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A STUDY IN AMERICAN INDUSTRIAL PRACTICE

The Baldwin Locomotive Works

1831–1915

JOHN K. BROWN

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Studies in Industry and Society

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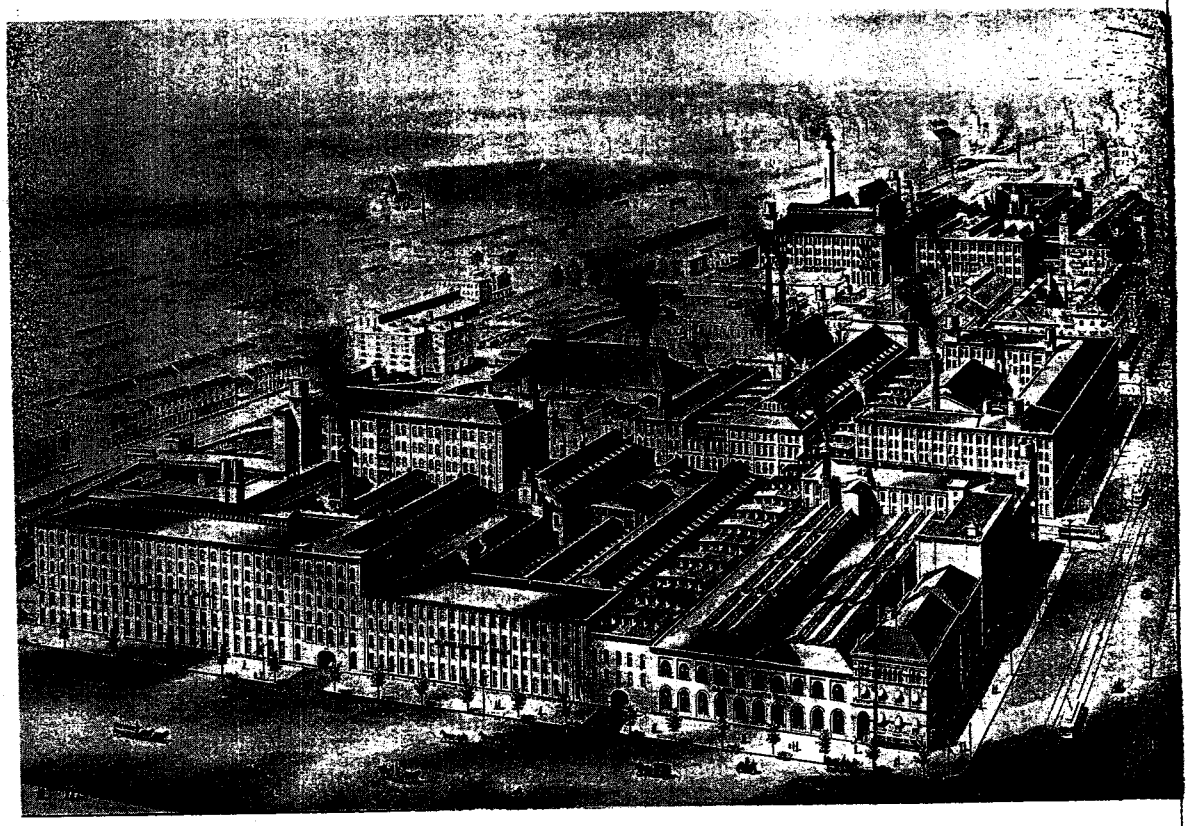
8. JOHN K. BROWN
   The Baldwin Locomotive Works, 1831–1915: A Study in American Industrial Practice

PREFACE

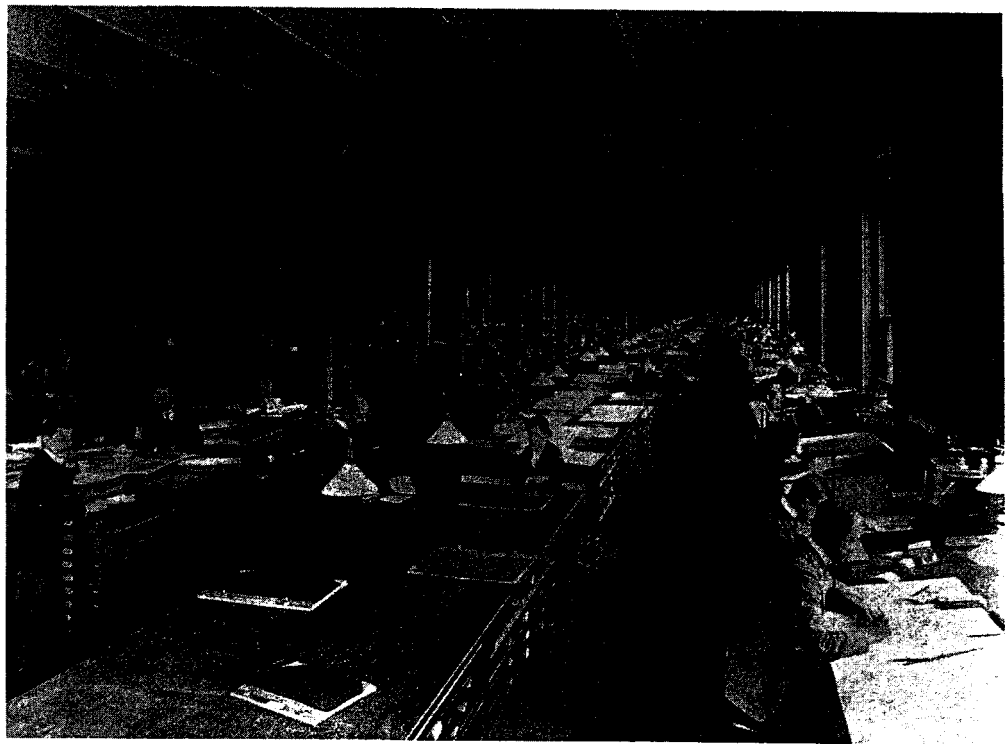
As the industrial age gathered force and momentum during the nineteenth century, the steam locomotive came to symbolize the new agencies of technology, commerce, speed, and power that reordered Western society and marked the most fundamental changes ever in humanity's lot on earth. Countless authors have traced the social and cultural impact of steam railways, but we remain only dimly aware of how these engines of change were actually made. That is the concern of this book, a history of the Baldwin Locomotive Works of Philadelphia, the largest and most successful locomotive builder in America or the world in the nineteenth century.

The chapters that follow detail aspects of the company's history and its place in the larger American industrial scene. My concern here at the outset is to build a locomotive. Compared with the bedlam of an erecting shop, the mind's eye is far quieter and much more orderly. Yet one must first see the process of building an engine to situate all that follows in this book. So join the throng on the way to work in the Baldwin plant early one morning in October 1905.

Just before the starting whistles blow out at seven A.M., Baldwin's day shift of over ten thousand men hurries through the teeming streets of Bush Hill, an industrial district rendered in brick and soot, crowded with factories, railway lines, coal yards, and worker tenements. The men split up into separate groups, heading for the different shops of a factory spread out over ten city blocks where the six thousand workers of the night shift are ready to lay down their tools. Upon arriving, the day men will begin work on any of the approximately 450 new locomotives that on this morning are at varying stages of completion in Baldwin's regular production schedule. From the foundries to the erecting shop, workers in eight skilled trades and scores of specialties apply their talents to engines ranging from little 4-ton electrics to massive 150-ton steamers. Baldwin



When Matthias Baldwin opened his first factory building on Broad Street in 1835, the neighborhood still had a rural quality. Over the next thirty years a throbbing industrial district grew up around the expanding locomotive works. This view circa 1905 shows the plant at the height of Baldwin's success. The shops filled seven city blocks and occupied portions of five more. AUTHOR'S COLLECTION



In 1905 draftsmen occupied two floors of Baldwin's office building at 500 North Broad Street. Like production workers, the designers specialized in particular components or aspects of design. The flat-file tables in the middle contained thousands of drawings for standard parts. Draftsmen used these standards whenever possible—even in custom engines. The boy leaning on one table (*center*) was a runner who took finished drawings down to the shops. H. L. BROADBELT

did not make a single standard steam locomotive, but it largely followed common steps in building these custom products.[1]

It all begins in the drawing room, actually two large floors of the office building at Broad and Spring Garden Streets, where 150 draftsmen work up new designs. Under Baldwin's eight-week production schedule, the draftsmen have three weeks on average to get out the plans for a new type of engine—and much of the firm's output at this time is custom designs. Referring to the contract specifications, they build a locomotive on paper, using established standard parts where possible and drawing new component designs as needed. After plans are drawn and checked, they first go to the purchasing department, which orders materials from outside vendors. Great quantities of costly semifinished materials, like boiler flues, steel tires, forged axles, and patented appliances, come from specialist firms, the expense reaching over 50 percent of the final price of a Baldwin engine.[2]

On this morning many orders have advanced to weeks four and five in the production schedule. This fortnight sees the receipt of materials from outside makers and the first work inside the factory. Highly skilled blacksmiths in the smith shops swelter despite the cool autumn weather, forging iron and steel parts ranging from leaf springs to engine frames. Individual smiths work up springs and a hundred other small parts on their own anvils, judging how far and fast to work the glowing plastic iron before returning it to the fire. Large pieces like a locomotive frame require a crew of four or five, using a jib crane to swing the work from the fire to the massive steam hammer needed for large forging jobs. While the smiths test their skills against iron in a pitched battle of ringing hammer blows, raging heat, and choking smoke, skilled molders and their assistants in the foundry begin making sand molds for cylinders, wheel centers, and other castings, using wooden patterns made up by the patternmakers. With this painstaking work under way, the foundry cupolas are charged with coke fuel and pig iron. By midafternoon the molten iron is ready for pouring. A single cylinder casting can require over 10,000 pounds of the bubbling liquid; the founders judge when the heat is right for the pour by seeing the iron's brilliant glow in the ladle.

We leave the foundry behind for our next stop in the boiler shop, although much of the heat and smell of liquid iron accompany us. Crowded conditions have forced Baldwin to place one of its boiler shops on a floor above the iron



A team of Baldwin forge men stand by their steam hammer sometime in the late nineteenth century. They are working a wrought-iron axle under the hammer, with the axle suspended from a jib crane so that it could be swung back into the fire for reheating as needed. Such work required coordinating the skills and efforts of a team of workers. CARL HOOPES

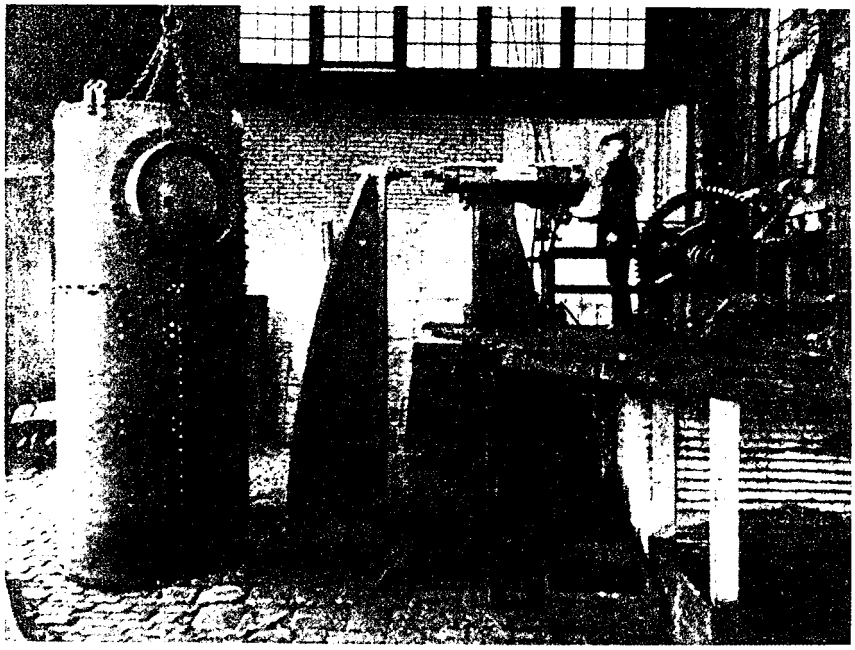


Located above the iron foundry, this boiler shop ran the length of a city block. Flat boilerplate was sheared, drilled, rolled, and stamped into separate components in other shops. Boilers were assembled here; their courses (or sections) were riveted together and fireboxes, tube sheets, staybolts, and steam domes installed. Without any workers to indicate the scale of this 400-foot-long room, it appears deceptively small. AL GIANNANTONIO

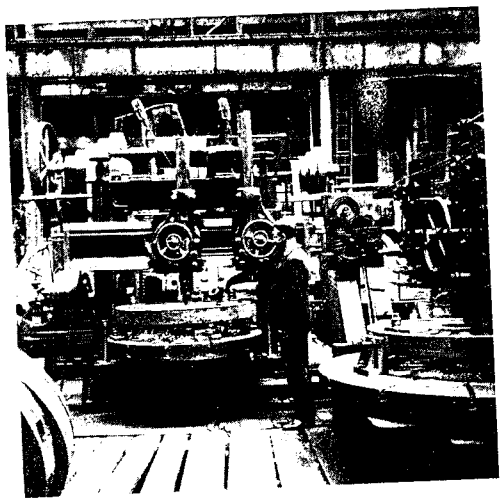
foundry. Boilermaking has the potential to be a real bottleneck in the production schedule. All parts entering into a boiler come from outside suppliers, so most of the steel plates, flues, staybolts, piping, gauges, and insulation do not arrive at Baldwin until the fifth week of the production schedule. The firm allots weeks five and six to the massively labor-intensive process of fabricating boilers, which can reach 40 feet in length and weigh up to 43,000 pounds even before the flues are added. To make each boiler in this two-week period, Baldwin allots four shops and over three thousand men on two shifts to the task. They employ powered tooling wherever possible: plate planers, drillers, punchers, and rollers that accommodate sheets over 20 feet long, as well as overhead cranes, hydraulic presses, and power riveters. Notwithstanding these tools, the work remains notably labor-intensive, and the firm must rigorously subdivide tasks to stay on schedule. Each stage has its own specialists: markers, drillers, rollers, flangers, riveters, chippers, and caulkers, many requiring helpers. Working in small groups that are paid piecework rates, the men hurry from plate to plate and machine to machine. The work is rushed but cannot be slapdash. Boilers under pressure are notoriously lethal, and Baldwin's customers often send inspectors into the plant to ensure that construction of their orders complies with railroad standards. The boiler shops are not as noisy as one would think. Huge hydraulic presses do most of the flanging work—making steam domes, for instance—while much of the riveting is accomplished by large hydraulic riveters rather than the brute-force hammering of the past.

While the boilermakers shear, roll, punch, flange, press, and rivet steel sheets as if they were paper, over five thousand machinists turn to precision machining operations. Baldwin's machine shops are scattered across seven city blocks, with the two major shops on Broad Street occupying four- and six-story buildings. Since the machinists must await the products of the foundries and smith shops, today they are working on orders in weeks six and seven of the production schedule. Machining work runs the gamut from crankpins

the size of a forearm to driving wheels 6½ feet in diameter to 5-ton cylinder castings. Most of the workers run machine tools driven by electric motors and using the new high-speed steel cutting tools. But operations like the final fitting of cylinder heads and journal bearings still call for the old ways: a fine file, a scraper, and practiced eyes and hands. In both hand and machine work, the men must utilize special fixtures, jigs, and templates that, when used with care, help ensure that parts are made with sufficient precision to be interchangeable among all engines in a batch order. Railroad inspectors are also intrusive in the machining departments, checking that Baldwin's work meets the railways' standards of precision. The machinists generally labor alone, although they need the help of crane operators and laborers to set up cylinders for boring or engine frames for planing. Here too the work is paid by the piece and highly specialized, but it calls for fine skill and judgment to bore a 10,000-pound cylinder casting on a true axis and to the correct diameters. A machinist's error at this point could ruin the casting, already the product of countless hours of labor by patternmakers, founders, and casting cleaners.



This hydraulic boiler riveter greatly speeded boilermaking while improving the quality of work over hand-riveting. An overhead crane picked up the boiler (*left*) and lowered it over the riveter. A boy placed the glowing-hot rivets in holes in the seam to be riveted. The hydraulic ram pressed the rivet against the anvil reaching up inside the boiler, setting the head. Then the crane operator repositioned the boiler for the next hole in the seam. Machine-riveting produced uniformly tight joints, improving boiler safety. HAGLEY MUSEUM AND LIBRARY



A group of boring mills, with driving-wheel centers mounted for boring the axle holes and facing the hubs. Judging from his attire, the man shown was probably a foreman, not an operator. Workers on these machines used special measuring tools, known as gauges, to bore wheels to the required dimensions. It was skilled but highly specialized work. One look at this shop suggests some of the dangers in locomotive building—the loose plank floor and absence of safety guards on the machines. AL GIANNANTONIO

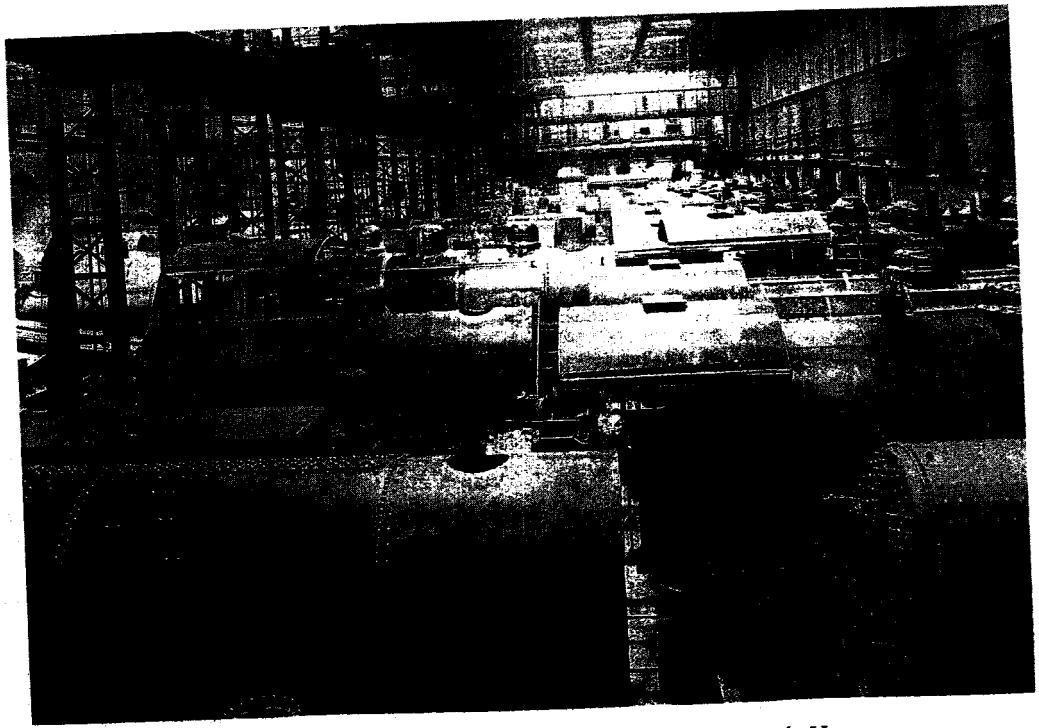
The work of draftsmen, patternmakers, founders, blacksmiths, boilermakers, pipe fitters, and machinists all converges in the erecting shop—a single room filling most of a city block on Broad Street, only a short distance from City Hall and the heart of downtown Philadelphia. Erecting occupies the eighth week in the production schedule. Today the shop is filled to its capacity of seventy-five engines. In previous decades this final stage of construction had been a notable bottleneck to improving output. But now frames and other machined parts are made with sufficient precision to come together with only minimal fitting, while electric overhead cranes speed the handling of large parts like boilers.[3] Today the army of thirty-two hundred workers in the erecting shop requires only a week on average to complete a locomotive. While all the men here are involved in erecting, a great range of skills and tasks come under that heading. Most are machinists and fitters, but large numbers of boilermakers, pipe fitters, insulation men, sheet-metal workers, painters, and laborers also work in the shop.

Most visitors to the erecting shop find it a confusing bedlam of parts and men, a chaos of designs in varying stages of completion. The first stage in erecting generally involves setting up the cylinders, precisely aligning the bare machined frames on jacks, and bolting the cylinders to the frames.[4] Next a flatcar arrives from the boiler shop across Buttonwood Street carrying a boiler that the 100-ton overhead crane silently places on its frames. Knots of busy men then descend upon the developing engine, each group specializing in a different task and proceeding quickly from one locomotive to the next. While erectors bolt the boiler to the cylinder saddle, boilermakers place hundreds of flues inside the boiler shell, each tube requiring ten separate steps to make a tight joint in the flue sheets.[5] Then the engine is wheeled—plucked off its jacks by an overhead crane and placed on its driving wheels, which have been laid out on an adjacent track.

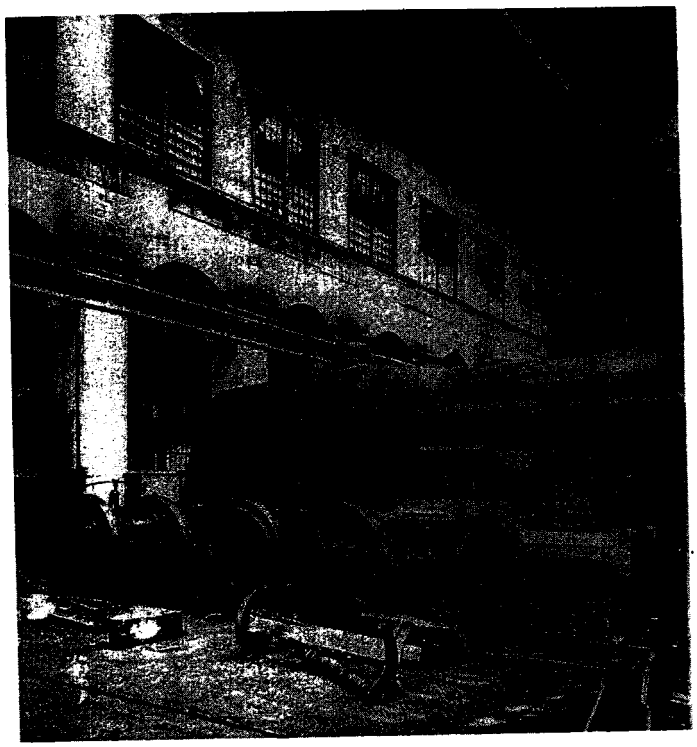
Now it looks like a real locomotive, and the pace of construction increases.

Specialist gangs drill, tap, and mount the remaining boiler fittings, the boiler is tested with hot water at 200 pounds per square inch, boilermakers caulk leaky flues and fittings, and the engine is prepared for a live steam test. The most skilled machinists in the plant set up the connecting rods, reversing gear, and valve motion. The bearings of these moving parts must be precisely aligned, so the machinists make final adjustments with files and scrapers. Other workers cover the boiler with its magnesia insulation and the sheet steel jacketing that protects the lagging, and a crane operator lowers the complete painted cab onto the engine. The locomotive is filled with 180-pound steam from a shop boiler, and a machinist cautiously opens the throttle. With the engine jacked up, the main drivers revolve in the air, showing that all is working properly.

After this crucial test, the remaining work is hurried forward. Erectors add the brakes, lubricators, air pump, injectors, handrails, cab fittings, running boards, fire grates, ash pan, leading truck, and dozens of other parts. The engine is nearly finished, and the overhead crane places it on the ready track leading out of the building. A shop switcher will soon haul the new locomotive uptown on the tracks of the Philadelphia and Reading to Baldwin's finishing



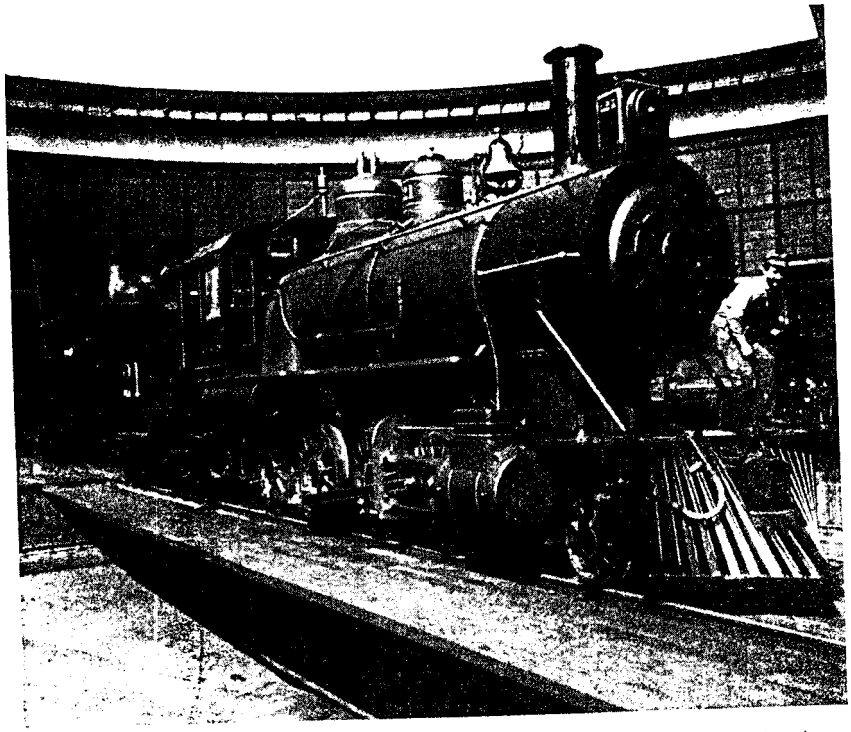
In the early years of the twentieth century Baldwin's output reached its all-time peak. Here in the erecting shop circa 1905 dozens of designs stand in varying stages of completion in one of the shop's two main bays. The overhead crane in the background delivered heavy materials and lifted finished engines over those still building. AUTHOR'S COLLECTION



Two engines stand in the early stages of erecting. The design and buyer cannot be identified, but that shown in the foreground is probably a 2-8-0-type freight locomotive. The wheels, cylinders, and frames await the boiler—not the normal erecting sequence, but procedures were often varied to compensate for delays in parts reaching the erecting shop. Note how the walls were whitewashed to reflect all the natural light possible. AL GIANNANTONIO

shop at Twenty-sixth Street. There it will join its tender from the Seventeenth Street shops, painters will finish lettering and detailing, and a Baldwin delivery engineer will take charge of the new locomotive. Under his care it will travel across country to its purchaser.

In a mere eight weeks Baldwin's thousands of workers take a novel design and translate it from words on a specification sheet into drawings and then into a finished mechanism in steel and iron, weighing upwards of 150 tons and capable of hauling 6,000-ton trains. While customers around the globe order uniquely different locomotives, the methods used in production reduce the constant variety and potential chaos to routine and order. During the month of our imaginary visit, October 1905, more than seven engines rolled from the erecting shop every working day. For the year as a whole Baldwin built 2,250 locomotives in hundreds of designs for customers around the nation and the world.



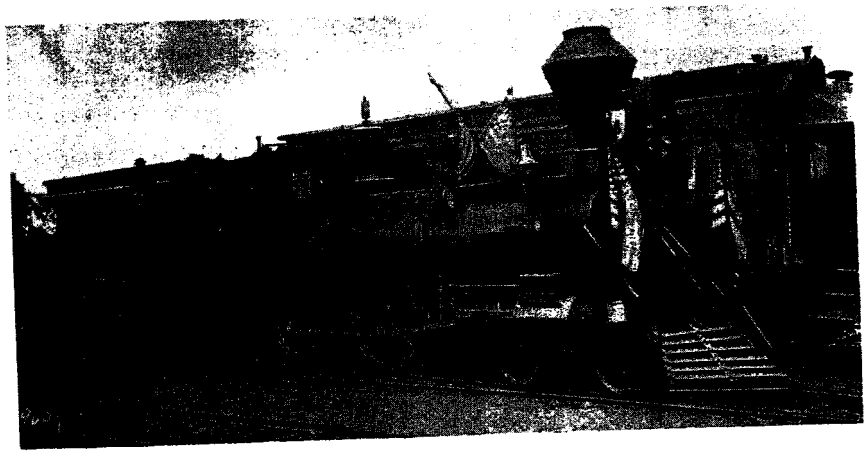
In October 1913 a new 2-8-0 freight locomotive for the Danville and Western Railroad stands on the turntable at Baldwin's uptown finishing shop. Most engines for American buyers were delivered without power in slow freight trains. Nonetheless, Baldwin sent along its own delivery engineers to ensure that the trip went safely, to set up the engine for the purchaser, and to iron out any last-minute difficulties that might otherwise hold up payment. LIBRARY OF CONGRESS

The company had reduced engine construction to a routine process, but that scarcely detracted from the aura of mystery surrounding these machines that shouldered the world's work. Locomotives provided the animated focal point of railroading, in turn the dominant force behind the economic and social transformations of industrial society.[6] From Baldwin's seven managing partners to its thousands of laborers, all involved took great pride in creating the leading technology to symbolize power, speed, and the progress of civilization. Locomotives so fascinated the general public that Baldwin needed admission tickets for visitors, and Baedeker's tourist guide cited the factory as a "highly interesting" attraction.[7]

People of the nineteenth century had a passionate faith in this technology that conquered time, tamed vast distances, and tapped the wealth of continents.[8] To modern eyes theirs was a naively romantic view, but bare facts suggest how it originated. Baldwin engines climbed Pikes Peak and hauled the Trans-Siberian Express. They roamed the American West on the nation's five major



Here five new Baldwin engines pose in 1893 on the tracks of the Philadelphia and Reading just outside the factory. Before going into service they were destined for display at the World's Columbian Exposition in Chicago. The lead engine, a 4-4-0 for the Baltimore and Ohio, represented a high point for this standard American-type wheel arrangement, used since the 1850s. Soon thereafter heavier cars and faster schedules made this type obsolete for most mainline services. BEN KLINE



The Pennsylvania Railroad had owned this Baldwin 4-4-0 for less than a month when it was pressed into service to haul a special train carrying Abraham Lincoln's body westward for burial in Illinois. Thousands of Americans turned out to see the train as it slowly passed, the engine and cars draped in mourning. RAILROAD MUSEUM OF PENNSYLVANIA (PMHC)

transcontinental lines. A Baldwin took the first train of the Jaffa and Jerusalem Railroad into Jerusalem, while others ran in England, birthplace of the railway age. They also played supporting roles in life's human dramas. In 1865 a Baldwin engine decked in black mourning crepe pulled the train carrying the body of the murdered Lincoln westward toward Springfield. Forty years later a wealthy California eccentric and former goldminer, Death Valley Scotty, paid the Santa Fe to carry him on a record-breaking forty-five-hour dash from Los Angeles to Chicago.[9] Like Pony Express relays, a succession of nineteen engines, seventeen built by Baldwin, propelled the old prospector's special express at lightning speed across the continent while the nation's newspapers chronicled the feat.

Partly because of such incidents, a highly romantic symbolic burden has attached itself to the steam locomotive from its origins to the present. Of all the icons of nineteenth-century technology, this machine has exerted the most enduring fascination. The subject of Whitman's poetry and Hawthorne's prose, gist for artists from George Inness to Charles Sheeler, and endlessly recorded in thousands of photographs, steam locomotives still haul an infinite freight of mental imagery—as totems of power and speed, as noble animated iron steeds, and as evocations of a mythic national past of confidence and simplicity when every boy dreamed of being an engineer.

This book offers an entirely different perspective on the locomotive, however. The first history of a major American locomotive builder in the nineteenth century, it seeks to describe how the Baldwin Works sold and made these complex and expensive capital goods. Equally important, it details how the firm's owner-managers ran such a high-technology company. Baldwin made locomotives for over a century and stood at the top rank of American industry for sixty years. Beyond the firm's own merit, tracing Baldwin's development provides a new perspective for understanding the era when the forces of industry, management, skilled labor, and technology first combined to remake the Western world.