tom Loftin Johnson," 151-155; and Massouh, "Technology and Managerial Innovation," 53 note 18. The Johnson Company was one of the first to merchandise their products through regional offices staffed by their own personnel rather than utilizing selling agents in various cities. See Glenn Porter and Harold C. Livesay, Merchants and Manufacturers, Studies in the Changing Structure of Nineteenth-Century Marketing (Baltimore, 1971), 137-147.

129.Massouh, "Technology and Managerial Innovation," 52-53.

130.Early catalogues for the Johnson Steel Street Rail Company are difficult to find. Copies of Catalogues No. 4 (Louisville, Kentucky, n.d. but probably 1885) and 5 (Louisville, Kentucky, n.d. but probably 1886) are in the Engineering Societies Library in New York City. A copy of Catalogue No. 6 (Louisville, Kentucky, n.d. but probably 1888) is located in the Imprints Department of the

Hagley Library, Wilmington, Delaware. Catalogues Nos. 8 (Johnstown, June 1, 1892) and 9 (Johnstown, June 1, 1894) are in the vertical file, Johnstown Corporation.

131.Massouh, "Technology and Managerial Innovation," 54.

132.The bulk of the trackwork and rolling process designs were patented in Moxham's name alone. Other engineers with the Company also began to patent trackwork and tool design, consigning their patent rights to the Johnson Company. How many of these patents actually represented true invention is discussed below in note 15.

133.Johnson, My Story, 29. There is no evidence that Johnson anticipated or even knew of the Beers 1859 patent. Rather, his own disclaimers in the patent application state clearly that his innovation came from pulling together different aspects of known ("old") processes and designs and uniquely adapting them to a peculiar engineering need (street railways).

134.The case in point is that Moxham covered the basic Johnson rail section with patents for two different types of roughing sequences, the first (No. 292,759) which entered the bloom on the flat, and the second (303,036) which entered the bloom on the diagonal. Had one sequence been superior to the other, he would in practice only use the one. By patenting both, he apparently hoped to dissuade other producers from adopting the less efficient method just to circumvent Moxham's patent rights. See Appendix D.

135.The Preface to Catalog No. 6 (which states in passing that the information was also contained in Catalog No. 5) contains frank language on the Company's intention to aggressively protect its patent rights. It declares that it "owns over 100 patents on girder rail devices and the methods of their manufacture ..." and advises that "we have retained the most capable counsel that we could obtain," and "have now six suits pending ..."

136.The steel rail pool was not designed to impact the street rail market, but tended to force those rail producers excluded from the pool into other markets. Moxham specifically anticipated this type of action from the Pennsylvania Steel Company, Papers of Pierre S. du Pont, File 26, Box 34 (1), Arthur J. Moxham to Pierre S. du Pont, January 26, 1894, p. 2. While many of the larger producers redirected their manufacturing efforts into structural steel, smaller companies probably did not have the capital to make such an

adjustment. The Johnson Company's principal antagonists during this period (1891-1895) included North Branch Steel, Pacific Rolling Mill, Tidewater Steel-Works, and Pennsylvania Steel.

137.Earliest attempts to challenge Johnson patent rights involved finding incrementally different methods of manufacturing the Johnson girder, most of which had been precluded by the Company's over-inclusive patenting policy on manufacturing processes. Later (and ultimately successful) attempts struck at the very heart of the Company's patents by challenging whether the patented product or manufacturing process actually constituted "invention." By the early 1890s, patent infringement law had become fairly sophisticated at determining by expert testimony and careful screening of drawings of competing claimants what was invention and what was imitation. The two most significant losses absorbed by the Johnson Company involved findings that neither the Johnson rail section nor Moxham's rolling process was actually "new", i.e. constituted invention, but rather reflected skillful mechanical adaptation of existing knowledge. Johnson Co. v. Pacific Rolling-Mills Co. Cir. Ct, N.D. California, July 27, 1891, 47 Federal Reporter 586; affirmed Cir. Ct. of Appeals, Ninth Cir., Nos. 33, 34, July 18, 1892, 51 Federal Reporter 762; and Johnson Co. v. Tidewater Steel-Works, Cir. Ct. E.D. Pennsylvania, March 1, 1892, 50 Federal Reporter 90; affirmed Cir. Ct. of Appeals, 3d Cir., June 6, 1893, 56 Federal Reporter 43.

138.The largest steel producer in the United States at that time, the Homestead Steel Works, began to produce the Johnson rail in the fall of 1894. Massouh, "Technology and Managerial Innovation," 55-56.

139.Groove rails, involving a cupped flange rather than a horizontal flat flange below the surface of the road, allowed far less obstruction to other vehicular traffic and would have been preferred by all railway companies except that the groove tended to fill with dirt and other roadway refuse where road paving was not very sophisticated and roadways were not routinely cleaned. Naturally cities attempted to include in franchise agreements the responsibility of the railway company to maintain the entire roadway, but few succeeded in securing maintenance of roadway beyond 12" of the actual track. In winter, grooved rails tended to cake up with ice and were not as easily cleared by the normal running of cars.

140.Younkin, "The Steel Foundry," 4.

141.Ibid. The first good customer of the steel foundry's casting of steel mill maintenance parts was apparently Cambria Steel Company which by the early 1890s was replacing the cast iron mill parts it traditionally used with cast steel parts.

142.Clearly, the initial planning for residential areas around the plant site began in late 1887 when Johnson and Moxham were planning the construction of the plant itself. The major overall plan however, as surveyed for Johnson by professionals in New York, was developed after the flood and mostly in 1890. Johnstown Tribune, December 22, 1887; July 6, 1889; September 9, 1890.

143.Johnstown Tribune, April 10, 1888; April 6, 1889; May 2, 1889; May 14, 1889; January 10, 1890; September 9, 1890. Arthur Moxham and his family moved from their Woodvale residence into their mansion on Grove Avenue on April 5, 1889, just seven weeks before the Great Flood wiped Woodvale from the Johnstown map. As with other sections of the Johnstown area, Moxham was also the site of many single and double houses constructed by W.V. Hughes of Hoover, Hughes & Co. Johnstown Tribune, July 30, 1889. By August 1889, Hughes had built over 30 two-story houses in Moxham with 15 still ordered. Johnstown Tribune, August 16, 1889. Moxham's large mansion, built on an entire city block in 1888-1889 and overlooking the Von Lunen Grove, burned to the ground in the late 1890s, and the property subdivided for smaller houses built after the turn of the century.

144.The Somerset Water Company was chartered September 7, 1888 with E.B. Entwisle as President and Arthur J. Moxham as Treasurer. Johnstown Tribune, September 8, 1888.

145.Johnstown Tribune, April 12, 1889, December 10, 1889. After the construction of the Archer processing plant at the Johnson Company, Moxham began experimenting with the introduction of artificial gas for domestic use as well. Johnstown Tribune, February 1, 1890; June 6, 1890; June 19, 1890; June 16, 1891.

146.Johnstown Tribune, February 11, 1890; June 9, 1890; August 9, 1890; August 11, 1890.

147.As notarized on April 22, 1882, the original Articles of Association of the Johnstown Passenger Railway Company reveal that 60 per cent of the outstanding shares were held by Daniel J. Morrell, President of Cambria Iron Company, through his attorney P. E. Chopie, and by James McMillan, who became President of the

company until it was sold to Tom Johnson in 1889. McMillan, the principal organizer of the railway company, was at the time the general manager of Wood, Morrell and Company (Morrell's dry goods company on Washington Street) and vice president of Morrell's Johnstown Savings Bank. The solicitor for the railway company was Cyrus Elder, Solicitor of the Cambria Iron Company. For elaboration on Cambria Iron's Company towns, see Morawskā, For Bread With Butter; The Life-Worlds of East Central Europeans in Johnstown, Pennsylvania, 1890-1940, especially 82-87.

148.Johnson, My Story, 34.

149.The Johnstown and Stony Creek Railroad was chartered January 19, 1888 with Arthur J. Moxham as President. It began surveying the line in late October 1887 and laying track in November 1887. Completed by late spring of the next year, the railroad commenced regular passenger service June 10, 1888. Johnstown Tribune, October 28, 1887; November 5, 1887; November 14-15, 1887; January 20, 1888; May 7, 1888; May 11, 1888; June 6, 1888; June 28, 1888.

150.The run took about seven minutes. Running every half hour, service commenced at the Moxham station at 4:00 am with the last train at 11:00 pm. The first train left the Bedford Street station at 4:15 am and the last at 11:15 pm. Shortly after regular service was initiated, the railroad installed a turnout at the Feeder Dam to allow trains to pass without stopping. The car shed, a 15 x 95 foot wooden structure located just off the loop, was constructed the next year. When service was terminated after 1893, the shed was torn down. Johnstown Tribune, April 12, 1889.

151.Johnstown Tribune, December 4, 1889. The volume of passengers became so great during the first summer that the railroad ordered and began using big summer cars. Johnstown Tribune, September 2, 1889.

152.Regular service was restored on June 19, 1889, running every half hour. Johnstown Tribune, June 21, 1889. For the first six months, no fare was charged, which delighted passengers until it was reinstituted at the beginning of the next year. Johnson, My Story, 39-41.

153.Johnstown Tribune, April 14, 1890.

154.Reduced ridership from competition with the street railway caused the railroad to consider an increase in fare over the standard five cents, a move they quickly abandoned when passengers complained. The railroad then announced a two-week trial period of maintaining the every half hour schedule to see if ridership increased. When it did not after one week, the schedule was radically cut back (which by the way also caused public outcry). Johnstown Tribune, May 12, 1891; May 21, 1891.

155.Johnstown Tribune, March 4, 1893.

156.Ridership the first year was estimated at 500,000, and the line was so profitable that the street railway's debt was paid off in the first year. Johnstown Tribune, May 17, 1884; June 9, 1884. By 1886-87, with incremental addition to the company's track mileage, ridership had increased tp 817,407. Johnstown Tribune, June 14, 1888.

157.Johnstown Tribune, June 27, 1889; Street Railway Journal 5 (July 1889): 203.

158.Johnson had proposed to perpetually lease the company's system and franchises with a right to purchase. Johnstown Tribune, August 12, August 14, September 9, 1889; September 25, 1889; October 2, 1889; November 2, 1889; November 8, 1889.

159.Johnstown Tribune, January 1, 1890.

160.Johnstown Tribune, June 19, 1890; August 8, 1890; March 19, 1891. Ironically, the problem of poor municipal management of bridges emerged as well when the original (horse-drawn) street railway company began to lay track. Johnstown Tribune, July 14, 1882. After the Great Flood of 1889, seven boroughs in the lower Johnstown Basin (Johnstown, Cambria City, Millville, Conemaugh, Prospect, Woodvale, and Grubbtown) were consolidated by the election of November 5, 1889. Residents of Moxham also voted in favor of annexation, and it became part of the Seventh Ward by Court decree on December 9, 1889, Johnstown Tribune, November 6, December 13, 1889. By court order, the Moxham section of the Seventh Ward was split off as the Seventeenth Ward in 1891. Gable, History of Cambria County I: 158. Arthur Moxham had been pressing for annexation of his community to the Borough of Johnstown since the first months of 1889, chairing Johnstown's consolidation conference and serving on the three-man Committee on Consolidation

that drew up the consolidation plan, Johnstown Tribune, February 2, April 27, July 1, July 15, August 24, 1889.

161.Johnstown Tribune, March 7, 1890; October 6, 1890.

162.Johnstown Tribune, November 10, 1890.

163.Johnstown Tribune, November 27, 1900.

164.Johnstown Tribune, March 11, 1893. The company reported the loss of 41 motor cars and 11 trailer cars in the barn fire, with only three cars surviving. Street Railway Journal 9 (April 1893): 206.

165.Johnstown Tribune, August 10, 1895; March 3, 1896; July 2, 1896.

166.Massouh, "Technological and Managerial Innovation: The Johnson Company, 1883-1898," 62 note 45; Chandler and Salsbury, Pierre S. Du Pont and the Making of the Modern Corporation, 29-30. As a culmination to this period of expansion and prosperity, the Johnson Company was rechartered for $ 1 million on April 13, 1893, Johnstown Tribune, April 15, 1893. A complicating factor from this period onward was however the death of A.V. du Pont, the principal financier of the Johnson Company at the various stages of its dramatic growth. The fragmentation of his stock and bond holdings among his heirs did not reduce du Pont family commitment to the Company, but did make it more difficult to make the hard financial decisions that were to come in the next five years. Most of the financial aspects of the Company were then taken over by R.T. Wilson, a New York financier and partner of Albert L. Johnson in his various railway and cable road ventures on the east coast. Johnson, My Story, 91, 98.

167.See generally Temin, Iron and Steel in Nineteenth-Century America, An Economic Inquiry, 221-223; Alfred D. Chandler, Jr., "The Beginnings of 'Big Business' in American Industry," Business History Review 33 (1), Spring 1959, 14-17.

168.Johnson, My Story, 45-47.

169.A. J. Moxham to Pierre S. du Pont, January 26, 1894, Papers of Pierre S. du Pont, File 26, Box 34 (1).

170.Johnson Company versus Pacific Rolling-Mills Company, Cir.Ct., N.D. California, July 27, 1891, 47 Fed. Reporter 586, affirmed Cir. Ct. of Appeals, Ninth Cir., Nos. 33, 34, July 18, 1892, 51 Fed. Reporter 762; November 27, 1893, 59 Fed. Reporter 242; Johnson Company versus Pennsylvania Steel Company, Cir. Ct., E.D. Pennsylvania, No. 59, January 23, 1894, 62 Fed. Reporter 156; No. 21, May 14, 1895, Fed. Reporter 212; No. 53, May 14, 1895, 67 Fed. Reporter 940, affirmed Cir. Ct. of Appeals, Third Cir., No. 20, October 20, 1895, 70 Fed. Reporter 214; Johnson Company versus Tidewater Steel-Works, Cir. Ct. E.D. Pennsylvania, March 1, 1892, 50 Fed. Reporter 90, affirmed Cir. Ct. of Appeals, Third Cir., June 6, 1893, 56 Federal Reporter 43; Johnson Steel Street-Rail Company versus North Branch Steel Company, Cir. Ct., W.D. Pennsylvania, November 12, 1891, 48 Fed. Reporter 191, 195, 196.

171.As stated before, Johnson well understood the weaknesses of the Company's patent claims, but concluded that the patents "served as a good business bluff and kept others out of the field ... In due time we were so strongly entrenched in a business way that we didn't need patent protection." My Story, 29.

172.A.J. Moxham to Pierre S. du Pont, January 26, 1894, Papers of Pierre S. du Pont, File 26, Box 34 (1).

173.Chandler, "The Beginnings of 'Big Business' in American Industry," 11-14.

174.Johnstown Tribune, July 22, 1890, March 9, June 30, 1891; Johnson, My Story, 90-91.

175.Johnstown Tribune, January 23, February 13, March 3, March 8, March 21, October 3, 1894. Even after the decision to move the rolling mill to Lorain had been announced and carried out, the PRR continued to survey and stake the Conemaugh-to-Moxham route that had been proposed by Moxham almost four years earlier, Johnstown Tribune, January 25, 1895, January 7, 1896.

176."Financial Plan of the Johnson Company of Ohio," June 14, 1894, appended with a four-page prospectus to a confidential letter A.J. Moxham to Pierre S. du Pont, June 26, 1894, Papers of Pierre S. du Pont, File 26, Box 34 (1). Similar sentiment is found in an interview with Moxham dated April 11, 1911, cited in Johnson, My Story, 315-316.

177.Johnstown Tribune, March 4, March 12, March 21, 1894.

178.A. J. Moxham to the Stockholders of the Johnson Company, elaborating on decisions made at stockholders meeting of March 6, 1894, April 13, 1894, Papers of Pierre S. du Pont, File 26, Box 34 (1).

179."Financial Plan of the Johnson Company of Ohio," June 14, 1894. Of the new stock issue of $ 2 million, approximately $ 1.1 million had been taken or optioned within eight months, Tom L. Johnson to Pierre S. du Pont, March 22, 1895, Papers of Pierre S. du Pont, File 26, Box 34 (2). Fragments of information on the Lorain plant and its planning were cited in the local Johnstown newspapers, see for example, Johnstown Tribune, March 3, April 7, April 23, 1894.

180.Johnstown Tribune, January 25, 1895. The last girder rail was rolled at the Moxham plant on January 26, 1895; Johnstown Tribune, January 28, 1895.

181.Johnstown Tribune, March 18, 1895. The first blast at the Lorain plant was April 3, 1895.

182.After completing his studies at MIT, Thomas Coleman du Pont apprenticed at his father's Central Coal and Iron Company, Central City, Kentucky, starting in September 1883 and rising to the position of superintendent by 1890. He is also widely accredited with modernizing the company's mining operations and transforming Central City from a one-store town with mud streets to a thriving city. In 1893, he attempted to translate his broad popularity inside the mines and in the town into election as the town's mayor, but was defeated in a race colored by management-labor tensions. Shortly thereafter, he joined Moxham at the Johnson Company, and by early spring 1894 was General Manager of the Moxham plant, a position he would retain until 1899. Chandler and Salsbury, Pierre S. Du Pont and the Making of the Modern Corporation, 30; John W. Donaldson, Caveat Venditor, A Profile of Coleman du Pont (privately printed, 1964) 5-9; John K. Winkler, The Du Pont Dynasty (New York: Reynal and Hitchcock, 1935), 157-158; Marquis James, Alfred I. Du Pont, The Family Rebel (New York: Bobbs-Merrill, 1941), 140-142; Alvin F. Harlow, "Thomas Coleman Du Pont," Dictionary of American Biography, Vol. XI, Supplement One, ed. Harris E. Starr (New York: Charles Scribner's Sons, 1964 ed.), 271-272; Johnstown Tribune, April 15, 1894. After "retiring" in 1899 and moving to Wilmington, Coleman reinvolved himself in three coal and iron mining enterprises in Kentucky, and the next year purchased all of the

outstanding shares of the Johnstown Passenger Railway Company, serving as its President until 1908. Johnstown Passenger Railway Company, Stock Certificate Books, $ 50 par value (January 16, 1900 to December 6, 1901), $ 100 par value (December 23, 1901 to June 5, 1908), Cambria County Transit Authority. Immediately after gaining control of the street railway company, Coleman offered employment in its management to his younger brother Evan Morgan du Pont, who had become disenchanted with his work in the track welding shop at Johnson Company and failed to establish a profitable ice business in Johnstown with Pierre's younger brother William. "Study of the Ice Business in Johnstown, Pa (and accompanying correspondance from Pierre S. du Pont), August 22, 1901, Papers of Pierre S. du Pont, File 413, Box 367; Storey, History of Cambria County I, 534-536; Johnstown Tribune, February 5, 1941. At Pierre's request, Moxham had taken William into the Johnson Company in 1894, though the Company's position growth had leveled off and no position was really open at the plant. Tom L. Johnson to Pierre S. du Pont, August 3, 1893; A. J. Moxham to Pierre S. du Pont, October 21, 1893, Papers of Pierre S. du Pont, File 26, Box 34 (1).

183.A. J. Moxham to Pierre S. du Pont, December 12, 1893; Pierre S. du Pont to A.J. Moxham, June 6, 1894; A. J. Moxham to Pierre S. du Pont, July 18, 1896, October 20, 1896, Papers of Pierre S. du Pont, File 26, Box 34 (1, 3).

184.After the Panic of 1893, these options faced many of those industrial enterprises that had already achieved as much internal efficiencies (such as plant layout, production management, and product standardization) as possible. Chandler and Salsbury, Pierre S. Du Pont and the Making of the Modern Corporation, 30-31. The financing of the Lorain plant relied on the successful sale of the additional stock issue, continued renewals of personal notes (see note 20 below), and continued high profits from the switchworks plant in Moxham. Virtually none of these factors performed as Moxham had hoped, particularly the profits from the switchworks which lagged by as much as 75 % behind Moxham's (admittedly over-optimistic) expectations, see T. Coleman du Pont to A.J. Moxham, April 14, 1896, Papers of Pierre S. du Pont, File 26, Box 34 (3). By 1894, the Johnson Company had begun to pay its dividends in additional stock (12.4 % in 1894) with stock purchase options rather than cash, a clear disincentive to those already holding stock and notes for income purposes; Johnson Company to Pierre S. du Pont, pro rata earnings statement dated April 13, 1894, Papers of Pierre S. du Pont, File 26, Box 34 (1).

185.A.J. Moxham to Pierre S. du Pont, February 25, 1896, Papers of Pierre S. du Pont, File 26, Box 34 (3). Personal notes were even more difficult to renew for both Pierre du Pont and R.T. Wilson

after the negative Dun report (note 21 below) challenged the financial viability of the Johnson Company and called into question the collateral both men were using to back their personal notes; see Pierre S. du Pont to A.J. Moxham, September 26, 1896, Papers of Pierre S. du Pont, File 26, Box 34 (3).

186.The Johnson Company, application to the Stock List Committee of the New York Stock Exchange to list $ 1,245,000 in 6% 20-year gold bonds, attaching its 1895 year-end statement, February 15, 1896, Papers of Pierre S. du Pont, File 26, Box 34 (4). An evaluation of the Johnson Company by the R.G. Dun Company (precursor of Dun and Bradstreet) in mid-1896 produced an extremely negative conclusion that "[A]t the present time they acknowledge their inability to take care of their maturing obligations. Their liability is a large and pressing one, and various accounts are accruing daily with practically no resources on hand for their liquidation", a conclusion to which Moxham took immediate and forceful exception, A.J. Moxham to R.G. Dun & Co., Cleveland, September 29, 1896, Papers of Pierre S. du Pont, File 26, Box 34 (3). While the Dun report exaggerates the condition of the accounts payable dimension of the Johnson Company, it fairly approximates the Company's recurring crisis handling of its maturing bond and note obligations (see note 20 above). Unfortunately, the 1896 Dun report on the Johnson Company is not included in the Dun archives at the Baker Library, Harvard University Graduate School of Business, Cambridge.

187.Daniel Nelson, Frederick W. Taylor and the Rise of Scientific Management (Madison: University of Wisconsin Press, 1980), 63; Street Railway Journal 11 (August 1895), 547; Passer, The Electrical Manufacturers, 1875-1900, 334.

188.Massouh, "Tom Loftin Johnson," 172-173; Nelson, Frederick W. Taylor and the Rise of Scientific Management, 63; Johnstown Tribune, February 7, March 4, 1896. As an indicator of Moxham's efforts to recapture underutilized plant value in Johnstown, the Johnson Company sold an acre of land at the northern end of the Moxham plant site (near the location of the original brickworks) to the Fowler Radiator and Manufacturing Company, T. Coleman du Pont to Pierre S. du Pont, November 21, 1896, Papers of Pierre S. du Pont, File 26, Box 34 (2).

189.Nelson, Frederick W. Taylor and the Rise of Scientific Management, 64-68; and Frank Barkley Copley, Frederick W. Taylor; Father of Scientific Management, 2 vols. (New York: Harper & Bros., 1923), I: 445-451. En toto, Taylor worked for Moxham and Coleman du Pont for eight months, March through November 1896.

Moxham's initial optimism for expanding the Steel Motor Works was based on its profit margin from its first month in operation in 1895; A.J. Moxham to Stockholders of the Johnson Company, March 24, 1896, Papers of Pierre S. du Pont, File 26, Box 34 (4). All of the Rights and Patents of the Steel Motor Company were sold to the Westinghouse Electric Manufacturing Company of Pittsburgh April 30, 1902.

190.Massouh, "Technology and Managerial Innovation," 64 ; Johnstown Tribune, April 7, April 18, 1898. Already by this time, both Tom Johnson and A. J. Moxham had divested themselves of their investment residential properties in Moxham, excluding the Moxham mansion in which T. C. du Pont was living. S.E. Young to Tom L. Johnston, November 19, 1897, Tom L. Johnson to S.E. Young, November 23, 1897, Papers of Pierre S. du Pont, File 339, Box 227.

191.The core company in the merger, Illinois Steel, was itself a merger of smaller Chicago steel holdings completed in 1889. By the early 1890s, Elbert Gary (then Illinois Steel's chief attorney but acting independently) initiated a major merger of steel wire interests that resulted (after delays caused in part by the Panic of 1893) in the incorporation of American Steel and Wire in early 1898 for $ 24 million. Shortly after that merger was completed, Gary was prevailed upon to work on the merger of Illinois Steel and the Elgin, Joliet and Eastern Railroad, but he persuaded the company that their real interest lay in securing their supply of Great Lakes ore stocks through the purchase of Minnesota Iron Company. His subsequent efforts resulted in the formation of Federal Steel August 31, 1898, and its incorporation September 10, 1898. After the merger was completed, Gary retired from his law practice and became President of Federal Steel. Vincent P. Carosso, The Morgans; Private International Bankers, 1854-1913 (Cambridge: Harvard University Press, 1987), 390-392; Hogan, Economic History of the Iron and Steel Industry in the United States I: 239-243, 265-272; Clark, History of Manufactures in the United States III: 45-47; Ida Tarbell, The Life of Elbert H. Gary, The Story of Steel (New York: Appleton, 1925), 72-97. There is some evidence that Gary unsuccessfully attempted to lure T.C. du Pont into accepting the Presidency of Lorain Steel in 1899; Pierre S. du Pont to Tom L. Johnson, February 12, 1900, Papers of Pierre S. du Pont, File 339, Box 227. Representing 16 % of the capital worth of the merger, the Johnson Company is rarely mentioned in any of the analyses of the Federal Steel merger, but one source indicates that the Johnson product line allowed an established entre into foreign trade markets. William Z. Ripley, Trusts, Pools, and Corporations (Boston: Ginn & Co., rev. ed., 1916), 162-163. There is little doubt that the Johnson acquisition would have been a good investment for any steelmaker -- it was an established steel

fabricator with an exceptional marketing structure and state-of-the-art plant facilities. Its trackwork plant in Johnstown was without peer. What the Johnson Company obviously lacked was the capital to move into basic steel production.

192. Stockholders in the Johnson Company did fairly well in the Federal Steel merger, considering the deteriorating condition of their own operations (described above). On careful inspection, however, it is clear that they actually received $ 28 market value (1898) in Federal Steel stock for $ 100 par value (1893) in Johnson Company stock. See Massouh, "Technology and Managerial Innovation," 65 note 52; and Chandler and Salsbury, Pierre S. Du Pont and the Making of the Modern Corporation, 32-33. Tom Johnson withheld the Lorain Street Railway and the Sheffield Land Company operations from the merger because he believed future expansion of the Lorain plant under Federal Steel would finally allow realization of profit from those investments. In January 1899, he offered the Presidency of the Johnson Company (i.e. its remaining Lorain investments) to Pierre S. du Pont who, at the age of 28, was languishing below the executive level at the Du Pont Company in Wilmington. Unable to secure promise of advancement and interested in pursuing his own extensive investments in the Johnson Company, Pierre took Johnson's offer and for over three years oversaw the Lorain operations. Chandler and Salsbury, 36-51; Pierre S. du Pont to A.J. Moxham (then President of Dominion Iron and Steel in Nova Scotia), report on Johnson Company operations, June 25, 1900, Papers of Pierre S. du Pont, File 250, Box 201. At the same time, under the advice of Tom Johnson, Pierre formed a syndicate through Flower & Co. (New York) with seven of his brothers, sisters and cousins that invested heavily (and successfully) in Federal Steel, at one time holding over a quarter of a million dollars in Federal Steel stock. Pierre S. du Pont to H.B., T.C., E.M. W.K. A.B. (Jr.) du Pont, January 17, 1899, July 23, 1900, Papers of Pierre S. du Pont, File 254, Box 201; Tom L. Johnson to Pierre S. du Pont, January 18, 1899, Pierre S. du Pont to Tom L. Johnson, January 29, 1899, Papers of Pierre S. du Pont, File 339, Box 227.

193. Carosso, The Morgans, Private International Bankers, 1854-1913, 466-474; Hogan, Economic History of the Iron and Steel Industry in the United States II: 463-493; Clark, History of Manufactures in the United States III: 54-57; Tarbell, The Life of Elbert H. Gary, The Story of Steel, 98-125. For overview of the conditions that made the giant merger possible, see also Glenn Porter, The Rise of Big Business, 1860-1910 (Arlington Heights: Harlan Davidson, 1973), 54-71; Chandler, "The Beginnings of 'Big Business' in American Industry," 17-25; Misa, "Science, Technology, and Industrial Structures: Steelmaking in America, 1870-1925," 249; and Temin, Iron and Steel in Nineteenth-Century America, 190-193.

194.Changes in the structure and facilities of the Johnstown plant between 1902 and 1917 are described in some greater detail in the Analysis of the Plant Site.

195.While not the focus of this study, the decline in electric street railways was a critical element in later changes in product lines at the Johnstown plant. The dynamics of the decline are discussed in Stanley Mallach, "The Origins of the Decline of Urban Mass Transportation in the United States, 1890-1930," Urbanism Past and Present 8 (Summer 1979): 1-17; and David J. St. Clair, "The Motorization and Decline of Urban Public Transit, 1935-1950," Journal of Economic History XLI (September 1981): 579-600; and graphically illustrated in George W. Middleton, Time of the Trolley (Milwaukee: Kalmbach, 1967). Examination of the impact of these transportation dynamics on cities can be found in George W. Hilton, "Transportation Technology and the Urban Pattern," Journal of Contemporary History 4 (July 1969): 123-135; Joel A. Tarr, "From City to Suburb: The 'Moral' Influence of Transportation Technology," in American Urban History, An Interpretive Reader With Commentaries, ed. Alexander B. Callow, Jr. (Oxford, 1973): 202-212; and Glen E. Holt, "Urban Mass Transit History: Where We Have Been and Where We Are Going," in The National Archives and Urban Research, ed. Jerome Finster (Athens: Ohio University Press, 1974): 81-99.

APPENDIX A

THE COLEMAN - DU PONT AXIS

No factor was more critical to the formation and early success of the Johnson Steel Street Rail Company than the fact that Tom L. Johnson, Arthur J. Moxham, Thomas C. Coleman, Jr., and Alfred V. du Pont were related by blood or marriage. The Company was borne in the age of the family business, when the inventor or skilled craftsman was also a company's businessman and entrepreneur. The prototype of this age was the Du Pont Powder Company, in which younger men in the family were brought into the business at the lowest levels and moved slowly through the ranks into management positions. Similar in format but smaller in scale was the Louisville Rolling Mill Company, a family-owned, managed and operated business since it was acquired in the early 1850s. Both companies were very rigidly family-run businesses, with few if any outsiders participating in either their operations or financing. And both companies developed the earlier pattern of absorbing the younger men of the family, no matter how remotely related, into either its basic operations, its agencies, or its subsidiaries.

It was precisely this pattern, already well-developed in the Du Pont Powder Company by the 1850s, that drove Alfred V. du Pont at the age of twenty-one to seek independence by moving to Louisville. Even so, his initial effort, the purchase of the Du Pont agency there, was financed by both loans from his family and backing by the Company itself. But his business acumen would become quite evident early on as he restructured the agency, bringing his younger brother Bidermann in as a partner, and used both his profits and his significant family backing to diversify his holdings over the next forty years to the point that by 1890 he was one of the wealthiest men in Louisville.

As entrepreneur and businessman, du Pont was always on the lookout for investment possibilities in Louisville, particularly in the early 1870s when he wanted to divest himself of the powder agency. This opportunity materialized when Thomas C. Coleman, Jr., President and successor to his father in the family-run Louisville Rolling Mill Company, sought refinancing in the mid-1870s and was willing to bring in the du Pont brothers since Bidermann had married his sister Ellen in 1861 and was already part of the extended family. Thus was borne what could be called the Coleman-du Pont axis, a merging of family-run and financed business interests that controlled significant parts of the Louisville economy by 1880.

In such close-knit and intensely loyal families as the Colemans and the du Ponts, intermarriage expanded not only the financial resources each could draw upon, but also the kinds of entrepreneurial talent accessible to each company. Du Pont backing made possible the Coleman exploration of steelmaking in the Birmingham, Alabama market in the late 1870s, and thereby expanded the entrepreneurial horizons of a young Welsh ironmaster related to Coleman by marriage, Arthur J. Moxham. Dora Morgan Coleman, the wife of Thomas C. Coleman, Sr., was Moxham's blood aunt and when he emigrated to the United States in 1869, Thomas C. Coleman, Jr. found a place for the boy in his rolling mill. Within seven years, young Moxham had completed his apprenticeship as an ironmaster and had married Coleman's daughter Helen. Two years later, the du Ponts would have such confidence in his ironmaking skills and business sense to invest large amounts of capital in his innovative steel rail rolling processes over a six year period in Birmingham, Alabama, Louisville, and Johnstown, Pennsylvania.

No less significant was the du Ponts' growing confidence in another of Coleman's young wards, Tom L. Johnson. Johnson's blood aunt Dullie (his father's sister) was Thomas C. Coleman, Jr.'s wife, and when Johnson's family returned to the Louisville area in 1869, Coleman placed the young boy in the rolling mill's offices. Soon the boy moved to the offices of one of du Pont's many Louisville companies - the small horse-drawn street railway - which he quickly reorganized and renovated into a profitable operation. His knowledge of the business and obvious entrepreneurial agility encouraged both du Pont brothers to invest in the purchasing of other railway lines, and ultimately to capitalize the production of one of his many railway inventions - the street girder rail.

The family pattern of business loyalty was continued faithfully by both Moxham and Johnson after their success in Johnstown, Pennsylvania. The Johnson Company plant in Moxham was a training ground in the 1890s for the next generation of du Pont men: William (Lammot's son who stayed but a short time), Thomas Coleman (Bidermann's eldest son who came up from du Pont's Central City coal operations to become general manager of the Johnson Company in 1895 and later purchased the Johnstown Passenger Railway Company), Evan Morgan (Bidermann's youngest son who came to Johnstown in 1896 to work in the track welding department, briefly flirted with the ice business, and ultimately moved over to the Johnstown Passenger Railway Company where he became general manager by 1910), and Pierre (Lammot's oldest son whom Moxham brought into his Lorain operation to liquidate the Company's other assets after steel mill was sold to Federal Steel).

As proven entrepreneurs and businessmen within the du Pont orbit, both Johnson and Moxham had earned the trust of Alfred V. du Pont. As co-executor of du Pont's will in 1893, Johnson became a trusted investment counselor and confidente of Pierre S. du Pont who (at the age of 23) was charged with overseeing the extensive financial interests left by the estate to himself and his seven other brothers and sisters. Johnson also played a significant role in the re-distribution of that portion of du Pont's estate willed to his elderly mother Margaretta Lammot du Pont. Johnson's investment advice was understandably quite prized, for his Johnson Company stock paid healthy dividends and almost doubled in value and his railway investments proved good investments as growth stocks. And while Pierre S. du Pont continued to follow Johnson's counselling (albeit quite conservatively) into the early twentieth century, it was Thomas Coleman du Pont who invested broadly in railway stocks even after he became President of the E.I. Du Pont de Nemours Company in 1902.

Arthur J. Moxham was an astute businessman and plant manager who understood his production processes first-hand from beginning to end. He had nurtured the Johnson Company from fledgling operation to national prominence through scientific management and sophisticated marketing techniques unrivaled in industry at the time. Thomas Coleman du Pont apprenticed under Moxham during times of both growth and hardship (1895-1902) and developed a healthy trust for Moxham's business sense. He turned to Moxham as a principal advisor during the purchase of the Du Pont Company in 1902, and loyally kept Moxham on the Executive Board of the Company until 1915 when he sold all of his company stock to Pierre S. du Pont.

In the charts which follow, the Johnson, Coleman, du Pont, and Moxham family lineages are briefly sketched and the connections detailed. The Johnson lineage is the easiest to trace, since Tom Johnson commissioned an extensive genealogy of his family for his biography shortly before his death in 1911. ["Genealogy of the Johnson Family from William Johnson 1714-1765 with special reference to descendants of Robert Johnson who came from Kentucky. Compiled for Thomas L. Johnson." n.d., n.a., typed manuscript from privately printed book (circa 1910), Filson Club, Louisville, Kentucky] This information was supplemented in part by obituaries of family members and career retrospectives published in the New York Times and the Cleveland Plain Dealer. While Tom Johnson considered Cleveland his home for over twenty-five years, the rest of his family moved to Brooklyn, New York following his brother Albert's business interests.

Long prominent in the Louisville area, the Coleman family can be traced in the various books [such as Johnston's Memorial History of Louisville] and manuscripts of that city's history, and

archival materials at the Filson Club in Louisville. Information on several of the Coleman lines is detailed in the Johnson genealogy (above), and clarified by genealogical notes from an interview of Mrs. Walter S. Carpenter III (May 20, 1969) by Michael Massouh, in the Papers of Pierre S. du Pont, File 339, Box 227, Hagley Library, Wilmington, Delaware. Family records are supplemented by recorded census data for Louisville (Thomas C. Coleman, Sr., Jefferson County 1850, 1860; Thomas C. Coleman, Jr., Bullitt County 1880, 1900, 1910), Kentucky, and the probated wills of Thomas C. Coleman [20 October 1860/22 July 1861, Will Book 5, p. 491, Jefferson County, Kentucky] and Dora Coleman [3 January 1882 (codicile 1 April 1886)/30 March 1898, Will Book 21, p. 567, Jefferson County, Kentucky]. Record of the family's Louisville Iron Company is contained in Stockholder Record Book, Louisville Rolling Mill Company, 1850-1887, in the Hagley Library, Wilmington, Delaware.

While the du Pont family lineage has been exhaustively explored in genealogical studies commissioned by the family [e.g. "Genealogy of the Du Pont Family 1739-1943," copyright Pierre S. du Pont, 1943 (with several updates), Filson Club, Louisville, Kentucky; archival materials in the Manuscript Department of the Hagley Library, Wilmington, Delaware] or family histories [see Bibliography], most materials focus on family operations centered in Wilmington, Delaware since the turn of the century. Little effort has been expended exploring "the Louisville side" of the family, at least the activities of du Pont family members (Alfred V. du Pont, A. Bidermann du Pont and his family) while in Kentucky between 1852 and 1898, save those cited in the Bibliography. Lacking background knowledge of both the Johnson and Coleman lineages in Louisville, many previous researchers of du Pont enterprises have concluded (if they sought to explain it at all) that both Tom Johnson and Arthur Moxham were simply friends of Alfred and Bidermann du Pont from the Louisville period. This would be wholly insufficient to explain how these two men became intimate to the financial and business operations of Thomas Coleman du Pont and Pierre S. du Pont both before and after the turn of the century.

Arthur J. Moxham was the most difficult to trace genealogically, partly because his family origins were in Wales (and were not explored in this study) and partly because he was an intensely private man and about whom little has been written. His family lineage is connected through his mother's side to the Colemans in Louisville, and through the Colemans to the du Ponts. The one primary source that exists on the Moxham family is his son Egbert Moxham's typescript memoir entitled Rosemary of which only three privately bound editions exist (in possession of family members). Other fragments of Moxham's life can be found either in Louisville (because of Arthur's connection with the Coleman

family and where Arthur maintained a family burial plot in the Cave Hill Cemetery) or at the Hagley Library (due to Moxham's extensive business connections with both Pierre and Thomas Coleman du Pont). The Arthur Moxham biography published in the American Dictionary of Biography was based on an interview of his son Egbert. The probated will of his mother Catherine Moxham [6 October 1875/27 March 1882, first probated 30 April 1878, Llandaff district, Glamorgan, Wales, Will Book 11, p. 176, Jefferson County, Kentucky] contains some minimal family information. The most precise sources of the Moxham brothers'marriages and children is the Egbert Moxham memoir and the Johnson geneology (p. 30 and 31), since Arthur married one of Tom Johnson's aunt's (Dullie) daughters (Helen Coleman, in 1876) and Edgar married another (Bessie Coleman, in 1882). Both Edgar and Arthur, together with Arthur's wife Helen and three of his children (Thomas, Dulcinea and Florence) are all buried in the Cave Hill Cemetery in Louisville.

CHART A-1

THE JOHNSON FAMILY LINEAGE

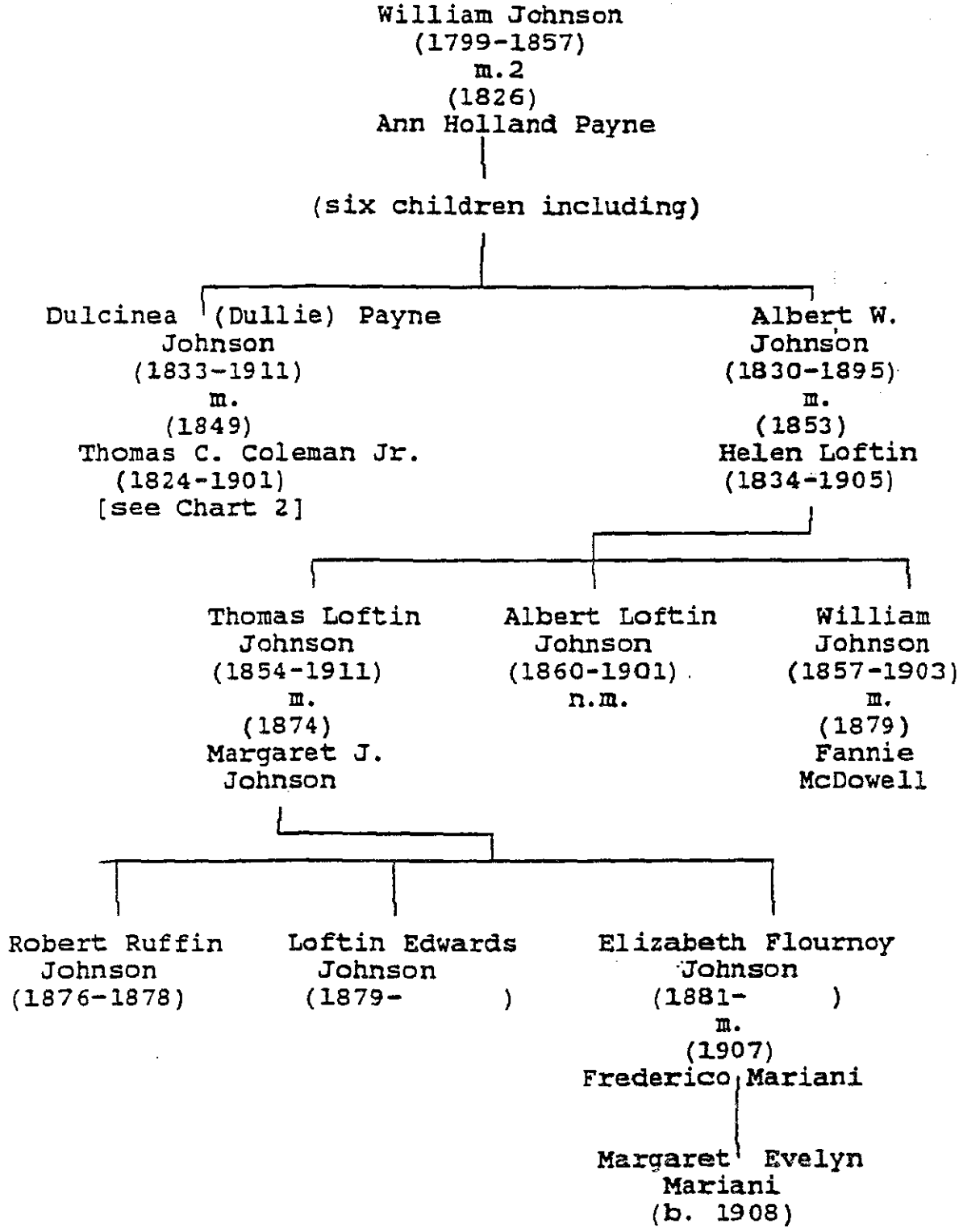


CHART A-2

THE COLEMAN FAMILY LINEAGE

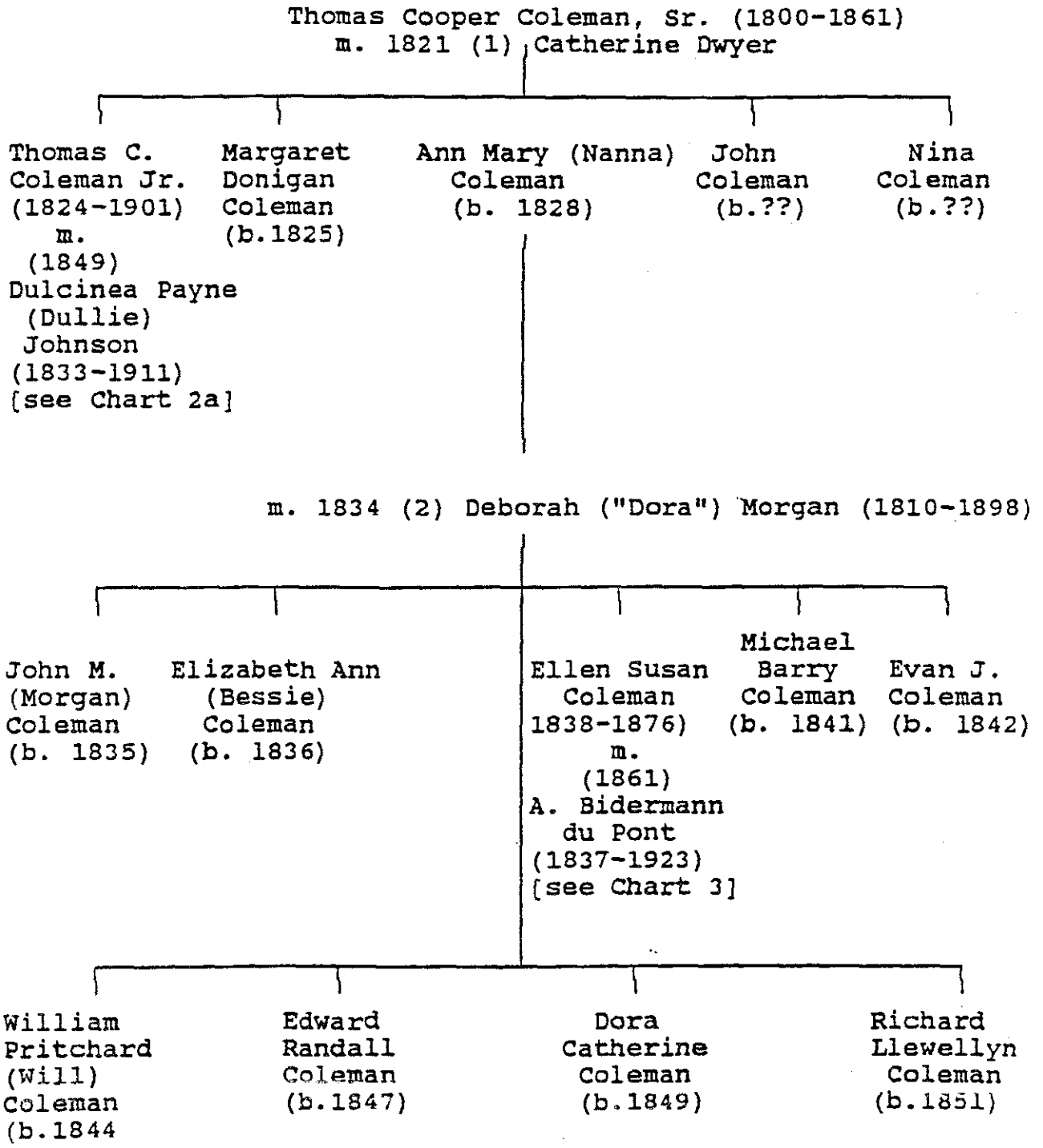


CHART A-2a

THE COLEMAN FAMILY LINEAGE
(continued)

Thomas Cooper Coleman, Jr.
m.
Dulcinea Payne Johnson

(13 children)

- Ann Mary Coleman (b. 1850)
- Catherine C. Coleman (1852-1853)
- Margaret Dwyer (Maggie) (b. 1854) m. (1891) Edgar C. Moxham [see Chart 4]
- Helen J. Coleman (1856-1932) m. (1876) Arthur J. Moxham (1854-1931) [see Chart 4]
- Dora M. Coleman (b.1858) m. (1878) Thomas Ward
- Jilson J. Coleman (b.1859)
- Elizabeth (Bessie) (1861-1886) m. (1882) Edgar C. Moxham (1858-1913) [see Chart 4]
- Dulcinea Coleman (b. 1863) m. (1888) Charles Alfred Marshall
- Jennie Coleman (b. 1866)
- Thomas C. Coleman (b. 1868)
- Ophelia (Phoebe) Coleman (b.1870)
- Alberta (Bertie) Coleman (b. 1872)
- Caddie J. Coleman (1875-1876)

CHART A-3

THE DU PONT FAMILY LINEAGE
Re: Louisville, Kentucky 1852-1900

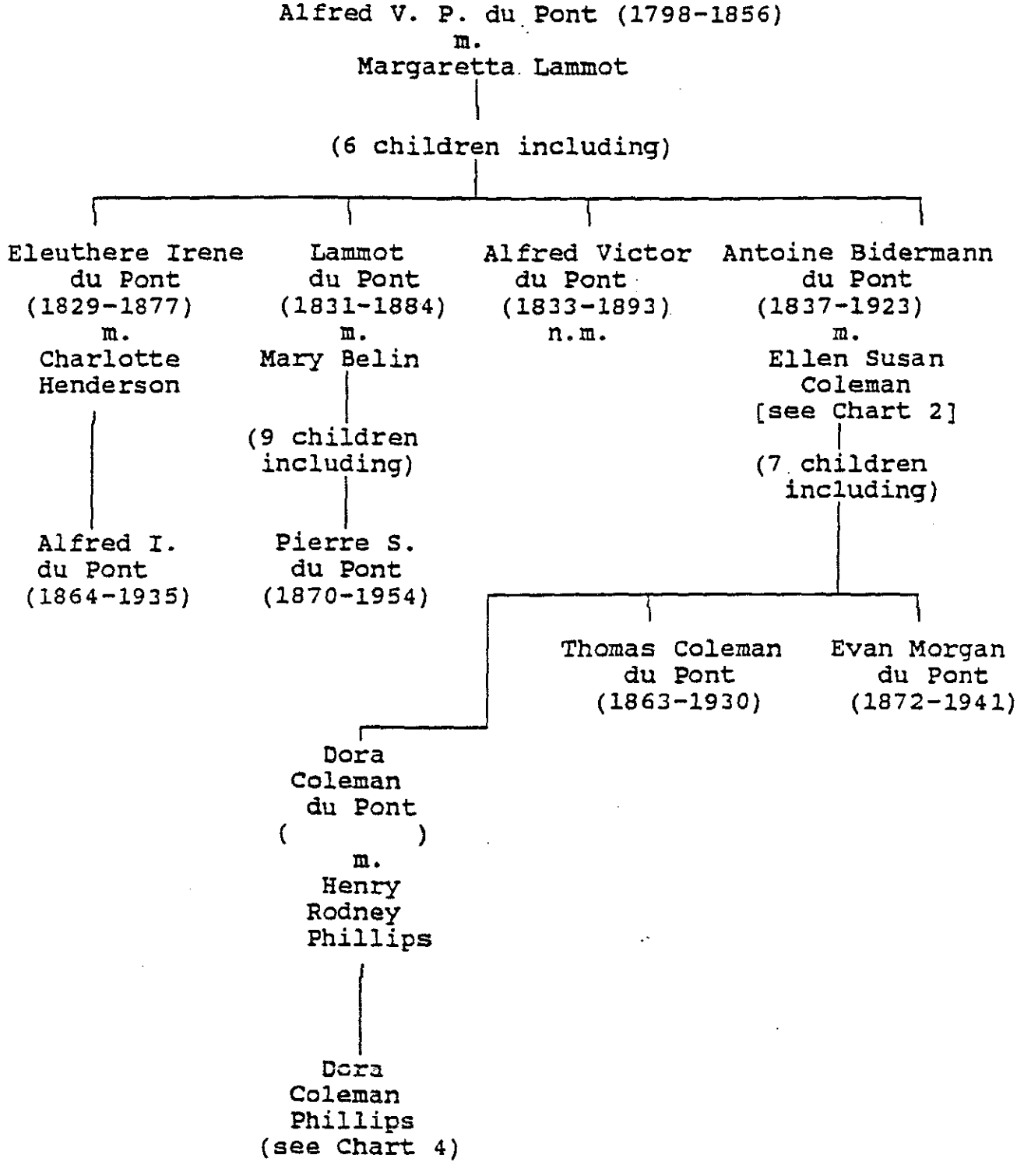


CHART A-4

THE MORGAN-MOXHAM FAMILY LINEAGE

John Morgan m. Elizabeth Pritchard
[Collena, Glamorganshire, South Wales]

12 children including

Thomas Cooper Coleman m. Dora Morgan
[See Chart 2]

Katherine (Catherine) Morgan (1816-1876) m. Egbert Moxham (1824-1864

- Florence Elizabeth Moxham (b. 1852) m. John Randall
- Arthur James Moxham (1854-1931) m. Helen Jilson Coleman
  [See Chart 2a]
  [See Chart 4a]
- Evangeline Margaret Moxham (b. 1856) m. ???
- Evan Pritchard Moxham (b. 1857) ???
- Edgar Coleman Moxham (1859-1913) m.1 Elizabeth Ann Coleman m.2 Margaret Dwyer Coleman
  [See Chart 2a]
  [See Chart 4b]

CHART A-4a

THE MORGAN-MOXHAM FAMILY LINEAGE
(continued)

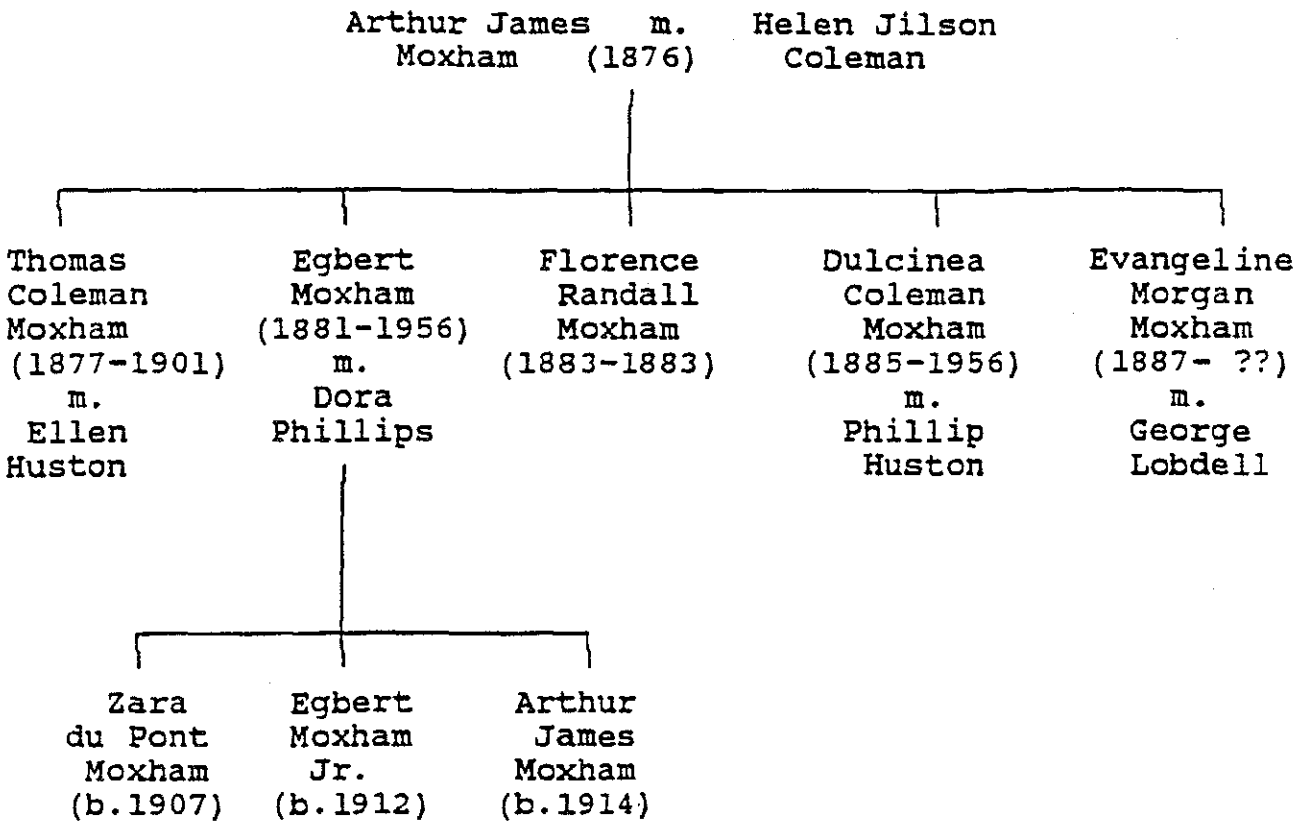
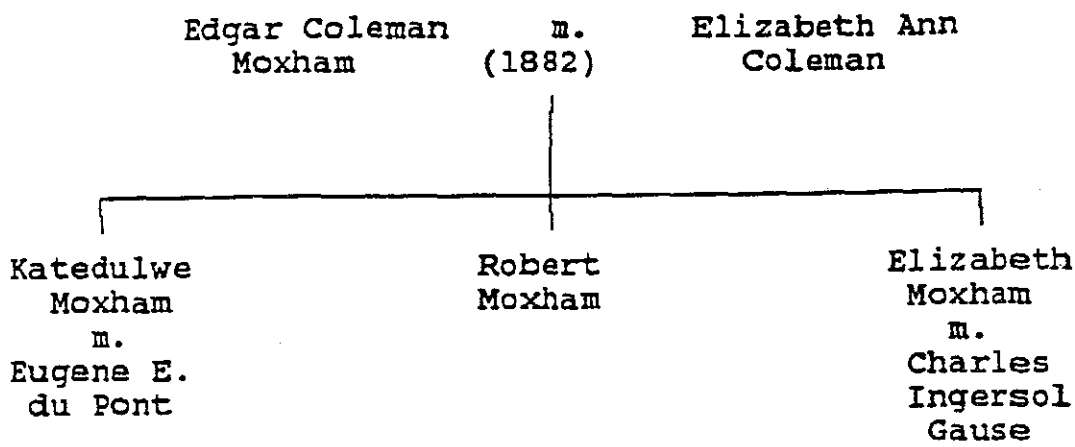


CHART A-4h

THE MORGAN-MOXHAM FAMILY LINEAGE
(continued)



APPENDIX B

CLIENTELE OF THE JOHNSON COMPANY, 1886-1893

The following is a list of the street railway, cable road, and steam railroad companies that ordered drawings and subsequently specialty trackwork from the Johnson Steel Street Rail Company (after 1888 the Johnson Company). It has been compiled from the first three volumes of the Company's Ledger Books of Drawings and Orders (Nos. 138 - 16,000, covering dates July 9, 1886 to May 17, 1893). This listing does not include other industrial manufacturers that ordered trackwork either on a subcontracting basis (like Thomson-Houston) or for their own plants. The date cited in parantheses after the company name indicates the first year trackwork was ordered. Companies for which the Johnson Company completed sufficient trackwork to indicate a major route or entire system was being constructed are marked with an asterisk (*). With these companies however, the first year of order does not necessarily correspond with the year the bulk of the orders were placed.

Street Railway Company (and date of first contract)

Albany Railway Co., Albany, NY (1890)
Allentown & Bethlehem Rapid Transit Co., Allentown, PA (1891)
* Amsterdam Street Railway Co., Amsterdam, NY (1890)
Anacostia & Potomac River Railway Co., Anacostia, DE (1891)
Anderson Electric Street Railway Co., Anderson, IND (1891)
Ann Arbor Street Railway Co., Ann Arbor, MI (1891)
Asheville Street Railway Co., Asheville, NC (1891)
Ashland & Catlettsburg Street Railway Co., Ashland, KY (1890)
Ashtabula Consolidated Street Railway Co., Ashtabula, OH (1891)
Atlanta Street Railway Co., Atlanta, GA (1890)
* Atlanta Consolidated Street Railway Co., Atlanta, GA (1891)
Atlanta and Edgewood Street Railway Co., Atlanta, GA (1891)
Atlanta West End & McPherson Barrachs Street Railway Co., Atlanta, GA (1890)
Atlanta West End Railway Co., Atlanta, GA (1891)
Attleboro & No. Attleboro Street Railway Co., Attleboro, NY (1889)
Auburn City Railway Co., Auburn, NY (1891)
* Aurora Street Railway Co., Aurora, IL (1890)
Baltimore & Ohio Railway Co., Chester, PA (1892)
* Baltimore Traction Co., Baltimore, MD (1890)
Beaver Valley Street Railway Co., Beaver Valley, PA (1889)

Beaver Valley Traction Co., Beaver Falls, PA (1891)
* Belle City Street Railway, Racine, WI (1892)
Beuton-Bellefontaine Railway Co., St. Louis, MO (1891)
* Binghamton Street Railway Co., Binghamton, NY (1890)
Birmingham Electric Railway Co., Birmingham, AL (1891)
Blakely & Dickson Traction Co., Scranton, PA (1893)
Braddock Electric Railway Co., Braddock, PA (1891)
Braddock & Turtle Creek Railway Co., Braddock, PA (1891)
Bridgeport Horse Railway Co., Bridgeport, CN (1891)
Brightwood Railway Co., Washington, DC (1892)
Bristol Belt Line Railway Co., Bristol, TN (1891)
* Broadway and 7th Ave Railway Co., New York City, NY (1891)
* Broadway & Newberry Street Railway Co., Cleveland, OH (1888)
Broadway Cable Road, New York, NY (1890)
Brooklyn Street Railway Co., Brooklyn, NY (1889)
* Brooklyn St. Railway Co., Cleveland, OH (1889)
Buffalo & Bellvere & Lancaster Railway Co., (1892)
* Buffalo Street Railway Co., Buffalo, NY (1890)
* Calumet Electric Railway Co., Chicago, IL (1890)
* Camden Horse Railway & Construction Co., Camden, NJ (1889)
Canton St. Railway Co., Canton, OH (1892)
Capitol Nth, O Street & S. Washington Railway Co., Washington, DC (1891)
Capitol Railway Co., Frankfort, KY (1892)
* Carbondale Traction Co., Carbondale, PA (1892)
* Cass Ave & Fairground Railway Co., St. Louis, MO (1892)
Cayadutta Electric Railway Co., Gloversville NY (1892)
Central City Horse Railway Co., Peoria, IL(1889)
Central Electric Railway Co., Paterson, NJ (1892)
* Central Passenger Railway Co., Louisville, KY (1887)
Central Passenger Railway Co., Pittsburgh, PA (1891)
Central Railway Co., Peoria, IL (1892)
Central Railway Co., Sacramento, CA (1889)
Central Railway & Bridge Co., Pittsburgh, PA (1891)
Chattanooga & No. Side Street Railway Co., Chattanooga, TN (1890)
* Chattanooga Electric Street Railway Co., Chattanooga, TN (1889)
Cheltin Ave Passenger Railway, Philadelphia, PA (1891)
Chicago & Northshore Street Railway Co., Chicago, IL (1893)
* Chicago City Railway Co., Chicago, IL (1887)
* Cicero & Proviso Street Railway Co., Chicago, IL (1890)
* Cincinnati Inclined Railway Co., Cincinnati, OH (1888)
* Cincinnati St. Railway Co., Cincinnati, OH (1886)
Citizens Passenger Railway Co., McKeesport, PA (1892)
Citizens Passenger Railway Co., Philadelphia, PA (1890)
Citizens Passenger Railway, Steelton, PA (1891)
* Citizens Street Railway Co., Indianapolis, IN (1891)
Citizens Street Railway Co., Memphis, TN(1891)
Citizens Street Railway Co., Springfield, OH (1891)

* Citizens Street Railway Co., St. Louis, MO (1887)
* Citizen Traction Co., Pittsburgh, PA (1889)
City & Suburban Railway Co., Baltimore, MD (1892)
City & Suburban Railway Co., Memphis, TN (1890)
City Electric Railway Co., LaSalle, IL (1891)
* City Passenger Railway Co., Altoona, PA (1890)
City Street Car Co., Stanton, VA (1890)
Clinton & Lyons Railway Co., Lyons, LA (1891)
Coalville Passenger Railway, Wilkesbarre, PA (1892)
Columbia Railway Co., Washington, DC (1891)
Columbia & Ironville Street Railway Co., Columbia, PA (1892)
* Columbus Consolidated Street Railway Co., Columbus, OH (1886)
Columbus Street Railway Co., Columbus, OH (1891)
Connecticut Tramway Co., New Haven, CT (1892)
Connellsville, New Haven, & Lussinning St. Rwy Co., New Haven, PA (1891)
Consolidated Light & Railway Co., Hamilton, WV (1892)
Consolidated Street Railway Co., Bay City, MI(1893)
Consolidated Street Railway Co., Grand Rapids, MI (1892)
Covington, Newport, & Cincinnati Street Railway, Cincinnati, OH (1892)
Crescent City Railroad Co., New Orleans, LA (1893)
* Crosstown Street Railway Co., Buffalo, NY (1890)
Cuyahoga Falls & Akron Railway & Power Co., OH (1893)
Dallas Cable Railway Co., Dallas, TX (1891)
Danville Gas Electric Light Street Railway, Danville, IL (1891)
Danville Street Railway Co., Danville, VA (1892)
* Davenport & Rock Island Street Railway Co., Davenport, IA (1890)
* Davenport Central Railway Co., Davenport, IA (1890)
Dayton Street Railway, Dayton, OH (1892)
Decatur Electric Railway Co., Decatur, IL (1890)
Delaware Electric Street Railway, Delaware, OH (1892)
Denver Tramway Co., Denver, CO (1888)
Des Moines Street Railway Co., Des Moines, IA (1889)
Detroit Citizens Street Railway Co., Detroit, MI (1892)
Detroit City Railway Co., Detroit, MI (1889)
Douglass Company Railway, West Superior, WI (1891)
Dubuque Electric Railway Light & Power Co., Dubuque, IA (1890)
* Dubuque Street Railway Co., Dubuque, IA (1891)
Duby Street Railway Co., Birmingham, CT (1893)
Duluth Street Railway Co., Duluth, MN (1889)
Duquesne Traction Co., Pittsburgh, PA (1891)
East Cleveland Railroad Co., Cleveland, OH (1890)
East End Passenger Railway Co., Erie, PA (1891)
East End Passenger Railway Co., Williamsport, PA (1892)
East End Railway Co., Bridgeport, CT (1891)

East 5th Street Railway, Kansas City, MO (1889)
East Harrisburg Passenger Railway Co., Harrisburg, PA (1891)
East Middlesex Street Railway, Maldin, MA (1892)
* East Reading Railway Co., Reading, PA (1889)
Easton Transit Co., Easton, PA (1892)
* Eckington & Soldiers Home Railway Co., Washington, DC (1888)
Electric Railway Co., Savannah, GA (1893)
Electric Railway & Power Co., Tiffin, OH (1892)
Electric Traction & Manufacturing Co., New Orleans, LA (1890)
Elizabeth Street Railway Co., Elizabeth, NJ (1890)
* Elgin Street Railway, Elgin, IL (1889)
* Elmira & Horseheads Railway Co., Elmira, NY (1889)
Elwood Street Railway Co., Elwood, IN (1892)
Erie City Passenger Railway Co., Erie, PA (1891)
* Federal Street & Pleasant Valley Passenger Rwy Co., Pittsburgh, PA (1889)
* Fifth Street Railway Co., Dayton, OH (1889)
Fort Clark Horse Railway Co., Peoria, IL (1890)
Fort Smith Street Railway Co., (1887)
Ft. Wayne & Belle Isle Railway Co., Detroit, MI (1892)
Ft. Wayne & Elmwood Street Railway Co., Detroit, MI (1892)
Fox River Street Railway, Racine, WI (1893)
Frankfort & Southwark Railway Co., Frankfort, KY (1891)
Galveston City Railway Co., Galveston, TX (1890)
Georgetown & Tenllytown Railway Co., Washington, DC (1889)
Glenwood & Greenlawn Street Railway Co., Columbus, OH (1890)
* Globa Street Railway Co., Fall River, MA (1892)
Gloucester Street Railway Co., Gloucester, MA (1891)
Grand Park Electric Railway Co., Atlanta, GA (1891)
Grand River Railway Co., Detroit, MI (1891)
Grand Street & Newton Railroad Co., (1889)
* Great Falls Street Railway Co., Great Falls, MT (1890)
* Hamilton & Lindenwald Electric Transit Co., Hamilton, OH (1890)
Hamilton Street Railway Co., Hamilton, OH (1892)
* Hampton & Old Point Railway Co., (1891)
Hartfield & Witherfield Horse Railway Co., (1893)
Haverhill & Groveland Street Railway Co., (1892)
Helena Electric Railway Co., Helena, MT (1890)
Helena Rapid Transit Co., Helena, MT (1892)
Herkimer & Mohawk Horse Railway, (1890)
Holyoke Street Railway Co. Holyoke, MA (1889)
Hornesville Electric Railway Co., Hornesville, NY (1893)
Houston Rapid Transit Co., Houston, TX (1891)
Interstate Street Railway Co., Pawtucket, RI (1893)
Jackson Street Railway Co., Jackson, MI (1891)
Jacksonville Railway Co., Jacksonville, IL (1892)
* Jamestown St. Railway Co., Jamestown, NY (1891)
* Jersey City & Bergen Railway, Jersey City, NJ (1889)

Johnson City and C Street Railway Co., Johnson City, TN (1891)
Johnstown, Glovarsville, & Kingsboro Horse Railway, (1893)
* Johnstown Passenger Railway Co., Johnstown, PA (1890)
Joplin Electric Railway & Motor Co., Joplin, MO (1891)
Kansas City Cable Railway Co., Kansas City, MO (1891)
Kaukakee Electric Railway, Kaukakee, IL (1892)
Knoxville Electric Railway Co., Knoxville, TN (1891)
Knoxville Street Railway Co., Knoxville, TN (1890)
La Crosse City Railway Co., La Crosse, WI (1890)
Lafayette Street Railway Co., Lafayette, IN (1891)
Lake Roland Elevated Railway Co., Baltimore, MD (1892)*
Lancaster City Railway Co., Lancaster, PA (1891)
Lancaster Street Railway Co., Lancaster, OH (1890)
Lancaster Traction Co., Lancaster, PA (1893)
Larchmont Horse Railway Co., Larchmont, NY (1890)
Lebanon & Annville Street Railway Co., Lebanon, PA (1891)
Lexington City Railway Co., Lexington, KY (1889)
Lima Electric Railway Co., Lima, OH (1892)
Lincoln Rapid Transit Railway Co., Lincoln, NB (1889)
Lincoln Street Railway Co., Lincoln, NB (1889)
* Lindell Street Railway Co., St. Louis, MO (1890)
* Louisville City Railway Co., Louisville, KY (1889)
Lowell & Suburban Street Railway Co., Lowell, MA (1892)
* Lynn & Boston Railway Co., Lynn, MA (1892)
* Lynn Belt Line Railway Co., Lynn, MA (1889)
Macon City & Suburban City Railway Co., Macon, GA (1890)
Macon Consolidated Railroad Co., Lynn, MA (1892)
Mahoney City, Shenandoah Giraidville, & Ashland St Railway Co., Shenandoah, PA 1892
Main Street Railway Co., Jacksonville, FL (1890)
* Manitou & Pikes Peak Railway Co., Manitou Springs, CO (1889)
Mansfield Electric Railway, Mansfield, NJ (1892)
* Marion Street Railroad Co., Marion, IN (1891)
Marquette & Presque Isle Railway Co., Marquette, MI (1890)
McKeesport & Reynoldton Passenger Railway Co., McKeesport, PA (1891)
McKeesport Passenger Railway Co., McKeesport, PA (1890)
Meriden Horse Railway, Meriden, CT (1889)
Merrill Railway & Lighting Co., Merrill, WI (1890)
Merrimack Valley Horse Railway Co., Laurence, MA (1889)
Metropolitan Electric Street Railroad Co., Macon, GA (1891)
Metropolitan Street Railway Co., Kansas City, MO (1893)
* Metropolitan Street Railway Co., Springfield, IL (1889)
* Metropolitan Street Railway Co., Washington, DC (1887)
Milwaukee & Wanwatosa Railway Co., Milwaukee, WI (1892)
* Minneapolis Street Railway Co., Minneapolis, MN (1889)
* Missouri Railway Co., St. Louis, MO (1889)
Mobile Electric Railway Co., Mobile, AL (1892)
Mobile Light & Railway Co., Mcbile, AL (1893)

Mound City Railway Co., St. Louis, MO (1890)
Mount Adams & Eden Park Inclined Railway, Cincinnati, OH (1891)
Mount Tabor Street Railway Co., Portland, OR (1891)
Mt. Clemons Street Railway, Mt. Clemons, MI (1893)
Muskegon Street Railway Co., Muskegon, MI (1889)
Nanticoke Street Railway Co., Wilkesbarre, PA (1892)
Natchez Street Railway Co., Natchez, MS (1891)
Natiek Street Railway Co., Natiek, MA (1892)
Negaunee & Ishpeming Street Railway Co., Negaunee, MI (1891)
Neversink Mt. Railway Co., Reading, PA (1891)
Newark City Railway Co., Newark, OH (1891)
Newark & Granville Electric Street Railway Co., Newark, OH (1892)
Newberryport and Amesbry Street Railway Co., Newberryport, MA (1889)
New Castle Electric Railway, New Castle, PA (1891)
New Orleans & Carrolton Railway Co., New Orleans, LA (1892)
New Orleans City & Lake Railway Co., New Orleans, LA (1893)
Newport Horse Railway Co., Newport, RI (1889)
Newton & Boston Street Railway Co., Newton, MA (1893)
Niagara Falls & Suspension Bridge Railway Co., Niagara Falls, NY (1891)
Niles Street Railway Co., Niles, OH (1892)
North Avenue Electric Railway Co., Baltimore, MD (1891)
* North Avenue Railway Co., Baltimore, MD (1890)
North Chicago Street Railroad Co., Chicago, IL (1891)
North Hudson Railroad Co., Hoboken, NJ (1889)
North Lincoln Street Railway Co., Lincoln, NB (1890)
Northampton Street, Northampton, MA (1892)
Norwalk Tramway Co., South Norwalk, CT (1892)
* Oakwood Street Railway Co., Dayton, OH (1890)
Oil City Street Railway Co., Oil City, PA (1891)
Omaha & Council Bluffs Railway & Bridge Co., Council Bluffs, IA (1889)
Omaha Motor Railway Co., Omaha, NB (1889
Orange Crosstown & Bloomfield Railway Co., Racine, WI (1892)
Orange Crosstown & Orange Valley Street Railway Co., (1888)
Ottawa Electric Street Railway, Ottawa, ONT (1892)
Ottawa Street Railway Co., Ottawa, IL (1889)
Ottawa Street Railway Co., Ottawa, IA (1889)
Ottumwa Electric Railway, Ottumwa, IA (1892)
Overland Railway Co., Nashville, TN (1888)
Oxford Lake Line, Anniston, AL (1891)
Passaic, Garfield & Clifton Railway Co., Pittsburgh, PA (1890)
Passenger & Belt Line Railway, Lexington, KT (1890)
* Paterson Street Railway Co., Paterson, NH (1891)
* Pawtucket Street Railway Co., Pawtucket, RI (1891)
Peoples Electric Railway Co., Sandusky, OH (1891)

* Peoples Railway Co., St. Louis, MO (1887)
Peoples Street Railway Co., Baltimore, MD (1889)
Peoples Street Railway Co., Scranton, PA (1889)
* Philadelphia Passenger Railway Co., Phila, PA (1890)
* Piedmont Cable Co., San Francisco, CA (1889)
Piqua Street Railway Co., Piqua, OH (1889)
* Pittsburgh, Allegheny & Manchester Traction Co., Pittsburgh, PA (1890)
* Pittsburgh & Birmingham Traction Co., Pittsburgh, PA (1890)
Pittsburgh & West End Passenger Railway Co., Pittsburgh, PA (1892)
Pittston Street Railway Co., Pittston, PA (1889)
Pittstown Street Car Co., Wilkesbarre, PA (1893)
Pittstown, Moosio, & Pleasant Valley Railway Co., Wilkesbarre, PA (1893)
Plainfield Street Railway Co., Plainfield, NJ (1892)
Pleasant Valley Railroad Co., Pittsburgh, PA (1889)
Plymouth Street Railway, Plymouth, PA (1892)
Portland Railroad Co., Portland, MA (1892)
Pottstown Passenger Railway, Pottstown, PA (1893)
Poughkeepsie City Railway Co., Poughkeepsie, NY (1890)
Providence Cable Tramway Co., Providence, RI (1889)
Punxsutawney Street Railway, Punxsutawney, PA (1892)
Queen City Electric Railway Co., Marion, IN (1892)
* Quincy Horse Railway & Carrying Co., Quincy, IL (1890)
Raleigh Springs Street Railway Co., Memphis, TN (1892)
Raleigh Street Railway, Raleigh, NC (1893)
Rapid Transit Street Railway Co., Newark, NJ (1890)
Reading & Southwestern Street Railway Co., Reading, PA (1891)
Richmond City Railway, Richmond, IN (1892)
Roanoke Street Railway, Roanoke, VA (1892)
* Rochester Railway Co., Rochester, NY (1890)
* Rock Creek Railway Co., Washington, DC (1891)
St. Louis Railroad Co., St. Louis, MO (1892)
St. Louis & Suburban Railway, St. Louis, MO (1891)
* St. Paul City Railway Co., St. Paul, MN (1889)
Salem Electric Railway, Salem, OH (1892)
* Salem & Winston Electric Railway Co., Winston, NC (1890)
San Diego Electric Railway,San Diego, CA (1892)
Sandusky Street Railway Co., Sandusky, OH (1890)
Sandwich, Windsor, and Amerstburg Railway Co., Windsor, ONT (1891)
Savannah Street Railway Co., Savannah, GA (1892)
Schenectady Street Railway Co., Schenectady, NY (1891)
Schenley Park & Highlands Railway Co., Pittsburgh, PA (1892)
* Schuylkill Electric Railway Co., Pottsville, PA (1890)
Schulykill Traction Co., Ashland, PA (1892)
Scranton Traction Co., Scranton, PA (1893)
Sea Shore Electric Street Railway, Ashbury Park, NJ (1892)

Second Avenue Electric Railway Co., Pittsburgh, PA (1889)
Second Avenue Passenger Railway Co., Pittsburgh, PA (1892)
Seventh Ward Street Railway Co., Syracuse, NY (1889)
Shamokin Railway Co., Shamokin, PA (1890)
Shenango Valley Street Railway, Sharon, PA (1892)
Shreveport City Railroad Co., Shreveport, LA (1893)
Shreveport Railway & Land Improvement Co., Shreveport, LA (1890)
Sioux City Cable Railway, Sioux City, LA (1892)
* Sioux City Street Railway Co., Sioux City, IA (1888)
South Baltimore & Curtis Bay Railway Co., Baltimore, MD (1892)
South Chicago City Railway Co., Chicago, IL (1890)
* South Covington & Cincinnati Street Railway, Cincinnati, OH (1890)
* South Covington & Cincinnati Street Railway Co., Covington, KY (1891)
* Southern Railway Co., St. Louis, MO (1890)
South Side Street Railway Co., Cleveland, OH (1889)
* Springfield Electric Railway Co., Springfield, OH (1891)
* Springfield Street Railway Co., Springfield, OH (1892)
Squirrel Hill Railway Co., Pittsburgh, PA (1889)
Stonehauer Street Railway Co., Stonehauer, MA (1887)
Street Railway Co., Grand Rapids, MI (1890)
Street Railway Co., Rome, NY (1887)
Suburban Rapid Transit Street Railway Co., Pittsburgh, PA (1892)
Suburban St. Railway Co., Scranton, PA (1888)
* Sunberry & Northumberland Railway Co., Sunberry, PA (1889)
Syracuse & Onondago Street Railway Co., Syracuse, NY (1890)
Syracuse Consolidated Street Railway Co., Syracuse, NY (1890)
* Tacoma Railway & Motor Co., Tacoma, WA (1890)
Taunton Street Railway Co., Taunton, MA (1893)
Terre Haute Street Railway Co., Terry Haute, IN (1890)
* Texas & Pacific Railway Co., Dallas, TX (1890)
Third Ave Railroad Co., New York, NY (1892)
Tiffin Electric Street Railway, Tiffin, OH (1892)
* Toledo Consolidated Street, Railway Co., Toledo, OH (1889)
* Toledo Electric Street Railway Co., Toledo, OH (1889)
Tonawanda Street Railway, North Tonawanda, NY (1892)
Toronto Railway Co., Toronto, ONT (1892)
Trenton Horse Railway Co., Trenton, NJ (1891)
Trenton Passenger Railway, Trenton, NJ(1891)
Trenton Passenger Railway Consolidated Co., Trenton, NJ (1891)
Troy City Railway Co., Troy, NY(1891)
* Troy & Lansingburg Railway Co., Troy, NY(1891)
Tuscarawas Electric Railway Co., New Philadelphia, OH (1890)
* Union Depot Railroad Co., St. Louis, MO (1891)

Union Passenger Railway Co., Baltimore, MD (1891)
* Union Railway Co., Chester, PA (1890)
Union Railroad Co., Providence, RI (1892)
Union Street Railway Co., Saginaw, MI (1891)
Uniontown Street Electric Railway Co., Uniontown, PA (1891)
United States Avenue Railway Co., New York, NY (1891)
United States Electric Railway, Paterson, NY (1893)
Upper Alton Horse Railway & Carrying Co., (1892)
* Valley City Street & Cable Railway Co., Grand Rapids, MI (1891)
* Vincennes Citizens Railway Co., Vincennes, IN (1891)
Vine Street Cable Railway, Cincinnati, OH (1890)
* Washington & Georgetown Railway Co., Washington, DC (1889)
Waterbury Horse Railway Co., Waterbury, CT (1889)
Wayne & 5th Street Railway, Dayton, OH (1892)
* West Chester Street Railway Co., West Chester, PA (1890)
* West Chicago Street Railway Co., Chicago, IL (1889)
* West End Street Railway Co., Boston, MA (1889)
* West End Street Railway Co., Lancaster, PA (1891)
West Side Railroad Co., Elmira, NY (1893)
West Side Railroad Co., Milwaukee, WI (1892)
West Side Street Railway Co., Buffalo, NY (1892)
* Wheeling Railway Co., Wheeling, WV(1889)
White Electric Traction Co., McKeesport, PA (1891)
White Line Street Railway Co., Baltimore, MD (1892)
Wilkesbarre and Suburban Street Railway Co., Wilkesbarre, (1891)
Wilkesbarre & West Side Railway Co., Wilkesbarre, PA (1889)
Wilkesbarre & Wyoming Valley Traction Co., Wilkesbarre, PA (1892)
* Wilmington City Railway Co., Wilmington, DE (1889)
Winchester Street Railway Co., Winchester, KY (1889)
Winston Street Railway, Winston, NC (1890)
Woodlands Ave & West Side Street Railway Co., Cleveland, OH (1889)
Worcestor, Lucestor & Spencer Electric Street Railway Co., Worcestor, MA (1892)
Yonkers Railroad Co., Yonkers, NY (1892)
* York Street Railway, York, PA (1887)
* Youngstown Street Railway Co., Youngstown, OH (1890)

APPENDIX C

THE JOHNSON COMPANY PATENTS, 1883-1895

The following is a listing of all the patents secured by Arthur J. Moxham, Tom L. Johnson, the Johnson Steel Street Rail Company (the Johnson Company after 1888) and individuals who consigned their patent rights to the Company for rail section design (side-flanged or center-bearing, girder, guard, or groove rails), trackwork design (such as curves, crossings, switches and frogs), trackwork peripherals (such as chairs, clips, cross-ties, and splice-plates), roll and roll mill design, tool design (such as dies and chucks), and track construction machinery (notably electric welding processes). Most of these patents cover products or manufacturing processes related specifically to either horse-drawn railway systems or (after 1888) electrified railway systems. There are 204 patents listed in all.

Included in each citation are the U.S. Patent Office Number, the name of the person to whom it was issued, and a brief description of the product or process patented. Since it is also important to know the date and place of application and the date of issue for the earliest patents of Moxham and Johnson, this information is cited paranthetically.

This listing does not include a significant number of patents for specialized cable systems, such as yoke design, slot rails, crossings, and braking systems, mostly developed and held by Johnson. It also does not include patents secured on the design of car fare-boxes (Johnson, 1872: 132535; 1873: 143698; and Moxham: 1874: 149671) or Moxham's earlier patents on processes for strengthening iron (1877: 192653 and 193540; 1878: 210049).

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1883
No. of Patents: 3

272554	Johnson	J-Bird railhead design (Feb. 20) (Filed 9-11-1882 Indianapolis)
276419	Johnson	Street railway curve and frogs (Apr. 24) (Filed 10-31-1882 Indianapolis)

Under Johnson Steel Street Rail Company:

289355	Moxham	Street rail and splice design (Nov. 27) (Filcd 7-25-1883 Louisville)

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1884
No. of Patents: 3

292655	Johnson	Double-flanged T-rail head design (Jan.29) (Filed 2-20-1883 Indianapolis)
292759	Moxham & Tranter	Roll design (J-bird design) (Jan. 29) (Filed 11-23-1882 Louisville)
303036	Moxham	Rolling mill (J-bird design) (Aug. 5) (Filed 11-26-1883 Louisville)

Year: 1885
No. of Patents: 19

310457	Moxham	Making steel girder rails (Jan. 6)
312213	Moxham	Rolling mill design (J-bird design) (Feb.10) (Filed 8-16-1884 Johnstown)
313512	Moxham	Securing girder rails in track (Mar. 10)
316994	Moxham	Girder rail and rail joint (May 5)
316995	Moxham	Metal chair for street railways (May 5)
317665	Moxham	Built-up girder rail (May 12)
318645	Moxham	Street railway switch (May 26)
319009	Moxham	Roll design (T-rail) (June 2) (Filed 3-8-1884 Louisville)
319010	Moxham	Metal cross-tie for railways (June 2)
319011	Moxham	Street railway frog (June 2)
321627	Moxham	Roll design (J-bird design) (July 7)
330997	Moxham	Three-high roll design (J-bird) (Nov. 24)
330998	Moxham	Roll design (J-bird design) (Nov. 24)
331525	Moxham	Street railway switch (Dec. 1)
331526	Moxham	Street railway switch (Dec. 1)
333474	Moxham	Street railway switch (Dec. 29)
333475	Moxham	Roll design (J-bird design) (Dec. 29)

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1885

Under Johnson Steel Street Rail Company:

331012	Townsend, J.	Street railway chair design
331013	Townsend, J.	Street railway frog design

Year: 1886
No. of Patents: 5

334265	Moxham	Splice bar rail chair (all types)
338181	Moxham	Street railway frog
340891	Moxham	Roll design (girder rails)
344396	Moxham	Roll design (girder rails)
350549	Moxham	Street railway frog

Year: 1887
No. of Patents: 26

355777	Moxham	Roll design
355778	Moxham	Metallic core post for tracks
355779	Moxham	Street railway chair
355780	Moxham	Center-bearing girder rail (process)
355781	Moxham	Roll design (Center-bearing type)
355782	Moxham	Rail splice joint (center-bearing type)
357849	Moxham	Street railway chair
358122	Moxham	Street rail chair spike design
358619	Moxham	Street railway frog
360036	Moxham	Roll design
360780	Moxham	Paving block for railway beds
364725	Moxham	Tongue switch for street railways
366497	Moxham	Curved crossing design
366498	Moxham	T-chair design
366598	Moxham	Movable tongue switch
367433	Moxham	Crossing design
367434	Moxham	Street railway chair
367654	Moxham	Pocket-filling device for girder rails
367655	Moxham	Combination crossing & switch
374265	Moxham	Railway crossing design

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1887

Under Johnson Steel Street Rail Company:

364996	Entwisle, E.B.	Railway chair design
367746	Entwisle, E.B.	Railway crossing design
368142	Entwisle, E.B.	Die for railway chairs (design)
362455	Marshall, C.A.	Railway gip and key
357532	Meysenburg, O.W.	Cast iron brace chair design
366507	Richards, C.A.	Grooved girder rail design

Year: 1888
No. of Patents: 24

378209	Moxham	Roll design
378210	Moxham	Roll design
378211	Moxham	Roll design (flangeless center-bearing)
383001	Moxham	Grooved girder rail
383002	Moxham	Double-grooved girder rail
383003	Moxham	Acute curve crossing design
391549	Moxham	Rail and rail joint design
391550	Moxham	Rolling machine
391552	Moxham	Two-part girder rail
391553	Moxham	Rail and rail chair design
394078	Moxham	Brace chair
394079	Moxham	Rail chair design
395248	Moxham	Expansion joint for track
395249	Moxham	Portable passing switch

Under Johnson Steel Street Rail Company:

387147	Colley, Frederick	Rolls, overhanging slot rails
381875	Entwisle, E.B.	Die for making railway chairs
387170	Lloyd, Charles F.	Flexible guide for rolling mills
394122	Lloyd, Charles F.	Rolling mill
394021	Simpson, Edward	Mill, side-flanged guard rails
394022	Simpson, Edward	Mill, side-flanged groove rails
394023	Simpson, Edward	Mill, side-webbed girder rails
394024	Simpson, Edward	Mill, side-flanged center-bear rail
391565	Street, Clement F.	Switch joint chair for railways
388097	Welch, Robert W.	Rail chair for girder rails

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1889
No. of Patents: 12

402470	Moxham	Railway crossing
408843	Moxham	Rolling steel or iron
408844	Moxham	Rolling steel or iron
413956	Moxham	Adjustable clamp

Under Johnson Company:

401691	Colley, Frederick	Roll design
401692	Colley, Frederick	Roll design
401963	Colley, Frederick	Roll design
410821	Colley, Frederick	Machine for rolling
410955	Colley, Frederick	Roll design
414153	Goughnour, Henry S.	Two-part railway chair
409114	O'Connell, Patrick	Interlocking brace chair
409131	Wettergreen, John	Railway brace chair

Year: 1890
No. of Patents: 12

423072	Moxham	Railway chair
427348	Moxham	Railway rail and chair
427349	Moxham	Rolling mill
435704	Moxham	Securing girder rail to track
436987	Moxham	Railway chair
436988	Moxham	Railway chair

Under Johnson Company:

442165	Berriman, Richard	Double brace chair
435680	Brown, William M.	Railway chair
442175	Entwisle, E.B.	Box chair for girder rails
418986	Reilly, Francis P.	Railway chair
436959	Suppes, Maximillian	Railway brace chair
436960	Suppes, Maximillian	Roll pass

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1891
No. of Patents: 4

{Moxham none}

Under Johnson Company:

447130	Entwisle, E.B.	Railway crossing
460063	Suppes, Maximillian	Railway rail
460064	Suppes, Maximillian	Railway rail
460096	Suppes, Maximillian	Making rails

Year: 1892
No. of Patents: 30

472767	Moxham	Box brace chair for girder rails
477672	Moxham	Expansion rail for railways
477673	Moxham	Rail for railways
477674	Moxham	Rail for railways
477675	Moxham	Expansion rail for railways
477676	Moxham	Railway crossing
477677	Moxham	Rail joint
477678	Moxham	Railway rail joint
477679	Moxham	Combined rail and cross tie
477680	Moxham	Railway rail joint
477681	Moxham	Railway crossing
477682	Moxham	Railway crossing
477683	Moxham	Rail for railways
477684	Moxham	Frog or cross for railway crossings
477685	Moxham	Railway crossing
477686	Moxham	Switch-piece for railway tracks
477687	Moxham	Railway crossing
477688	Moxham	Railway crossing
477689	Moxham	Railway rail joint
477690	Moxham	Railway rail and making the same
483801	Moxham	Railway chair
482802	Moxham	Railway rail chair
482803	Moxham	Channel-rail and chair
482804	Moxham	Railway rail chair and making same
482805	Moxham	Combined rail & chair

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1892

Under Johnson Company:

477641	Brown, William M.	Railway brace chair
486211	Hunter, Rudolph M.	Girder rail and manufacture (^)
482092	Lavelle, Patrick J.	Chair manufacture and die
478806	Murray, George	Railway brace chair
482807	Murray, George	Railway brace chair

Year: 1893
No. of Patents: 34

492469	Moxham	Tie rod for railway tracks
495985	Moxham	Rail chair for railway rails
495986	Moxham	Rail and support
495987	Moxham	Railway track
495988	Moxham	Rail joint
495989	Moxham	Welding metal
496890	Moxham	Welding metal
497808	Moxham	Railway rail and unting same
498074	Moxham	Rail and chair, and uniting same
500929	Moxham	Transfer table for railways
500930	Moxham	Switch piece
500931	Moxham	Railway chair
505988	Moxham	Method of securing metal objects
505989	Moxham	Railway rail support
505990	Moxham	Railway rail joint
508036	Moxham	Apparatus for welding
508037	Moxham	Welding clamp
508038	Moxham	Railway track

Under Johnson Company:

492458	Brown, William M.	Interlocking rail chair
494243	Brown, William M.	Railway brace chair
508095	Entwisle, E.B.	Railway switch
492885	Evans, Elmer O.	Joint box
492464	Evans, Henry C.	Railway rail and chair
495967	Evans, Henry C.	Railway rail and chair
505978	Ford, Hamilton E.	Joint and support
508012	Gull, John M.	Welding process
498724	O'Shea, Henry	Railway crossing

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1893

Under Johnson Company:

510047	Pfefferkorn, Wilh.	Tie plate
504818	Reilly, Francis P.	Railway chair
508049	Reilly, Francis P.	Rail support and cross-tie
489508	Suppes, Maximillian	Railway brace chair
496017	Suppes, Maximillian	Rack-rail
496916	Suppes, Maximillian	Girder joint
500973	Suppes, Maximillian	Electric welding machine

Year: 1894
No. of Patents: 22

513711	Moxham	Railway joint
513712	Moxham	Railway chair and cross-tie
518197	Moxham	Machine for straightening rails/bars
520654	Moxham	Making railway chairs
520694	Moxham	Tongue switch
526455	Moxham	Railway crossing
530196	Moxham	Bending flanged metal bars
530197	Moxham	Railway crossing
531444	Moxham	Railway rail
531445	Moxham	Electric connections
531446	Moxham	Railway track

Under Johnson Company:

519298	Benagh, Henry C.	Railway switch
526434	Brown, William M.	Joint metal bars
520359	Hunter, Rudolph	Electric welding apparatus
520360	Hunter, Rudolph	Electric welding apparatus
520860	O'Shea, Henry	Railway chair
520861	O'Shea, Henry	Railway frog
520862	O'Shea, Henry	Railway tongue switch
530240	Pfefferkorn, Wilh.	Machine for bending bars
520090	Suppes, Maximillian	Draw bar
517075	Suppes, Maximillian	Railway rail and chair
526466	Thomas, Henry W.	Roll bearing for rolling mill

Patent	Holder	Patented Product of Process (Date Issued)

Source: Annual Report of the Commissioner of Patents, 1874-1895.

Year: 1895
No. of Patents: 14

533725	Moxham	Pattern for switch work
536734	Moxham	Pattern for switch work
536735	Moxham	Pattern for switch work
539878	Moxham	Pattern for switch work
540796	Moxham	Pattern for switch work

Under Johnson Company or as Individuals:

537601	Brown, William M.	Railway switch
546773	Brown, William M.	Welding clamp
550045	Goughnour, H.J.	Slack adjuster
533713	Leighton, Herbert	Straightening machine
533714	Leighton, Herbert	Straightening machine
533735	O'Shea, Henry	Switchwork pattern
532817	Raymond, Ward	Railway switch
544006	Raymond, Ward	Chuck for machine tools
551649	Raymond, Ward	Railway track construction

Note:
Hunter consigned most of his work out of Philadelphia for Thomson-Houston Electric, including 13 patented welding processes and electric designs in 1894. Johnson Company began laying track with continuous electric welding in 1892.

APPENDIX D

TECHNICAL ANALYSIS OF THE JOHNSON AND MOXHAM PATENTS

Using a design borrowed from the early railroads in the 1830s, street railways constructed their track in fairly crude fashion. A flat strip of wrought iron, called a strap rail, was spiked directly onto yellow pine beams (stringers) running the length of the track route. These beams were then laid across cross-ties and gravel filled in on either side. The rail and the surface of the stringer protruded above street level, and the flanged wheels of the streetcars rode on the inner edge of the rails.

Rolled from cast into wrought ("pure") iron, strap rails tended to wear unevenly, and to split and camber at the ends making smooth jointing difficult to maintain. The rail and stringer surface itself attracted freight wagons which would track along the line as the smoothest route down a fairly primitive road surface, and groove tracks along the sides of the rail where gravel would be loosened and the roadway deteriorated. Protrusion of the rail head was extremely disruptive of crossing vehicular traffic, not to mention tracking wagons attempting to turn in either direction. And the wooden beams used for stringers were subject to constant deterioration from foul weather, not to mention manure and urine from horses pulling the cars.

An experienced street railway executive since the age of 19, Tom L. Johnson engineered a unique rail for street railways that would provide the strength of material and stiffness to allow uniform joint splicing and direct spiking onto the crossties. The rail head itself (a variation of a "street-L" design used in some railways as a strap rail) allowed a larger head for greater wearing surface and an extended offset flange to allow other vehicles to track directly on the offset itself rather than the track ballast. The offset also allowed the rail to be set down into the street surface, reducing protrusion and obstruction of other traffic. The outside of the rail head was even rounded to facilitate crossing traffic. The webbed design, basically an already common I-beam, allowed closer packing and tamping of the ballast. (see Plate 1. Diagram of Johnson Girder Rail Section)

Much of the claims made for the Johnson girder are enumerated in his 1883 patent [U.S. Patent Number 272,154. Street-Railroad Rail, Tom L. Johnson, Indianapolis, Indiana, filed September 11, 1882, patent issued February 20, 1883], and all were valid to a significant degree. Most importantly, and admitted outright in his patent application, Johnson claimed no "new" invention but rather maintained he had brought together disparate elements of existing technologies in a unique fashion to meet a unique market need. The I-beam structure and its rolling processes were common

in design and production railroad rails since the 1830s, and the L-face rail design had been used for decades. His innovation was to understand how existing technological advances in both production and market fields could be brought together through design.

Aspects of his design reveal however that he received practical engineering advice on the design related to its production, which would have come from his old friend and colleague Arthur J. Moxham, an accomplished ironmaster. Two examples will suffice. First, his design adds a shoulder to the underside of the rail head at the web. At first glance, one might conclude the shoulder was added simply as an element of uniqueness to secure easy patenting. That conclusion is too simple. While the shoulder probably does little to add stiffness to the rail section (except at the joints where spliced with cast steel plates) as Johnson claims, it does facilitate rolling by reducing the volume of material on the rail head flange and making the section area more symmetrical during drafting, i.e. reducing the extrusion effect during hot rolling that would cause the rail to camber. At the same time, the shoulder allows the producer to design uniform splice plates for both sides of the web, avoiding the need to design an intricate fit of inside and outside splice plates.

Secondly, the vertical location of the rail head itself over the web appears a compromise of several considerations. To prevent flexing ("wobbling") of the rail head and thereby promoting longer structural life, the rail head ought to be directly over the web. Yet the rail head is offset, opening the possibility of minor counterclockwise flexing and structural cracks at the web. But understanding the multiple uses of the rail in city streets most assuredly lead Johnson to extend the inside flange for use of other vehicular traffic, which itself would cause minor clockwise flexing and reduce the <u>average</u> tendency of the rail section to crack at the web. Finally, the offset, to the degree that flexing in either direction did occur, would in fact cause a minor tamping effect on roadway ballast around the rail.

In short, while Johnson's rail section design was an application of existing technologies, it was an application to a unique market problem which only Johnson, an experienced street railway executive, would understand. Just as clearly, the design had been altered to accommodate peculiar production considerations, specifically those of drafting wide, offset flanges and a shoulder. It may well be that Johnson realized some of these advantages after the design was successfully rolled, and his claims simply incorporated some of them. Nevertheless, the design proves to be an innovative application of existing technology, expertly adapted to the discipline of existing production technologies.

Bringing the Johnson girder design to successful production was a fairly intricate task. While flat rolling of I-beam structures from iron was common for railroad rails by the 1870s, the standard railroad T-rail head design was a far heavier rail, and possessed neither the offset in surface flanges nor the width exhibited in the offset (inside) flange designed for tracking of other street vehicles. The Johnson rail was a much lighter rail (designed at approximately 32 pounds as opposed to 100-120 pounds for railroad T-rails) and required unique (and uncommon for the time) drafting design and sequencing.

After two years of perfecting the roll design for the Johnson rail in Louisville, Moxham recognized the rail could not be rolled of wrought iron, and his Louisville plant did not have the capacity to roll it from steel. In order to focus his attention on trackwork design and fabrication, Moxham contracted with Daniel Morrell of the Cambria Iron Company to roll the rails from steel. Cambria Iron had rolled a more primitive girder rail design with offset for the cable road in San Francisco in 1877, but had not pursued the street railway market because of its small market size. Electrification of street railways was still some ten years off.

Wrought iron was the standard rolling material for the early railroads and horse-drawn street railways. Cambria Iron had pioneered commercial production of steel T-rails for railroads in 1871. But by 1880, street (strap) rails were still rolled from iron, primarily because of the higher cost of steel. Furthermore, because of the lightness of street rail, wear strength was less a problem than cambering and wear unevenness. Track was repaired when the ride was so jarring that ridership declined rather than when rails simply wore out.

The principal difficulty with the standard street rail then was not its durability but its spiking and jointing. The Johnson design addressed those two problems admirably, but its offset design guaranteed it could not be rolled from wrought iron. Wrought iron, the material used in strap rails, is essentially a carbon free, laminated composite of layers of pure iron and slag. Produced primarily by puddling techniques, wrought iron is never reduced to a liquid state and therefore never homogenizes itself, leaving layers of oxides in the metal. While the grain structure (porosity) of the resulting metal can be flattened and elongated by forging, and perhaps increasing the metal's strength and ductility, irregularities in the metal remain, exposed during wear. These oxides could be eliminated in the process of making steel prior to adding back the appropriate carbon content.

Wrought iron remained a viable metal for both T-rails and strap rails because the rolling action exposed the metal to

longitudinal stress, essentially compressing and forming the metal along the same line as its grain structure. As Moxham discovered in his rolling experimentation in Louisville, the drafting of Johnson's widened and offset flanges subjected the metal to transverse stress, essentially drafting it across its grain structure, causing cobbling. The metal tended to crack and splinter before it would completely fill out the flanges.

This was not common knowledge at the time, for even by the mid-1880s, most ironmasters (virtually all steelmakers and fabricators started as iron rolling mills) considered iron, with its reduced carbon content to be more ductile (less brittle) than steel. The experienced ironmaster like Moxham would have discovered however that during hot rolling, wrought iron could be less workable that steel for reasons not related to either its properties at room temperature or its cleanliness. While wrought iron could prove to be more ductile when stressed in a longitudinal direction; it proved to be less ductile when stressed in a transverse direction.

Moxham had learned, and accommodated into his production processes, a lesson concerning the properties of iron that could only become known through experience: that for a given temperature or level of cleanliness, some steels have greater inherent ductility that low carbon (wrought) iron. This would allow such steels to be rolled into more complex shapes, largely requiring application of transverse stress (drafting) in flat or diagonal rolling. For those shapes that are possible for both steel and low carbon iron, such steels may be easier to roll into a specific shape than iron.

It is instructive that Moxham designed his roll processes to the Johnson rail section template based on his experience in rolling wrought iron, and even though the material used was changed to steel when ultimately (and successfully) rolled by Cambria Iron, the integrity of his roll design stood up. He was a roll engineer by apprenticeship and practical experience, the common and traditional method of learning the craft in the latter half of the 19th century, and adapted his designs and sequence over a period of three years by practical intuition.

One can certainly not argue that Moxham's roll design was radically different than common practice of the day. I-beam structures had been rolled for over forty years before Moxham attempted the Johnson rail section. Certainly some complex shapes requiring drafting (transverse stress) were not uncommon among rolling mills, and at least one of the early steel mills (Cambria Iron) had experimented somewhat with offset rail heads. But apparently no rolling mill prior to 1883, except for Louisville Iron and Steel Company in the 1880-1882 period, had been set up

specifically to roll this type of offset rail section from either iron or steel. (See Plate 2. Diagram of Moxham's Roll Stand from No. 292,759)

The resulting roll design and sequence patented in 1884 [U.S. Patent Number 292,759, Roll for Rolling Car-Rails, Arthur J. Moxham and John R. Tranter, Louisville, Kentucky, filed October 23, 1882, patent issued January 29, 1884; U.S. Patent Number 303,036, Rolling Mill, Arthur J. Moxham, Louisville Kentucky, filed November 26, 1883, patent issued August 5, 1884] is in most respects consistent with modern rolling practices. [see Table I, appended] In the initial patented sequence (# 292,759), the roughing sequence (passes one through six) is designed to heal porosity, refine the grain structure and prepare the form for the finishing sequence. The first five passes alternate between working (compressing or dummy) passes and forming (or edge) passes, though it is doubtful the rail came through passes two and four with the degree of straightness claimed in the patent application. The sixth pass is the major forming pass. The later patent (#303,036), prescribes an alternative four-pass roughing sequence that enters the bloom into the sequence on the diagonal. (See Plate 3. Diagram of Moxham's Roll Stand from No. 303,036)

In the finishing set (warm-working passes seven through eleven), little drafting is accomplished and it is possible that with greater reduction at pass seven, the sequence could be accomplished in two or three fewer passes. Such a conclusion however lacks Moxham's experience and eye - to produce the designed cross section and a straight rail using the steel blooms at that level of technology, eleven passes may have been required.

Other questions arise from a closer scrutiny of Moxham's description and drawings (No. 292,759), questions that would arise only because the inevitable advance of time, experience and technical knowledge. The modern day roll engineer would have doubts about whether, without bevels on the sides of passes, such deep passes wouldn't cause cobbling in the finishing set or whether a 16" diameter roll wouldn't be too small to withstand the firecracking in the roughing stand. [In fact, when Moxham built his own rolling mill in 1888, he used 26" rolls] Doubts would indeed be raised concerning Moxham's claim of an increased cross-sectional area after the fifth roughing pass (the same is claimed for the fourth roughing pass in No. 303,036).

In summary, it is clear that both Johnson and Moxham were accomplished technicians in their fields, based on practical experience and innovative market and production sense. In their patents, neither man created new knowledge in his field, and neither man claimed to. Rather, they had successfully brought

together state-of-the-art technical knowledge from separate (marketing and production) fields into a product that met a peculiar market need. The question of its production presented a series of complex problems (regarding material, structure and roll design) that could be overcome only with relevant experience of the ironmaster on the floor (remembering that little industrial laboratory capacity had developed in the steel industry by this time), perseverance (even at Cambria Iron the successful roll of the Johnson section was accomplished after five months of experimentation), and significant financial backing.

This conclusion is supported as well by the legal history of the Johnson and Moxham patents, the latter of which were successfully challenged in the early 1890s as not representing true "invention" i.e. new knowledge, but rather representing a common application of contemporary knowledge. It could be argued that Johnson (whose patent was never challenged but could have been without difficulty) simply adapted a common railroad I-beam structure by changing its head to an L-face design to accommodate street railways. Similarly, it could be argued that Moxham simply adapted standard rolling practices to accommodate the peculiarities of Johnson's design. Neither, it could be argued, was particularly innovative; both were simply competent craftsmen.

Such a conclusion would be far too simple. It belies the sophistication of the 'craftsmanship' exhibited in the Johnson application and the Moxham adaptation, particularly if one considers the time and the state of technical knowledge. Innovation in fact took place. Johnson saw the application because he was familiar with disparate pieces of technical knowledge and he had access to (and could communicate with) Moxham who in turn could anticipate production problems. For his part, Moxham's experience on the roll floor and his intuitive sense for mechanical properties of iron at certain temperatures contributed to his innovative adaption of roll technology to the offset design and his intuitive abandonment of wrought iron in favor of Bessemer steel.

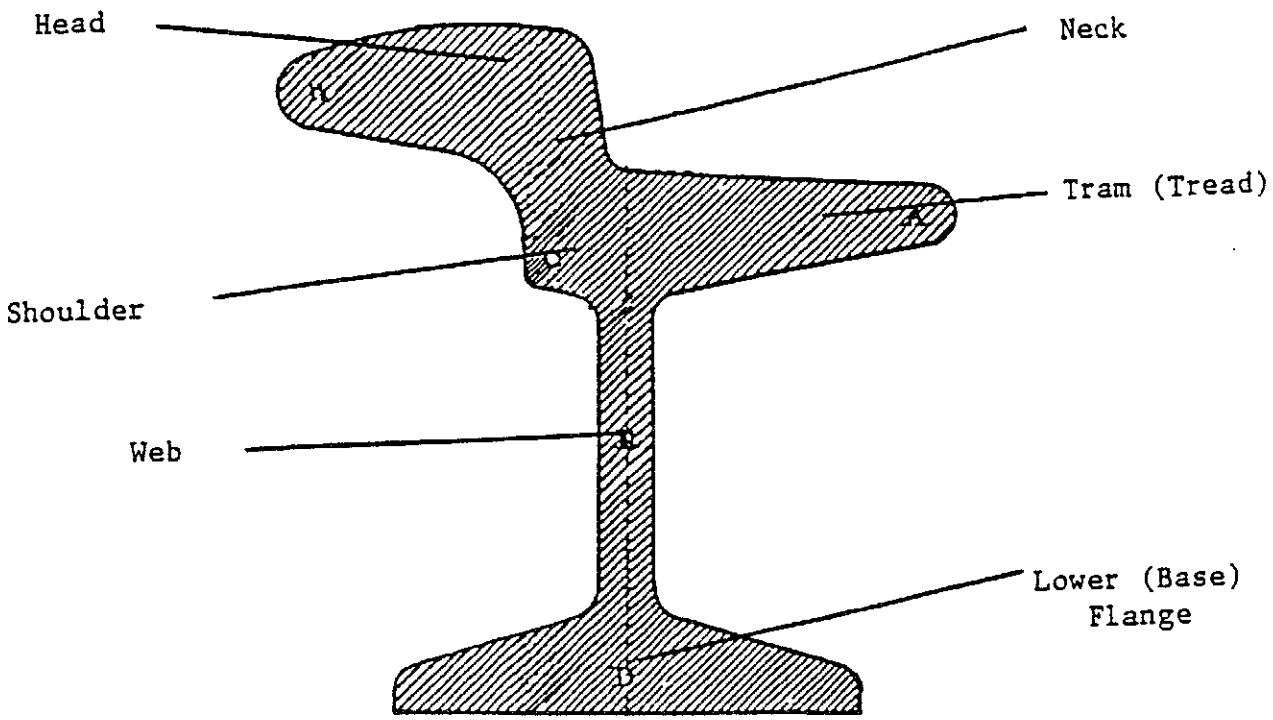


Plate 1. Diagram of Johnson Girder Rail Section

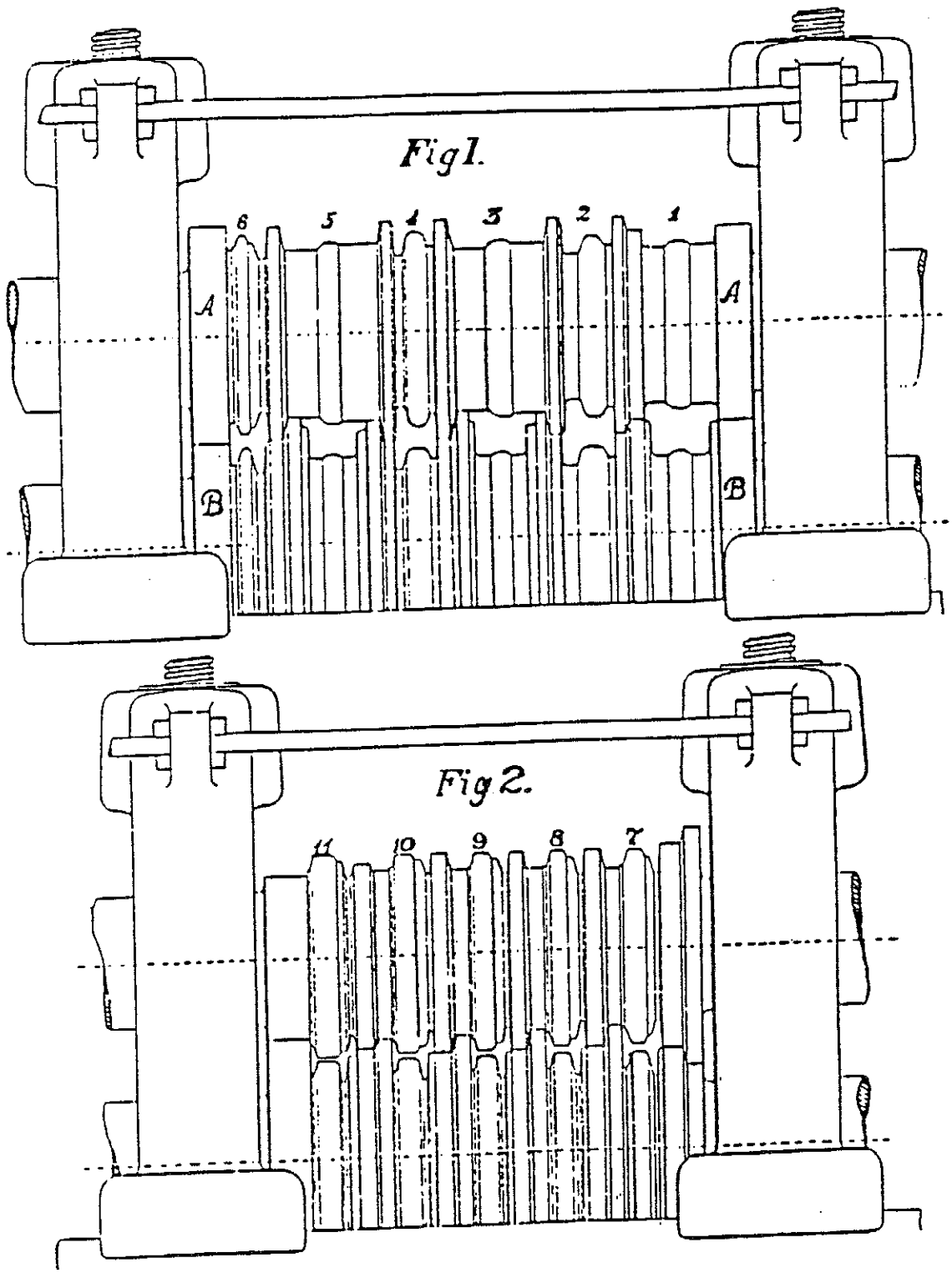


Plate 2. Diagram of Moxham's Roll Stand from No. 292,759

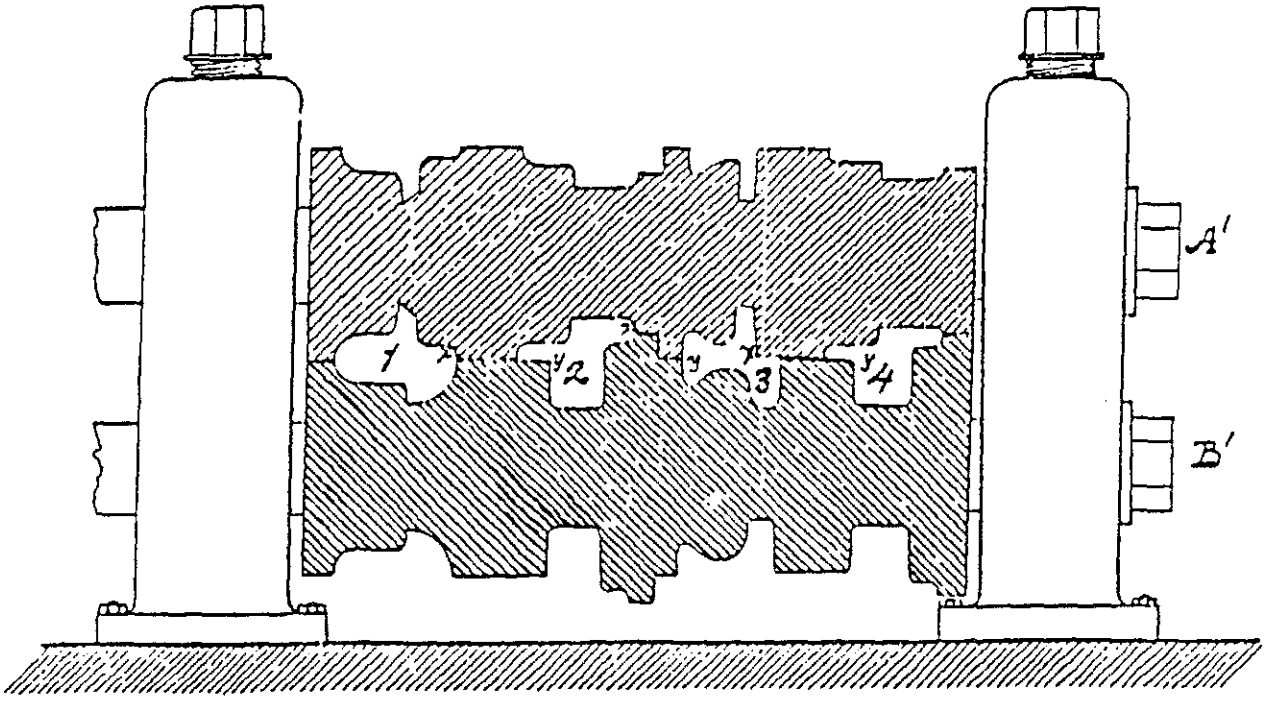


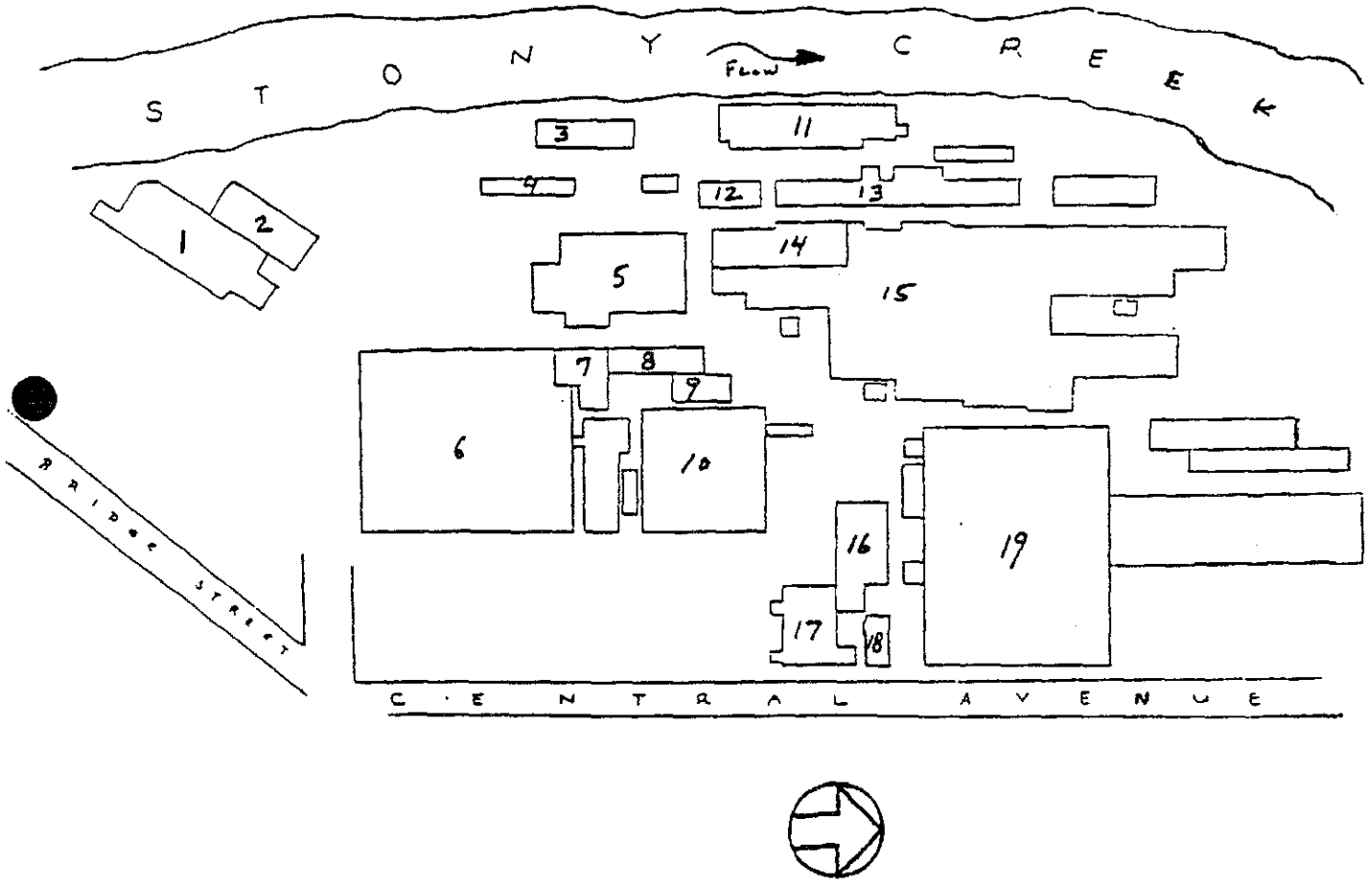
Plate 3. Diagram of Moxham's Roll Stand from No. 303,036

APPENDIX E

THE JOHNSON STEEL STREET RAIL COMPANY

Descriptions of Extant Buildings and Facilities

General Reference Map to Plant Site:



The Iron Foundry

1. The Iron Foundry. A one-story brick and metal clad structure with gabled monitor roof. One 40-56' bay, heights 22'9" - 32'9" and total of 40,800 sq. ft. of floor space. The original foundry and core ovens, constructed in 1890, were contained in the southeastern face (front) of the core building. A machine shop and a blacksmith shop were added to the southwestern wing of the core building in 1895, and the wing further extended in 1899. In 1902-03, the northwestern section of the core building (the wheel floor) was completed, more than doubling the size of the building, and the frontal sections (around the core ovens) squared off. A chipping room was added to the northeastern end of the original core building in 1921. Until 1960, the iron foundry still made pure iron castings, and most of one cupola is still on site. It is currently used for pattern storage.

2. Storage Facility. This one-story brick and metal clad structure, with gabled roof and corrugated metal covering, was constructed in 1926-27 as a pattern and sand storage facility and contained a carpenter shop. It contains a 25-25' bay, with heights of 10-21 1/2' and 17,600 sq. ft. floor space. It is currently being leased to C. C. Korns.

The Upper Shops Storage Area

3. Pattern Storage. [Pump House] A two-story building with gabled wood roof, containing 21,270 sq. ft. of space. It is however two buildings attached. The southern half of the structure, brick with somewhat ornate brickwork around doors and windows, is the plant's original pump room with pattern storage on the second floor. It was probably built in 1891 or 1892. Under the wooden floor-boards is a large brick foundation on which the pumps were probably set and a brick-lined flue channel leading east from the building and curving north toward the position of the original roll mill. This section was probably converted entirely to pattern storage after the rail mill was moved to Lorain, Ohio in 1895 (although plant maps continue to refer to the structure as the pump house as late as 1898). The northern half of the structure is wood-sided and was probably built after 1900. Both sides are currently used for pattern storage.

4. Machinery Hall. A one-story wooden structure constructed on brick pilings in 1900. With 12' of height and 5,400 sq. ft. of space, the building continues as a storage facility.

5. The No. 1 Electric Foundry. A one-story brick and metal-clad structure with gabled metal roof, constructed in 1922; height 33' with 44,500 sq. ft. space. This foundry is used to make small (up to one ton) castings.

The Upper Shops

6, 10. The Upper Shops. [Switchworks] A series of one-story brick and metal clad structures, with gabled monitor roofs of corrugated metal, containing five rail tracks, height 23-29', bay size 32'8" to 75', 240,465 sq. ft. space overall. The buildings are fronted (on the east) by a large open space along Central Avenue, which served as the primary lay out yard for trackwork from 1889 until 1959 when trackwork lines were discontinued. Originally, the upper shops were the site of wooden structures of the switchworks moved from the Woodvale plant site in June 1889 and the plant's primary lay out yard. When the plant became part of U.S. Steel, the upper shops were almost entirely re-constructed into their current form. Bays 5-8 (in the center of building 6 on the map) and 9 (the small attached bay designed as grinding bay for trackwork) were constructed in 1902. In 1904-07, the bolt, hammer and shear shop (bays 10-13, building 10 on the map) was added. In 1906 the southern-most bays (1-4) were added. The present configuration, buildings and lay out yard, is essentially the same as it was in 1907. Currently, the upper shops are used for preparing primary end plates and structural sections prior to fabrication in the lower shops. The Johnstown Corporation also maintains a mill liner operation in these bays and a shop for forged steel grinding balls (bays 12-13).

7, 8. The Electrical Department and Boiler House. The current structures are one-story brick buildings with gabled, monitor-type roofs and corrugated metal covering, predominantly constructed between 1910 and 1930. They encompass 17,380 sq. ft. of space and contain one 51' bay. These two buildings stand however exactly on the site of the plant's first (1888-89) electrical department and boiler house and the western walls of both structures appear (at least from the type of the brickwork and foundation) to be original.

9. The Electric Power House. A one-story brick structure with gabled, monitor-type, wood roof with slate covering. It reaches a height of 26' and contains one 53' bay. Constructed in 1907.

10. Described with 6 above.

The Steel Foundry Area

11. The Roll Shop. [Mine Car Shop] Currently a one-story 30,000 sq. ft. brick and metal clad building constructed in 1922 as a mine car shop. It has a gabled, monitor-type corrugated metal covered roof, a height of 32', and two rail tracks. It was converted to a roll shop in 1967 when U.S. Steel installed a new 30-ton electric furnace in its No. 2 Foundry (below, No. 15) in order to expand its roll product line. The mining car facilities were then moved into the upper shops.

12. Metallurgy Department. A one-story 6,600 sq. ft. brick building with slate-covered wooden roof, constructed in 1906. This facility has continued the same function since construction: testing samples from the melting unit and final product analysis, work previously completed in the plant's first laboratory (see General Office cluster below).

13. Pattern and Carpenter Shops. A large, one-story brick and corrugated sheet iron building, with gabled, corrugated metal covered roof, interior height of 10-13'. The southern two-thirds of the structure, entirely brick-cased with ornate brickwork and high-vaulted windows, is the original track welding shop constructed in 1892. Its ceilings are wooden-beam (probably original) supported by 1 1/2" rounds. The northern end of the building is the carpenter shop extension, built in 1911, onto which a second floor (a Tin Shop for sheet metal work) was later added.

14. Pattern Storage. Two brick structures, one a four-story brick structure with gabled, corrugated metal roof and elevator used for pattern storage, and the other a one-story lean-to, appended to the No. 2 iron foundry in 1914.

15. The No. 2 Electric Foundry. [The Steel Foundry] A huge 243,946 sq. ft. metal clad structure with gabled, monitor-type, corrugated metal covered roof, height 24-33' and bay size 41'10" - 66'11", with six rail tracks. This site has undergone significant conversion and bears little resemblance to its original building. Initially, the site contained the steel foundry, the core ovens, and the roll mill (the latter approximately at the site of the current shakeout bay). When the rail mill was dismantled in January of 1895, the entire site was converted to foundry operation. Major alterations and conversions were completed in 1907 by U.S. Steel. In 1967. the foundry's two 30-ton open hearth furnaces were replaced by a 30-ton electric furnace in order to expand the plant's roll capacity. This is considered the large foundry, making castings of one ton or more.

The General Office Cluster

The General Office cluster of buildings was constructed between 1889 and 1893, comprising general offices, drawings rooms and laying out floor, the main machine shop and an industrial laboratory. Except for the Laboratory building which was torn down around 1962, the cluster still stands as it did in 1895. And while the interiors of each building have been converted several times, the building exteriors remain virtually unaltered. Because of this and the fact that these buildings all date to approximately the same period of the plant's development, the General Office cluster is diagrammed below. Diagram A reflects the building cluster as it stood in 1895, with all core buildings intact but without additions from the U.S. Steel period (after 1902). Diagram B reflects the cluster as it stands today, indicating the development extensions to the Engineering Building (1907) and the Middle Shops (1924), and the construction of the Lower Shops (1907), indicated in dotted lines.

The buildings in the current General Office cluster (as depicted in Diagram B) are specified as follows:

16. The Middle Shop. [The Machine Shop] Two attached one-story brick buildings enclosing 19,000 sq.ft. of space. The northern wing (or front) of the building with ornate brick work, gabled offset roof, exterior brick chimney, and characteristic square tower with pyramidal roof (on the eastern corner) is the plant's original 53' x 125' machine shop, constructed in 1891. The rear (southern) extension was added in 1924, allowing the building to abut the rear of the Engineering Building (see below). The newer section has a flat tar and slag covered roof with ceiling height up to 27'6" and one rail track. This structure continues its original (1891) function as a maintenance shop for the rest of the plant.

17. The Engineering Building. [The Drawing Rooms and Laying Out Floor] A two-story 35,200 sq. ft. brick building with gabled, monitor-type wood and slate covered roof adjoining both the Middle Shops (by common wall) and the General Office Building (by second-floor enclosed walkway). Victorian in style with corbelled brickwork, the multiple window facades along Central Avenue are flanked by square towers with pyramidal roofs. The three northern-most facades are window-less by design, one containing the second-floor drawings vault. Constructed in 1893 as the Drawing Room Building and Laying Out Floor, the building exterior is essentially original. The laying out floor was open from the ground floor to the second story sky-light, ringed on three sides by an enclosed balcony of drawing rooms where drawings were completed by the Company's engineers and stored in the vault. Blueprints were made in a small extension off the second floor on

the northwest corner of the building. The rear extension to the building was added in 1907. Trackwork designs were layed out in wood from a carpenter shop in the rear of the first floor until 1958 when trackwork lines were discontinued. Toward the end of the 1960s, pilings were constructed directly on the laying out floor and an interior shell constructed independent of the outside building structure, a second level of flooring added, and the original skylight covered over with batting and tar paper (the hump of the covered over skylight is still clearly visible). Currently the first floor is used for engineering and the second floor for training rooms.

18. The General Office Building. A three-story brick building with gabled, wood and slate covered roof. Originally constructed in July 1889 as a two-story structure, it was converted the next year to its three-story (and current) form, adding its characteristic square towers with pyramidal roofs and gabled roofing, in October of 1890. It is currently used for executive offices.

The Lower Shops

19. The Lower Shops. A huge 189,303 sq. ft. one-story brick and metal clad building with monitor-type gabled wood and slate covered roof, constructed in 1907; ceiling height 24', with 47' bay size and two rail tracks. It is currently used for machine and fabricating work on products from the upper shops.

DIAGRAM A

The Johnson Company 1895
The General Office Cluster

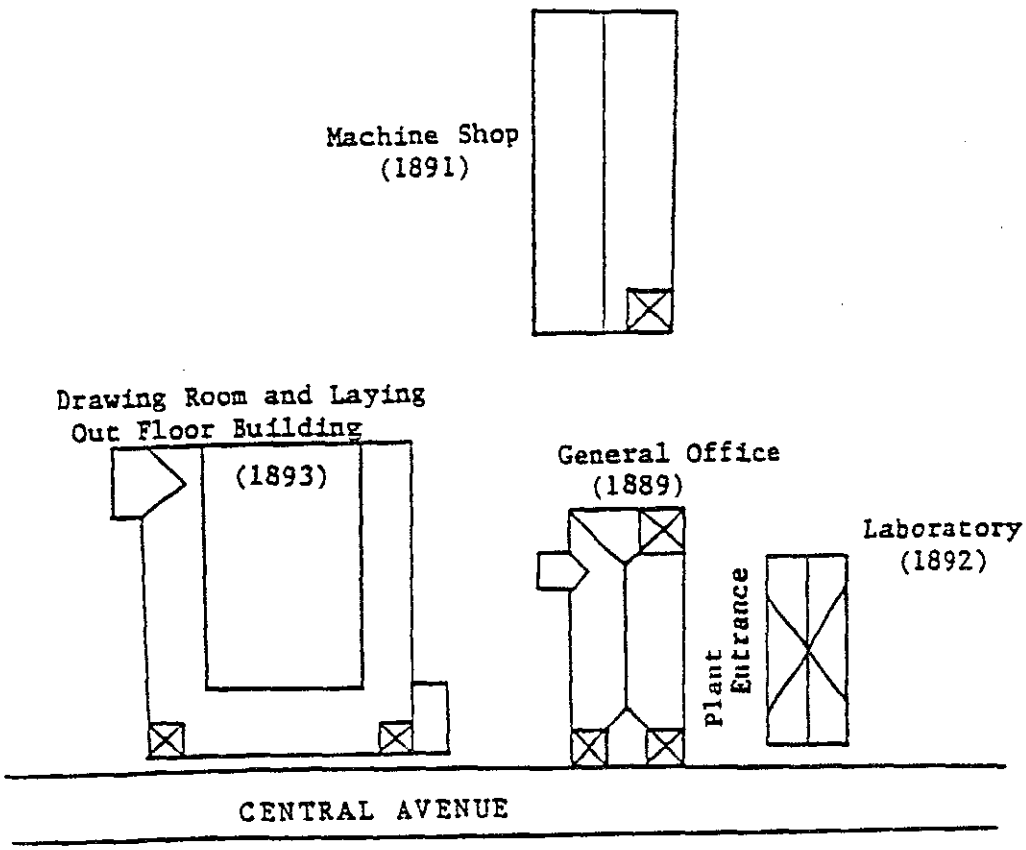
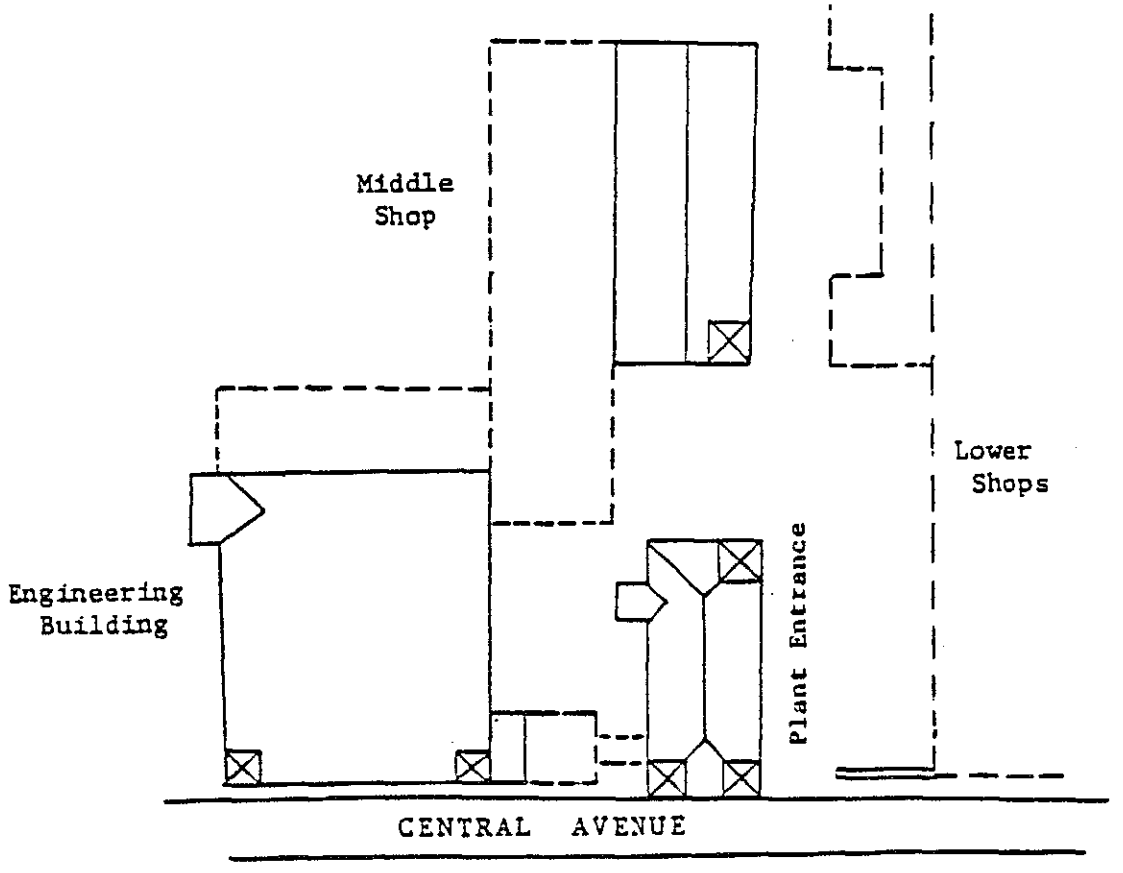


DIAGRAM B

The Johnstown Corporation 1988
The General Office Cluster



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Tom L. Johnson file (TLJf), Papers of Pierre S. du Pont, File 339, Box 227, Manuscript Department, Hagley Library. This material encompasses a wide range of relationships between the two men, mostly regarding investments in street railways (including in Johnstown) and the health of the Johnson Company in the 1894-1896 period.

The Johnson Company file (JCf), Papers of Pierre S. du Pont, File 26, Box 34, Manuscript Department, Hagley Library. This material largely centers on the period 1893-1898 in which the Company planned and began to build a fully integrated mill in Lorain, Ohio.

The Johnstown Corporation vertical file (vf), including brief historical sketches of the plant (largely focusing on the U.S. Steel period 1902-1958), some lengthier

descriptions of operations in the post-World War II period, and some materials reproduced from other sources. This material is not filed in any systematic manner.

The Johnstown Passenger Railway Company file (JPRCf), Papers of Pierre S. du Pont, File 27, Box 57, Manuscript Department, Hagley Library. This material relates mostly to the 1895-1900 period, prior to takeover by Thomas Coleman du Pont.

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Arthur J. Moxham file (AJMf), Papers of Pierre S. du Pont, File 250, Box 201 (general file) and File 254, Box 201 (Federal Steel Syndicate file), Manuscript Department, Hagley Library. This material mostly relates to Moxham's decision to built the Lorain mill, its financing, its construction, and its subsequent operation as an investment. It also includes material related to Moxham's participation in the Federal Steel syndicate in 1898, after the Johnson Company holdings were reorganized as Lorain Steel Company.

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Johnson Company versus Pacific Rolling-Mills Company, Cir. Ct., N.D. Calif., July 27, 1891, 47 Fed. Reporter 586 (companion case Johnson Co. versus Sutter Street Railway Co.), affirmed Cir. Ct of Appeals, Ninth Cir., Nos. 33, 34, July 18, 1892, 51 Fed. Reporter 762.

Johnson Company versus Pacific Rolling-Mills Company, Cir. Ct, N.D. Calif., November 27, 1893, 59 Fed. Reporter 242.

Johnson Company versus Pennsylvania Steel Company, Cir. Ct, E.D. Penna, No. 59, January 23, 1894, 62 Fed. Reporter 156.

Johnson Company versus Pennsylvania Steel Company, Cir. Ct., E.D. Penna, No. 21, May 14, 1895, 68 Fed. Reporter 212.

Johnson Company versus Pennsylvania Steel Company, No. 53, May 14, 1895, 67 Fed. Reporter 940; affirmed Cir. Ct of Appeals, Third Cir., No. 20, October 28, 1895, 70 Fed. Reporter 214.

Johnson Company versus Tidewater Steel-Works, Cir. Ct., E.D. Penna, March 1, 1892, 50 Fed. Reporter 90; affirmed Cir. Ct of Appeals, 3d Cir., June 6, 1893, 56 Fed. Reporter 43.

Johnson Steel Street-Rail Company versus North Branch Steel Company, Cir. Ct., W.D. Penna, November 12, 1891, 48 Fed. Reporter 191, 195, 196.

F. U.S. Government Patents

Annual Reports of the Commissioner of Patents, for the years 1874 through 1895 inclusive. During the period 1883-1895, the Johnson Company held or was directly consigned (mostly by Arthur J. Moxham) 204 patents on rail design (side- or center-bearing girder rails); frog, switch, crossover, tie-plate, chair, and splice-bar design; roll design, the sequence of rolling passes ("rolling mill design"); and other track implements (e.g. the highly profitable "Marchall Clip") and processing procedures (e.g. electric track welding machines) for electric streetcar systems.

Also during this period (but not counted in the 204 total above), the Company held or was directly consigned over two dozen patents on rail and trackwork design for cable systems. Finally, both Tom L. Johnson and Arthur J. Moxham pursued patents individually, the former in the design of trackwork, yokes, slot rails, braking systems and other safety devices for cable systems, and the famous (and lucrative) Johnson car fare-box. Moxham, during his years with the Birmingham (Ala) Rolling Mill, patented several iron-making processes designed to improve metal strength.

III. Unpublished Materials

Hunter, Robert John, "Biography of Daniel J. Morrell, Ironmaster," Masters thesis, University of Pittsburgh, 1954.

Massouh, Michael, "Tom Loftin Johnson; Engineer-Entrepreneur, 1869-1900," Ph.D. dissertation, Case Western Reserve University, September 1970.

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Moxham, Egbert, "Rosemary," unpublished memoir, 1956.

Murdoch, Eugene C., "Life of Tom L. Johnson," Ph.D. dissertation, Columbia University, October 1951.

Pisney, Raymond F., "The Louisville Agency of E. I. Du Pont De Nemours and Company, 1831-1887," Masters thesis, University of Delaware, June 1965.

Rawlinson, Gordon R., "Tom Johnson and His Congressional Years," Masters thesis, Ohio State University, 1958.

Shappee, Nathan David, "A History of Johnstown and The Great Flood of 1889," Ph.D. dissertation, University of Pittsburgh, 1940.

IV. Newspapers

The Cleveland Plain Dealer

The Johnstown (Daily) Democrat

The Johnstown Tribune

The Louisville Commercial

The Louisville Courier

The Louisville Times

The New York Times

V. Maps, Charts, and Surveys

A. Plant Surveys, scale

The Johnson Company, May 31, 1895 (E.F. Schult, N.B. 269), as amended October 15, 1898 (A.P. Stockwell, N.B. 332, p. 54). Serial No. 4409 Plan Department of the Associated Mutual Insurance Co's, Index No. 6573-1.

Johnson Company Properties along Central Avenue, from Stonycreek to General Office and Laboratory, April 7, 1896. (vf, no. 2395)

Johnson Company Properties, from Moxham Bridge to Ferndale Bridge, September 1897. (vf, no. 27235)

Johnson Company Properties, March 28, 1898. (vf, no. 28638)

Stonycreek River Channel Line, B & O Railroad Bridge to City Limit (Moxham Bridge), August 1898. (vf, no. 17772)

Stonycreek River Line, February 1, 1892. (vf, no. 10840)

Stonycreek River Line, Summer 1893. (vf, no. 17651)

Lorain Steel Company, December 1906. (vf, n.n.)

Lorain Steel Company, utilities maps (water mains, sewer, compressed air, steam, gas), 1913. (vf, nos. 76975-76979)

Lorain Steel Company, track survey, n.d. (circa 1920). (vf, n.n.)

Lorain Steel Company, sewer lines, 1930. (vf, no. 119992)

Carnegie-Illinois Steel Corporation, Johnstown Works, January 1932, revised to 1945. (vf, n.n.)

Carnegie-Illinois Steel Corporation, Johnstown Works, sectional maps, July 15. 1937. (vf, n.n.)

B. Surveys of Johnson Company Auxilliary Enterprises

Topographical Map of Moxham and Adjacent Coal Lands, showing properties on north side of Stonycreek between Moxham and Rocky Run, March 1894. (vf, n.n.)

Original Warrants for Ingleside Mine, n.d. (circa 1890). (vf, n.n.)

Deposits of Ingleside Coal Company, 1893. (vf, n.n.)

Blueprint Plan for the Town of Moxham, 1893. (vf, no. 30491)

Proposed Reservior for Stony-Creek Water Company, n.d. (vf, n.n.)

Johnstown & Stony Creek Railroad, right-of-way south of Johnstown (Bedford Street to Benscreek), March 9, 1895. (vf, no. 28017)

Johnstown & Stony Creek Railroad right-of-way (five sections, Meadowvale to Woodvale), n.d. (circa 1888). (vf, no. 37836)

Johnstown & Stony Creek Railroad, right-of-way Bridge Street (Ferndale Bridge) to Moxham Bridge, n.d. (vf, n.n.)

Johnstown & Stony Creek Railroad, track survey, Messenger Street to Plant, November 1906. (vf, n.n.)

Johnstown & Stony Creek Railroad, track survey, Messenger Street to Plant, January 1923. (vf, n.n.)

Johnstown & Stony Creek Railroad, Bedford Street Siding, August 23, 1890. (vf, n.n.)

Johnstown & Stony Creek Railroad, proposed track route Maple Avenue (Woodvale) to Moxham, n.d. (circa 1888). (vf, n.n.)

Johnstown & Stony Creek Railroad, Proposed Trackwork for New Engine House, November 1927. (vf, no. 113858)

Johnstown Passenger Railway Company, survey of all routes, including planned interurban route Benscreek to Windber, 1900. (vf, n.n.)

C. City Maps

Sanborn Map, Johnstown, Pennsylvania 1886.

Sanborn Map, Johnstown, Pennsylvania 1891.

Sanborn Map, Johnstown, Pennsylvania 1895.

Sanborn Map, Johnstown, Pennsylvania 1913.

Sanborn Map, Windber, Pennsylvania 1924, amended to 1936.

1890 Atlas of Cambria County, Johnstown, Pennsylvania (circa May 1889).

VI. Architectural Drawings

General Office, August 6, 1889. (vf, no. 4339)

General Office Foundation, July 1, 1889. (vf, no. 4340)

General Office, 2d Floor, July 1, 1889. (vf, no. 4341)

Drawing Room and Laying Out Floor, 1st Floor, February 23, 1893. (vf, no. 14421)

Drawing Room and Laying Out Floor, 2d Floor, February 25, 1893. (vf, no. 14422)

Drawing Room and Laying Out Floor, March 7, 1893. (vf, no. 14423)

Drawing Room and Laying Out Floor, Roof Trusses, January 20, 1893. (vf, no. 14881)

Drawing Room and Laying Out Floor, Windows (detail), February 9, 1893. (vf, no. 15031)

Drawing Room and Laying Out Floor, Windows (detail), February 9, 1893. (vf, no. 15032)

Drawing Room and Laying Out Floor, Extension, July 28, 1906. (vf, no. 51335)

VII. Photographic Materials

Most images of the pre-Moxham plant sites of the Johnson Company have been lost. The 1888 Catalog (No. 6) contains a lithograph of the Woodvale Switchworks, and the Johnstown Corporation archive contains a photograph of the lay out yard taken just prior to the Flood of 1889. Lithographs of the earlier Louisville Rolling Mill sites can be found in the 1871 and 1877 Caron's Directories of Louisville.

Images of the Moxham plant are a bit more plentiful. The first images are lithographs in the 1888 Catalog of the Mitis Foundry and the Rail Mill. The 1890 Atlas of Cambria County contains a fairly true-scale drawing of the Moxham plant circa early 1890, depicting the temporary switchworks, the two-story General Office Building, and the brickyards. The Johnstown Corporation possesses two large-scale photographs of the early plant, one which can be dated to spring 1891 and the other to February 1893 (both looking east from across the Stony Creek), and a smaller photograph of the temporary switchworks, taken about 1892 (in which a portion of the original car barns can be seen). A 1897 photograph at the Johnstown Flood Museum (again looking

east) shows the Steel Motor Company in the original Track Welding Shop. The Flood Museum also contains two photographs of engineers working in the Drawing Rooms, dated 1899.

Later photographs of the Moxham plant are more plentiful, but most depict specific track orders in the lay out yard of the Upper Shops in the 1920s. One smaller photograph shows the lay out yard and portions of the Upper Shops in 1901. There are two plant views of note: a 1911 view from the same vantagepoint as the 1891 and 1893 photographs, and a 1928 aerial view. All of these photographs are in the Johnstown Corporation archive. Images of the construction of the Lorain plant in the 1890s can be found in the collection of the Black River Historical Society.

Some photographs or other depictions of the principal actors in the Johnson Company history do exist. Formal portraits of Tom Johnson from throughout his life are contained in his autobiographical My Story. Only one early photograph of A.J. Moxham has been found: a posed photograph of the management of the Johnson Steel Street Rail Company taken in 1886, one original copy of which is in the Johnstown Corporation archive. Other photographs of Moxham can be dated after 1906. Only two depictions of Alfred V. du Pont were found: an early photograph published in the Louisville Courier Journal (for which they may not have the original) and a charcoal portrait done late in his life. The latter is reproduced in My Story. Both Bidermann and Thomas Coleman du Pont have several images existing from the Louisville period, most of which are in the Hagley Library Imprints Department.

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