INDUSTRY'S MASTER MACHINE: FACTORY PLANNING AND DESIGN IN THE AGE OF MASS PRODUCTION, 1900 to 1930

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Submitted to the Department of Urban Studies and the Program in Science, Technology, and Society on October 14, 1986 in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

ABSTRACT

Factory buildings of the nineteenth and early twentieth centuries loom large in the urban landscape as symbols of industry, projecting powerful images of the enterprises they once housed. The factory is a primary artifact of industrialization and the absence of pertinent scholarship is startling. Factories provide important evidence about industrial technology, work, and the relationship between managers and workers. They also reflect social values and attitudes surrounding industrialization and the factory as a workplace.

Mass production has been a major theme in the history of technology and its study, as a force behind both social and technological change, has revealed important relationships between the economy, technology, and twentieth century lives. It is in this context that the examination of the emergence of the modern, rational factory is most illuminating. Historians of technology have studied many aspects of mass production: changes in technology and the organization of production, the creators of the system and their motivations, and the consequences for workers and society. While this scholarship has addressed the technological and managerial steps in the hundred year history of the "American system" of manufacturing that led to mass production it has largely neglected the development of the modern, rational factory. By overlooking the emergence of the rationalized factory, scholars of industry and technology have missed a final and critical step in the ongoing effort to achieve fast, cheap, and predictable production--the systematic organization and control of the factory. The rational factory represented physical plants built to fit new production techniques aimed at carrying out new ideas about mass production, especially organizing production to flow easily through the factory. Without the new factory, it is unlikely that assembly line production would have worked as well as it did, or as soon as it did.

<u>Industry's Master Machine</u> examines the period of transition from the turn of the century to the early 1930s and focuses on the Ford Motor Company and the automobile industry where the modern, rational factory was born. In 1900 all factories embodied the principles of nineteenth century industry. By the end of the first decade the shift had begun as characterized by the factories of the Ford Motor Company built between 1910 and 1920. By 1930 the principles behind the modern factory were

well established in the form of Ford's River Rouge plant.

In addition to the transformation of American industry, changes in fatory design reflect ideas and attitudes about industry, workers, and the new urban environment. Inside the factory, engineers were changing their ideas about what a factory should be and public opinion outside the factory helped to mold those ideas. In the end, the factory building proved to be a final and critical step in achieving modern, rationalized production. Engineers realized that the factory building could be used as a powerful tool in the quest for efficient production and control over workers. Industrial engineers considered the factory building to be the "master machine," "containing and coordinating all the little machines." The new factories allowed managers and engineers to achieve their goal of industrial rationality--to run the plant as if it were a machine itself. They used rational factory planning and design to confront the increasingly complicated task of organizing and controlling growing numbers of workers, machines, and materials in one place.

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Karl Marx, Capital, 1867

The factory should be considered the master tool with which the factory manager is equipped. If it is not properly designed and constructed for its work the whole manufacturing function will suffer.

Paul Atkins, Factory Management, 1926

Introduction

Factory buildings of the nineteenth and early twentieth centuries loom large in the American urban landscape as symbols of industry, projecting powerful images of the enterprises they once housed. The multi-story brick structures stand in stark contrast to the generation of low-rise concrete and steel suburban factories that epitomized the influence of rational planning and control of modern mass-production industries. The transition from the large urban factories common at the turn of the century to a new kind of factory outside the city is an important chapter in the industrial history of the United States. The shift represents a significant step in American industry as it embraced the ethos of mass production. Even a cursory comparison of a nineteenth century textile mill and a 1920s automobile factory reveals a dramatic shift in thinking about how factories should be built. What happened during the first two decades of the twentieth century to so dramatically change the way people thought about how to build factories? Who was responsible for the shift to the rational factory? What role did the new factories play in managerial and technological changes? The answers to these and other questions will add to our understanding of the transition to twentieth century mass production and the managerial strategies that accompanied it.

The changes in factory design reflect the transformation that took place in American industry in the early twentieth century--the onset of mass production and the introduction of the assembly line--as well as innovations in power generation and construction technology. Mass production has been a major theme in the history of technology, and its study as a force behind both social and technological change has revealed important relationships between the economy, technology, and twentieth century lives. It is in this context that the examination of the emergence of the modern, rational factory is most illuminating. Historians of technology have studied many components of mass production: changes in technology and the organization of production, the creators of the system and their motivations, and the consequences for workers and society.[1] While this scholarship has addressed the technological and managerial developments in the hundred year history of the "American system" of manufacturing that led to mass production it has largely neglected the development of the modern, rational factory. By overlooking the emergence of the rationalized factory, scholars of industry and technology have missed a final and critical step in the ongoing effort to achieve fast, cheap, and predictable production--the systematic organization and control of the factory. Alfred Chandler writes that "the modern factory was as much the specific organizational response to the needs of a new production technology as the railroad and the telegraph enterprises were responses to the operational needs of the new technologies of transportation and communication."[2] The rational factory represented physical plants built to fit new production techniques aimed at carrying out new ideas about mass production, especially organizing production to flow easily through the factory. Without the new factory, it is unlikely that assembly line production would have worked as well as it did, or as soon as it did.

The Nineteenth Century Factory

The coming of mechanized mills and factories changed the face of nineteenth century America. In just over one hundred years, production shifted from small inconspicuous mills and shops to large industrial complexes that towered over small towns. Changes in industry's architectural aspect speak volumes about invisible decisions within the factory, about expansion and management, and especially about innovations in technology and production processes.

The nineteenth century industrial landscape was dominated by a building style that, because of its development in the textile industry, came to be called the "mill building." Early millwrights designed textile mills around the needs of the industry and the limitations of nineteenth century technology. The industry's needs were simple and straightforward--water power to run the machines, space for the machines, and lighting for the operatives. But the technologies of power, construction, and lighting limited the possibilities for meeting the demands, resulting in long, narrow, multiple storied buildings. In addition to textiles, the mill building style suited almost every other industry of the period and became the standard factory building, merely built large or small according to a company's production volume.

A typical textile mill, after Arkwright's introduction of powered spinning machines, measured thirty feet in width in order to allow two rows of spinning machines. In spite of the narrowness they were imposing buildings; Gary Kulik describes the massive stone and brick mills as "structures of utilitarian stateliness and arrogant grandeur. Whether they were seen as palaces of industry or as prison-like workhouses...they inspired awe."[3] (see illustration)

Power transmission technology proved to be the most restrictive component of nineteenth century mill construction. In order to run one or more floors of machines, the mill wright had to plan a network of gears and shafts that carried power from the water wheel to each machine. Indeed, the transmission of power usually proved more difficult than the actual generation of power. Power transmission and distribution requirements, according to Louis Hunter, "virtually compelled the ranking of machines in rows and segregation of operations by floor."[4] The restrictions imposed by available shafting, belting, and pulleys, thus limited mill layout and design. The long, narrow, multiple storied building was the only practical shape for the early power system.5

The technologies in use in the early nineteenth century continued, with minor improvements, well into the twentieth century. Increases in late nineteenth century production came largely from new management stragegies such as economies of scale, centralization, and insights into better organization of production. Factory size and centralization along with distribution of power quickly became the major factor in size of production output. As Chandler writes, "beyond centralizating their activities, there was relatively little change in the technology or organization of production in [the non-heat using industries]...In these industries, until well into the twentieth century, the relatively labor-intensive and simple mechanical technology created few pressures or opportunities to develop new types of machinery, new forms of factory or plant design, or new ways of management."[6]

The textile and related industries operated quite well in the traditional mill buildings. The mill that emerged from the demands of the early industry continued to satisfy the needs of the maturing industries. Similarly, the same style fulfilled the requirements of most of the metal industries until the end of the nineteenth century.

Twentieth century mass production would grow out of nineteenth century metal industries. Using what European observers called the "American system" arms makers introduced interchangeable parts, a crucial element of mass production.[7] Other industries adopted the American system and continued to innovate their manufacturing system through inventions and experimentation.[8] Surprisingly, even though metal working industries made important advances in production they continued to house their operations in traditional mill buildings. It seemed that through the nineteenth century, and into the twenieth, the standard mill building satisfied the industry's needs.

The steel industry proved to be the exception within the metal trades as it, with the guidance of Alexander L. Holley, took steps toward rational factory planning. Holley designed steel mills around Bessemer's time and money saving process. Most of Holley's work involved the conversion of older plants to the Bessemer system. A comparison of the Edgar Thomson Works (1885), which he designed specifically for the Bessemer system, with an earlier plant reveals interesting differences. The early plants were designed without consideration for organization of operations and flow of production. The Edgar Thomson Works were planned by Holley for continuous flow production and became the most efficient steel producer in the nation. Holley described his reasons for the plant's design:

> As the cheap transportation of supplies of products in process of manufacture, and of products to market, is a feature of first importance, these works were laid out, not with a view of making the buildings artistically parallel with the existing roads or with each other, but of laying down convenient railroads with easy curves; the buildings were made to fit the transportation.[9]

Holley's rationale for the design of the Thomson Works anticipated the arguments of industrial engineers of the twentieth century. His emphasis on fitting the building to transportation was precisely the same point made constantly by industrial engineers as they reorganized and redesigned the plants of other kinds of metal working industries to fit transportation and production. The auto industry led in planning the rational factory in the twentieth century.

Builders of nineteenth century processing plants recognized the importance of factory design earlier than designers of manufacturing operations. Steel mills, like other continuous process plants (flour, tobacco, refining, distilling), by the very nature of their work depended more on flow of production than other manufacturers. Thus, the physical organization of the plant became a major concern. Physical organization in the steel plant proved more difficult than other processing works because of the weight and bulk of materials and because the several stages of steel production involved very different activities. By figuring out how to organize the complex operations, the managers of the steel industry began the steady movement toward modern production.

The Twentieth Century Factory

Atkins's statement, opening this essay, reflect's the early twentieth century belief, especially among industrial engineers, that factory buildings in mass production industries loomed increasingly important as tools of industry. Though nineteenth century engineers and factory owners paid attention to the design and construction of factories and mills, the belief in the factory as a "master machine" derives from an engineering philosophy that emerged with twentieth century mass production. When the Ford Motor Company engineers introduced the moving assembly line in 1913, they created an overwhelming need for the rational factory--a factory that ran as though it were a machine itself. The new production system could work only if it succeeded in gaining greater coordination and control over work and workers, the kind of control achieved only with a well designed mechanical system. The rational factory thus coincides with the development of mass production. In the rational factory every machine and worker was part of a well-planned (and constantly replanned) system in which all decisions were made by engineers. Every movement was charted and every moment of the day accounted for. Workers had no control over their work; they in fact became merely part of "the master machine."

The job of planning and designing factories, unusual at the turn of the century, devolved upon a new group of professionals called industrial engineers. Breaking away from mechanical and civil engineering, industrial engineers shared a strong belief in efficiency and industrial rationalization, and that belief guided them as they designed and built the new factories. Compared with civil and mechanical engineering, their work was unspecialized. In general, industrial engineers' interest lay more with the organization of production than with any particular engineering problem. But because many were trained as mechanical engineers they understood industrial operations well enough to know where factory operations could be made more efficient. The auto factories were perhaps the most important, and undoubtedly the most expensive, of all factories because they contained within one plant, all of the complex operations necessary to make the most difficult industrial product yet manufactured. The moving line system, automatic machines, rationalized plant design, and shop layout made possible levels of production that were undreamed of a few years earlier. During the second decade of the twentieth century the auto industry underwent complete transformation from batch to mass production, with the assembly line being the most obvious of the widespread changes that fostered large scale production.

More extensive experimentation with factory planning and design occurred in the auto industry than any other industry in the early twentieth century. Engineers in other industries had experimented with production processes, most notably small arms, bicycles, agricultural implements, and sewing machines.[10] Others tried out novel ways to build and organize factories such as Oliver Evans and his flour mill and the famous Chicago packing house from which the Ford Motor Company is reputed to have borrowed the idea of a moving line. But none of those industries took on the formidable task of organizing thousands of men and machines under one roof and coordinating the large quantities of parts and raw materials entering the factory as well as the thousands of operations required to produce an automobile. The sheer complexity and scale of auto making differed from any enterprise that preceded it. The auto industry was important not only for developing the rational factory but also for changing the way almost all engineers thought about production.

The auto industry gave birth to the rational factory because, unlike any other industry of its day, auto production required thousands of separate operations, combining materials processing, production of parts, and assembly. Chandler observes that

> the development of the mass production techniques in the metal working industries required more time, thought, and effort than it did in others. And the additional effort required to make them more profitable and productive meant, in turn, that these industries became the major seed bed for modern factory technology and modern factory organization.11

The auto industry provides the focus for this study because of its role in the development of the rational factory and because of its significance in the history of twentieth century technology. The auto industry was for the twentieth century what firearms, railroads, and textiles were for the nineteenth--the source of technological and managerial innovations that spurred the industrial revolution. With the introduction of the assembly line, the auto companies inspired change in production methods in most industries, just as the older enterprises set precedents for production with the introduction of integrated production systems and interchangeable parts.

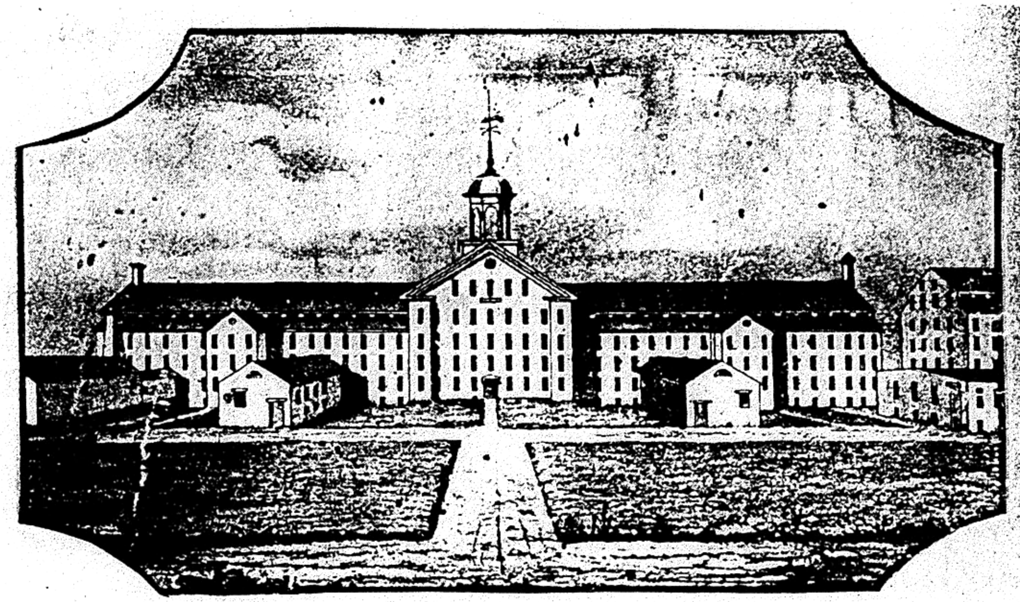
Industry's Master Machine examines the period of industrial transition from the turn of the century to the early 1930s. In 1900 all factories embodied the principles of nineteenth century industry. By the end of the first decade the shift to another kind of factory had begun, as characterized by the factories built by the Ford Motor Company between 1910 and 1920. By 1930 the principles behind the modern factory were well established, as evidenced in the form of Ford's River Rouge plant.

Architecture, like other technological systems both reflects and influences social relationships, and factories are no exception. Building design and layout affects movement, surveillance, and communication--important elements in social organization that ultimately affect status, power, and control. In their design, factory buildings contribute to the organization of production on the shop floor, the degree of communication possible between workers, and between managers and workers. They are also symbolic as they reveal information to the rest of the world about the enterprises they house.

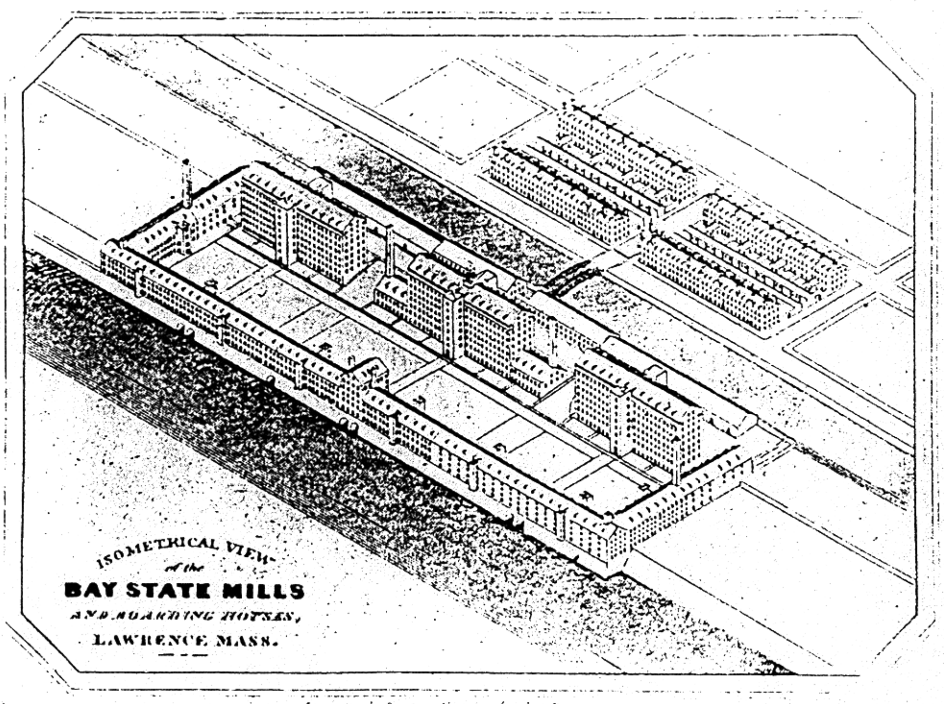
Factory buildings limited and supported changes in technology, management, and the labor process. Engineers realized that factory buildings could be made an important element in production; that they could be used as powerful tools in the quest for efficient production and control over workers. Industrial engineers considered the factory buildings as the "master machine," "containing and coordinating all the little machines," that helped them to control every detail of production. The new factories allowed managers and engineers to achieve their goal of industrial rationality.

The importance of the rational factory thus lay in its organizing function, in coordinating the disparate operations of mass production. In doing so, it helped to create a powerful industrial system. Without the principles of coordination and flow of movement underlying the rational factory other individual elements of the system could not have resulted in the speed of production all entrepreneurs desired.

The rational factory represents engineers' ability to design a physical plant to fit new production techniques, a demonstration of engineering innovations that removed nineteenth century constraints on factory design. Though they remained important, considerations of power transmission and construction no longer limited factory design to the mill building; instead, the rational factory could be built to fit the production process and to control the labor process.



Hamilton Mills, Lowell, Massachusetts, built 1846, showing a typical facade of a nineteenth century textile mill. (from John Coolidge, Mill and Mansion (New York: Columbia University Press, 1942)



Bay State Mills, Lawrence, Massachusetts, built 1846, showing the layout of a typical textile mill complex. From Coolidge, Mill and Mansion

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Notes: Introduction

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2. Alfred Chandler, The Visible Hand (Cambridge, Mass: Belknap Press, 1977), 244.

3. Gary Kulik, "A Factory System of Wood," in Brook Hindle, ed., Material Culture of the Wooden Age, 308.

4. Louis Hunter, History of Industrial Power in the United States (Charlottesville: University Press of Virginia, 1979).

5. For detailed discussion of waterpower see Hunter and Anthony Wallace, Rockdale (New York: Knopf, 1978)

6. Chandler, 248.

7. See Merritt Roe Smith, Harper's Ferry Armory and the New Technology, (Ithica: Cornell University Press, 1977).

8. See Hounshell for discussion of the manufacturing of sewing machines, furniture, agricultural equipment, and automobiles.

9. Engineering, vol. 26 (July 12, 1878), cited in Chandler, 262, emphasis in original.

10. Nathan Rosenberg; also see Hounshell; and Smith.

11. Chandler, 281.

Chapter One:

Engineering the Factory

The first years of the twentieth century witnessed the beginnings of dramatic changes in factory planning and design. Behind the changes lay the new and rapidly growing profession of industrial engineering. Through their strong belief in systematization and rationalization, industrial engineers tried to solve complex problems in production and industrial organization that plagued turn of the century manufacturers. They changed almost everything about the factory--the design of the buildings, the layout of machinery, the organization of work, and the system of management.

The story of the rational, engineered factory, as conceived by industrial engineers, is a new chapter in the story of mass production. We know about the rapid changes in technology, about the revolutionary conception of interchangeable parts,[1] and increasing division of labor[2] but we do not know yet how all of the components of mass production actually came together in the factory.

Although work like industrial engineering went on throughout the nineteenth century, the story starts in earnest at the end of the century, a time when American industry began to outgrow its factories and management techniques and a new generation of professionally trained engineers entered the job market. American industry grew in the second half of the nineteenth century when national and international markets opened up as a result of new transportation and communication networks. The new markets encouraged additional manufacturing ventures, substantially increasing ever-growing competition. Schemes for competing emerged as important tools for survival in the world of corporate capitalism. Some manufacturers formed monopolies to control markets, others sought increased sales through advertising and marketing.[3] Some tried to increase profits by enlarging production, thereby decreasing unit costs. In this way they could sell their product at a lower price and, at the same time make a sizable profit. New management techniques further reduced costs by tightening the chain of command in factories and intensifying the work process. Daniel Nelson writes that engineers who took over managerial positions turned to rational management techniques as they increasingly realized its importance to successful business.[4] The industrial organization as well as management and marketing techniques perfected during this period became, and remained, the foundation of modern manufacturing and business administration.[5] Larger profits, a primary goal of manufacturers, required either higher selling prices or lower production costs. Competition discouraged price increases, so the capitalist's attention usually focused on lowering production costs. Costs could be reduced by cutting wages, by doing the work with fewer workers, by increasing the speed of production, and by employing economies of scale. These became major goals for industrial engineers.

The last two decades of the nineteenth century witnessed long-lasting changes in the development of the "multifunctional, multiregional, and multiproduct" manufacturing enterprise. The expansion led to the reduction of production and distribution costs.[6] Alfred Chandler explains that by increasing both output and number of functions performed firms could take advantage of "economies of scale and scope."[7]

The Birth of Management Science

As firms grew larger and more complex, increased managerial responsibilities outgrew the capacity of older management strategies. The new scale of production required a different way of managing the factory, requirements that gave rise to new professionals who gave management advice and often managed the factory themselves to achieve economy, efficiency, and control. The new professionals, industrial engineers, based their work on an engineering idea that promised to rationalize production and industrial organization in a way that would solve a multitude of problems. The idea that factory production could be carefully planned and organized for greater efficiency and reliability came to be known as systematic management, and later as scientific management. Engineers argued that the new techniques would objectively and rationally solve the problems plaguing business, industry, and society.

Industrial engineering grew out of the management movement at the turn of the century. The industrial engineers, trained as both managers and engineers, became the most persistent publicists for the theories of efficiency. Scientific management guided the new engineers as they sought economy and control in manufacturing. A leading engineer wrote that "industrial engineering, of which shop management is an integral part, implies not merely the making of a given product, but the making of that product at the lowest cost."[8] Through their jobs as factory planners, industrial engineers reorganized every detail of the factory to increase productivity and reduce wasted time, energy, and materials; they introduced new management techniques, rationalized the labor process, and redesigned the factory. As Calvert writes, the new engineers left the "engineering of materials and enter[ed] the engineering of men." This represented a momentous shift from what some called "pure engineering" to management.[9]

In the early twentieth century, men who called themselves industrial engineers were usually educated in traditional engineering programs--Henry R. Towne, an early proponent of systematic management and a leader in industrial engineering, studied engineering at University of Pennsylvania and the Sorbonne and received a doctorate of Commercial Science from New York University. Charles B. Going, a lecturer at Columbia University and editor of Engineering Magazine, received a Masters of Science from Columbia University's School of Mines. Henry L. Gantt, a protege of F.W. Tayulor, studied graduate engineering at the Stevens Institute of Technology, and Paul Atkins, lecturer at University of Chicago and consulting industrial engineer, graduated from Yale's School of Engineering.

Industrial engineers planned the rational factory to accomodate the more efficient production and larger output of growing companies. With greater and more diversified output, the factory could not be run in the ad hoc ways of nineteenth century industries. The new factories were larger with more workers and more operations taking place simultaneously, requiring increased management and record keeping.

Speedy and reliable throughput achieved through new machine layout and tighter managerial control was, as Chandler explains it, critical to the success of the new industrial integration. Economies of scale and scope would work only with reliable throughput.

Planning and directing production emerged as the greatest challenge industrial engineers faced. It allowed them to use their engineering knowledge of machinery and production as well as their belief in scientific management. Industrial engineers boasted that they were the only people with the proper skills to plan the new rational factory.

F.W. Taylor, though considered the father of scientific management, was not the first to propose industrial reform based on principles of efficiency. Manuals published in England in the early nineteenth century, about which Maxine Berg has written, examined "the connections between technology and the science of workshop organisation."[10] Before mid-century Charles Babbage wrote his widely received book _On the Economy of Machinery and Manufactures_ (1835) and Andrew Ure his _Philosophy of Manufactures_. All of these addressed the wide range of issues important in running a factory for commercial success--from the technical details of production to the health of "Factory Inmates." Following from Adam Smith, they sought the best and most efficient organization of the operations of production.

Early industrialists were as interested in control of the workplace as their turn of the century successors. Babbage, Ure, and others recognized that systematic organization of the factory and workshop increased control over the manufacturing process and increased profits by improving efficiency. Reorganization and division of labor decreased the level of skill needed from the worker thereby eliminating the need for skilled hands, and increasing the manufacturer's control over labor. Much like Taylor fifty years later, Babbage was interested in the "deliberate engineering" of the workplace.[11] He experimented with time-motion studies, looking to the possibility of increasing production speed. (Berg,185, Babbage,ch 4)

In The Philosophy of Manufacturers (1835), Ure foresaw a factory so completely automated that the capitalist would obtain complete control over production.[12] Like managers almost a century later, Ure sought to eliminate the skilled worker from the factory. He believed that "the more skilled the worker, the more self willed and intractable he became, the less fit a component of the mechanical system, in which by occasional irregularities, he may do great damage to the whole." Other industrialists and observers, whose names are less familiar today, wrote about similar ideas and practices such as quantities of scale, tool and machine improvement, division of labor, all of which should lead to the most important issue--efficient work processes and greater control by the manufacturer.[13]

The idea of engineering the perfect factory was also in the air on the other side of the Atlantic and, by the third quarter of the century, American industrialists, managers, and engineers were talking and writing about what modern scholars call "systematic management." During those decades the science of management was born in manufacturing enterprises undergoing rapid growth. Owners and managers of manufacturing companies developed and experimented with new ways of running their production operations as they grappled with increasing difficulty in meeting production deadlines and making profits. The problems arose, in part, from the specialization that came with growth.

The specialization occurred at three levels--product, labor, and management. Division of labor took on new dimensions, each worker performing a smaller part of the total production. Specialization of product became more and more common, to the extent that a company might only make machine tools and maybe only one type of machine tool. With increased responsibilities, management duties were also divided and specialized. With work being handled by many people who possessed only partial understanding of the over-all operation "parts were being lost, orders going astray, and other oversights occurring which sapped the efficiency of the operation."[14] The consistent theme found in much of the literature of the period was "eliminate confusion, oversight, and neglect; coordinate efforts, return firm control to the top people in the organization; accomplish these things through the use of standardized procedures in routing managerial work through 'method' or 'system'."[15]

Systematic management was not a unified movement as scientific management would be; only in hindsight does it resemble a movement. Systematic management began in the late 1870s and 1880s with efforts to eliminate confusion and inefficiency by better organizing production. When one or two men could no longer oversee everything in the factory, systematic management was deemed necessary. The new management methods advised centralized cost accounting, production and inventory control, reduced foremen's authority, and introduced incentive wages.[16]

Scientific management, also called Taylorism after its main proponent, F. W. Taylor, grew out of the systematic management efforts. Scientific management is often considered to be the beginning of management science because F.W. Taylor, his colleagues, and proteges worked hard to popularize their system. But the work of the few scholars mentioned demonstrates that scientific management represented merely a continuation of the already growing management movement. Taylor and scientific management are important, however, because the management system he proposed in the late 1890s captured the attention of engineers and industrialists to a much greater extent than the earlier efforts.

Engineers' interest in business and industry was hardly new at the turn of the century. As early as 1835, a leading engineer referred to mechanical engineering as one of the "business professions." The theme was repeated in 1905 when Henry R. Towne told students that "the dollar is the final term in almost every equation which arises in the practice of engineering." "In other words," continued Towne, "the true function of the engineer is, or should be, not only how physical problems may be solved, but also how they may be solved most economically."[17] Engineers agreed that "whatever else engineering was, it was first of all a business." Monte Calvert has described the engineers' thinking as the ideal of the "engineer-entrepreneur." The engineer-entrepreneur was more interested in profits than engineering excellence. Contrary to the many common images of early engineers, the correctness of an engineering design was judged, not by its elegance, but by its ability to make money.[18]

Recognizing the concern for profit that runs through their rhetoric sheds light on engineers' meaning of efficiency. As Towne declared, "the dollar," not time nor conservation of materials, nor performance, "is the final term" in engineering practice. This emphasis on economic efficiency would become more pronounced throughout the twentieth century as industrial engineers developed their managerial role.

Taylor presented his first important paper to the American Society of Mechanical Engineers (ASME) in 1895. In "A Piece Rate System," he outlined his proposal to increase worker motivation through the use of piece rate wages. The use of incentive wages was not new, but Taylor's proposal differed from previous methods. He proposed a differential rate system by which he offered two different rates for the same job:

> a high price per piece, in case the work is finished in the shortest possible time and in perfect condition, and a low price, if it takes longer time to do the job, or if there are any imperfections

Taylor claimed that under his system workmen had the potential to earn more than usual for a good day. "This," he asserted, "is directly the opposite of the ordinary plan of piece-work, in which the wages of the workmen are reduced when they increase their productivity.[19]

"A Piece Rate System" and subsequent papers outlining the rest of Taylor's system created an uproar among the engineers, which led to a split within the association. The majority of engineers in ASME who believed themselves to be the entrepreneurial elite within the shop culture,disapproved of Taylor's system.[20] These men did not follow systematic rules to plan or govern the shop; they were highly skilled craftsmen who understood the workings of the shop and made decisions based on their personal knowledge and experience. On the other hand, a small but growing group propounded management engineering, based on scientific management, as a replacement for traditional ad hoc decision making.

The proponents of management engineering, and especially those closest to Taylor, believed that their system differed from earlier management techniques.[21] A close comparison, however, reveals that they were surprisingly similar. Systematic management initiated centralized cost accounting, production and inventory control, reduced foremen's authority, and introduced an incentive wage. Taylor advocated all four and added a planning department and time study.[22] Taylor also advocated much broader use of his management techniques than earlier engineers had.

The major points of Taylor's reform were to pay workers based on a piece rate or incentive wage, increase managers' knowledge of work process and skill, limit foremen's range of control, develop a scientific way in which to perform each element of a man's work (time study), and scientifically select and train workmen, that all work should be planned by management rather than workers, and workers should use tools furnished by the company. The program would remove any control the worker had over his own work. In practical terms, Taylor's proposal led to the breakdown of jobs into smaller and smaller operations; with each successive breakdown, the skill and judgment required by the individual worker diminished. The proposal also changed the managers' jobs. Managers had previously relied on personal experience to make decisions. This change removed the personal element that had characterized the relationship between managers and workers.[23]

In 1903, Taylor presented a paper entitled "Shop Management" to the ASME. More complete and sophisticated than his first paper on piece rates, "Shop Management" was nearly two hundred pages of detail about managerial techniques, giving practical advice about how to run an efficient shop. Its instructions included how to set wages depending on the skill and output of the worker, how to increase labor output and prevent soldiering (a practice in which workers made tacit agreements among themselves to limit output, see Aitken and Nelson), and how to organize work in the shop with the introduction of a planning department. In the years following the paper, questions of principles and social significiance arose and Taylor wrote "Principles of Scientific Management" in 1911 to answer some of those questions.[24]

In the introduction to Principles, Taylor condemned the waste of human energy. He decribed the waste as a national crisis, comparing it to the needless wasting of natural resources. He argued for the importance of national efficiency, the purpose for which he purportedly wrote the paper. The way to national efficiency was through system. "In the past, " he said, "the man has been first; in the future the system must be first." Taylor's purpose was threefold: to point out the suffering of the country from the losses due to inefficiency, to demonstrate that the solution to the crisis lay in systematic management [his term], and to prove "that the best management is a true science, resting upon clearly defined laws, rules, and principles."[25] Reform should begin in the workplace, he suggested, arguing that "system" would spread from there.

In the twentieth century, scientific management came to "refer to all efforts to rationalize industry and make it conform to the image of the machine."[26] By rationality, Taylor meant the use of precise, measured amounts of human effort in order to produce the most work. In order to do this, one must use scientific method to study the job and the worker. By scientifically and rationally analyzing every movement of every job, the manager could be assured of the most efficient job possible.

Responses to the new management principles varied widely. Some engineers eagerly embraced scientific management, but others disapproved of its use. Some industrialists readily employed engineers to introduce scientific management into their factories, others payed little attention to it. Workers and unions were in almost complete agreement--they saw the new management techniques as a threat to their skills and independence.

Workers objected to all or part of Taylor's system, depending on the industry. The most famous case of resistance to Taylorism was at the Watertown Arsenal. Workers at the arsenal struck to protest the introduction of the system which they regarded as "un-American." The strike was so successful that it resulted in Congress "outlawing time study and premium payments in all work done on government contract."[27]

Even the managers did not universally accept scientific management. With the new system their jobs would be changed almost as much as the workers'. David Noble writes that adopting the entire systrem made management, as well as labor, accountable to the engineers in the planning department.[29] Foremen lost as much autonomy as workers, as both jobs underwent similar specialization. Under Taylor's system, foremen would not supervise general activities in the factory; rather they became functional foremen and watched over only one small part of production--the work of one foreman being broken down and spread among eight functional foremen.

Some engineers distrusted Taylor's proposals. Many of the members of ASME, were unconvinced that the new management system was "a science worthy of the professional attention of engineers." This skepticism was reinforced when an ASME committee evaluated Taylor's system on its scientific merit, and found Taylor's method arbitrary and inexact rather than scientific.[29]

Industrial Engineers and the Society of Industrial Engineers

Taylor and early innovators in scientific management all belonged to ASME. In an 1886 paper Henry R. Towne suggested to members of the organization that since management techniques had no institutional base, ASME should form an economic section to "share knowledge, and develop standard procedures, and forms."[30] The majority of the association's members rejected the proposal and the engineers behind Towne's proposal eventually formed their own organization--The Society for the Promotion of Scientific Management. The Society was renamed the Taylor Society shortly after Taylor's death. In 1917 the Society of Industrial Engineers was formed, in close association with the Taylor Society; the two merged in the 1930s.[31]

The formation of the Society of Industrial Engineers reflected the growth of the of industrial engineering profession. A direct outgrowth of the scientific management movement, industrial engineering, unlike other kinds of engineering, focused on the organization of production rather than any particular piece of engineering. Though often trained as mechanical engineers, industrial engineers' work focused only secondarily, on the mechanical operations of production. Their primary pursuit was engineering of the production process rather than the engineering of machines.

An offshoot of mechanical engineering, industrial engineering shared a knowledge base with the older group with respect to machining and the type of work orientation. Like mechanical engineers, early industrial engineers worked primarily in metal-working shops. The pioneering efforts in industrial engineering took place in steel plants and machine shops, origins that helped to shape the profession.[32]

Industrial engineers remained loyal to many of the issues and values of the mechanical engineer. However, they shifted their primary attention from the physical capabilities of machines to the organization of the factory. In fact, they came to view the factory as the most important machine. Most of the early industrial engineers, such as F. W. Taylor,Henry Towne, and Frederick A. Halsey, were trained as mechanical engineers and their broad mechanical knowledge must have facilitated their efforts to introduce efficiency methods into the factory. But their concern for larger profits through more efficient organization of production led industrial engineers to carry the business orientation further than the mechanical engineer.

In his presidential address to the Society for Industrial Engineering in 1920, L.W. Wallace talked about the "confusion in the minds of many as to the real function of the Industrial Engineer." Discussions during the meeting confirmed Wallace's point. Some argued that the industrial engineer was primarily a mill builder, confining himself to "industrial layouts, designs of mill buildings, and equipment, some appraisal work, and some engineering promotion."[34] Another engineer, supporting the mill architect definition, suggested that the role of the mill architect (plus production engineer) remained primary in 1920 and all other duties should fall within the category of counsel or advisor of industry.[35]

The majority of engineers agreed with some version of Henry R.

Towne's 1905 description of the industrial engineer as the ideal manager who combined technical knowledge with administrative powers "who can select the right man for the various positions to be filled, who can inspire them with ambition and the right spirit in their work; who can coordinate their work so as to produce the best final result; and who, throughout, can understand and direct the technical operations."[36] These men believed that their job was much broader than that of mill architect. The industrial engineer studied and implemented industrial standards, and used them in planning the factory. He considered problems of reorganization, personnel, equipment, buildings, and all the features of management and control in industrial or commercial organization.[37] Another engineer emphasized the importance of economy when he described industrial engineering as "the science and art of developing means of most economical operation and control of a whole industry."[38]

Until the early twentieth century the term industrial engineer was seldom used. In the late nineteenth century it was an ambiguous term, which usually referred to mill builders and production engineers, the inheritors of the early millwright's trade. The millwright, who learned his trade through apprenticeship and experience, studied the power needs for individual factories, figured out how large and what kind of power system to use, and what kind of building to construct around it.[39]

In the nineteenth century, the men who were sometimes called industrial engineers built factories and planned some production details. Later, after Taylor's introduction of scientific management into ASME the engineers who followed Taylor became known as industrial engineers. Their jobs were similar to, but broader than, the mill-wrights' job. Planning the factory took on many new details. Scientific management created much new work as every element in the factory became part of the planning problem. The complexity of the job increased as industry grew and technology developed.

The development of the profession was presaged in 1901 when one engineer said that:

> "the great opportunity for the engineer of the future is in the direction of management of our manufacturing industries...as competition grows sharper and greater economies become necessary, the technically trained man will become a necessity in the leading positions in all our industrial works...He must be an engineer of men and capital as well as of materials and forces of nature."[40]

Many of the early figures in the profession defined their work in terms of management and economic efficiency rather than mechanical technology. Charles Going, in 1911, wrote Principles of Industrial Engineering in which he described industrial engineering as the "formulated science of management." "Industrial engineering," he asserted, "has drawn upon mechanical engineering, upon economics, sociology, psychology, philosophy, accountancy, to fuse from the older sciences a distinct body of science of its own."[41] Similarly, H.L. Gantt said "the aim of our efficiency is not to produce goods, but to harvest dollars." And Henry R. Towne explained that "industrial engineering...implies not merely the making of a given product, but the making of that product at the lower cost."[42]

The picture that emerges from the discussions about the practical definition of the industrial engineer is one of a generalist who planned the organization of production and the physical layout of shop floor, monitored the flow of materials, conducted time studies, and more. The industrial engineer was different from other engineers. Mechanical engineers designed machinery and its accoutrements, and constantly improved them. The electrical engineer designed circuitry, the civil engineer designed bridges and roads and structural systems for buildings. Each branch of engineering had its specific orientation, but the industrial engineer primarily engineered work and capital instead of the materials.

The industrial engineer was thus the professional who reorganized work processes, usually following the principles of scientific management. He believed his work could improve efficiency in many types of workplaces, industrial and non-industrial, wherever organization of work was important. Most industrial engineers, however, worked in industry and the confusion over their professional identity suggests that they did many jobs within the factory, and that the responsibilities of different men varied from place to place.

Industrial engineers, unlike other engineers, based their work on a set of ideas about general processes rather than a specific practices. This meant that their job more often involved planning rather than invention. Taylor's scientific management created an ideology of work and society--that any organization of men, whether for industrial production or business, or even schools and hospitals, could be organized in a way to be more orderly and efficient, thereby producing better results.

Many industrial engineers also said their work grew out of the new needs of industry to coordinate the many and varied elements of manufacturing. As Gantt had said, it wasn't that industry needed them in order to produce goods, but to "harvest dollars." Industrial engineers were oriented toward efficiency to create profit.

In 1905, an anonymous correspondent to the American Machinist complained that too few young engineers exhibited the business knowledge needed to be good engineers. He wrote "that a common fault of technical graduates was their lack of 'business knowledge and qualification'."[43] As scientific management gained influence in business and engineering, universities created departments to teach students about the new ideas. By 1913, seventeen schools had established instruction in business administration, commercial finance, but only three combined business and engineering or industrial education--MIT, Carnegie Institute of Technology, and Harvard. Based on demand from industry, Carnegie created its commercial engineering program in 1910 to combine business and engineering, and to further the study of scientific management and production. Harvard established its program

> to study the principles underlying the modern organization of business and of recent applications of system. A brief introduction outlines the present tendencies of industrial organization and indicates its forms and problems. This leads up to a study of the modern factory and of factory methods of production. The consideration determining the location of the factory and the type of factory building and equipment are examined, but especial attention is given to questions of internal organization.[44]

In 1913 MIT began classes in its department of Engineering and Business Administration which aimed to "furnish a broad foundation for ultimate administration positions in commerce and industry by combining with a general engineering training, instruction in business methods, business methods, business economics, and business law."[45] Before setting up the new program, MIT conducted a survey of industrialists, businessmen, and engineers regarding the merits of the proposal. Thirty-five responded with enhusiasm for the program, among them such notables as Charles T. Main, T.C. Dupont, E.H. Gary, and presidents and chairmen of many other companies. In support of the engineering and business administration program, they also described frustration with young college educated engineers who worked in business and industry. The president of Northern Pacific Railroad Company wrote:

> it is a fact that we do not get enough men as engineers who display satisfactory qualities in a business way. They look at their problems purely from a scientific and engineering point of view, without enough consideration of the fact that somebody must provide the money for doing the work, and that work is not done simply to satisfy engineering pride and skill, but for the purpose of providing some facility that will be economical in maintenance and produce a real return upon the money invested.46

Charles T. Main, a well-known industrial engineer, replied to the questionnaire that:

> In my opinion such a course would be very desirable. If there is any one thing which is lacking in the graduates of the Institute, it is a knowledge of ordinary business affairs. Most of the men are unable to write an ordinary business letter, to say nothing of important reports or specifications, and if little knowledge of this sort would be combined with the engineering courses, I think it would make the graduates better all round men.[47]

Another consulting engineer, Hollis French, said that "there is no doubt of the difficulty in obtaining the services of a competent administrative man. We find no difficulty in obtaining good engineers, but a good administrator, who is at the same time an engineer is a hard combination to find.[48]

MIT's course of study included general science, engineering studies, and business. Within engineering, mechanical engineering students learned about factory construction and power plant design.

With the new business emphasis, engineers' roles in industry became more central to factory operations. This was the real beginning of their influence in industry. As they assumed much of the management, their philosophy became more and more influential.[49] As the rationalizing ideology came to dominate industry each element of the enterprise underwent reformation. By the first decade of the twentieth century the factory building became the target. Between 1905 and 1930 dozens of books and articles were written describing "A Better Way to Build Your New Factory." The principles on which the new assumptions were based were, of course, "scientific." Buildings became one more factor to help in making production more rational and efficient.

Industrial engineers believed that they knew the best way to run industry (or just about any enterprise). Guided by the principles of scientific management, they set out to engineer the factory, always working toward their goals of maximum profit and control. "Modern conditions," wrote one engineer, "brought into organized industry a demand for systematic coordination of all factors which bear upon it."[50] The engineers wanted to organize the factory in the name of efficiency, so that the engineer-manager controlled everything. In doing so they considered every piece of machinery and every movement in the plant. Their attention to detail would, they believed, improve efficiency and increase profits.

Profits alone did not drive the engineers to recreate the factory. As strong as the desire for profits was their belief in the idea that scientific management, with its foundation in scientific rationality and uniformity would improve society. The factory could serve as a model for the efficient society that would emerge at the hands of engineers.

Engineers' work in the factory was not a one time consulting job. Their new prescriptions for reorganizing methods of production required a full-time staff of engineers to keep a watchful eye out for problems and necessary changes. The engineer would direct changes within the factory and manage ongoing operations. So, the engineers not only wanted to change the way industry worked, they also wanted to make themselves indispensible to the new system.

In their role as factory planner and manager they did not limit themselves to merely the technical side of production. They believed that their knowledge applied just as well to the organization of men as it did to the organization of machines. Their job developed into advising and supervising technical details of production as well as managing men and directing policy.[51]

The "Engineered" Factory

As engineers analyzed production processes "it became clear that existing factories were not arranged in a manner suited to [production operations]." With the knowledge that the new efficient production system needed a different factory the designing and construction of industrial plants "assumed the standing of a separate phase of engineering work."[52]

Since the early days of manufacturing, Babbage and Ure had talked about the systematic arrangement and operation of factories. Babbage was concerned with the organization of work and wrote that he "found the domestic arrangement, or interior economy of factories was so interwoven with the more general questions [about the general advantages of machines and tools] that it was deemed impossible to separate the two subjects."[53] He discussed a "domestic economy"--the organization and layout of the shop floor--which to him was as important as the machines themselves.

By the twentieth century the physical components of factory organization became a major focus for industrial engineers. Through building design and shop floor layout they addressed a multitude of problems; redesigning the plant and shop floor was one way to manage the problem of organizing the many elements of production, human and technical.

As early as 1903 an editor of the Engineering Record pointed out the importance of the "mill architect" by describing the old means of building factories:

> It was formerly held by most manufacturers that they knew what they needed in the way of machinery, that the local millwright was competent to put in their power plant and a local builder to design and erect their mills...The local mason's buildings answered their purpose, although the floors sometimes sagged and the shafting was more often out of alignment, owing to the deflections of the structural framing.

As graduates of technical schools assumed positions in manufacturing enterprises, they changed the methods of plant design, bringing, this editor suggested, "skill and experience gained in bridge design...to the structural planning of the buildings."[54] The new mills were better illuminated, more comfortable to work in, resulting in a demand for the mill architect.

At that time it was unclear out of which engineering tradition the mill architect would come. The editor called mill architecture "one of the most interesting branches of civil engineering" while others were already using the term industrial engineer. The confusion developed because factory planning had no formal course.

Setting up a manufacturing operation had become too specialized for most owners and their staff to do alone. Industrial engineers, "especially trained in the planning and building of shops and factories,"[55] advised on site selection; size and design of building; heating, ventilation, and lighting systems; shop floor layout; type of production organization, and routing schemes for work flow; materials handling systems; and just about anything else that had to do with managing production in the factory. The object of the advice was always a plan which would allow low cost production.

The industrial engineers based most of their advice on assumptions that developed directly out of scientific management, assumptions about production, workers, their role in society, and the nature of industrial society. Production was the engineers' life-blood. They believed it should be standardized in order to be efficient and efficiency was the only way to create profits. Industrial engineers believed themselves to be saviors of industry.

Many industrial engineers diverged, however, from Taylor's scientific management in their emphasis on appropriate building design. Taylor believed that a good organization plan was more important than a building; that capitalists should spend their money on setting up the organization rather than building more factories. In <u>Shop Management</u>, he maintained,

> Almost all of the directors of manufacturing companies appreciate the economy of a thoroughly modern, up-to-date, and efficient plant, and are willing to pay for it. Very few of them, however, realize that the best organization, whatever its costs may be, is in many cases even more important than the plant...There is no question that when the

work to be done is at all complicated, a good organization with a poor plant will give better results than the best plant with a poor organization.56

To many industrial engineers, planning factory buildings and floor layout provided the means by which to organize efficient production. The factory building thus came to be considered part of industrial technology, not merely a passive structure. Designing new factory buildings became a major part of the industrial engineer's career. They called the building itself the "master machine," the "master tool," and "the big machine containing and coordinating all the little machines."[57] The engineers did not, however, believe that plant design was as perfect as machine design; the shortcoming was due more to lack of attention than any inherent problem. Addressing that lack of attention in the profession, one engineer argued that engineers' "vision must be broadened to embrace the idea of the plant as a working unit--a machine whose operation is a primary requisite to economical production."[58] As the master machine, the factory building was carefully measured, planned, and designed. Like other technologies, engineers believed that "the plant building by its design and arrangement function[ed] to make production easier or more difficult."[59]

The engineers argued that the factory building's vital role in production required a professionally trained engineer to design it. They based their argument on the belief that when planning a factory it was necessary to have knowledge of both the production process and business policies and management.[60]

By 1910, factory architecture took on a new significance. As industries grew, large factory buildings became the major expense in setting up a manufacturing operation, adding to the importance of good planning and design. In 1912 Henry Tyrrell, an engineer known for his role in the introduction of reinforced concrete, wrote <u>Engineering of Shops and Factories</u> in which he described the changing nature of factories and explained the importance of the industrial engineeer. "Those who were formerly content to carry on manufacturing in shops of the old type," he began, "have long since discovered that the buildings themselves can be made one of the largest factors in economic production." He further observed that:

> the planning and arrangement of plants was formerly done by their owners or manager, who made little or no provision for their extention or development, and who considered that business success depended wholly on good management. It was then the belief that the buildings were of little importance, but it is now well known that they can and should be arranged and designed to facilitate production the greatest extent.61

Industrial engineers advised on building type and size, construction method, production flow, and even "the labor problem." Charles Day, author of <u>Industrial Plants...</u> , described his work as "the latest manner of arranging and planning industrial plants." He claimed that industrial engineering was "based on a logical scientific method of analysis which recognized not only all physical means available, but those more subtle factors having to do with the human element--men and women upon whom all industrial undertakings depend."[62]

These and other works addressed every detail of running a factory, from getting the raw materials into the plant to motivating workers. For each detail there were suggestions for a physical plan that would improve efficiency. One engineer summed up the general problems of poor factory planning:

> Many factories have modern equipment and efficient methods but an unbalanced distribution of floor space, with some

departments badly congested and others misplaced. Some industries located in multi-story buildings are handicapped by a lack of flexibility, which might have been avoided if space had been available for single-story construction, or for a combination of single-and multiple-story. Some building widths or the spacing of columns are not well suited to the machinery size or spacing and prevent an ideal arrangement from being adopted. In some instances headroom is not sufficient for overhead handling by traveling cranes or trolley hoists.63

The old factories were inadequate for many reasons. One of the most common complaints was that their design did not allow adequate expansion. Many engineers, in their prescriptions for new factories emphasized the necessity for anticipating expansion. "A well designed factory," said one engineer "should be as flexible and adaptable to enlargement as the unit system of filing cabinets."[64] Plants should, they believed, have the potential of being enlarged without unbalancing the layout.

Arrangement of factory interior space influenced production efficiency in several ways. One of the most important was the impact on materials handling,the movement of all parts, raw materials, and in-process production through the factory. "The design of the building," said one engineer, "should allow work to go forward as though the building did not exist at all."[65] The proper arrangement would reduce transportation to a minimum.[66] In poorly planned factories the right materials were not where they should be when they should be. Excessive movement meant that more workers were employed to do the moving and less production was completed because of insufficient supplies at the appropriate stations. Materials handling, the engineers argued, was one of the most wasteful parts of production and proper arrangement of departments could eliminate unnecessary movement. By the

1910s they proposed a variety of technical solutions to materials handling such as craneways, gravity slides, elevators, and assembly lines, all of which will be more fully described in following chapters.

Careful arrangement could also improve management of workers, one of the most troublesome problems for the engineers. The well designed building should "facilitate the economic management of labor," wrote Tyrrell.[67] Engineers assumed that workers did not want to work and that through work slow-downs and other tactics they would produce as little as possible. Controlling labor presented a constant problem for the engineers; "it means," wrote one engineer, that "many a manufacturer is today facing the necessity of abandoning a plant which produces excellent goods, simply because of excessive labor costs."[68]

Not surprisingly the relationship between workers and engineers developed into an antagonistic one. Engineers dehumanized workers; rather than working with them, engineers wanted to control them as they did other variables in the factory. In an article about efficiency, one engineer wrote "I shall ignore the human element entirely as it actually exists in the shop and describe the people handling the operations as people who, whatever they may be outside the factory, are while in the factory simply animate machines,...[trained] to do their work with all the precision of the most marvelous engineer..."[69]

To assure the highest productivity possible from workers, some engineers stressed the importance of good visibility in the shop so that all workers remained in view at all times. In Planning a New Plant, Noyes advised that one man supervis no more than 300 feet of the shop floor.[70] Others exhorted owners to build factories with open spaced and no hidden corners in which workers could hide as they shirked their duties. To that end many typical building shapes that took the form of L's, E's, and H's should be avoided. This meant that the ideal factory would be a rectangular shaped single-story building, with as few columns as possible. In multiple story buildings reinforced concrete construction was preferred over mill construction because concrete buildings required fewer columns--the contained three bays rather than the four common in mill construction. Concern with visibility and control of workers' movement around the factory also led to arguments against unnecessary walking or elevator riding by workers, further supporting the single-story argument. Hugo Diemer wrote that "avoidance of unproductive travel demands a minimum of passage ways," and that any necessary passages

> should be under the close supervision of watchmen who must note all wandering clerks and workmen, and who must be so informed as to the employees and their duties, that they may be able to observe and report illegitimate or aimless wandering.[71]

Proper arrangement was also important for the peaceful coexistence of workers, suggested some. One engineer advised that "in certain localities it is not feasible to have union and non-union men working side-by-side in the same shop unless their work falls under widely separate heads...at these times union men refuse to work when non-union men are engaged in their midst."[72] "Union and non-union men must sometimes be housed in different buildings."[73] Charles Day gave the most specific advice when he cautioned manufacturers to segregate the foundry workers, often the most militant group of workers, from employees of other departments "in order to gain adequate control of the labor situation." He described measures taken by the Wagner Electric

Company in St. Louis, Missouri:

> The employees of all departments other than the foundry enter the plant through the service building "L," where they dress for their work before going to their departments. Separate service facilities and entrance and exit are provided for the foundry operatives.74

Agreement on factory size and shape and number of floors was far from universal. Engineers engaged in much discussion , for example, on the optimum number of stories for a factory. Some argued for single-story plants and others for multiple stories; sometimes the same arguments were made for both. "Where the business is likely to grow," wrote one builder, "the disadvantage of a single-story building is that the organization becomes spread over so great an area that it cannot be properly supervised." The multi-story plant, he continued, "lends itself more readily to the expansion of business and unquestionable it simplifies the general supervision of work."[75] Others were convinced that workers were best supervised in single-story buildings because they could be kept in sight by the manager. Some insisted that materials handling would be easier and faster in one floor, others said that it was more efficient in a multi-floor factory, that "in general it is easier to walk up a flight of stairs than to walk several hundred feet through departments." Finally, proper ventilation was difficult in the single story building and workers objected to "the closed-in effect."[76] The multiple story advocates apparently won out in the early decades of the century, for there were far few single-story factories built before World War II. Typical one-story plants included foundries, railroad car works, steel mills, machine shops, and forge shops. Producers of machine tools, arms, clothing, shoes, and automobiles almost always located in multi-story plants.[77]

The shop floor layout, which consisted of machine placement and process arrangement in each specific area, and the arrangement of departments, also attracted the attention of the engineers. In discussing shop floor layout, they talked about speed of operations and best use of workers' time and energy. Proper location of departments bore directly on predictability of production flow and on ease in supervision of workers, their location, wrote Diemer, "will have a decided influence on the cost of production."[78]

Other concerns were not as technical, such as worker motivation and productivity. Worker motivation, considered by some as one of the most important factors in high output could be improved by making the factory more comfortable. Wrote one engineer,

> poor air and insufficient light and warmth inevitably result in poor work as regards quantity and quality, even though the workers may be picked for their cheerful and sunny dispositions. Agreeable and healthful surroundings will tend more than anything else to make workers contented; and discontent in a factory organization at the present day is sure to lead to trouble.[79]

Even the best factory layout and design depended on two fundamental conditions--location of the factory and sound construction. Good location meant a good labor market, that is, penty of workers willing to work for low wages (best location would differ depending on type of manufacturing). Ease and expense of transportation depended on appropriate location, and all of this ultimately affected manufacturing costs and profits.

Sound construction was an obvious concern to manufacturers. Not only was it a good investment, but certain types of construction eliminated problems in the factory. The introduction of reinforced concrete in factory construction in the first decade of the twentieth century revolutionized factory construction. It had many advantages over the earlier wood and masonry mill construction. Concrete almost eliminated vibration which, in multiple story factories, cost money through wasted energy. Vibration also caused significant discomfort for workers and damaged machines over time as well as causing machines and shafting to need constant realignment. Reinforced concrete buildings were stronger than wooden ones allowing heavy machinery to be safely installed on upper floors. Concrete was also fireproof, greatly reducing insurance premiums, and many manufacturers trusted it so readily that they cancelled their fire insurance. The "daylight" factory was also a function of concrete construction. A concrete factory did not depend on exterior walls for support, allowing for small exterior columns which then left large areas free for windows. Later chapters will discuss daylight factories in more depth.

Architects as Factory Designers

Engineers were not the only ones interested in designing factories. By about 1920 architects began working with, and sometimes competing with, engineers for factory design jobs. The term "industrial architect" began to apply to architects as well as engineers. Architects and engineers joined together to build factories. Architects also began to learn about structural engineering and production processes, sometimes helping to plan the plant layout as well as the building design. In doing so, they encroached on the engineers' territory, inciting a barrage of criticism from engineers.

Though some architects designed factories in the nineteenth century, they were a small minority. Most nineteenth century architects designed houses, civic, and commercial buildings which brought steadier work and greater recognition. The other side of the issue is that architects trained in the nineteenth century beaux arts tradition knew little or nothing about the requirements of a manufacturing building. They could merely copy construction of other factories and then decorate the building, which some did. In 1909 the editor of the Architectural Record disparaged the fact that the architect had played such an insignificant role in developing manufacturing plants. He said that he had trouble finding a few factories influenced by architects. The reason, he explained was the American factory building had always been considered the subject of the engineer.[80]

As the factory became the symbol of twentieth century progress, architects' interest in its design increased. Factories were still not great public buildings like train stations, libraries, schools, and churches, but they became more important as they grew to physically dominate any area in which they were built and became the centerpiece of wealth and power in the society. Eventually they became as important and costly as those other great buildings. The factory emerged as the symbol of much that was changing in the United States. Like the train station had once signified a community's wealth and importance, the factory came to mean jobs and growth. For some it meant great wealth too. Many industrialists wanted their factory to be attractive, believing that it would provide good advertising and aid community relations.

In 1923 the editor of Architectural Forum wrote that "the great outstanding promise that industrial buildings hold for the profession is the opportunity of creating a style of architecture that will truly interpret modern conditions...the simple requirements of industrial buildings should suggest appropriate forms that may eventually lead the way to the long sought American style."[81]

His quote illustrates the different motivations of the architects and engineers. Engineers, whose professional concerns were with production and efficiency, sought to build a rationalized efficient factory. Architects whose interests were style and aesthetics saw the factory as the opportunity to develop an "American style" of architecture. They believed that industrial buildings offered greater freedom and range of expression than other types of building because modern factories had no prototype. The scale of industrial buildings was also new, an element of the design process in which architects must have taken great pleasure.

The style theme runs through much of the architects' writings. Industrial architecture relied on functional form rather than historic style or ritual, leading one architect to point out that industrial buildings escaped the "useless application of historical detail to contemporary structures," and in so doing the buildings "served to develop the contemporary concept of architecture."[82] Industrial architecture eliminated non-essentials; it swept clean the habits and preconceived ideas about architecture.[83] The utilitarian nature of industrial buildings meant that "the design must grow out of what is essential to the objects of the plant." Consequently, a proper architecture for a factory building is "simply making beautiful and attractive what has to be there anyhow for utilitarian purposs."[84]

This discussion went even further as they debated whether Gothic or Renaissance traditions were better suited for industrial buildings. Renaissance was deemed less favorable because "it often demands the use of projecting cornices, which when applied to some types of industrial buildings involve more expense than the Gothic."[85]

Architects considered factories to be the only original modern architectural form, a fact which some accepted with a note of bemusement. Wrote one editor, we must "consider the somewhat paradoxical possibility of an important contribution to the development of American architecture through the medium of designing industrial buildings."[86] One notes the surprise in his writing that "industrial buildings" could contribute to architectural style!

Finally, architects argued that making the factory attractive, architecturally, would cost the manufacturer less than five percent of the total cost of the building. Borrowing from the rhetoric of social engineering and proponents of welfare capitalism, they claimed that the advantages of an attractive building would easily pay for the five percent. The advantages of an attractive factory, the architects argued, were better employee morale leading to less absenteeism. They added that the attractive factory was good advertising for the company and good for relations with the local community. Furthermore, by hiring an architect rather than a contractor, the manufacturer would probably save money in the long run.[87]

Interest in the factory as an architectural form grew during the twentieth century as Walter Gropius and the Bauhaus movement used the

American factory as the inspiration for a new architectural style. Reyner Banham has demonstrated the important influence of American industrial buildings--factories and grain elevators--on the work of both Gropius and Corbusier by looking at their designs, their publications, and their notebooks. In Gropius's notebooks, Banham found extensive sketches and notes of his tour of the United States. What Gropius saw on his tour clearly influenced his later work. His attention to the factory influenced other architects in the early years of the century and perhaps accounted for American architects' growing interest in factories.[88]

For many years the architects played only a minor role in factory construction; if he had participated at all in designing the building his role was secondary to the engineer. Architects complained that heads of industry had used all resources except architecture in building large industrial plants. Admitting that a purely architectural interest would be with the exterior treatment of the building, a number of articles pressed upon architects the importance of understanding the internal plan. By the 1920s the situation began to change. Architects who designed factories were sounding more like engineers. They talked about flow diagrams and plant layout. Recognizing, like engineers, that "the production line is the real backbone of the plan," thus, "the architect must keep it always in mind."[89] From the plan, they maintained, the "architect receives the key to exterior design." The architect argued that his "natural faculties" for securing logical and convenient arrangement of parts" were the best a manufacturer could find.[90]

This shift toward production organization, probably more than architects' earlier role in "decorating" the exterior, brought on engineers' wrath. One engineer wrote that:

> the design of factories has little relation to general architecture. To handle the task requires a thorough knowledge of the production processes, an understanding of factory management and production control, including an appreciation of the reaction of workers to the equipment and facilities. These subjects are foreign to the training of the typical architect.91

Many critical articles appeared in engineering journals. Engineers accused architects of overstepping their bounds and engaging in work for which they were not educated. In a biting presidential address to the Brooklyn Engineer's Club in 1905, Richard S. Buck expressed the tension between architects and engineers which engineers viewed as aesthetics versus economy and efficiency.

> While a certain modest observance of fundamental facts must be maintained, this is deemed by architects a bar sinister on architectural escutcheon. It is on these rainbow-hued conceptions, those lofty flights of fancy which have expression in beautifully rendered drawings from which all inharmonious accuracy is carefully eliminated that the architects lavish their devotion.92

Some of the early twentieth century industrial buildings designed by architects probably deserved the engineers' sarcasm. They were flights of fancy, which must have repulsed engineers--sewage works designed as Victorian residences and foundries looking like classical and Victorian civic buildings. Buck further stated that the principle of engineering (and industrial structures depended primarily on engineering) "is not to tickle the fancy and please the eye."

Though industrial engineers believed that factory design belonged in their professional territory, they realized that architects were historically the designers and supervisors of building construction.

Some engineers realized that their role in any kind of building construction was very recent. Their young profession became useful to the building trades primarily with the advent of a new era of technology and new demands on buildings. In this light it seems that engineers' criticism of architects who designed industrial buildings might have been territorial competition. Engineers perhaps feared that architects would assume their historic perogative and take over the designing of the factory building. Therefore they made an effort to make it clear that factory buildings were very different than other kinds of architecture.

Engineers sometimes sought alliances with architects and architectural firms, but then found themselves often subordinated to the architect. When engineers joined with architects it usually meant becoming part of an architectural firm instead of architects joining an engineering firm; they were consultants to architects more often than consultants to industry. Though the engineer in an architectural firm performed many of the same jobs as the industrial engineer, one primarily solved technical problems in construction and the other solved basic manufacturing problems.

A number of firms made up of architects and engineers specialized in industrial building construction, notably Albert Kahn, Associates of Detroit; the Turner Company of New York City; and the Austin company of Cleveland, Ohio. Firms of this type came under some criticism from engineers who believed that such large consulting firms had trouble "securing really good men" because good men preferred to be independent. Furthermore, they argued, a company of this type was primarily a business organization and the business brach of the company might encourage poor engineering in order to lower costs.

The difference between an architectural perspective and an engineering one is important. Architects' first concern was the building. They considered manufacturing processes important only insofar as they had to in order to design an appropriate building. Engineers directed their attention first to the manufacturing process and designing the factory building became a means to the end of efficient production.

Notes: Chapter One

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24. See Harlow S. Person, Foreward to Scientific Management (New York: Harper Brothers, 1947).

25. F.W. Taylor, Principles of Scientific Management, 7.

26. Calvert, 235.

27. Hugh G.J. Aitken, Scientific Management in Action (Princeton: Princeton University Press, 1985), first published as Taylorism at Watertown Arsenal (Cambridge, Mass: Harvard University Press, 1960) ,150-152.

28. David Noble, 271.

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30. Calvert, 236.

31. Noble, 277.

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Chapter Two

Factory Welfare Designs

> Within the last few years another aspect has been added to the purpose of the manufacturing industry, namely, that it is an instrument of social service.

In 1905, the Ludlow Manufacturing Association in Massachusetts, built an employee clubhose which included a theater, gymnasium and dance hall, poolroom, bowling alley, card and smoking rooms, baths and swimming pool, and locker rooms. Later, in 1911 John H. Patterson, owner of the National Cash Register Company, built baseball diamonds, tennis courts, a dance area, and a golf course for his employees in Dayton, Ohio. Four years later he installed a children's wading pool near the factory.[2]

These improvements represent examples of the welfare capitalism movement in which, between about 1900 and 1930, factory owners and managers made significant changes in factory environments as part of a new management philosophy that, some scholars believe, came close to revolutionizing worker-management relations. Welfare capitalism, also called "industrial betterment" or "factory welfare work," referred to "any service provided for the comfort or improvement of employees which was neither a necessity of the industry nor required by law."[3] This included a number of services: improved health and safety in the factory, housing, educational programs, pension, health insurance, job security, and workmen's councils. Industrialists and engineers used welfare work in order to increase productivity, improve control over workers, and reduce conflict with labor. Welfare work was expected to help achieve these goals with worker cooperation rather than the technological and engineering innovations of scientific management.

Welfare work grew from a belief that gained popularity in the early twentieth century--as tools of production, workers would work better if they were kept healthy and happy. Employers realized that it payed "to improve and perfect their animate machines."[4] Welfare work was to the worker what oil was to the machine. "It seems to me," Washington Gladden, a minister and social reformer, wrote in 1893 "that the social side of the machinery needs lubrication as well as the physical side. The very complicated mechanism of organized labor must be frequently and carefully oiled...Doubtless it costs something to keep the machinery properly lubricated; it costs time and thought and patience, and some money; but would it not pay?" [5]

William Tolman, a former New York City relief worker and the "father" of social engineering put it like this:

> Setting aside any consideration of altruism or philanthropy, it is good business to provide the best light, pure air and water, the essentials of health for factory and workshop. That there is a response is evident when the increased production is shown at the end of the month."6

By the end of the nineteenth century new ideas about industrial society swept the country, social reform philosophy met with the engineering ideology of efficiency to create the progressive movement and welfare capitalism.

In the early twentieth century engineers involved themselves in social and political reform in ways that they had never done before. Their new interests resulted, in part, from a change in valu°es that came with a shift in professional orientation from early engineers' ideas about manipulating the physical world to the values more in tune with the business world.[7]

Engineers' influence went far beyond business and industry. They got involved in city planning, sanitary reforms, good government movement, educational reforms, and public control of utilities.[8] Some used their influence to encourage engineering type expertise in political decision-making. Most combined their reform and business interests by encouraging urban reforms that would be attractive to industry.[9] The relationship between engineers and society proved to be an important one--engineers moved away from purely technical interests into social realms and much of society caught a fascination with efficiency that endures to the present.

Their growing confidence to move beyond their traditional work came, in part, from the widespread acceptance of one of their major doctrines, scientific management. Many engineers, especially Taylorites, believed that "the ultimate significance of scientific management was moral," and that scientific management should be the model by which to run society.[10] Many reforms of the period reflected engineers' participation, creating what Samuel Haber called "the efficiency craze." Haber indicates that the craze began in 1910, and for the most part, disappeared with America's entry into World War I.[11] According to Haber, "through its various forms, efficiency provided something to almost everyone's taste." At its peak in 1914, an efficiency exposition at the Grand Central Palace in New York City featuring an address by F.W. Taylor attracted 69,000 people.[12]

Progressive Reform

Ideas of efficiency had a profound impact on many social realms, the most obvious being business and industry. But efficiency also became a guiding principle for the Progressive Movement and related philanthropic activity where its effects are perhaps less well known. In Efficiency and Relief published in 1906, Edward T. Devine wrote about philanthropy and "its special province [in the] increase of efficiency." In his treatise, Devine coined a new term, "social economy," to identify the new kind of social work that worked toward "efficiency" in society.[13]

Even earlier, in the nineteenth century, social reformers like Washington Gladden and Josiah Strong talked about efficiency. Gladden in Tools and the Man wanted to change employers' attitudes in the interest of both workers and management. He proposed greater cooperation, even profit sharing, concluding that the creation of humane relationships within industry would result in greater efficiency. He, like industrial engineers two or three decades later , recognized that technology accounted for only part of industrial productivity and that the "the human machine" must be respected. On a slightly different theme, Josiah Strong, working with William Tolman, promoted industrial efficiency as a way toward a better society.[14]

Progressive reformers employed ideas of efficiency in their diverse social programs. Settlement houses taught neighborhood residents how to work better; visiting programs taught immigrant women how to be efficient homemakers; political reforms sought more efficient governments through non-partison politics; tenement house reformers believed that better housing would make better workers.[15]

At the turn of the century ambivalent mood characterized the country's attitude toward industry. Material life improved each day, it seemed, but more and more people began to notice the social cost of American industry. Muckrakers wrote about factory conditions and lives of factory workers in books like The Jungle and The Octopus.[16] These writings came at the end of the "Gilded Age" when industrialists and businessmen accumulated great fortunes. Reformers, as members of the middle class, sought to ameliorate at least some of the injustices to the working class by encouraging industrialists to use part of their great wealth to make the lives of their workers a little safer, healthier, and happier.

Most scholars date welfare capitalism from about 1890 through the 1920s, the same years that progressive reformers tried to impose social and political changes throughout the country. That the dates of these two movements correspond is probably not coincidental though scholars of welfare capitalism have ignored, or even denied, the relationship between the two movements.

Some reforms of the progressive period directly addressed factory conditions. Factory reform became a pressing social issue at the turn of the century, with some states passing factory reform legislation as early as the 1880s. During this period factory inspectors made unannounced visits (though their arrival was often expected) to examine health and safety in the factory and to insure against abuses of child labor laws. The factory inspections provided additional fuel for poignant accounts of factory life.[17]

In addition to health and safety regulations, factory reform included legal limitations on length of the working day, restriction of children's and women's labor, and worker compensation. The reforms exerted a significant influence on the factory's environment and created minimum standards for working conditions.[18]

Progressivism was more than a group of social reforms, it was a set of ideas dominated by a belief in science and experts, in rationalization and bureaucratization. Robert Wiebe has written that "the heart of progressivism was the ambition of the middle class to fulfill its destiny through bureaucratic means."[19] Progressives tried to make sense out of the disorder that grew up alongside of industrial capitalism and urbanization. Reformers looked at some of the grossest social injustices like housing and labor laws and at what they saw as corruption in government and business. The ideas and values that formed the base of the progressive movement also lay behind welfare capitalism.

Welfare Capitalism in Action

Factory welfare work existed long before professional managers began to think about it. Welfare capitalism, initiated by industrialists in the nineteenth century, was a broadly based movement whose ideological roots can be traced to the paternalism of early American industrial communities. Welfare capitalism, as an integrated system, began with "model company towns" such as Pullman and LeClaire in Illinois.[20] These towns were built by industrialists who believed that the proper social and physical environment would encourage the kind of personal and moral development that made for loyal, hardworking employees. Their attempts met varying degress of success, with Pullman where workers staged their 1894 strike of such magnitude that it shook the nation, being the most famous failure.

Even though not always successful, company town experiements led the way to further development of welfare capitalism's ideology--provision of security, education, wholesome entertainment, and physical comfort to achieve peace in the workplace.

During the last years of the century, workers worried their employers in a number of ways. They slowed down production through deliberate attempts to control the pace of work. Another factor, labor turnover increased by the turn of the century as more factories were rationalized and workers sought work places in which they could maintain more control over their own work. Turnover was expensive for a company. No matter how "unskilled" a job might be, it took several weeks for a worker to be fully integrated into the operation. Studies of the period estimated that hiring and training a new employee cost as much as $500. In the 1910s, turnover was so high that large plants had to hire twice the number of employees needed during the year to maintain their work force. Worst of all, said one executive of the auto industry, "turnover breeds inefficiency and inefficiency breeds turnover."[21]

There were other problems. Unionism, always frightening to industrialists, grew in the late nineteenth century and reached a peak just after World War I. Between 1875 and 1900 over 20,000 strikes plagued American industry. Most threatening were the mass strikes, notably the railroad strike of 1896. The goal of mass unionism was to mediate changes in work process as well as unhealthy working conditions, low wages, and long hours. Through welfare capitalism, industrialists responded by improving working conditions but rarely changed jobs, wages, or hours.[22]

Finally, many companies suffered from a bad public image. Modern industry was supposed to mean progress and prosperity. But many factories were exposed as unsafe, unhealthy, and inhumane workplaces. The two images did not fit. The bad image hurt public relations. It also threatened industry with widespread social reform in the form of laws that would impose specific regulations. Capitalists preferred to make changes themselves rather than risk potentially harsh laws. The most striking example is that of workmen's compensation laws which, contrary to convensional wisdom, were supported by businessmen who feared an acceleration of employer liability laws which meant potentially unbounded reibursement to employees for job related injuries and death. [23]

Companies responded individually to low worker motivation, high turnover, unionism, and bad public image by offerring their workers benefits designed to make their lives more pleasant. Physical conditions inside the factory were improved, such as lighting, heating, ventilation, and sanitary facilities. Additional amenities in the factory might include dining rooms, libraries, clinics, commissaries, and locker rooms. Even more interesting were the programs that affected workers' lives outside the factory--company housing, education, and recreational programs. Some companies also offered profit sharing, insurance, and pension funds.[24]

In addition to stimulating worker motivation and loyalty, employers talked about improving the character of their employees. Workers were almost always referred to as persons with dull minds, low morals, and questionable character; they were assumed to lazy, drunken, unreliable, and prone to lying; they were depicted as full of lust, uncontrollable passion, and violence. Running through the literature of welfare work (and other reform literature) was the theme of moral uplift and improvement of the lower classes. Absenteeism and low productivity came in part, employers believed, from the inferior culture of immigrants and the lower classes. Thus, educated workers would be better workers.[25] One writer went so far as to argue that it was the industrialist's responsibility to improve workers' character for the good of the society. He wrote:

> Not from the churches, not from the universities or colleges not from the common schools, but from the hands of the great captains of industry who are recognizing and providing for an all-round development, the character of the plain people is being moulded and shaped along lines of civic and social usefulness. Never before in the history of the world has the employer had such colossal opportunities for guiding and uplifting the thousands of men and women who spend at least one-third of each working day in his employ. If employers realized that they hold within their grasp the possibilities of industrial contentment, social stability and communal welfare, they would plan and scheme how to improve the conditions of their employes [sic] with the same zeal as they now devote to promoting the efficiency of their business.[26]

In 1914, George M. Price outlined four different motivations behind "employer's welfare work"--philanthropy, fear of unionism and radical political movements, efficiency (because it pays), and industrial justice (to begin to reduce hardships endured by workers due to low wages). Some businessmen claimed humanitarian motives; that their form of welfare capitalism was pure altruism. They insisted that no economic advantage resulted, that profit never figured into their plans to improve the lives of their workers. 27

Others claimed that welfare work was simply good business, denying the slightest suggestion of altruism. To make this point, one person explained: "When I keep a horse and find him a clean stable I am not doing anything philanthropic for my horse."[28]

A National Civic Federation survey in 1914 found 2,500 companies with welfare programs in operation. The Federation, by establishing a department for advising on welfare work, one of the only departments from which union representatives were excluded, legitimated welfare work for many businessmen.[29]

Industrialists devised a variety of welfare programs which can be divided into three categories: basic health and safety, personal security and social services.

Health and safety programs were sometimes voluntarily introduced by the factory owner, but most states required minimum safety precautions. Early in the century owners and managers denied the existence of hazardous conditions in the factory, insisting that workers caused most accidents themselves through careless negligence. Though designed to ameliorate hazardous conditions, most factory inspections were shams.[30] Before workmen's compensation legislation, which began in 1911, employers escaped their obligation to compensate workers for accidents in the factory. Once faced with the threat of paying large sums for severed limbs or death, employers instituted serious safety programs. In the long run companies found safety programs cheaper than compensating workers and their families. Safety programs consisted of a variety of efforts, from simple campaigns like posting safety slogans around the factory to more costly measures such as the installation of safety guards on machines.[31]

Personal security programs included pensions, health insurance, profit sharing, and guarantees of job security. Many companies also built worker housing. Housing was a mixed blessing for workers. While usually less expensive for the worker than other housing, company housing meant that the company possessed yet another hold over workers; if the worker changed jobs or struck he faced immediate eviction.

The welfare programs most relevant to factory planning and design were social programs that often included new facilities right inside the factory. These facilities attempted to give workers a message that the company cared about their welfare.

One of the most frequent additions was the workers' dining room. Formerly, workers carried their lunches or bought them from sandwich carts brought onto the shop floor and ate at their machines or outside on the factory grounds. Bars and cafes sprung up nearby many factories, providing another option for meals. Many of the bars offered free food along with drinks. (see illustration)

Industrialists built dining rooms for several reasons. Factory inspectors pointed out the health hazards inherent in the practice of eating on the shop floor near the dirt (and often chemicals) of production. The usual absence of washing facilities exacerbated the problem. Managers did not like workers to leave the factory for lunch, especially to patronize the neighboring bar. Not only were workers often late in returning from outside lunch trips but their performance was usually impaired from lunch-time imbibing. The bars and cafes created another, less obvious problem for management--they served as gathering places for union organizing. Welfare secretaries also convinced management that employees could work better with a healthy, hot lunch provided in a peaceful, wholesome atmosphere where workers could experience a real break from work. The effort and expense in providing dining facilities varied widely. At the Iron Clad Factory in Brooklyn the "dining room [was] the most important feature," a large room with many windows, each holding a flower box, and a ceiling covered with grape vines, the dining hall held small tables arranged like a restaurant or hotel. Waiters in white uniforms served workers. On a more modest level the Waltham Watch Company of Waltham, Massachusetts, gave workers the use of a plain room with small tables. The company supplied a counter "for the sale of simple forms of food" and provided facilities for heating food and coffee.[32]

Most companies that supplied lunch rooms also offered some form of subsidized lunch. The Pierce-Arrow Company furnished a hot lunch for fifteen cents, National Cash Register employees paid fifteen cents for a hot lunch in "Welfare Hall," the Plymouth Cordage Company sold a "substantial dinner" for ten to twelve cents, and the Natural Food Company of Niagara Falls gave their employees a free lunch.[33]

Much like dining rooms, sitting rooms, smoking rooms, and libraries were built to provide workers with quiet retreats to refresh and educate themselves during their breaks and after working hours. Sitting rooms, or rest rooms offerred women, and sometimes men, a haven from the busy factory. Some companies like the Shredded Wheat Company, National Biscuit, and National Cash Register "required" their workers to take a ten to fifteen minute break each afternoon. Amenities like sitting rooms (as well as classes in sewing, cooking, and homemaking) often characterized welfare programs for women. Many companies assumed that women would marry and leave factory work which meant that they did not need long term welfare programs like pensions and health insurance. Factories employing women tended to improve the physical environment of the factory to a greater extent than factories employing men. Men, they believed, were more interested in personal security--pensions, profit sharing, housing, and job security.[34] Some of the most interesting physical changes under welfare programs were recreational facilities. Guided by their beliefs that workers possessed weak character, many industrialists devised recreational programs to influence their employees' behavior outside of the workplace. Businessmen feared that leisure threatened work values, that workers would not use their increased amount of leisure time in wholesome, healthy pursuits. The programs were intended to counter the influence of "unhealthy" commercial leisure like dance halls, saloons, pool halls, and amusement parks, which were thought to be "injurious to industrial morality." Company recreation would increase efficiency by keeping the worker healthy and, perhaps more importantly, it would build "character" and create a team spirit among workers as it instilled loyalty in the company.[35] Good recreation, like other welfare work, was considered to be maintenance for one of the most important machines in the factory--the worker.

Industrialists sometimes went to great expense in order to make company recreation attractive and convenient for workers. Several companies built swimming pools inside their factory. Others built bowling alleys and installed pool tables in a club room. Some built elaborate club houses for employees' use. Still others added auditoriums and ballrooms to the factory. Less striking were ball fields and picnic areas on the factory grounds.[36]

Less frequent than some of the other additions were classrooms in the factory. Companies set up training programs for boys and young men, clases in English, Americanization, cooking, sewing, and music. Many companies also installed commissarries, and clinics for employees' convenience.[37]

Industrial Engineering and Welfare Capitalism

Industrial engineers played an important role in welfare capitalism; in many ways they legitimated it. Engineers took what might have been viewed as an idealistic, humanitarian idea and turned it into a practical tool to increase production. "There are two reasons for employers giving workers good air, good light, proper temperature, safe and comfortable working conditions, good lunch facilities, and encouraging athletic and recreational facilities," wrote industrial engineer Hugo Diemer.

> The first is that better health and better attitude...help to produce the largest possible output at the lowest possible cost...The second reason is based on the idea that industry and society are interdependent, and that industry and business have certain obligations to society in the way of helping to develop and maintain a healthy and intelligent citizenship with proper American standards and ideals. It will be noted that neither of these reasons involves anything in the way of philanthropy or paternalism.[38]

Thus argued Diemer, and others, that welfare work was good business. Diemer meant that welfare work was no longer philanthropy, but part of the economic and managerial practices in industry, that, as one author wrote "production is far more a matter of efficient men than improved machinery...that capital can prosper only as long as it secures the good-will of its workers by providing better advantages for them."

Industrial engineers' involvement with welfare work is worth looking at, not because their contribution was especially unique, but because they employed welfare capitalism in order to balance their efforts to rationalize the factory. In their use of welfare work, the engineers, influenced by progressivism and factory reform, employed a kind of environmentalism in their factory planning. They directed their work at a special set of problems--worker productivity. Though old problems, they took on new meaning in the rational factory. The problems were social, not mechanical; about workers not machines.

After the factory had been reorganized, new machines installed, and work arranged according to time study, industrial engineers began to realize that productivity still was not as high as they wanted it to be. They had been concentrating only on the technical details of production and overlooked the human element. In their planning, they forgot that production depended on human will as well as technology. Engineers could design the ideal technical production system, but if workers did not want it to be productive, it would not be. As work became increasingly rationalized, workers' individual output was expected to grow. But as their jobs changed, allowing them less control over how they performed their task, workers refused to speed up their work to the extent believed possible by engineers. There was no way around it; without motivated workers no amount of planning would attain the desired rates of production. This dilemma led to the combining of scientific management and factory welfare work.

As discussed in chapter two, predictability became an important part of the new industrial system--the ability to keep contracts; faithful delivery of promised goods became a critical link in the expanding industrial system. Worker cooperation affected predictability just as it did productivity. Washington Gladden, even as early as 1894, realized this connection when he wrote:

> [with good relations] he [the employer] can make his contracts with confidence; he will feel well assured that he will not be interrupted by threats of a strike when the tide of business turns toward prosperity.[40]

The writing of industrial engineers illustrates their efforts to combine scientific management and welfare work. By 1910, books on factory planning and design appeared with chapters or sections extolling the effectiveness of "welfare features" in the factory.[41] These new sections proposed a combination of managerial strategies--the concurrent use of scientific management and welfare work. Engineers recognized the importance of the "human side" of the factory. Some writers explained in detail how and why welfare practices contributed to productivity. Others treated industrial betterment in a perfunctory fashion, suggesting that they grudgingly accepted the necessity of the new elements of factory planning. Generally, writings of industrial engineers' reveal that their purpose in using welfare work was to produce efficient workers, "treat the operative as one of the factors of production whose efficiency should be raised to the highest pitch..."[42]

Social Engineering

In 1901 William Tolman introduced his idea of social engineering in an article entitled "The Social Engineer, A New Factor in Industrial Engineering."[43] Social engineering grew out of welfare capitalism and industrial engineering. The new movement reflected the growing interest in social reform and the strong influence of engineering as a profession and an ideology.

Because of its high visibility and perceived role in society, engineering became so popular that its ideology influenced many professions. The term "engineering" was used increasingly even for non-technical jobs. One such use, "social engineering," appeared just after the turn of the century and became a force in welfare capitalism. Like other parts of the engineering movement, social engineering was affected by scientific management. The social engineers' goals, like those of industrial engineers, were profits and efficiency. The social engineer's job, however, merely supplemented other engineering work. His, or her (and they were often women)[44] main function was to improve working environments in order to assist the "efficiency work" of the industrial engineer. Social engineers believed that workers, like machines, had to be taken care of. Caring for workers, they realized, would improve production by improving worker morale and loyalty to the company.

William Tolman, the "father of social engineering," along with Reverrend Josiah Strong, a minister of the social gospel, established The American Institute of Social Service in 1902 for the purpose of "social and industrial betterment." The Institute gathered information on employer welfare work from around the world to disseminate to American industry.[45] Tolman wrote his Social Engineering under the auspices of the Institute. In it he described the need for, and function of, the new professional--the social engineer.

Tolman wrote about the desire for "industrial peace and contentment" and its importance to the efficiency of a firm. This peace would come, he argued, when the industrialist established a connection between himself, his staff, and "the rank and file of his industrial army." The social engineer would provide this contact because the "industrial army" had grown too large for the employer to do it himself.[46]

The Institute, based in New York City, encouraged industry to use its services in the interests of workers, society, and the industry. Some of the largest firms in the country appear on the lists of the Institute's clients--Prudential Insurance, General Electric, McCormick Harvester, Sherwin-Williams, H.J. Heinz, and National Cash Register.[47]

According to Tolman, the social engineer could ease the curious concern of many employers that improved workplace conditions might raise workers' suspicion about the empoyer's motivations. Though unstated, he referred to workers who had begun to question the motives behind factory welfare work, arguing that welfare features were implemented to draw attention from low wages and long hours. If an employer paid fair wages for reasonable hours they would have no trouble with workers' loyalty, argued the critics. The social engineer would serve as a point of contact between the owner, the administration, and the work force.

Obviously, social engineers were not real engineers; social engineers manipulated people rather than the physical environment. They advised industrialists on welfare features in factories. They talked about efficiency promotion (that is, getting workers to accept "efficiency work"), hygiene, safety, security, benefit asociations, housing, pensions, employee thrift, education, recreation, and community betterment.[48]

The social engineer's work was not altruistic. He concerned himself with improving the factory's working environment only to the point where it would be profitable. As with everything in industry, environmental improvements were judged, in the end, by the degree to which they enhanced profits. Tolman wrote that there was "little room for sentiment; the ordinary employer demands a cash equivalent for each dollar paid out."[49] Improving the factory environment for profit seems a more convincing explanation for the social engineer's existence than the mediating role advanced by Tolman.

Worker Response

Not everyone responded favorably to welfare capitalism. Unions and individual workers believd that motives behind welfare capitalism were greed and power, not altruism and social justice.

Understandably, unions criticized welfare programs. Authors of welfare proposals made no secret of their intentions to keep unions out of the factory. Managers hoped that industrial peace and stability would follow the introduction of welfare programs. For many workers, welfare capitalism meant that a major issue in the labor movement--working conditions--ceased to be a problem. Consequently, union membership declined and organizing efforts met with little success. Unions called fewer strikes and those called were less intense between 1918 and 1930, the peak years of welfare capitalism.

Labor leaders argued that welfare practices lulled workers into inactivity. They believed that welfare programs replaced hour and wage reform.[50] Welfare programs gave employers more control over workers than they would have had with higher wages. With better wages workers did whatever they wanted with their money. With welfare programs employers determined how money was spent. Consequently, "the welfare of the workers is constantly becoming more and more dependent upon the good-will, success and prosperity of the particular industry in which they are engaged."[51]

Welfare work had profound implications for the workers' community. If the factory's programs succeeded in appealing to workers, the community would become dependent on factory-supplied recreation and social services. Dependence would grow as other sources of recreation and services disappeared through disuse. Some workers foresaw the potential dangers in allowing the factory to provide their socializing as well as their employment and they opposed each new addition in the factory's welfare work. At the 1928 convention of the Amalgated Clothing Workers of America one worker proclaimed that :

> Welfare is a deadening anesthetic. It is Delilah's method of robbing Samson of his power...It puts the employer's collar on the worker...It chains him to the factory not only as a producer of goods but also in every other respect. Even his recreation is handed to him at the factory, in the factory atmospherre, and with his employer's label. Under the welfare system the worker is a "factory hand" even while singing and dancing.[52]

Some workers clearly rejected welfare efforts. In one case rather than use a library the company built, workers collected their own library fund. Workers often refused to take advantage of subsidized meals; when asked why he did not buy the two cent coffee, one worker replied that he was "afraid that if he took two cents' worth of coffee he would be expected to do seventeen cents' worth of work for it.[53]

Although many workers opposed the practices of welfare capitalism, it did work for a while. Two of the main goals of welfare work were met--turnover declined and union organizing abated. Organized labor seemed to have had little influence in curtailing welfare work. The success welfare capitalism enjoyed in the 1920s, however, finally came to an end during the Depression of the 1930s. But its demise did not result from trade union criticism. It ended for the same reason it was so successful--it depended on a sound industrial economy. It worked in the twenties because there was plenty of money and low unemployment. It collapsed in the thirties because of scarce money and high unemployment.

Bureaucratization of Paternalism

To some, welfare capitalism seems little more than age-old paternalism used by an increasingly sophisticated industrial system. As one industrial engineer, described the system:

> Recognition of planning and control of production as an essential feature of industry became widespread in the United States about 1910. The application of research methods to the factory, to the markets, and to merchandising was a natural sequence. The ulimate result was the correlation of planned control in all the major divisions of industry, namely, finance, production, distribution, and personnel.[54]

The system is the same one described in chapter two, a system that took shape as industry grew in order to take advantage of economies of scale and scope. Organization and management of production was systematized and rationalized in the effort to gain control over increasingly complex elements of production. Control, industrialists hoped, would improve efficiency and predictability of work in the factory. Industrial engineers reorganized factory layout and work flow in a way that should have created the desired increase in productivity. The changes did lead to improvements in productivity but not as great as engineers and owners hoped for.

By the early 1900s capitalists realized that they needed a system to manage the workforce just as they had a system to manage the technical side of production. Turnover, threats of strikes, and workers' noncooperation seemed to be the final hurdle to achieving a smooth, and more importantly, reliable flow of production--thus, welfare capitalism became part of a broad based strategy with which industrialists addressed "the labor problem." Welfare capitalism, especially in the 1920s, was an effort to stabilize the working class; to stop (or at least curtail) the radicalization of workers.

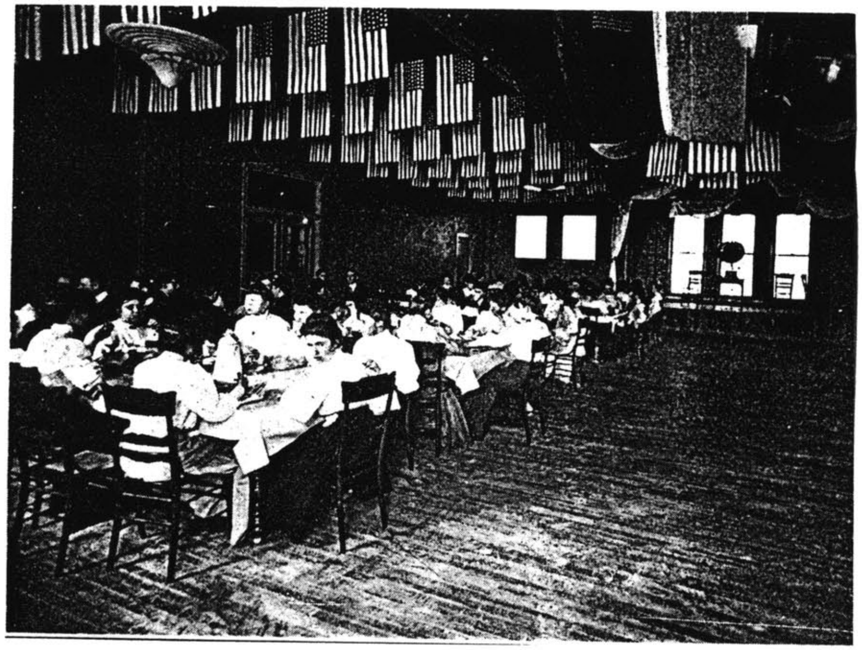
Welfare capitalism was a new form of paternalism and it became a serious component of the production system. As part of the system, paternalism, under the name of welfare work or industrial betterment, became bureaucratized. Like so many other reforms related to the progressive movement, welfare work came under the supervision of experts, newly trained experts in social engineering. Social engineers, or welfare secretaries, formalized the relationship between the worker and the company, a necessity born of the increasing size of the workforce. With thousands of workers, owners and managers could not practice the old style of paternalism under which they claimed to maintain personal contact with employees.

By the 1920s specialization of professionals in the factory was as visible as the specialization of production operations. Social engineers assumed principal responsibility for welfare work as industrial engineers deferred their role in that part of factory planning. Harrington Emerson, a spokesman for industrial engineers since the earliest days of the profession said in 1922:

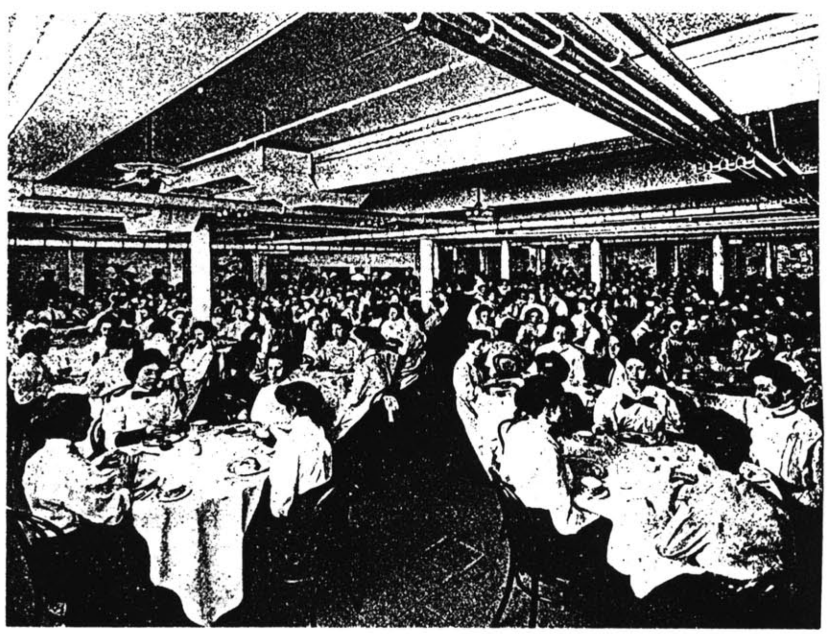
> When I was much younger I thought that the function of the industrial engineer was to spread himself all over the map. He was concerned with the health of the operators, with their education, their morals and their happiness--all that was part of the function of the industrial engineer. As I went along I discovered it was none of his business whatsoever; that he was there to secure industrial competence...Happiness, of course, is a great thing for the human race, but it is not the business, as I see it, of the industrial engineer to take up the subject of happiness.[55]

Social engineers were reformers who brought the attitudes of the social reformer into the factory. They wanted to change certain elements of factory life without altering the basic structure of industry and to teach workers to adjust to the factory situation. Like other reformers, social engineers stressed education, socialization, and environmental improvements. Unlike other reformers, they worked in a small, well-defined world with a captive population. To improve relationships between workers and management social engineers regularized contact with workers. Sometimes contact was personal, sometimes institutional (such as in company dining rooms). The point was to remind workers that their best interest was always the company's concern.

Many scholars fail to see welfare capitalism as more than a collection of welfare activities.[56] They have examined welfare capitalism by exposing specific practices as manipulative devices to deceive and control workers. Their arguments are persuasive so far as they go, but they overlook the underlying system of which welfare capitalism was only a part. Only by looking at the industrial system in larger context can we see how welfare capitalism moved ideas of paternalism out of the nineteenth century and into the twentieth.



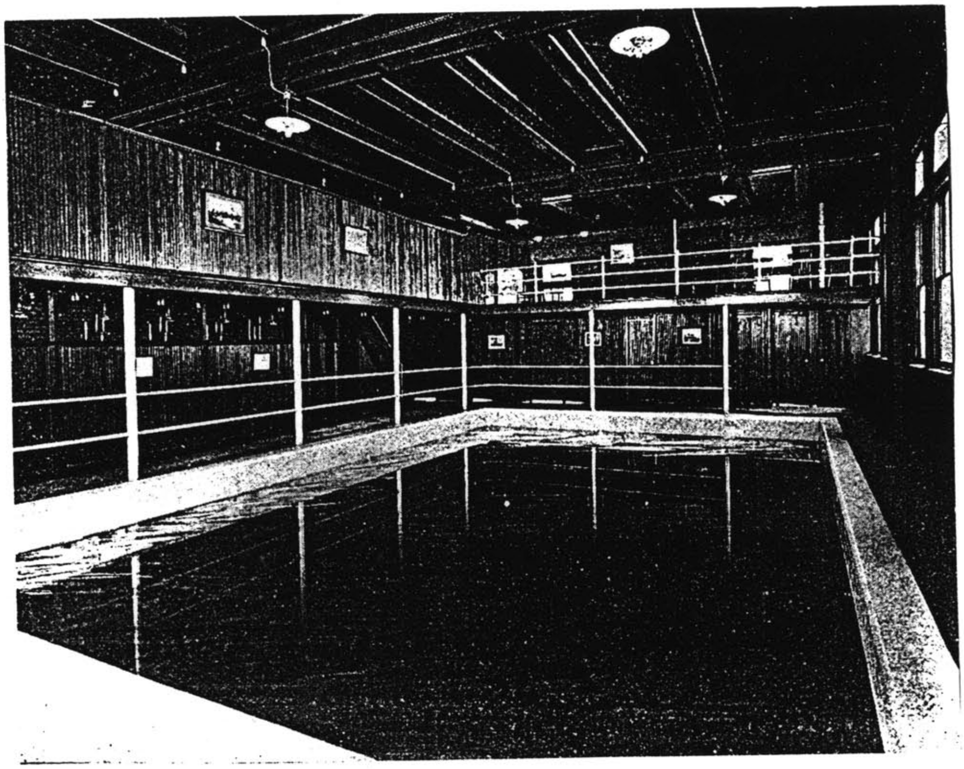
Employees lunchroom of the Acme White Lead and Color Works
From William Tolman, Social Engineering



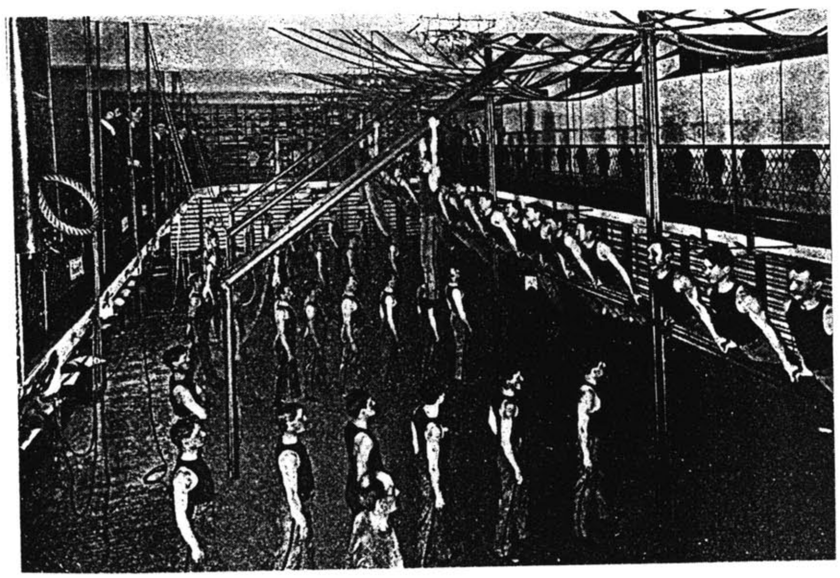
Employees dining hall of the Royal Worcester Corset Company
From George Price, The Modern Factory (p. 320)

The Roof Garden for the Women and Girls of the H.J. Heinz Company. From William Tolman, Social Engineering.

Rest and Reading Room at the Acme White Lead and Color Works. From Tolman, Social Engineering.



Swimming pool for employees of the Standard Sanitary Mfg. Company, Pittsburg. From George Price, The Modern Factory, p. 312.



Setting-up Drill at the Thomas G. Plant Company. From William Tolman, Social Engineering.

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15. Paul Boyer, Urban Masses and the Moral Order (Cambridge, Mass: Harvard University Press, 1978).

16. Upton Sinclair, The Jungle (1920); and Frank Norris, The Octopus (1903).

17. Carl Gersuny, Work Hazards and Industrial Conflict (Hanover, NH: University Press of New England, 1981), chapters 2-5.

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19. Robert Wiebe, The Search for Order (NY: Hill and Wang, 1967), p. 166.

20. Stanley Buder, Pullman (NY: Oxford Univeristy Press, 1967), Anthony Wallace, Rockdale (NY: Knopf, 1978),and Jonathon Prude, The Coming of Industrial Order: Town and Factory Life in Rural Massachusetts,1810-1860 (NY: Cambridge University Press, 1983).

21. George C. Nimmons, "Modern Industrial Plants," The Architectural Record, vol. 45, 1918, 351-352.

22. Melvyn Dubofsky, Industrialism and the American Workers, 1865-1920 (NY: Crowell, 1975).

23. James Weinstein, The Corporate Ideal in the Liberal State (Boston: Beacon Press, 1968),45, and Roy Lubove, Strugge for Social Security (Cambridge, Mass: Harvard University Press, 1968).

24. see George Price, The Modern Factory (NY: John Wiley and Sons, 1914); Tolman; Brandes. The following list of typical welfare activities appeared in Diemer:
1. Recreation--men's club, entertainments, smokers, athletic teams, outings, gymnasium classes, orchestra, quartet, men's summer camp.

2. Community Club--monthly socia meetings, sunday hikes, gymnasium classes, choral club, spanish classes, dancing classes, women's summer camp.

3. Social Service--cafeterias, health, case work, reception committee, savings fund, fiction and periodical library, rest room, house organ.

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26. Tolman, 4.

27. See Price.

28. Brandes, 31 and chapter 4.

29. Weinstein, 18-20.

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31. See company papers such as The Ford Man for safety precautions.

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37. Price, 339-342; Tolman, chapter 9.

38. Diemer, 332, my emphasis.

39. Abraham Epstein, "Industrial Welfare Movement," Current History, vol. 25 (July 1926), 516.

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42. O.M. Becker, "How to Increase Factory Efficiency," Engineering Magazine, vol. 51 (1916); The Factory Management Series, p. 135; Tyrell; Tolman; Diemer.

43. William Tolman, "The Social Engineer, A New Factor in Industrial Engineering," Cassier's Magazine, June 1901, 91-107.

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54. Diemer, 3.

55. SIE Proceedings, Detroit, Michigan, 1922. See discussion following the address by Col. Benjamin A. Franklin,"How Industrial Engineering

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Chapter Three

New Methods, New Factories:

The Ford Motor Company's Highland Park Plant

In 1910 Henry Ford moved manufacturing operations to a new plant just outside of Detroit. The Highland Park plant represented the beginning of a new era in the design of automobile factories, an era when new assumptions about production dictated important changes in the planning and design of factories. The new plant signaled a significant step in the development of the rational factory, a factory planned to work as predictably and obediently as a machine. Such a factory would not need to depend on welfare programs but would rely on industrial engineering practice.

Instrumental in the development of the rational factory, the auto industry combined more different kinds of operations on a larger scale than any other industry. Though others experimented with new building forms, auto companies provided the most exacting industrial environment. The demands of the auto industry for the perfect factory went far beyond earlier requirements for a strong, solid structure to hold machinery. The new industry required a factory strong enough to hold machines that seemed to grow heavier each year, but engineers also wanted the building design and layout to aid in production flow and in the management of workers.

Engineers changed the way they designed factories in the early twentieth century because the factory, like other industrial technology, had to be made more productive. Careful management of men, materials, and speed of production became the crucible that determined whether a company would survive in a tough business climate. The new factory buildings had to aid in that management. In the Visible Hand, Alfred Chandler includes plant design as one of the tools used by growing industrial enterprises to increase speed and volume of production and, most importantly, to assure a steady flow of production.[1] The following chapters examine that development at the Ford Motor Company.

The Ford Motor Company experimented with factory design and layout more explicitly than most companies. Ford seemed more willing than many industrialists to abandon an old building and build a new one when either production volume outgrew the original structure or when engineers' thinking about production advanced beyond its capabilities. By looking at the buildings of the Ford Motor Company one is able to discern the stages in the development of mass production and the changing role of the factory building. Such an examination helps to clarify and underscore the revolutionary changes in factory design and organization during the early years of the twentieth century.

The Early Automobile Factories

The design of early twentieth century factories evolved from two nineteenth century styles: large mill-type buildings and smaller shops which housed a variety of enterprises such as wagon and machine shops, firearms manufacturers, and perhaps blacksmiths. Preceding the auto industry in the early attempts at large scale production, textile manufacturers, and later, bicycle, sewing machine, agricultural equipment, and firearms makers, all used mill type construction. Mill construction, characterized by long, narrow, multi-story buildings, was used most widely in the textile industry but came to be the standard building type for all large scale production operations barring any special requirements for heavy or special equipment or unique working environments.

The small shops varied in appearance and function. They housed operations too small to warrant a mill building as well as those that would not easily conform to work in the multi-story building. Most machine shops, for example, depended on single-story buildings because the weight of machine tools and forges was too great for upper stories. Machinists also required good light which was best provided by saw-tooth roofs on one-story buildings. For the most part, the small shops in any city could fulfill their requirements.

The early auto industry, as small companies made up of skilled machinists, was located in small shops throughout the Northeast and Midwest. Turn of the century auto makers produced only a few cars each day. The first automobiles were built one at a time by the skilled workers by fitting together components purchased from other shops. In 1904, the Michigan Bureau of Labor reported:

> In general a large part of the modern factory for the manufacture of automobiles does not differ materially from that which will be found in any well-equipped machine shop adapted to produce "parts" in large quantities; but there are some points of divergence which differentiate these plants from those of others, and the most important is the inspection of materials.[2]

The auto industry was established in Detroit during the final years of the nineteenth century. Ransom Olds, the man behind one of the first successful auto companies in the United States, began production of the Oldsmobile in 1899. Olds was the first to bring the automobile into quantity production and the first to build a factory "designed and laid out for the manufacture of the motor car."[3] During its early years the Ford Motor Company was merely one of many struggling auto companies in the Detroit area. The Bureau of Labor Statistics report chose to acknowledge only three auto companies--Olds Motor Works, Buick, and Packard--implying that he Ford Motor Company was not a contender for an important place in Michigan's industrial community.

Henry Ford's first factory on Mack Avenue in Detroit fit the Bureau's description--a relatively small, inconspicuous building. In 1903 one of Ford's first investors wrote:

> The building is a dandy. I went all through it today. It is large, light, and airy, about 250 feet long by 50 feet wide, fitted up with machinery necessary to assembling the parts, and all ready for business.[4]

Ford entered into an agreement with the contractor, A. Strelow, who owned the Mack Avenue property--Strelow would build a factory to Ford's specifications and Ford would rent the building for at least three years. Later, in September of the same year, the corporation met and decided to increase the size of the building. A committee reported that:

> A. Strelow made the proposition that he would put a second story on the present site 72 feet wide by 172 feet long for the sum of $5,000. The Company to advance the money for so doing. The Company also to pay the additional insurance necessary and the increased taxes thereon. If the Company shall occupy the building for a period of two years from date hereof, he to pay back to the Company the sum of $2,000... He also agrees to erect a tramway to the east of the building on his own ground and to make no charge for the ground, but the Company to pay for the cost of erecting.[5]

Work in the shop looked very different than it would in the Highland Park plant less than ten years later. In the Mack Avenue plant Ford first employed "ten or a dozen boys and a foreman."[6] Machinists worked at the pace and in the manner of their choosing. Management was minimal, with the owner and foreman also being skilled machinists rather than school educated engineers or managers, creating more of a collegial relationship than a hierarchy. The shop floor was divided into small working groups, each assembling a single car at a time. The design of factories changed little during the first few years of the century while production remained stable and made few demands on the factory building.

As demand for autos grew, pressures mounted for increased speed and volume of production, placing heightened awareness on the development of appropriate plant design. Ford, like other auto makers, moved operations from the small shop to larger buildings of the mill type. The production process remained essentially the same, the only change being that the number of workers increased. In 1904 the Ford Motor Company moved to a building on Piquette Avenue in Detroit. Henry Ford and John Dodge, an early partner in the company, oversaw "letting of contracts and construction of buildings from beginning to end."[7] Ford's personal attention to plant construction reveals the extent of his involvement in the company. In the early years he participated in designing, engineering, and supervising, overseeing every detail of management and production. After the Piquette Avenue plant, Ford never again directly participated in the details of factory planning.

The plant on Piquette Avenue was built in the style of mid to late nineteenth century textile mills, a long narrow building measuring 402 feet by 56 feet with three floors. The building resembled hundreds of other small manufactures of the nineteenth and early twentieth centuries, having nothing that would identify it as an auto factory. It was one of the last of its type, the unspecialized auto factory. The Ford Motor Company could produce automobiles in the Piquette plant because the process by which they were made differed little from the way any other heavy goods such as carriages, wagons, or machinery were built. They were made the way cars had always been made, built one at a time by workers in small groups, filing and fitting parts.

Surviving drawings of the plant layout provide an interesting look at the organization of early auto production, organization that could easily be changed if models or production methods changed. Nothing in this small factory was heavy or unmoveable.(illust)

The earliest auto companies were in the business of design and assembly. This meant that they produced few or no parts themselves, but instead bought everything from small manufacturers.[8] Ford was one of the first to establish a major in-house manufacturing operation. In 1905 he set up the Ford Manufacturing Company to produce engines and rear axles.[9] When transportation by horse cart between the manufacturing plant on Bellevue Avenue and the assembly plant on Piquette Avenue, a distance of about four miles, proved to be too slow, the company purchased additional buildings next to the existing plant on Piquette Avenue in order to move engine production closer to assembly operations.[10] But even with the expansion Ford was constrained by lack of space to try out his ideas. Then, in 1908 the company built the first Model T, which enjoyed immediate success. In 1909 the Ford Motor Company produced 10,000 cars, twice the output of 1908. This created a strain on space at the Piquette Avenue plant even without the newly added manufacturing operations.[11]

Not all auto companies built factories as small as Ford's. The three companies already noted, Olds, Buick, and Packard, had built major factories before Ford built Highland Park, and all three factories received attention for their modern design.

Olds built two factories plus several additions between 1899 and 1903, each one built for the purpose of increasing production volume. The company's first factory, built in 1899, had 125,000 square feet and a capacity of eighteen finished cars per day. In 1901 Olds built a second plant, and in 1902 added to it, increasing production capacity to fifty cars per day. By 1903 additions increased floor space to 570,000 for the two plants.[12]

The illustrations of the Olds and Buick plants show complexes much like those of the textile industry. Both plants consisted of standard mill buildings placed in hollow rectangular configurations and both have additional low rise, monitor roofed buildings (best seen in the lower part of the Olds illustration) which were probably used as machine shops because of the excellent light allowed by the special type of roof.

The Flint, Michigan Buick plant, in 1911, boasted the largest auto factory in the world. The plant preceded Ford efforts to manufacture as many parts as possible and to process some necessary materials. Within one plant were ignition works, body works, spring works, hub and cap works, wheel works, gray iron foundry, and brass, bronze, and aluminum foundries.[13] Construction on the Packard plant, began in 1903 following the design of Albert Kahn, the young architect who would become famous for his industrial buildings. From 1903 to 1905 Kahn designed and oversaw construction of nine buildings for Packard, all of standard mill construction and organized much like other factory complexes. With the tenth building in 1905, Albert and his brother Julius, an engineer, began their experiment with concrete.[14] Packard Number Ten attracted considerable attention from the industrial community. To Detroit industrialists the building represented a significant advance in factory construction. Three important changes resulted from the use of reinforced concrete. It greatly reduced floor vibration from the new, larger, and heavier machines and made multiple-storied structures more practical for heavy manufacturing. Second, it required fewer interior columns than older mill construction and opened up space on the shop floor. Lastly, the strength of reinforced concrete meant that most of the exterior wall area could be used for windows, opening up the interior of multi-story buildings to natural light for the first time. In his use of reinforced concrete in the new factories, Kahn played a role in the revolution in industrial building. "By introducing reinforced concrete in the factory," historian Hawkins Ferry notes, "almost overnight, Kahn eliminated the deficiencies in mill construction."[15]

When Henry Ford decided that his company needed a new factory, the inventor turned to the architect who, like himself, seemed to be the most inventive.

The Crystal Palace

With business booming, Ford built his third plant in 1909. The new plant in suburban Highland Park marked a transition from an older to a more modern form of industrial structure. It looked much like the multi-story mill-structure but contained important innovations in construction technology and in the arrangement of space. Its designers took into account changes in attitudes about workers and work processes which prevailed in an era of technical and organizational innovation. It also created a stir in architectural circles because of the unusual amount of glass used to enclose the building. The "window walls" inspired observers to call the building the Crystal Palace, a reference to the London's famous glass hall built by Joseph Paxton for the Great Exhibition in 1851.

Industrialists and engineers considered the Highland Park plant special for reasons other than its reinforced concrete and acres of glass. It housed the first experiments with the moving assembly line and Ford's particular style of mass production. The company's innovations in technology, management, and marketing, not to mention its eccentric president, constantly drew public attention to the Highland Park plant.

The auto industry's growth exceeded all expectations. As Alfred Chandler has noted, "by 1923 an industry that had barely existed in 1900 ranked first in the value of its product, the cost of its materials, the value added to manufacture, and wages paid." It is not surprising that such an industry developed innovative factory buildings before other industries. In the world's most dynamic and fastest growing industry, automotive pioneers were forced to look beyond traditional methods of production and beyond traditional means of housing those operations.[16]

The story of the Model T is perhaps the most spectacular of the auto industry. From the beginning, its sales outstripped all competitors and the small firm found the demand impossible to fill. The "T", introduced in 1908, became the single most popular model ever produced in the United States. With the automobile still a new phenomenon and a large part of the population highly skeptical about its utility, the Model T helped to persuade people that the motor car was a good idea. It was strong, durable, easy to drive, and easy to fix and so successful that for eighteen years it was the only car Ford made. During that time it became the object of much affection in the country, with songs and stories written about it. The T's fame assured Henry Ford's and it made him one of the richest men in the world.

Much of the T's success came from its low price which ranged from $850 in 1908 to $290 in 1926, with a low of $260 in 1924.[17] Ford is noted for his foresight in pushing for the design of a light car that could be produced inexpensively, as well as his insight into lowering production costs. Historians have given Ford credit for the idea of the cheap car when they should have praised him, instead, for his genius in implementing someone else's idea. The idea for the cheap car for the masses came not from Henry Ford, but from Ransom Olds. A report of the state of Michigan in 1904 described the Olds Motor Works as the preeminent auto company, its success due, in part, from a change in philosophy that a modern reader might mistake for Henry Ford's.

> They [Olds] thought in order to make a success of the business it would be necessary to throw away all of the patterns and commence anew and devote their whole energy to one style and finish. They also decided to make a machine light enough and to sell at a low figure so that the general public could buy them instead of only a few. With this in view they started out to make a mobile to weigh five hundred pounds and to sell at $500.00, but when the machine was finally completed it weighed six hundred pounds and could not be sold for less than $650.00.[18]

This description was written as Ford struggled with the newly formed Ford Motor Company, just two years after the failure of his first industrial effort, the Detroit Automobile Company. The report which also included Buick and Packard, compeletely ignored Ford Motor Company as a company worth investigating.

Ford's move to Highland Park meant more than additional space for manufacturing operations. It also signified the beginning of major changes in technology, production processes, management strategies, and labor relations. For Ford himself, the move meant that he was less involved in factory life than he had been earlier. His office, now located in the separate administration building, removed him from the mainstream of the factory and its day-to-day operations. Complex management tasks required more than the casual style used at the Piquette plant. The separation of administration, both physically and occupationally, from production marked the beginning of a new era in management at Ford Motor Company.

Highland Park was designed around a set of assumptions about how to produce an automobile, assumptions that would change dramatically over the next few years. Before operations left Piquette Avenue, Ford engineers gradually changed from group assembly, a method by which crews of workers built one complete car, to rudimentary line production methods in the assembly rooms. They first experimented with the sequential flow of different manufacturing operations. In 1906 they worked out the first sequentially-arranged machine operations to produce parts for the Model N. This meant that rather than placing similar machines together, machines were placed in the order of oeprations thereby reducing time and labor costs of transporting partially completed operations between machines. The company experimented with operations flow and in 1906 the first sequence of operations was worked out for the Model N. This meant that rather than placing all similar machines together, machines were placed in an order of operations thereby reducing time and labor costs of transporting partially completed operations between machines. "Before that," noted one of the company's engineers, "we had all lathes in one place, all drill presses in another and then we moved the materials around from place to place. We then worked out the idea of sequence to avoid carrying the material from one machine to another."[19] After those initial experiments plant layout and materials handling became the most important tasks of factory managers and engineers. The two activities emerged as the primary determinants for building design and would become major deteriminants for success. Casual layout in the early shops worked because production was slow, its volume low, and skill, rather than efficiency ruled the shop. But as engineers improved machines and increased speed, plant layout became increasingly important. In the company's first decade, Ford engineers constantly rethought layout as they tried new methods to increase production speed. Shop-floor layout merged with new construction as a crucial factor in the firm's success. The job of coordinating and planning organization of production and the responsibilities of building design and construction fell to the plant layout department.[18]

A.M. Wibel, one of the layout engineers, described the department as planning and integrating "the overall picture of production and materials handling." Movements necessary for producing a car had to be mapped out before installing all of the machinery and equipment. The constantly changing production quotas complicated the job as machines were added. M.L. Weismyer, who moved to the layout department in 1918, described his job as "cutting out little templates and laying them out on a floor plan, juggling them around to get the most efficient layout, and then making a drawing of that and selling it to the superintendant."[20]

Highland Park was built in two sections, the "old shop"--buildings built before 1914--and the "new shop"--buildings built during and after 1914. The old shop housed production facilities before the introduction of the moving assembly line and the intense Ford concern about the continuous flow of all work through the factory. The new shop consisted of buildings planned specifically to line production methods after 1914. To be sure, the old shop contained the first stages of assembly line production, though it was designed on the basis of pre-assembly line technical knowledge. In the old shop, the initial manufacturing methods more closely resembled the traditional methods in the Piquette Avenue plant. The various departments had many individual stations where one man might build a steering column, a radiator, an engine, or a transmission. But once experiments with the assembly line began, Ford's engineers discovered the deficiencies of the old shop.[21]

The design of the old shop and new shop rested on a set of assumptions closely linked to technology, management, and the labor process--assumptions that set it apart from earlier and later plants. As Ford and his engineers gained experience in manufacturing and as they set their goals on larger, faster, and cheaper production of the Model T they, like other managers and engineers, sought predictability and accountability in the plant operations. To that end, the company's factory buildings were designed to facilitate efforts to order and control production as well as workers--efforts that resulted in the system that came to be known as Fordism.

Fordism constituted both a business strategy and a method of mass production. It concentrated on a single style of one product. Produced at high volume, the Ford cars could be sold at a low price and still provide a margin of profit. To manufacture the low cost automobiles Ford established a minute division of labor using highly specialized machines which required a minimum of skill to operate. Eventually, the work would be connected by a moving assembly line which automatically set the time allowed for any operation.

Speed, efficiency, and control, the ruling principles of Fordism, demanded both organizational and physical changes in the company and the factories. Fordism resembled the broader scientific management movement, though important distinctions existed. As David Hounshell has pointed out, a fundamental issue in Fordism was the mechanization of as many operations as possible. Mechanization reduced level of skill required of most workers and increased managerial control over production.[22]

Standardization was central to achieving the goals of Fordism--production of a single model, inexpensive but good, in large quantities with a small margin of profit. Its success depended on speedy, efficient production, and careful control of production and workers.

For Ford, though, control was more than a way to maintain high production standards, it was also a personal obsession. Ford had the final word on all decisions made in his works. Indeed, he opposed unions because they would dilute his control. He wanted to shape workers' lives both in the factory and outside; he wanted workers with no previous factory experience so that he could teach them to work his way. His famous sociological department investigated workers in their homes to ensure that they were living up to his expectations of what constituted "good American values." If not, they had to reform or find another job.[23] His desire for control is also apparent in his struggle with stockholder. When stockholders of the Ford Motor Company angered Ford in a legal battle over dividends (stockholders argued that profits should be distributed through dividends rather than reinvested in the company), Ford bought them out, guaranteeing his autonomy and control.[24]

When Ford moved production to Highland Park in January, 1910, all or part of nine buildings were complete.[25] (see diagram of plant layout) Building A, the main factory building was four stories high, 860 feet long, and 75 feet wide. In order to leave open as much space as possible on the shop floor, four utility towers were erected on the outside of the building. These towers contained the elevators, stairs, and toilets.2[6] Based on the standard mill construction, Building A, and the other four story buildings, looked like other factories, except for the extra large windows.

Adjoining the first building was a single-story machine shop, Building B, with a saw-tooth roof. The saw-tooth roof added to Highland Park's abundant light. It covered the single-story buidings that were erected between the four-story structures. An English invention, the saw-tooth roof took its name from the jagged profile which resembled the tooth edge of a saw. The vertical side of the saw-tooth contained glass and faced North. The saw-tooth roof provided evenly distributed, well diffused light without sharp shadows or contrasts. The diffused light was preferred for the precise and delicate work of machinists.[27]

The rest of the complex into which the company moved included the first two stories of the administration building, Building O, to which two additional floors were added later, a small part of the first power house, and half of the heat treatment building. The main four-story building held assembly operations, stock rooms, tool cribs, painting, and other light operations. The single-story saw-tooth roofed building housed the huge Ford machine shop. The number of machines and their tight arrangement made their installation anywhere but a ground floor impractical. According to an engineering appraisal years later, the construction of the main factory building was inadequate for heavy manufacturing because of capacity of only about fifty pounds per square foot, a load limit suitable only for assembly and storage. After 1910, Model T production expanded so rapidly that, according to two of the plant's engineers, the company added new buildings as fast as it could; one building was barely finished before another was started. The period of hectic growth compounded the normal problems of rational planning for the layout and arrangement of work processes.[28]

The attention plant engineers gave to the production processes yields important insights about the factory as machine. The most significant difference between Highland Park and other plants was the placement of buildings, reflecting new ideas about production. In 1910 these ideas were just beginning to form into a mature system. Ford and his engineers realized early on that materials handling, or the movement of parts and sub-assemblies, to and between operations would be one of the most significant elements of fast, efficient production fundamental to the flow and organization Ford sought. Engineers everywhere agreed that the "old-fashioned high cost of manufacturing was because of the way things were lugged around the shop."[29] Consequently, in designing Highland Park, materials handling served as a major directive.

The most novel feature of the plant, the organization of the buildings, emphasized the movement of materials. Except for two processing facilities (heat treat and foundry) the power house, and the administration building, the buildings of the old shop shared common walls, essentially making the plant one large integrated building. (see diagram) This contiguity meant that, as the model T was built, parts and sub-assemblies travelled shorter distances, a factor which meant faster flow of materials and considerable saving time and labor. Few factories before or after Highland Park were built in such a tight formation. Most large factories before the 1920s were built in hollow squares, or in H, L, or I configurations. These shapes allowed natural light to enter the workshops of the multiple-story buildings. Instead of leaving the usual space between buildings, the Ford Motor Company covered those spaces with glass and utilized them as work space.

The building arrangement thus eliminated costly and time consuming travel between buildings. In 1910, horses and wagons commonly supplied transportation within industrial complexes. (illust) Except for the few factories equipped with narrow gauge railroad tracks, most companies used teams of horses pulling trucks or wagons for the movement of materials between buildings. The expense of the horse-drawn method; which included wages of the teamster and his helper, cost of feed, repairs and renewals to harness, wagons, shoeing, veterinary services, depreciation of wagons and trucks; came to approximately $1,850 each year for each team. More important than the cost were the limitations imposed by the method of transportation. In addition to the awkwardness of the large draft animals on the plant grounds, only eight to ten loads (with a two ton limit) per horse team could be expected to be moved in one day.[30] As late as 1920 the Ford Motor Company used teams of draft horses for hauling materials at construction sites.[31]

After moving into the old shop Ford and his engineers intensified efforts to increase production by making it more efficient. By 1913, they had developed new ideas about how to manage production, and how a factory should work. The most important of these were first and foremost, production flow; then specialized machines (creating a fine division of labor); standardization of product and process; and minimization of materials handling. These ideas about how to run the factory, though thought through by 1913, were not completely realized in plant operations. Production flow and materials handling continued to be problematic. Standardization of the production process, largely accomplished by dividing labor and installing single-purpose, specialized machines, proved satisfactory. But the goal of control over production and workers would not be possible without automatic flow of materials through the plant.

Flow and speed of production became the most important element in the Ford Motor Company's manufacturing operation. Every facet of production, including factory design, was subordinant to production flow. As one of the Ford engineers said:

> It was arranged so that raw materials would go into one end of the building and the finished product come out the other...The railroad tracks came in at one end of the building, the bodies were taken up to the top floor, the painting operations and other operations taking place, and they were then brought down from floor to floor into assembly. The plant was designed to bring out the finished car in Manchester Street. The C craneway and the F craneway were built with this same idea in mind.32

Machines were designed to speed flow. Ford engineers, collaborating with machine shops, designed and built specialized or single purpose machines to perform only one operation and to carry on the operation continuously. Ford employees in the tool department designed the fixtures and gauges that transformed general purpose machines into specialized ones. The special fixtures made insertion of a part into the tool nearly automatic, the worker had to make no adjustments at all to the machine.

The labor process was divided to produce cars faster. A good description of Ford's division of labor is the following 1913 account of the early flywheel magneto assembly, the first moving assembly:

> Originally, one workman assembled the whole flywheel magneto and turned out about 40 in a 9-hour day. It was a delicate job, had to be done by an experienced man, the work was not very uniform and it was costly. In the Spring of 1913 a moving assembly line with 29 men was put into operation. The entire job was divided into 29 operations and it was found that with these 29 men, 1188 flywheel magnetos for every 9-hour day were produced, making a saving of 7 minutes time on each assembly... This moving assembly line is a good example of the Ford system of process assembly, which has behind it a few fundamental principles, such as: Keep the work at least waist high, so a man doesn't have to stoop over; Make the job simple, break it up into as many small operations as possible and have each man do only one, two, or at the most three operations; Arrange so the work will come to each man so that he shall not have to take more than one step either way, either to secure his work or release it; Keep the line moving as fast as possible, consistent with good work.33

Single purpose machines, the moving assembly line, and other "improved" processes changed the ratio of workers to operations and required more care in the allocation of space. In some cases, like the magneto assembly, workers were added as processes were divided into many small operations and many workers were required to perform each simple operation over and over. In other cases, workers were eliminated by a new process or machine that provided one worker with the means to do the work of many. According to a 1924 Bureau of Labor Statistics report, spot welding, for example, allowed one welder to do the work of eight riveters; the multiple drill press increased one man's productivity by eight to twelve times; the vertical turret lathe meant that one worker could produce sixty flywheels per day instead of the twenty-five previously machined on a regular lathe. Similar reductions in time and labor resulted from other specialized machines designed by Ford engineers and mechanics to perform specific jobs such as turning and milling crankshafts, die-casting pistons, and presses for body fabrication.[34]

The introduction of these machines proved to be important for several reasons. The reduction of man hours needed to complete an operation meant an increase in speed and volume of production. The higher productivity of new machines also meant that a given volume of production required less floor space. Manufacturers could produce the same amount with fewer men or keep the same number of men and produce more. In either case production costs decreased. Most companies chose to increase production volume allowing them to take advantage of economies of scale, with additional cost reductions.

The Ford Motor Company adopted new machines as fast as, or faster than other auto makers. As the number of machines on the shop floor grew production increased yearly. The specialized machines greatly improved individual worker productivity.

Production Rates[35]

1909-10	14,000	1912-13	168,000	1915-16	534,000

1910-11	35,000	1913-14	248,000	1916-17	785,000
1911-12	78,000	1914-15	308,000	1917-18	707,000

Average man-hours per car built for each available year[36]

1912	1,260	1915	533	1921	322
1913	966	1919	425	1922	273
1914	617	1920	396	1923	228

When additional machines with greater capacity were added to the newly available floor space they created a serious traffic problem. Always a problem, materials handling became a major deterrent to rapid and smooth flowthrough.

Materials Handling and Shop Floor Layout

New layout schemes went hand-in-hand with innovations in materials handling to make the factory into a place of orderliness and predictability. To avoid the chaos of hundreds of laborers delivering parts and materials by hand trucks, engineers began to rationalize materials handling based more on their own experience than theories of management. Improvements in materials flow, whether through more efficient arrangement of machines, assembly lines, or mechanized handling, developed incrementally. Better machine layout increased production speed as well as eliminating previously available floor space that had been used for temporary storage. That required parts to be delivered more frequently and predictably. With each step, slight improvements were made, eventually leading to the moving assembly line and mechanized handling.

As the layout department figured out the best arrangements for machines and departments, materials handling stood out as the next hurdle to the kind of production flow they desired. So fundamental to smooth production, the demand for improved materials handling increased with increased volume and speed of production. Rapidly being recognized as one of the most important functions in the factory, materials handling also ranked as one of the most troublesome. Materials, parts, and partially or totally completed assemblies were constantly on the move in the Ford shop. Materials and parts travelled from railroad cars to loading dock, from loading dock to separate department, and then to the various work stations. Assemblies in progress continuously moved from one work station to another. Completed assemblies had to travel to the final assembly area. All of these movements had to be timed and coordinated so that materials reached the appropriate place when needed, but not so early as to cause a backup of supplies on the shop floor. By 1912 Ford engineers had mapped out all movements of parts and sub-assemblies, correlating the movement with plant layout. (37)

Highland Park's old shop contained few mechanical or automatic handling devices. In 1912, the old shop had two cranes which moved materials as well as heavy equipment through the machine shop, and a monorail that formed a small railway system. One craneway ran lengthwise between the first and second machine shops, the second ran perpendicular to the first and the back of the second machine shop for unloading and moving materials into the building. (see plan) The monorail moved along tracks placed around the entire first floor and could deliver goods to areas beyond the craneways.

The craneway formed the main distributing artery in the plant. In general, pieces purchased from outside as well as those manufactured by the company were "unloaded directly into the craneway by means of the crane." Materials were then loaded either into bins or directly onto the floor for "temporary storage pending delivery to the machine shop."[38] Materials and parts destined for storage rather than machining, travelled by elevator to the upper floors of the four-story buildings, and then down by elevator to the first floor assembly area when needed.[39]

This system, in practice in 1912, had several problems, the most important being the large volume of parts and materials moved by hand, that is to say by men pushing hand trucks. The company employed 800 to 1000 "truckmen, pushers, and shovers" to move materials from the craneway or monorail to work stations or to storage areas, from storage areas to work stations, and between work stations.[40] (illustration) Oscar Bornholt, one of the Ford engineers, wrote in 1913 that "trucking in the machine shop is always looked upon as an unnecessary expense...and all its labor is non-productive."[41] Likewise, after examining the old shop in early 1914, the industrial journalists Horace Arnold and Faye Faurote reported that "handling of materials and work in progress of finishing is now the principal problem of motor car cost reduction."[42] Most importantly, the truckers frustrated Henry Ford.

In addition to the slowness of the handling system, it was impossible to assure reliability of having supplies available when needed. If workers ran out of parts or materials, their idle time added up to a significant loss of money and delayed output. To keep the system in order "to straighten out tangles of all description in the handling of materials, to trace lost items which range from the smallest part to finished cars, and to ferret out opportunities for improving conditions," reported Abell, "a force of clerks is detailed." Employed in the department of the shop superintendent, the clerks had "no regular routine and are available for whatever contingency may arise at any time."[43]

One Ford Motor Company policy exacerbated handling problems--purchases of all materials were, without exception, restricted to carload lots, "the subsequent distribution of this material through the manufacturing processes becomes a handling problem of unusual magnitude."[44] The plant must have been a-buzz with truckers working constantly to have parts and materials at the right place at the right time. In an early effort to simplify the transportation and inventory of incoming parts, the company, by 1913, insisted that suppliers pack all small parts in boxes or cartons which could be piled on the floor. All bins, previously repositories for all parts and materials were eliminated. Even parts manufactured by the company were loaded into cartons or trays that held only a specified number. The standardized boxes made inventorying supplies much faster, a necessary improvement given the constantly increasing volume of production. Abell wrote in 1913 that "by reason of the change, the cost of handling stock materials is now slightly less than the expense involved in handling half the quantity of stock a year ago."[45]

Ford's engineers sought ways to eliminate both manual and mechanical transportation around the factory; by reorganizing shop floor layout and placing machines closer together, they shortened the lines of travel. In a 1913 interview one of the layout engineers described the importance of the right layout:

> every time we would get a change of production, it would require a complete re-layout of the plant. There was a constant shifting of departments and God help you if you had a particular job like those Bullard multimatics and you ran out of room...before you had enough machines to do the particular job.[46]

Oscar Bornholt provided a detailed example of changes that both facilitated production speed and minimized handling. In describing the cylinder department he explained that the "cylinders are trucked from the foundry to the border of the aisle, down which are located the machines which perform the operation." The cylinders, being light, were carried by the operators from the end of the aisle to their machines while the machines automatically made cuts on the positioned cylinders. The, "the cylinders move to each successive machine until they land in the assembly department which borders the cylinder department." Bornholt proceeded to explain the savings of the system, "in placing the machines according to operations it is necessary only to truck the cylinders to the first operations and after the last." He further explained that "if the cylinders were to be machined in departments consisting of like machines (the old method), it would be necessary to truck to and from each department...It would be conservative to estimate that the cylinder would have to be trucked about twelve times."[47]

Bornholt's description is one of the best surviving accounts of the Ford Motor Company's rational for changing machine layout. No verbal description is needed to see similar changes in assembly; one can see from the following photographs how dramatic were the changes in assembly from 1913 to 1914--before the introduction of the moving assembly line.

By 1914, machines were closer together than was usual "so that there is but barely room for the workman to make his usual movement."[48] With workers closer together and production going faster, more parts and materials passed through the factory. But with the new tight arrangement less room existed for materials on the shop floor. In order to open up floor space, Ford's engineers conceived of the idea of moving the unfinished components by elevated slides, troughs, and conveyors. Gravity slides made of inclined sheet iron were built next to the work stations. After completing an operation the worker dropped the component onto the slide "so inclined as to carry the piece by gravity to within easy reach of the next man." This saved the work of the pusher who, in the earlier scheme, moved a box of partly finished pieces by hand cart to the next station as well. The gravity slides also helped to speed the process. Ford engineers found that the gravity slides, chain conveyors, and the assembly line not only helped reduce labor costs, but also "cleaned up" the floor, "making more room for tools and workmen where it was thought the limit of close placing of production agencies had been reached."[49]

Henry Ford himself pushed shop floor crowding one step further. His idea, reported by the plant's construction engineer William Pioch, was to get the machines as close together as possible to save floor space.[50] Another observer, journalist Fred Colvin, remarked about the orderly delivery of parts in the crowded factory, "the delivery is timed so as to avoid undue accumulation of stock around the delivery stands, and to always have materials on hand."[51] He was impressed with the quantity of materials used in the shop, noting that "work is piled on every hand beside the machines, leaving only a comfortable passageway for the men." He quickly added that the piles turned over regularly since so many pieces must be completed every day to keep up the supply.[52]

New technology not only increased production but also enabled semi-skilled workers to take the place of skilled workers. The new speed of operations made the potential for rapid production enormous. Labor spent in moving materials was unproductive. As late as 1934, a National Bureau of Economic Research study found that forty percent of the auto industry's labor saving changes came from handling materials.[53] The study reported that "one marked tendency in the modern movement for greater industrial efficiency is the effort to reduce handling through the arrangement of equipment and processes to provide straight lineflow. The serialization of processes and machines reduces inter-process handling to a minimum."[54]

One of the layout engineers described his job as cutting out little templates and layout them out on a floor plan until he got the most efficient layout. A superintendent went to him, for example, and said

> We've got to re-layout this crankshaft job. We've got fifty new machines coming. We've got to arrange the department in order to get these machines in, and while we're doing it we can save some labor by putting in some conveyors. In order to make room for this equipment we've got to re-layout this department."[55]

He described the process of layout as a matter of sticking the machine tools as close together as you could to conserve space to get as many in as possible. The theory pretty well was that the closer together they are and still have room to work, the cheaper it is, because they don't have so far to move the stock."[56]

With each expansion, the plant layout department had to reorganize machinery. Small departments underwent regular change due to the introduction of new parts or new machines or new methods for manufacturing. The layout department did not determine the types of machines to be used but rather, decided how to arrange the machines after they had been chosen by production engineers for the most efficient operation. Layout engineers also estimated the number of pieces that would be produced by each machine and the number of machines needed.[57]

Not all buildings at Highland Park boasted the practicality of the shop floors. Both the power house and administration building were showplaces built at considerable expense. Ford apparently took great pride in the power house, wanting it visible and insisting that it be kept spotless. He believed that the public was as fascinated with the huge generators as he was, and had the building walled in plate glass. He also believed that it would be a great advertisement. More than glass made the power house a showcase, however. It contained the finest fittings available, including brass and copper fixtures, chains and rosettes, wrought iron railings with mahogany handrails, " and all workmanship to be first-class in every particular."[58] Atop the power house hung the huge FORD sign between the five stacks. William Vernor, the mechanical engineer for the power house, explained years later that only two stacks were needed but Henry Ford wanted the sign and insisted it be hung from the power house stacks.[59]

Like the power house, the administration building became the plant's public face as well as Henry Ford's office. The high-ceilinged lobby led to a broad winding staircase which would take a visitor to the offices. The marble staircase, carved ceiling, and luxurious furnishings of the lobby created a sharp contrast to the factory buildings behind.[61]

Though some claimed the two Ford buildings to be unusual in their elegance, other companies made similar efforts to attract attention to their plant. Earlier factories also boasted "the handsomest engine room in the country," and many plants displayed administration buildings of fine architecture.61

<u>The Daylight Factory</u>

Highland Park has been almost universally praised by American architectural and industrial historians as the first "daylight" factory. Though recently Reyner Banham in <u>A Concrete Atlantis</u> has shown that several "daylight factories" in Buffalo, New York predate Highland Park. Those familiar with nineteenth and twentieth century industry acclaim the "daylight" factory as a revolution in improving working conditions by opening up the dark interiors of mill buildings. But why were the large windows deemed so important when, by the time of their introduction in 1910, electricity could have provided lighting adequate for industrial production? The large windows did not always provide increased ventilation as often touted. In many factories, only a few panes in any section actually opened. The large areas of windows were expensive to replace when broken. They also had to be kept clean if their benefits were to be enjoyed and keeping them clean was no small task.

One answer lies in the industrial welfare movement. Threatened by unionism and high labor turnover, industries adopted measures to pacify as well as attract and keep good quality workers.[62] Problems with labor turnover were especially acute in Detroit. Auto companies competed for skilled workers as workers frequently changed jobs; in 1913 the Ford Motor Company had a turnover rate of 370%.[63] One way to keep good workers was to build attractive factories. Factory beautification was part of the industrial welfare movement's focus on improving worker morale through social and environmental improvements such as libraries, classes, gardens and better factories.

Some of the interest in the daylight factory, no doubt, came from ideas inherited from the larger social reform movements of the late nineteenth and early twentieth centuries. Reformers heralded the importance of abundant sunlight and ventilation for their purifying effects. The long-standing belief in sunlight's purification qualities persisted even when turn of the century scientists found more effective measures to improve the health conditions of the lower classes.[64]

Though the widespread popularity of the "daylight" factory was probably a result of the industrial welfare movement, its introduction to the United States was more likely a product of architectural and technological innovation. Daylight factories became possible only with the introduction of new construction technology--reinforced concrete.

Highland Park may have been the first American factory to use the kind of steel window frames that allowed maximum window space, but it was not the first attempt to open up the factory to sunlight. A number of reinforced concrete factories had been built before Highland Park. Undoubtedly many daylight factories exist that have escaped the historian's attention, such as the reinforced concrete machine shop built at McKeesport, Pennsylvania in 1904 by Robert Cummings, a structural engineer. Concerned about light in the plant, Cummings designed the factory with abundant windows, which, except for larger frames of wood, admit as much light as Highland Park's windows.(illust) Cummings' concern for adequate lighting for the workers is well illustrated in correspondence with the firm, though the company's lack of interest is inconsistent with the general mood regarding sunlit factories.

> Firm to Cummings, June 21, 1905
> We do not see our way clear to follow your suggestion in regard to white washing this building, as the light would be entirely too strong for the workmen.
>
> Cummings to Firm, June 26, 1905
> My suggestion as to whitewashing the interior of your building was based on the supposition that too much light for the mechanics could not be obtained.65

Cummings' building easily could have escaped the Kahns' attention, but similar German factories could not have. German immigrants, Albert and Julius frequently returned to Germany and other European countries where well-lit factories could be found before Highland Park was built in 1910.[66] One presumes that one or both of the Kahn brothers visited some of those factories. Surviving Kahn records are scanty so it is impossible to know if the Kahns introduced window walls in the spirit of architectural style or if they realized that opening up the factory to sunlight was important to the industry.

Though Albert has typically been credited for designing and building Highland Park, Julius clearly played an influential role. But in spite of the acclaim they have received, they are probably responsible only for designing the building shell. Though only vague references remain it is highly likely that Ford's engineers designed the layout of the factory buildings and turned the basic plans over to the Kahns to enclose.

When Kahn worked on the Highland Park plant, industry was not yet a desired client for American architects. Kahn's interest in industrial buildings was probably a combination of serendipity and the influence of the noted German architect Peter Behrens. Though Kahn does not mention Behrens specifically, Kahn's papers contain numerous letters indicating that both Albert and Julius made regular trips to Europe during which they examined new architecture. Behrens work, especially noteworthy both because it had the attention of the art world and that it had an unusual client, industry, could not have escaped the brothers. Behrens, famous for his work as artistic advisor for Germany's AEG[67] wrote about architecture's importance to industry long before his counterparts in other industrial countries. Behrens' work with AEG began in 1907 when he began an extraordinary career as industrial designer, architect, and writer. With remarkable foresight, he wrote essays about industry, society, and architecture which were widely read in Europe.[68] Behrens believed that through good design he could alleviate some of the devastation wrought by industry. He also believed that industrial efficiency grew out of good design.[69] Though Albert Kahn was undoubtedly influenced by Behrens, the imagination and idealism of Behrens is hard to find in Kahn's work or in his writings. Working for the pragmatic American industry Kahn sought to aid in increasing production efficiency, though only scant evidence exists to document his concern for matching factory buildings with the production process. In 1931 he wrote that "the development of the automobile has indeed taught us the importance of simplification which is equally important in architecture."[70] Other than this statement, however, the record remains silent about Kahn's theories of industrial architecture.

Kahn's first factory commission came from Henry B. Joy whose house Kahn had designed. Impressed with the architect's work Joy hired Kahn to build the new Packard Motor Car factories. In his own words, Kahn undertook the job "with practically no experience in factory building." He admitted that Julius, his brother the structural engineer, played a very important role in the eventual success of the Packard plant.[71]

George Thompson, one of Ford's engineers, later described Kahn's special character that enabled him to work so well with industry.

> Mr. Kahn was a wonderful architect but he didn't know anything about [the industry]. He was extremely quick in grasping his client's needs. He would be sitting there sketching almost as fast as anybody could talk as to what it was to be, and would be back the next morning with sketches.72

Evidently, Kahn's speed was an earmark that appealed to Ford!

Impact of New Building Technology and Electricity

Developments external to the auto industry made the new factories possible. The most important was reinforced concrete construction coupled with improvements in structural steel, both introduced in industrial buildings in the late nineteenth century. Reinforced, or structural concrete, is the placement of steel rods in concrete columns or slabs to strengthen the structure. Concrete alone cannot carry the weight that reinforced concrete can. Because of its strength, reinforced concrete buildings could be supported on its internal columns thus relieving the outside walls from bearing the building's weight. The concrete opened the way for changes that ultimately transformed the factory.

By the time engineers designed the Highland Park plant, assumptions had changed about how to build a factory. In 1904 one standard existed for large factories--wood or brick mill type construction. By 1909, when actual work began on the plant's buildings, new construction technology had expanded the possibilities. The most important new construction technology was reinforced concrete and in years to come, it would revolutionize building design and construction.

The Kahns gained recognition by using reinforced concrete to build the four story factory buildings at Highland Park. Hawkins Ferry notes that the introduction of reinforced concrete in the factory, almost overnight, eliminated the deficiencies of mill construction.[73] Reinforced concrete accomplished three improvements in factory design. It greatly reduced floor vibration from machines, making multiple stories more feasible. Reinforced concrete required fewer interior columns than older mill construction, opening up space on the shop floor. Lastly, the strength of the concrete meant that the window walls could be used in multi-story factories.[74]

Builders and engineers perfected reinforced concrete construction about the same time industry began to expand through changing technology, management, and production processes. Without the potential to build new factories, industry's growth might have been curtailed. The new concrete factories were especially important for the growing automobile industry with its increasingly heavier machines and expanding size of operations.

Wood or masonry buildings of the nineteenth century were necessarily built with load bearing walls such as those in the following report of a typical textile mill. The Durfee Mill in Massachusetts, built in 1875 by mill engineer Frank P. Sheldon, consisted of a five story building with a sharp roof, 376 feet six inches by 72 feet with walls of stone.

The first story contained walls two feet six inches to three feet wide. The second story walls were two feet six inches to two feet eight inches wide, and so on until fifth story of one foot ten inches in width. The windows measured four feet five inches wide with heights decreasing from eight feet four inches on floors one, two, and three to seven feet four inches on the fifth floor.[75]

The advantage of the internal load bearing columns made external walls into little more than shells to enclose space. This opened up numerous possibilities for new building styles. The first major change came with enlarged windows like those in the Highland Park buildings. These early open factories began the era of the daylight factories.

The new material allowed for a vast variety of sizes and shapes in buildings. New dimensions, however, did not appear during the early years of concrete construction. Other constraints created by power sources and distribution, by materials handling, and by lighting persisted to keep the size and shape of factory buildings within the mill tradition.

Power distribution by belting from a central source proved the strongest determinant of building dimensions. Until electric, individually driven machines became possible (and popular) the textile mill remained the most practical model for any facility requiring widespread distribution of power. Even without the real limitations one must assume that builders and factory owners would continue to build in the familiar style for a short time.[76]

In addition to providing added strength, concrete almost eliminated fires. Pre-concrete factory owners lived in constant fear of fire that could wipe out their entire factory as well as the neighborhood, and maybe the whole city. Previous changes in factory construction had all been attempts to decrease fire danger. Slow-burn mill construction, whose name reveals the hopes of its inventor, replaced early, lighter, and easily burned construction styles. Mill owners built flat roofs instead of pitched in order to eliminate the hazard of fires starting in the dead space of roof rafters. Concrete proved to be so fireproof that many companies stopped paying for fire insurance. Its success is well illustrated in insurance rates.

Insurance Rates per $100 of Value[77]

Concrete		Wood Mill Construction Brick Sides		Wood Mill Const. Wood Sides	
Bldg.	Contents	Bldg.	Contents	Bldg.	Contents
.10-.40	,39-.70	.20-.75	.60-1.00	.75-1.50	1.00-2.00

Reinforced concrete differed from earlier construction in many ways. It was stronger, often less expensive, and it used different technology and techniques. Reinforcing bars constituted the major new technology. The bars or rods improved plain concrete because, in Carl Condit's concise explanation,

> concrete by itself can work only in compression, it will quickly fail if it is used for members subject to high bending forces, such as beams and floor slabs. It is reinforced with iron or steel bars, however, the elastic metal will take the tensile and shearing stress and the rigid concrete will sustain the compressive forces."78

At the turn of the century many engineers and builders patented their own designs for reinforcing rods--round rods, square rods, rods twisted in dozens of different ways, looped rods and hooked rods. One of the important discoveries was that simple imbedment of metal did not improve the strength of concrete. In writing about this problem one engineer recounted his experience; when he asked why plain square iron rods were placed below the surface of a sidewalk, the worker answered "it is said to be good for concrete." The engineer, Robert A. Cummings, wrote and lectured about his own discoveries, as well as those of others, with reinforced concrete construction. He explained over and over again that the only way to strengthen concrete was to suspend the rods in the middle of the concrete mass, a difficult task.[79]

The earliest concrete buildings of the late nineteenth century were monolithic construction, meaning that floors, walls and roof were poured into forms assembled using plain, unreinforced, concrete. Problems arose first because the unreinforced concrete had to be used in massive amounts to assure its strength. Only relatively small buildings could be constructed with the monolithic technique because the concrete had to be poured in complete units. Half a column, or half a floor, could not be poured one day and half the next because wet concrete does not adhere well to dry. Early concrete had to be used with great care to avoid disasters that befell many buildings.[80]

Concrete buildings were made by pouring the wet concrete into forms constructed by skilled carpenters. When the concrete dried after a few days, the forms were torn down and discarded. The forms which created the outline of the entire building proved the most expensive and time consuming element of concrete construction. "Forty to sixty percent of the cost of concrete work is right there in the forms, so that if you eliminate the forms you are getting a more economical form of construction."[81]

Albert Kahn explained that reinforced concrete "had been in use for some time abroad where labor costs were lower, but adopted here (U.S.) only hesitantly because of its greater cost and the danger connected with its use."[82] By the early 1900s concrete builders developed a new technique that reduced both cost and construction time. The new method, slab construction, used unskilled laborers to pour slabs of approximately four by six feet. The laborers built the simple forms and poured the concrete on the ground. (see photo) The slabs were then assembled much like bricks. The slab method reduced cost because it used inexpensive labor and reused forms. It was also faster because forms did not have to be constructed and torn down, while many slabs could be poured in advance, ready for use when needed. Concrete construction, and especially the slab method led to larger buildings and changed the nature of construction work.

Most of Highland Park's buildings were concrete slab construction with concrete covered steel girder beams, with a brick facing.[83] The concrete held reinforcing rods designed by Albert Kahn's brother and partner Julius.[84] An engineering survey written many years later reported structural weaknesses in the original buildings. Though the survey did not give reasons for the weaknesses it did explain that the building could hold no more than fifty pounds per square foot.[85]

Electrification

Factory electrification meant two things--electric lighting and electric motors. Electric lighting, installed before electric power, improved visibility and safety. It also raised productivity in some factories that chose to run production twenty four hours.

Though lighting was important, electricity's major impact lay in the new possibilities for shop floor layout; it eliminated the necessity to arrange the shop floor according to the position of the main shaft. The new flexibility allowed engineers to experiment with shop floor layout.

In water or steam driven factories power distribution required a cumbersome system of gears and belts to deliver energy from the central source to individual machines. The water wheel or steam engine, located in the basement, turned a vertical shaft which extended upward through each floor. On each floor a line shaft connected to the main shaft. The line shaft was attached to the ceiling and extended the length of the floor, it turned as the main shaft turned. Belts and gears attached to the line shaft powered individual machines.[86] Machines had to be placed parallel to the shafting and the shaft turned constantly.

This system contained many problems. The multiple transmissions meant lost energy. The shop floor layout was restricted to parallel placement of machines. One part of the factory could not be used without everything being engaged; if one machine was on, they were all on. The belts from line shaft to machine often broke, injuring nearby workmen, the belts interfered with movement through the factory, limited light, and needed constant maintenance.

The first factories to install electricity simply replaced steam as a power source. This changed nothing about the way the plant worked. Power transmission to machines and machine placement remained essentially unchanged, electricity simply replaced the steam engine as a central power source. By the end of the nineteenth century, however, some engineers advocated group drive to replace central power sources. Industries which required intermittent use of machinery would profit by installing electric motors to drive small groups of machines. Belting and shafting still transferred power from the motor to the machines but one group of machines could be operated without engaging the entire factory. Group drive allowed changes in the shop floor layout because the line shaft no longer dictated placement.

The most important change came with unit drive machinery--one electric motor attached or built into one machine. Unit drive allowed independent operations of machines using no belts and no shafting. It increased range of machine speed, efficiency of power use, and flexibility in machine control.[87]

Even with the innovations, many industries continued to use steam, or even water power for many years. Industries like textile used a steady amount of power throughout the day, and the power load remained constant through the work week. This meant that the older power sources remained sufficient. These companies thus put off the expensive conversion to electricity for a number of years.[88]

In the 1880s and 1890s engineers and industrialists debated electrification's potential affects on industry. Some argued that electricity would result in savings in energy and capital. Others believed that while electricity had many advantages, it would not result in a significant cost reduction. Most establishments spend no more than three percent of their operating costs on energy production.[89]

The real advantages in electrifying the factory were not cost savings. Electricity made all the difference for the industrial engineer. Unit drive, and even group drive, systems allowed him new freedom to reorganize production. Without the constraining shafts to dictate machine placement; the engineer moved away from the parallel rows to experiment with other arrangements. New arrangements improved production flow and increased efficiency and floor space. The new system allowed the actual organization of production to be rationalized to keep up with modern ideas about management and production. All of this helped the industrialist move toward his constant goal of increased production, which in many cases rose by twenty or thirty percent.[90]

Other improvements in the factory resulted from electrification. Some industrialists hailed the improved appearance of the shop floor and claimed improved morale. Removal of the cumbersome belting resulted in better light and cleaner factories. The new power system reduced fire risk due to the elimination of the openings in floors through which shafting passed. Of economic significance was the freedom to expand production (and buildings) as needed. The old system made expansion difficult because building size was limited according to the power system. Expansion had to be planned for in the original construction or a new power system had to be installed. The new system opened vast possibilities for the industrial engineer.

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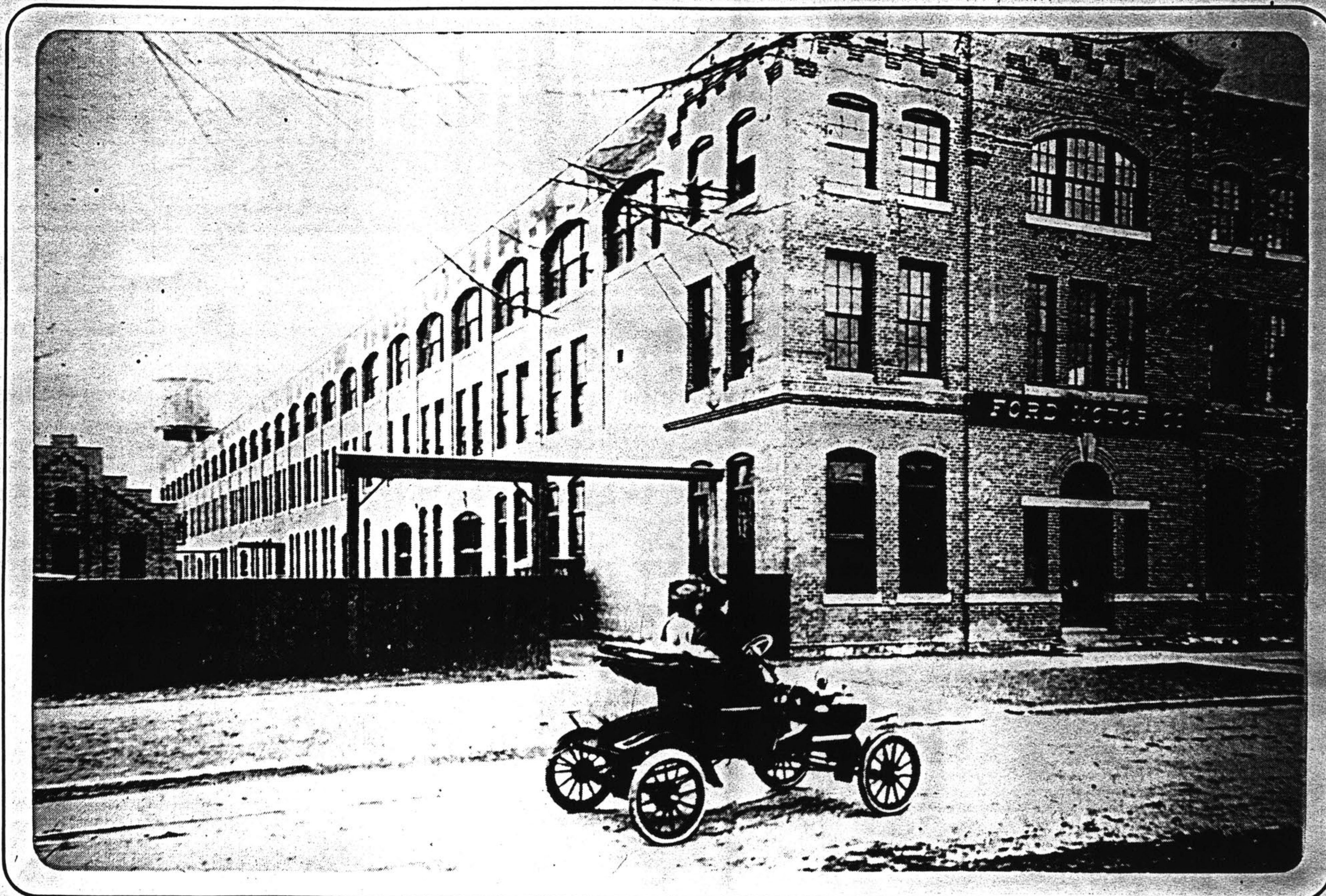
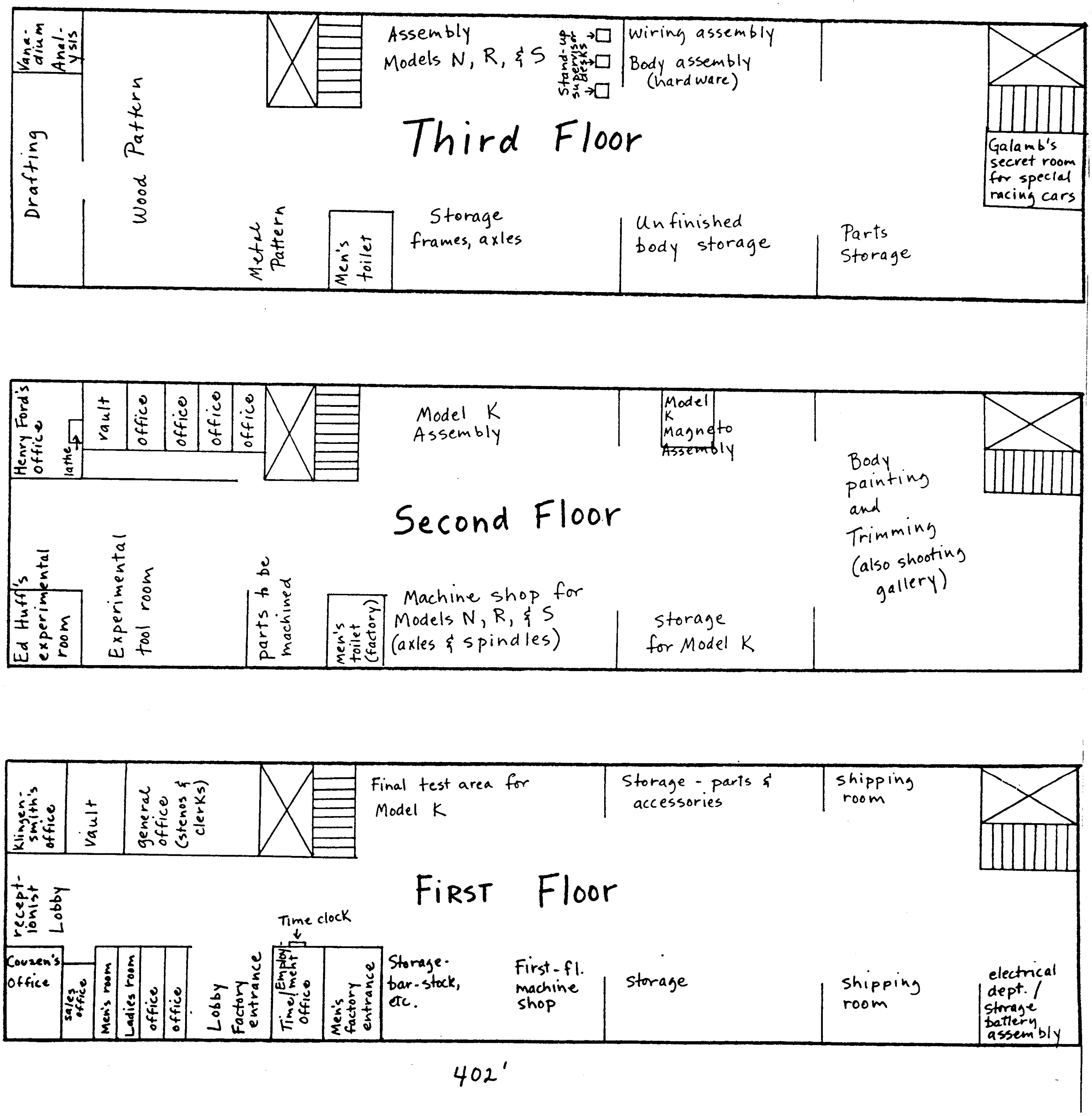
For all the revolutionary innovations that took place within it, Highland Park remained fundamentally an old style factory. When Ford moved production to Highland Park he sought space large enough to hold his rapidly expanding operations. Once established in the new factory the company's engineers set to work to make production as fast and cheap as possible. In the end they found that efficient production necessitated careful planning of the factory building. Through their efforts to streamline production Ford's men developed new expectations for factory buildings.

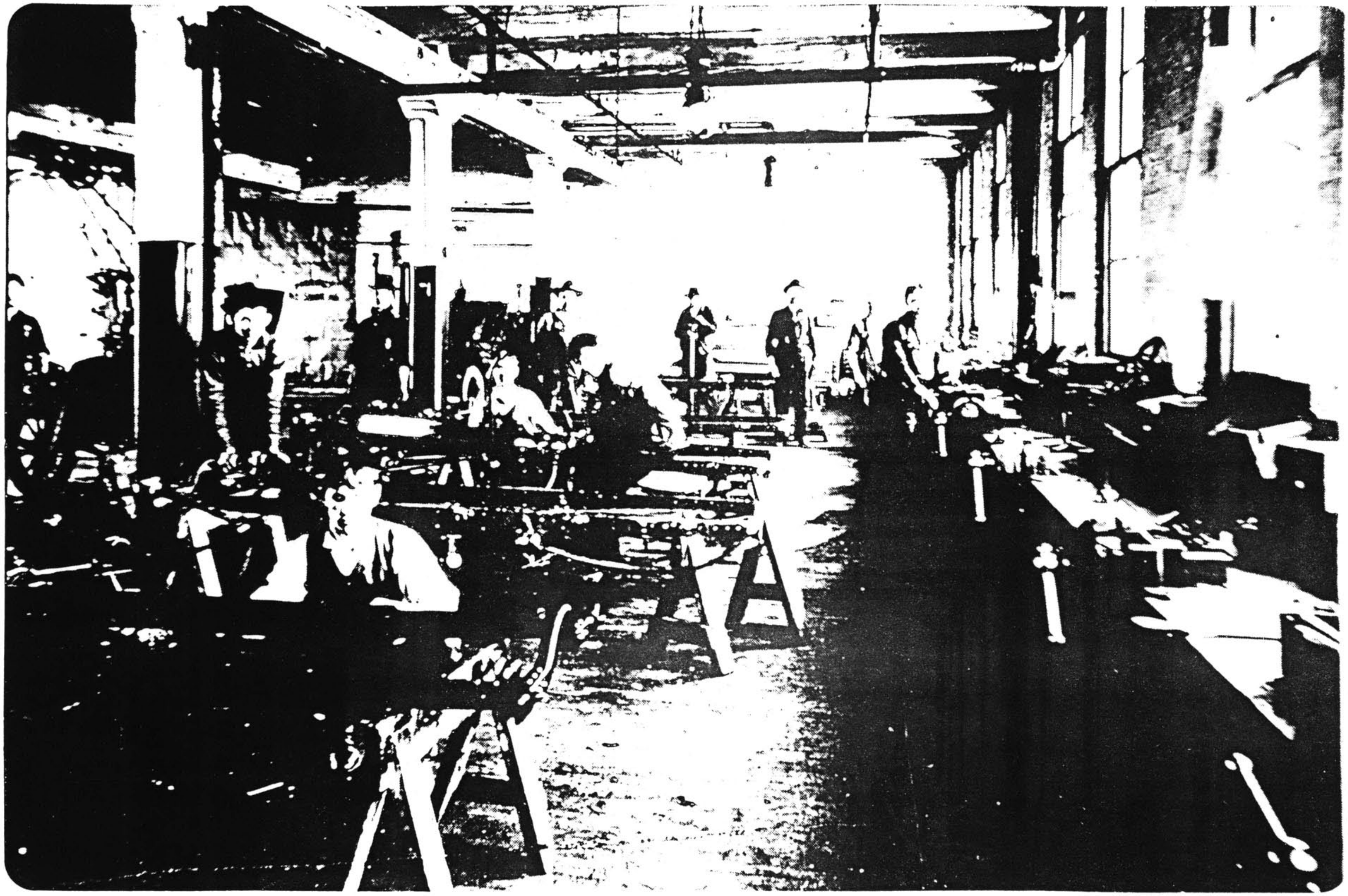
Highland Park's old shop proved to be neither an old style plant like the Piquette plant, nor a modern rational factory. It was an intermediate experiment. When Ford's engineers originally thought about building the factory they had only the old style of production to direct them, and the old production methods were not very demanding. Innovations in production increasingly required that the factory building be planned around production. Older factories had been planned according to the power source, new factories had to be built with attention to the production process.



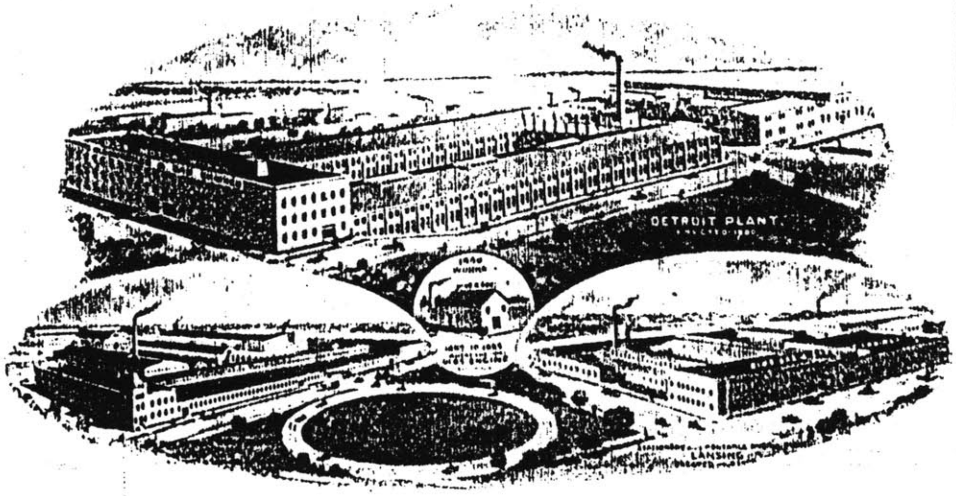
Piquette Avenue plant of the Ford Motor Company, 1909. From the FMC Archives.



Drawn from plans in the FMC Archives

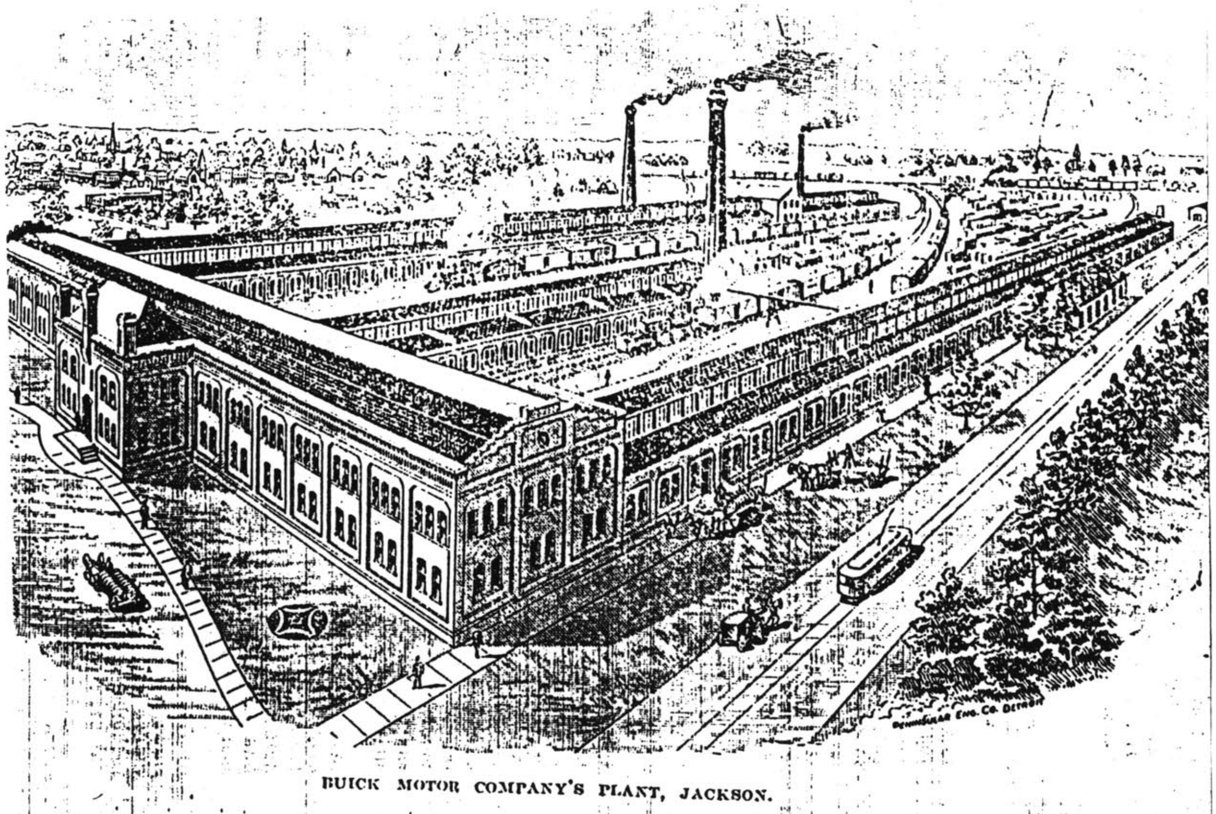


Piquette Avenue plant interior, around 1910. From the FMC Archives.



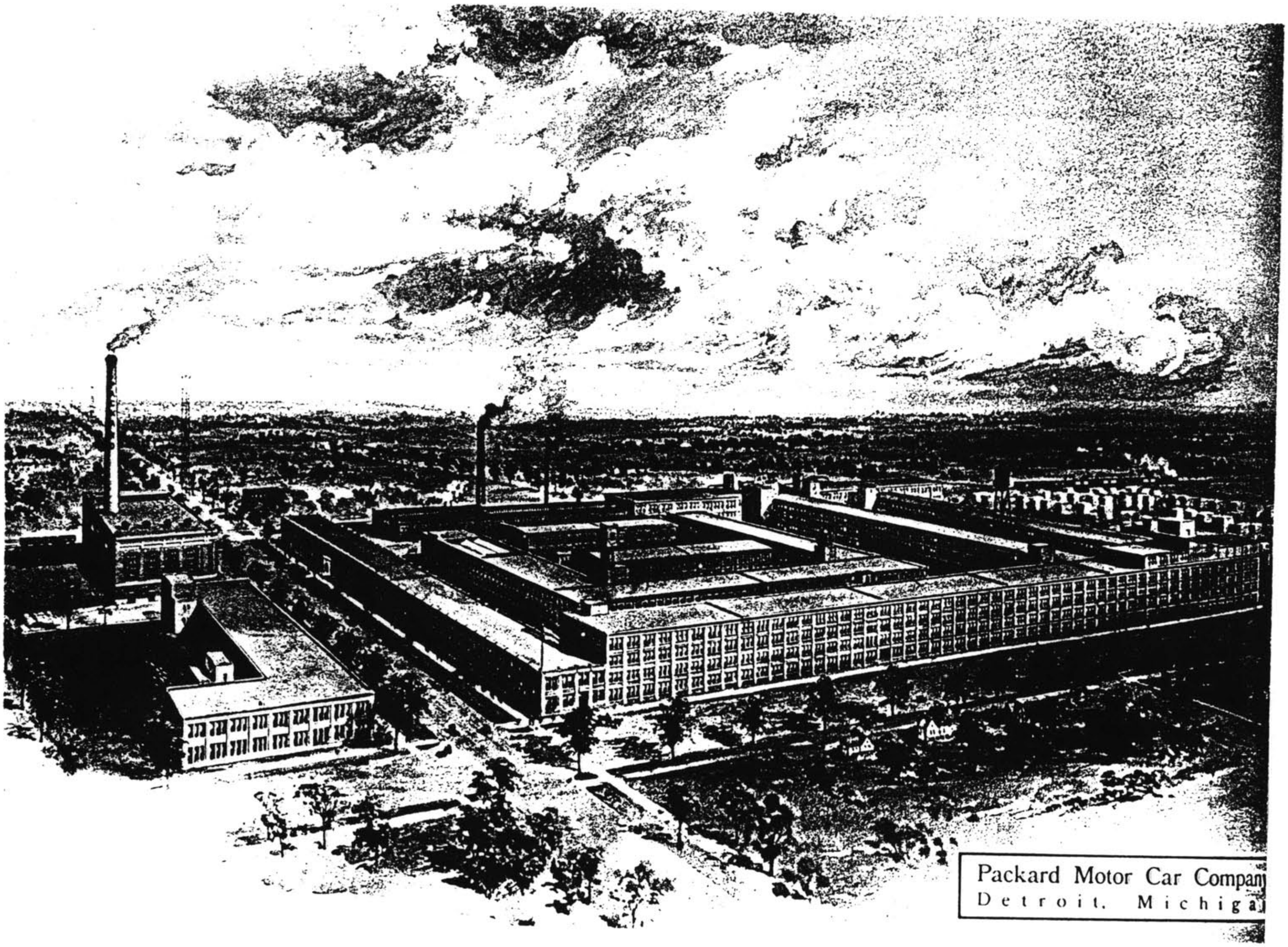
Olds' Automobile and Motor Plants, Detroit and Lansing, Mich.

From Michigan State Bureau of Labor Statistics.

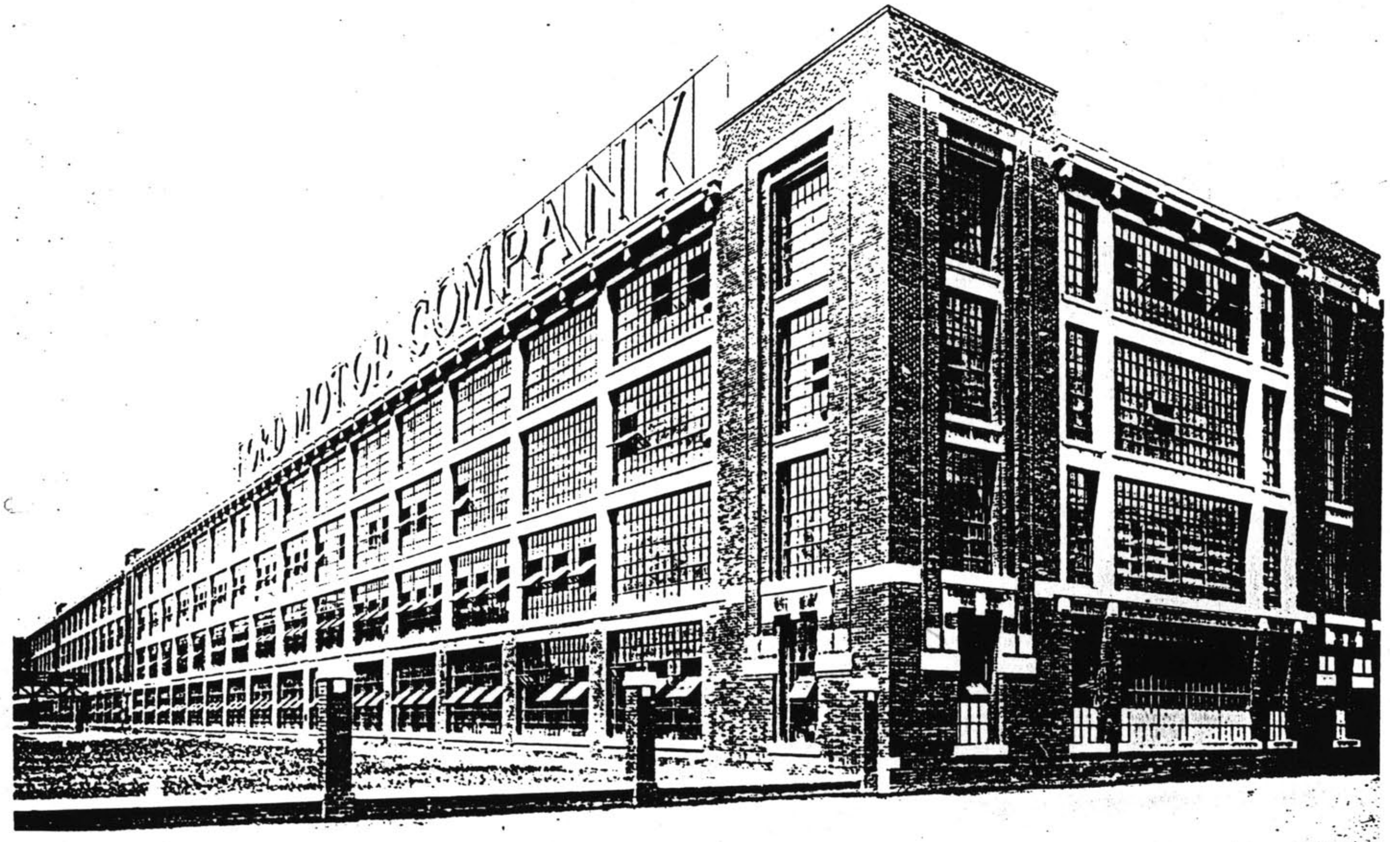


BUICK MOTOR COMPANY'S PLANT, JACKSON.

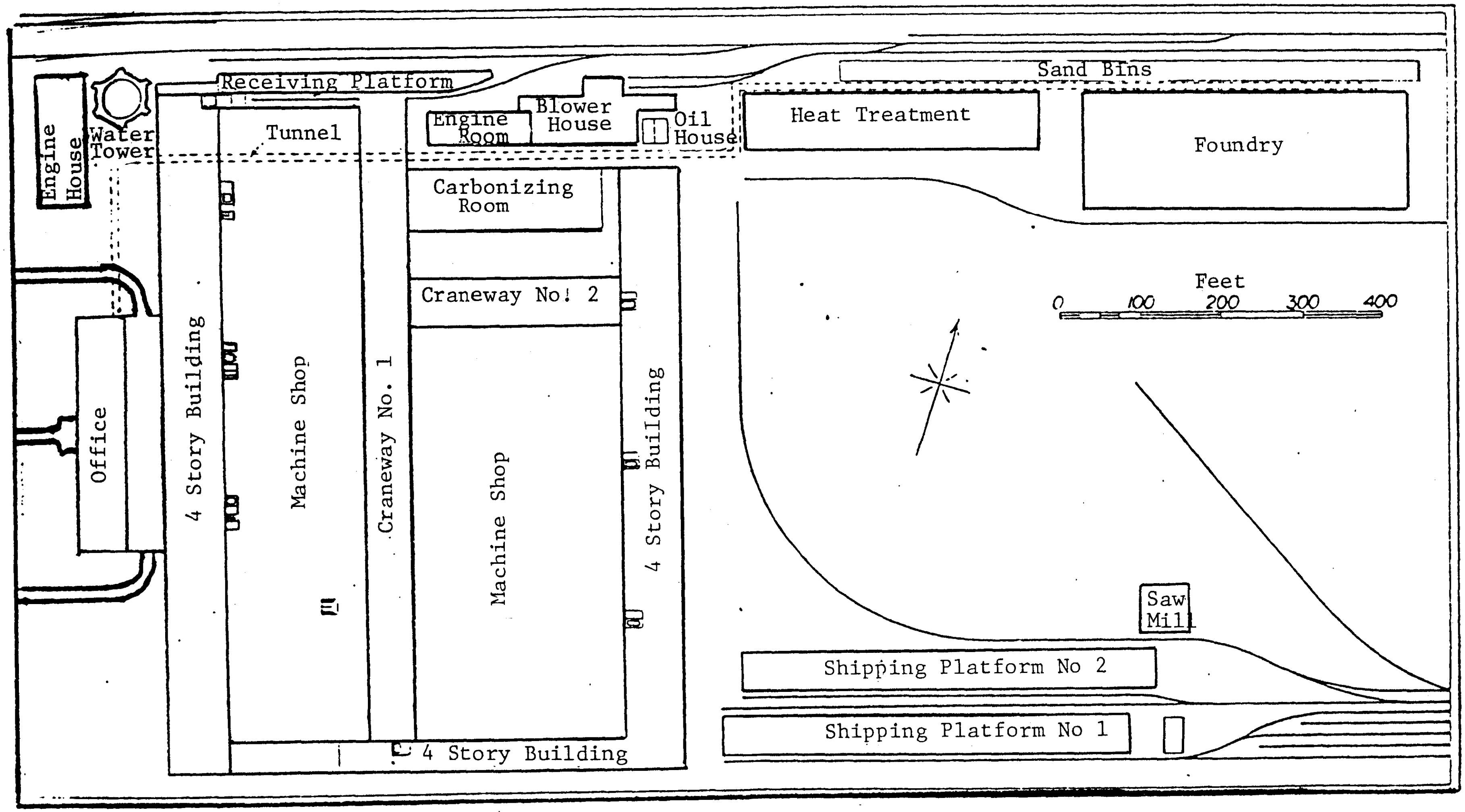
From Michigan State Bureau of Labor Statistics



The Packard plant designed by Albert Kahn, 1903. Photo from Albert Kahn Associates.

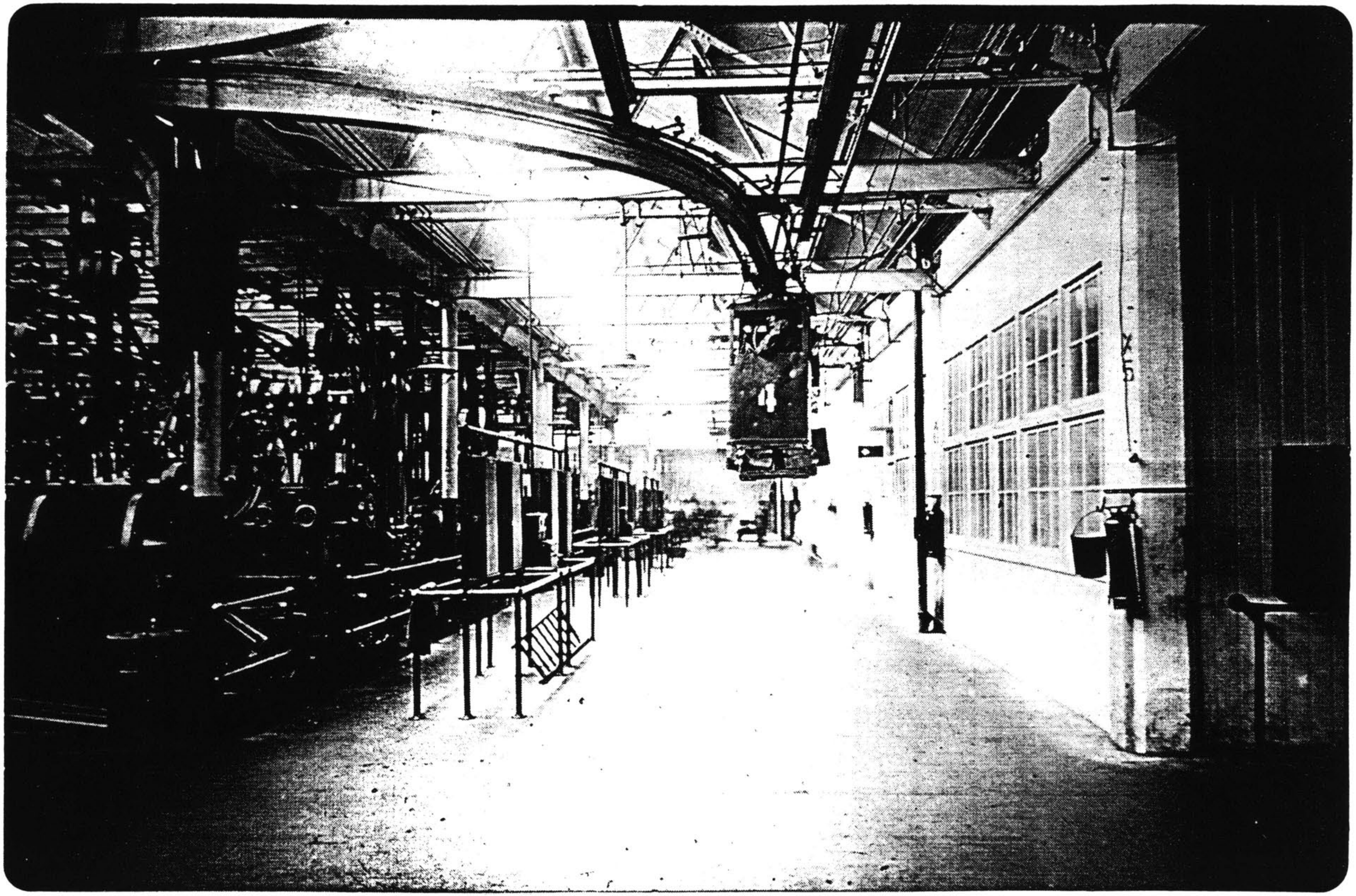


Highland Park's Old Shop, original building (1910)
(Ford Motor Company Archives)

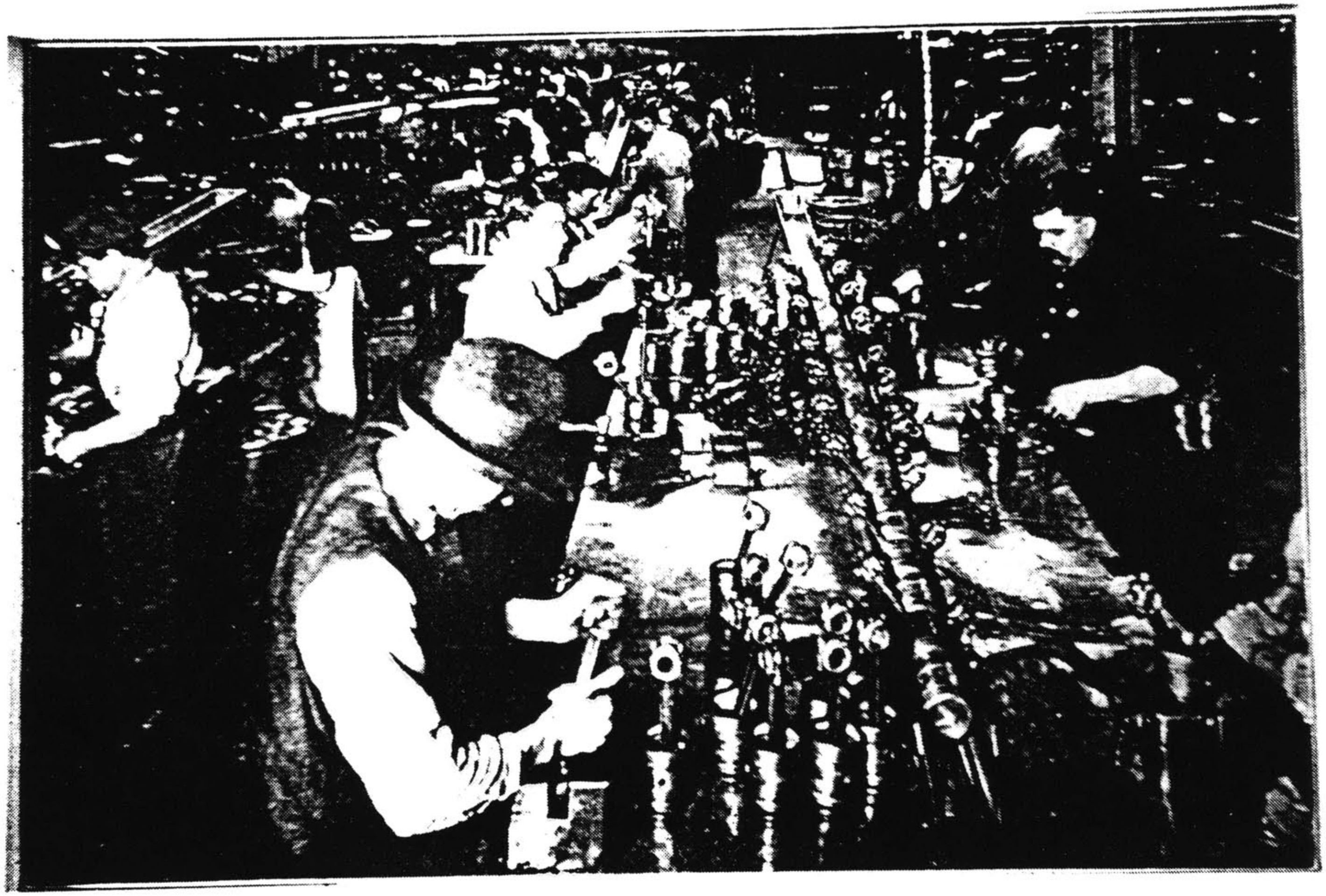


General Plan of the Works of the Ford Motor Company, 1912

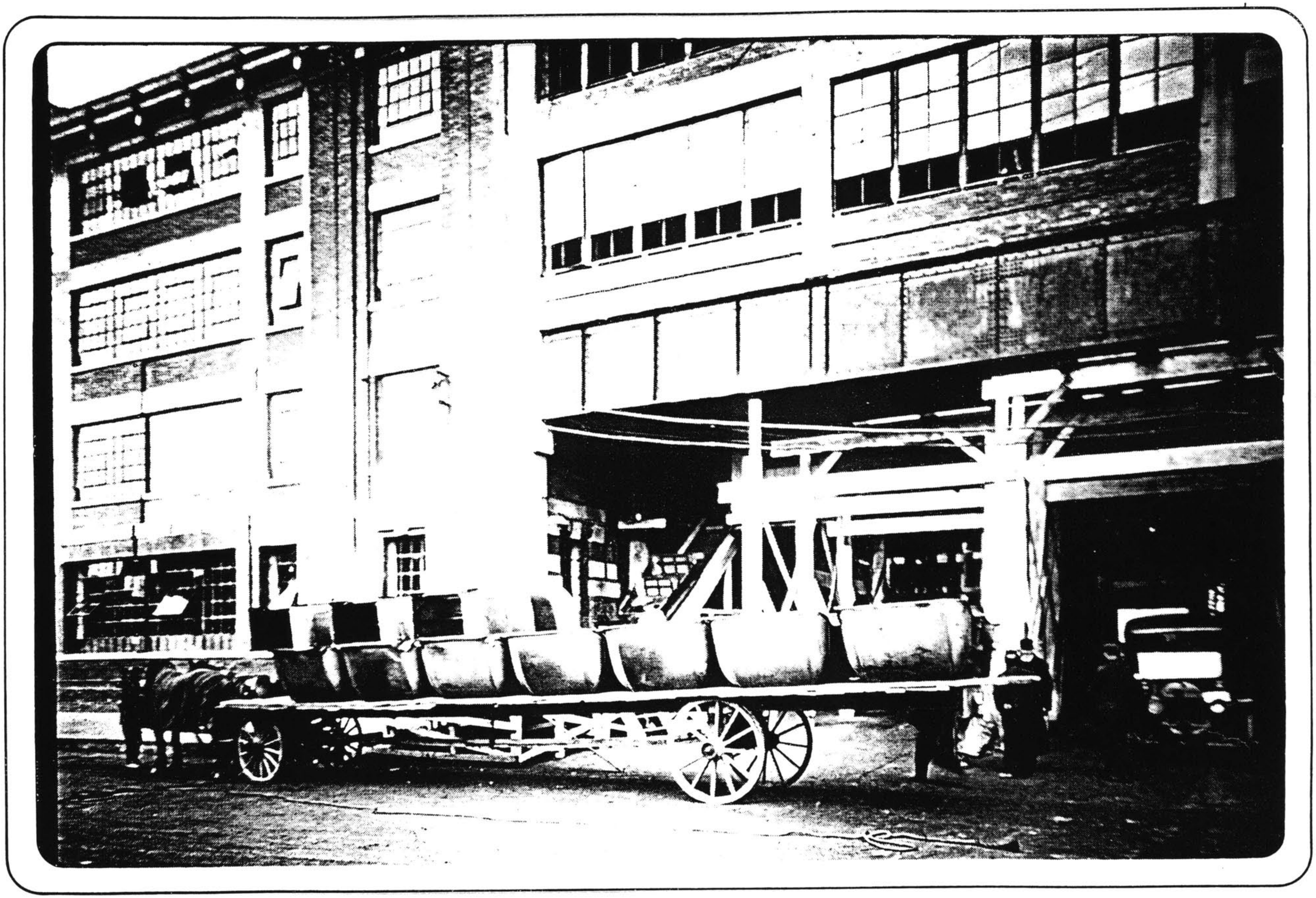
(taken from O.J. Abell, "Making the Ford Motor Car," Iron Age, vol. 89, June 6, 1912, p. 1385)



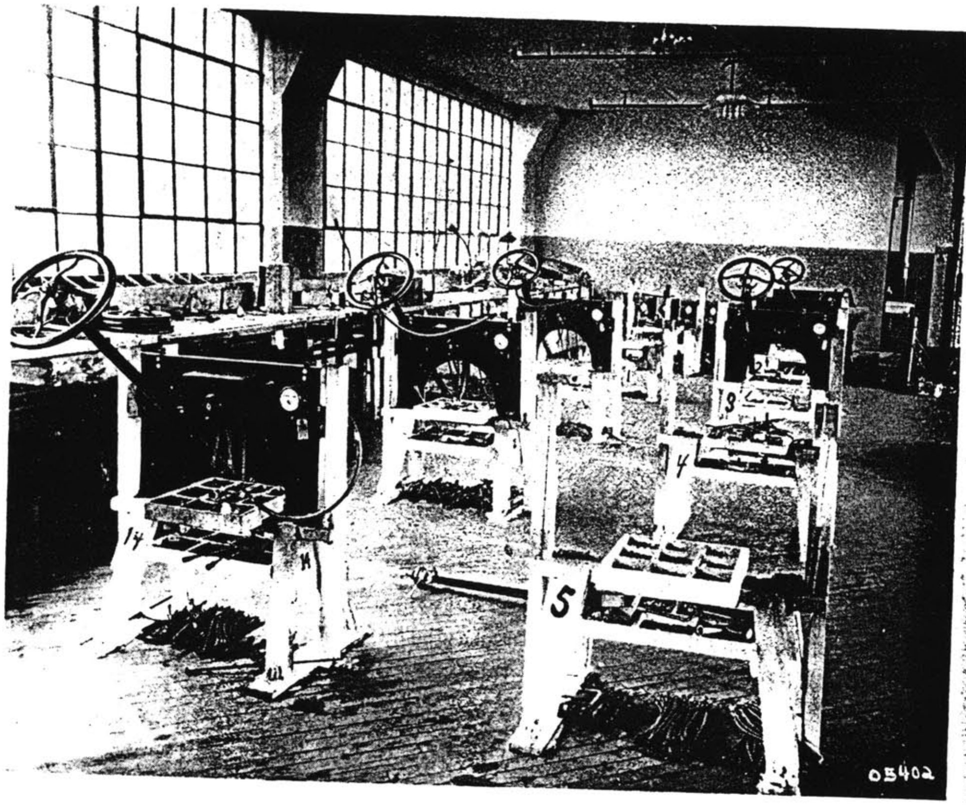
Monorail in Highland Park's Old Shop. From FMC Archives.



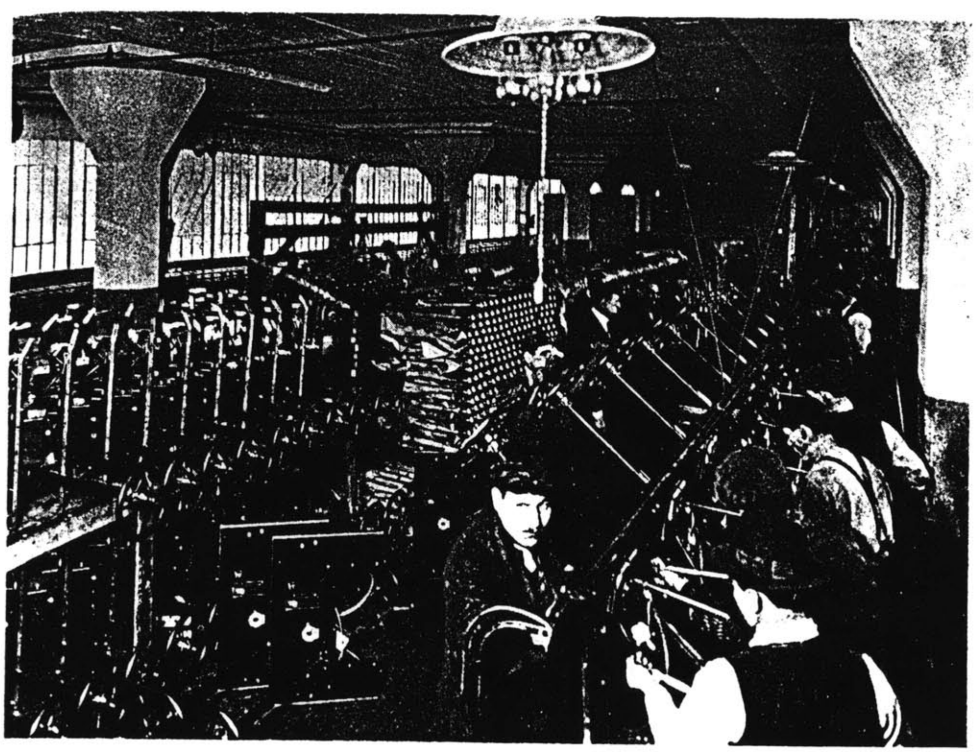
Piston assembly using early gravity slide. From FMC Archives.



Horse-drawn truck transferring Model T bodies at Highland Park's Old Shop.
From FMC Archives.



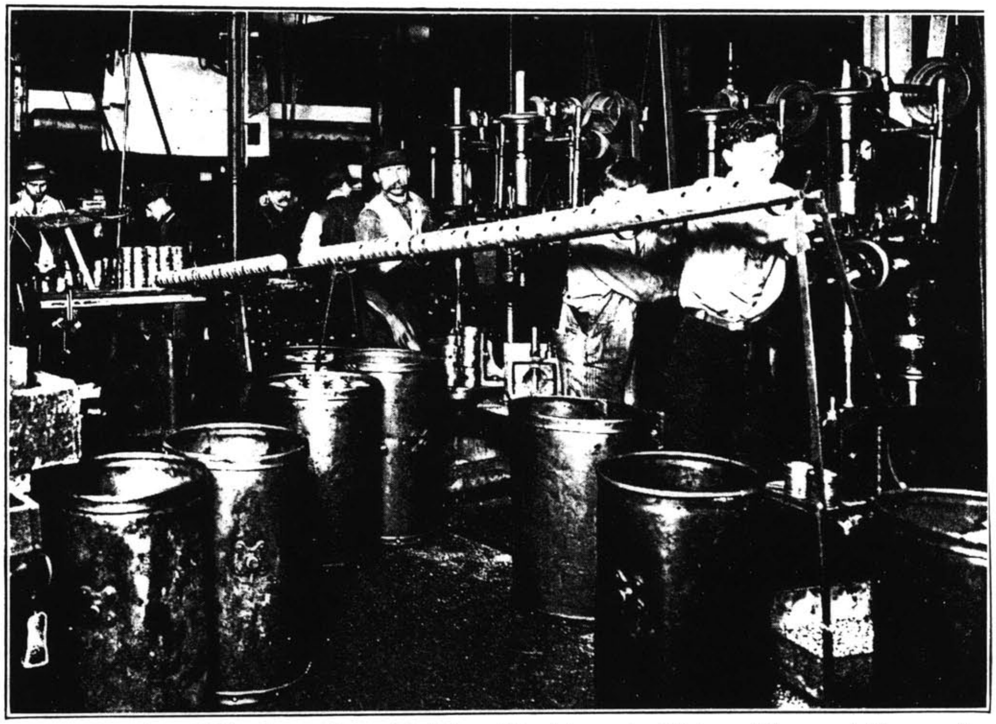
Dashboard assembly, Highland Park 1913. FMC Archives.



Dashboard assembly line, 1914. FMC Archives.

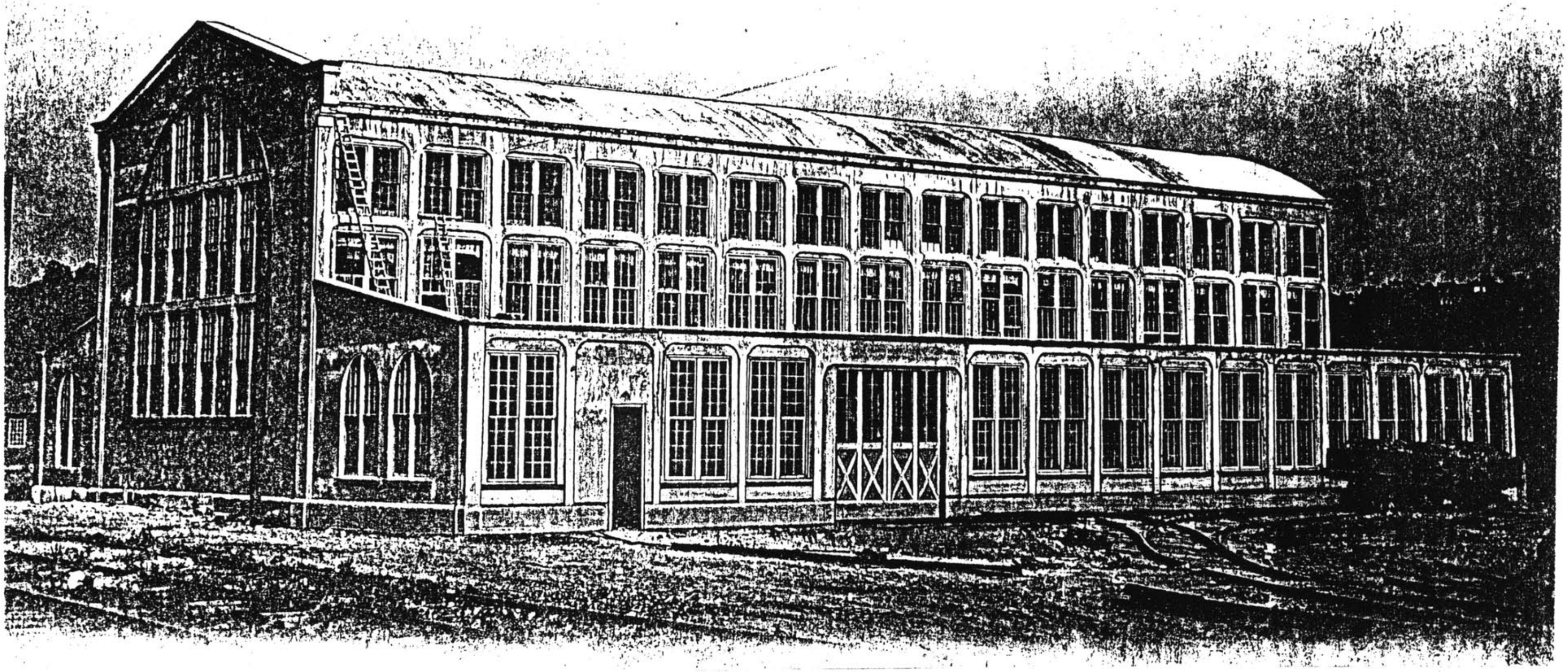
Shop Transportation. Hand-Truckers Moving Filled Component Receptacles

From Arnold and Faurote, Ford Methods and Ford Shops.

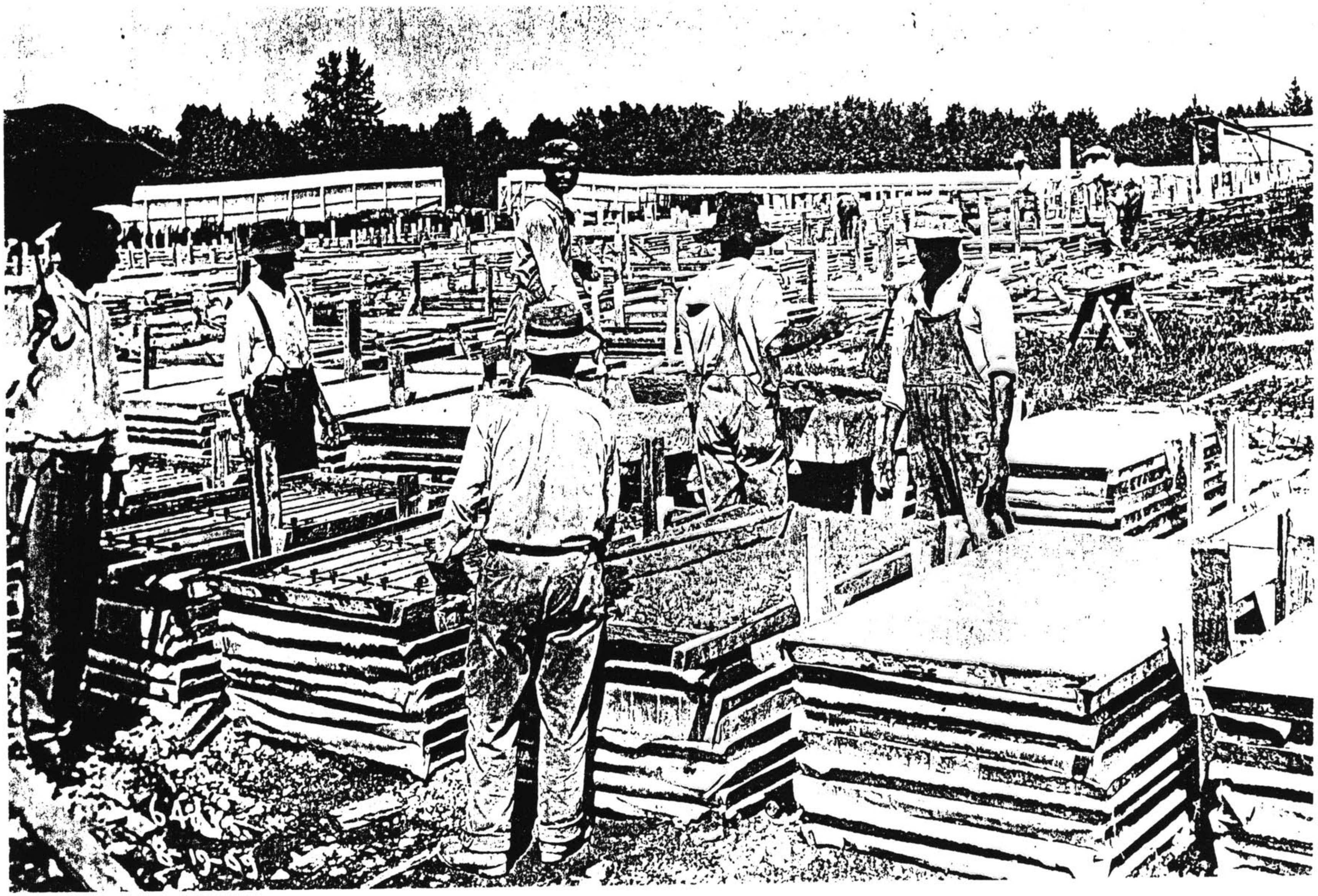


Piston Gravity Slide from Four Drilling Machines to Piston, Pin, and Connecting Rod Assemblers

From Arnold and Faurote, Ford Methods and Ford Shops.



Taylor-Wilson Manufacturing Company Machine Shop, McKeesport, Pennsylvania. Built by Robert Cummings, 1904-05. Cummings Collection Photo Albums, Mechanical and Civil Engineering Collection, Smithsonian Institution.



Slab concrete production, construction site of Harbison-Walker Refractory, 1909.
Built by Robert Cummings. Cummings Collection Photo Albums, Mechanical and Civil Engineering, Smithsonian Institution.

Notes: Chapter Three

1. Alfred Chandler, The Visible Hand, (Cambridge, Mass: Belknap Press, 1977), 243.

2. State of Michigan 21st Annual Report of the Bureau of Labor Statistics, Lansing 1904, 208.

3. ibid, 209.

4. Letter from John W. Anderson to his father, June 4, 1903; Ford Motor Company Archives, The Edison Institute, Dearborn, Michigan, (henceforth noted as FMC Archives), Acc 1, Box 114

5. FMC Corporate Papers, FMC Archives Acc 85, Box 1.

6. Anderson letter.

7. FMC Corporate Papers, Acc 85, Box 1.

8. Olds bought engines from the Dodge Brothers and transmissions from the Lelands; Keith Sward, The Legend of Henry Ford (NY: Rineholt, 1948), 7.
Ford also bought sub-assemblies from the Dodge Brothers.

9. It was established as a separate company as a tactic to buy out a major stockholder. Allan Nevins, Ford: The Times, The Man, The Company (New York: Scribners, 1954), 278-79.

10. Good evidence regarding the additional buildings and the move is not available. Nevins talks about Piquette expansion and photos in the FMC Archives show the buildings in the expansion. The photos suggest strongly that the additional buildings were not built for the plant but already existed on the site.

11. John B. Rae, The American Automobile (Chicago: University of Chicago Press, 1965), 61.

12. State of Michigan Bureau of Labor Statistics

13. Nevins, 448.

14. Grant Hildebrand, Designing for Industry (Cambridge, Mass: MIT Press, 1974), 28.

15. W. Hawkins Ferry, The Buildings of Detroit (Detroit: Wayne State University Press, 1980).

16. Alfred Chandler, Giant Enterprise: Ford, General Motors and the Automobile Industry (NY: Harcourt, Brace, and World, 1964).

17. Dodge Case 1917, Acc 33, box 41.

18. State of Michigan Bureau of Labor Statistics, 209.

19. Conference with P. Martin, Hartner, and Dagner, June 3, 1926, re. Additional Tax Case, FMC Archives, Acc 96, Box 12.

20. Weismyer Reminiscences and Wibel Reminiscences, FMC Archives, oral histories.

21. Daniel Nelson, Managers and Workers (Madison, Wisc, 1975),13.

22. David Hounshell, From the American System to Mass Production (Baltimore: Johns Hopkins University Press, 1984), see chapter 6.

23. Stephen Meyer, The Five Dollar Day, (Albany: State University of New York Press, 1981), see chapter 6.

24. Allan Nevins and Frank Hill, Ford: Expansion and Challenge (New York: Scribners, 1957), 105-111.

25. Insurance Appraisal, FMC Archives, Acc 73, Box 8, vol 1.

26. Hildebrand, 44.

27. ibid.

28. Meyer, 80; Hildebrand, 2; Albert Kahn Papers, Detroit Institute of Art, passim; Engineering Appraisal, Ford Industrial Archives, Redding, Michigan, Ar 65-71:22, HP 1949.

29. "Movement Costs," Automotive Topics, vol. 40 (June 22, 1916), 1082.

30. Rockwood Conover, "The Factory Transportation of Production and Materials," The American Machinist, vol. 44 (June 15, 1916), 1036.

31. Contract with Brice and Cass Day, Nov. 24, 1920; FMC Archives, Acc 361, Box 7.

32. Conference with Martin, Hartner, and Dagner.

33. Fay L. Faurote, "Special Ford Machines," report for the Additional Tax Case, FMC Archives, Acc 96. Though the figures are wrong, the passage gives the reader a clear idea of the principles of Fordism.

34. Martin La Fever, "Workers, Machinery, and Production in the Automobile Industry," Monthly Labor Review, vol. 19 (Oct 1924), 735-760.

35. Henry Ford, My Life and Work (NY: Arno Press, 1922),145. Numbers rounded to nearest thousand

36. See La Fever.

37. Horace L. Arnold and Fay L. Faurote, Ford Methods and Ford Shops (New York: The Engineering Magazine,1915), 25.

38. Oliver J. Abell, "Making the Ford Car," Iron Age, vol. 89 (June 6, 1912), 1384.

39. Oliver J. Abell, Iron Age, vol 89 (June 13, 1912), 1455.

40. Arnold and Faurote, 25.

41. Oscar Bornholt, "Placing Machines for Sequence of Use," Iron Age, vol 92 (Dec 4, 1913), 1276.

42. Arnold and Faurote, 25.

43. Abell, Iron Age, June 13, 1912, 1456.

44. Abell, Iron Age, vol 89, 1386.

45. Abell, Iron Age, vol 92 (July 3, 1913), 2.

46. Wibel Interview, February 11, 1913, FMC Archives, Acc 940, Box 22.

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48. Arnold and Faurote, 29-30.

49. ibid, 272.

50. William Pioch Reminiscences, FMC Archives, oral histories.

51. Fred Colvin, American Machinist, September 1, 1913, 442.

52. Fred Colvin, "Ford Crank Cases and Transmission Covers," American Machinist, July 1, 1913, 53

53. Harry Jerome, Mechanization in Industry (NY: National Bureau of Economic Research, 1934), 188.

54. ibid, 190.

55. Wiesmyer Reminescences.

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57. Stanley Ruddiman Reminiscences, FMC Archives oral histories.

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59. William Vernor Reminiscences, 3.

60. John R. Lee, "A Day's Visit to the Ford Factory," Ford Times, vol. 5 (Jan 1912), 107-108.

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62. Hildebrand, 44.

63. Meyer, 24.

64. William Tolman, Social Engineering (NY: McGraw Hill Book Co., 1901), Chapter 3 ; George Price, The Modern Factory (NY: Wiley and Sons, 1914),chapter 5; O.M. Becker, "How to Increase Factory Efficiency--Natural Lighting," Engineering Magazine, vol. 51 (1916), 835-852.

65. Robert Cummings Papers, Division of Mechanical Engineering, Smithsonian Institution.

66. B.R. Brown Reminiscences and R.T. Walker Reminiscences, FMC Archives oral histories.

67. Allgemeine Elektricitats-Gesellschaft was Germany's equivalent to General Electric.

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70. Albert Kahn, "Architectural Trends," Journal of Maryland Architecture Society, April 1931, 122.

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79. Robert A. Cummings, "Proposed Methods for Reinforcement of Concrete Compression Members." Cummings Papers, Smithsonian, Box 27.

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82. Kahn, "Architectural Pioneers," 377.

83. Chandler, Giant Enterprise, xii.

84. E.R. Breech Papers, Ford Industrial Archives, Acc AR 65-71:22.

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87. R.T.E. Lozier, "Direct Electrical Drive in Machine Shops," Cassier's, Jan 1896, 291-289; Warren T. Devine, "From Shafts to Wires," Journal of Economic History, June 1983, 366.

88. R.E.B. Crompton, "Electrically Operated Factory," Cassier's, Jan 1896, 292; Stephen Green, "Modifications in Mill Design Resulting from Changes in Motive Power," New England Cotton Manufacturers Association (NACM), no. 63, Oct 1897, 128-136.

89. Charles T. Main, "Choice of Power for Textile Mills," NACM, April 28, 1910, 1; Devine, 360,363; American Machinist, Feb 14, 1901, 176; also see Duboff, 513.

90. See American Machinist, Devine, DuBoff.

Chapter Four

The Rational Factory: Highland Park's New Shop from 1914 to 1919

Between 1910 and 1913 production at the Ford Motor Company grew from fewer than 2,000 Model T's a month to over 15,000.[1] In the face of the dramatic rise in production volume, Ford began to think about another building campaign. The company needed the new buildings to house expanding operations, but more interestingly, Ford layout engineers saw the new buildings as an opportunity to further rationalize the factory.

The early Highland Park buildings had been innovative for 1910 style production, that is, production based primarily on static assembly. By 1913 innovations had outmoded both the early production style and the buildings designed for it. The new buildings would be designed specifically to house the recently introduced moving assembly line. By their design, the buildings would aid in the rapid movement of materials around the factory, an indispensable feature of assembly line production.

In 1913 Ford engineers, along with architect Albert Kahn, began work on plans for a new section of the plant. To distinguish between the new and old buildings, Ford personnel began to call them the "new shop" and the "old shop." The decision to expand the buildings evolved around the need for more manufacturing space and the realization that the design of the new buildings could be instrumental in advancing the newly introduced assembly line system. In order to produce enough cars to keep up with ever-growing consumer demand for the popular Model T, the new Highland Park structures needed abundant floor space, and mechanical transportation inside the factory walls. In 1913 the company boasted an annual production of 200,000 Model T's, yet even that volume failed to satisfy demand. More than just the simple addition of manufacturing space, the engineers intended the new shop, by virtue of its design, to aid in the organization and control of production; with 14,000 workers in the factory, producing so many cars, organization of production and the movement of materials became more important than ever.

Technological and economic priorities guided design of the new shop. With the design and construction of each new building, transportation became more and more important--movement of materials into the plant, movement of parts being assembled, transportation of finished parts to their destinations, motion of men as they assembled parts, and movement of men through the plant. This emphasis contrasted with the schemes of the companies described in chapter three, which sought increased production through improved worker motivation achieved by welfare capitalism. The Ford Motor Company thus made a strong statement about its attitudes toward workers as well as about social movements. In building the new shop, Ford and his engineers continued to disregard most trends and forge their own.

Much like the move into the Piquette Avenue plant, and then into the old shop at Highland Park, the move to the new shop was preceded by important changes and growth in production. Each component of Fordism had been put into operation by 1913, albeit some were in rudimentary states. The new components helped to direct plans for the new shop. The engineers must have known that their system, though not yet fully developed would lead them to new successes in production. The new shop provided them with an opportunity to experiment with building a factory around production. The words "experimental" or "exploratory" best describe the Highland Park plant. The Ford engineers did not know what the best plan for production would be but they planned the new shop according to their 1913 priorities. In 1913 they judged materials handling, including the moving assembly line, to be the next major step in advancing production.

The introduction of the moving assembly line in 1913 presaged the auto industry's future, for with it came the realization that almost all movement through the factory could be mechanized and thus closely controlled by management. Mechanized materials handling provided the final piece of Fordism that created the potential for an entirely new system of production. In the new system, workers merged with the machinery as assembly and machining operations were completely routinized. Workers had no choice but to perform their jobs with a prescribed set of movments. The new technology also allowed the foreman to control the speed of production simply by controlling the speed of the line. Finally, unskilled laborers no longer moved all materials around the factory because mechanical handling could do much of the work faster and with greater predictability.

The moving line was the final step in Fordism and the innovation became the foundation of the complex materials handling system that vastly improved speed and reliability of production output. The assembly line led to such a major change in production that the Ford layout department engineered a new factory to better suit it.

The engineers who had designed the old shop worked from 1910 assumptions about production when skilled mechanics performed their work at individual stations and small groups completed final assembly. In planning the old shop, the primary concerns were sufficient space, good light, and convenience of moving materials, in that order. During the three years after the old shop was built, the company's innovations in production outgrew the older facility.

Space, a constant concern to the company, continued to be important for the growing enterprise, but movement soon became the overwhelming priority in designing the new shop. By 1913 the old shop had become too crowded to handle additional production and Ford's engineers realized that they needed a different factory building if they wanted to continue with their experiments to increase speed and volume of production as they lowered its cost. They knew that "one thing that had a good deal to do with the old-fashioned high cost of manufacture was the aimless way in which things were lugged around the shop."[2] When the engineers began planning new factory buildings they focused on materials handling, and especially on housing the assembly line. Improved materials handling, they believed, would make production faster and more efficient. It would also eliminate many unskilled laborers--the pushers, shovers, and draggers--who had always been the major agents of materials transportation.

Not surprisingly, complaints about the old shop helped to shape the plans for the new shop additions. The shop managers expressed dissatisfaction with the plant organization, as one manager related to Arnold and Faurote: "There was not floor space enough; machine tools and factory departments were not placed as the management knew they should be, and...truckers, pushers, and draggers engaged in needless handlings of materials and work in progress."[3] As usual, the complaints emphasized transportation, the "all important factor which influenced the length of the manufacturing cycle."[4] Henry Ford viewed transportation as a key to better management of production. As he aptly expressed in his often quoted statement:

> if transportation were perfect and an even flow of materials could be assured, it would not be necessary to carry any stock whatsoever. The carloads of raw materials would arrive on schedule and in the planned order and amounts and go from the railway cars into production.[5]

Ford's engineers learned a great deal from the old shop. It was not only too small for growing production, but also proved inadequate for the new type of production. When the company built the old shop inefficient transportation created only minor problems, in 1910 manual handling was appropriate for the speed and type of production in the Ford shop. But by 1913 the configuration of the old shop and its limitations for shop floor layout had become problematic to the shop general manager.

In planning the new shop, Ford engineers, especially Edward Gray, worked more closely with architects than they had in designing the old shop. William Knudsen, the head of the assembly department, indicated that the new buildings had been more carefully planned and "all mechanical equipment arranged for in the contract." This was done, he added,

> in hope of showing a decrease in the cost of our building. On the first buildings none of this was included in the contract and continual changes, necessitating cutting, and removal of walls, in some instances ran the cost way beyond the estimates.[6]

In 1914, two buildings were completed, marking the beginning of

Highland Park's new shop. In 1916, another six-story building was constructed. The buildings were 62 feet wide, 842 feet long, and six stories high, built parallel to each other and joined by a six story craneway of the same length. The most striking features of the new shop were the giant six-story glass-roofed craneways each built between two six-story factory buildings. The craneways became the heart of the new transportation system and did much to solve the materials handling problems. Railroad tracks, laid in the craneways, allowed the supply train to pull right into the factory. Two five-ton cranes moved along the length of the craneway lifting materials from the floor of the craneway and placing them on one of almost two hundred cantilevered platforms from which pushers and shovers transported materials to work stations by hand-truck. Compared to the layout of the old shop, the new shop layout looked very modern and efficient with its long glass-walled buildings joined by the giant craneways. (see diagram and illust. of craneway)

Constructed of reinforced concrete with brick facing, new shop buildings resembled those of the old shop. By 1914, though, the engineering of reinforced concrete had been greatly improved. Some structural weaknesses had been found in the older buildings, but the new buildings would prove to be among the sturdiest of factories. Although the new buildings maintained the traditional mill building proportions, the technological and managerial innovations inside belied that traditional appearance. Along with the installation of the crane system, M.L. Wiesmyer and the other layout engineers reorganized the sequence of production operations in order to make the best use of the new cranes.

Surprisingly, the foundry occupied the top floor; rough stores and machine operations demanding most light occupied the other top floors. Work in progress descended "in natural course of operations, until it reached final assembly on the ground floor."[7] By placing the machine shop on the top floor the engineers took a bold step. The machine shop in the old shop, as in other factories, was located in a single-story building to provide good lighting and a solid floor that could withstand the machines' vibration. Placement of the machine shop on the top floor was possible only because of stronger construction and because the crane was able to lift heavy materials easily and conveniently to the sixth floor. The arrangement of the departments aptly reflected the Ford Motor Company's philosophy of rationalization. The reordering of production flow through the factory was supposed to eliminate as much handling of materials as possible, making production more automatic. Organization of production flow, became the major variable remaining to be perfected in mass production.

Though the opening of the new shop received less fanfare than the old shop, its completion held far more significance for the company and the industry. The new shop inaugurated the era of the rational factory--a factory planned as though it could be run just like a machine. In the rational factory engineers had to coordinate all activities and movement in the factory so that each meshed with the next like cogs in a huge machine. The new Ford system demanded close supervision of every worker and of every operation. Speed of production of each part had to be maintained for the entire system to work. And in order for that speed to be feasible, delivery of parts and raw materials on time was absolutely necessary. There were many different kinds of transportation to think about--railroad freight cars, outgoing shipments, transportation within the factory limits, and even moving the work force in and out of the plant between shifts. The efficient movement of men and materials absorbed the attention of industrial engineers in all factories, but Ford's engineers faced an unprecedented challenge. They had to do more than coordinate the usual stream of parts and materials through the factory. The increased speed and volume of production meant the management of greater quantities of materials. Most important, the moving line system required a degree of precision never before achieved in materials handling. The story of Highland Park's new shop is one of engineers searching for a way to have everything in the factory in the right place at the right time.

The challenge led Ford engineers to invent new methods of factory transportation and discover unique ways of using old methods. At Highland Park, their most impressive new materials handling technology was the building design itself--the building arrangement and the addition of the craneways dramatically reduced materials handling needs. Rather than viewing the building as an obstruction to smoothly flowing production, Ford's engineers conceived of it as part of the industrial machine. Without the new building arrangement, the new production system could have been only partially successful. For production speed depended on fast and reliable delivery of materials. The new shop made speed and reliability far more probable than it had been in the old shop.

Fordism in the New Shop

The production system around which the new shop was organized had three basic elements: manufacture of a single, standard model; the division and simplification of work through automatic, specialized machines; and a mechanized materials handling system. The absence of any one of these three elements would have limited the company's success. Each had been introduced individually between 1908 and 1914 and each had achieved its own success. But in the new shop the three principles gained new importance as they were integrated to provide the foundation of a carefully thought out system of production.[8]

The importance of the new shop lay especially in the attention paid to materials handling. Any company could have decided to produce only one model or introduce specialized machines. But the new handling methods played the critical role in completing Ford's system of producing large numbers of Model T's at low cost. Few companies before Ford could boast the forethought of building the factory according to such a complex and detailed production process.

The single model, the T, lay behind Ford's initial success, the first of his long trail of successes. Its simple, durable design appealed to thousands of Americans and thus created overwhelming demand. The principle of holding product design constant had its greatest impact on production in the new shop. The single model, produced year after year with only minor changes, opened the way for quantity production. In later years three of Ford's major engineers agreed that standardization increased production, "we would not have had a shop big enough [for] our production if we had followed the old methods [producing several models]."[9] The production of the single model also facilitated the development of the rational factory. According to one writer, it "influenced machine selections, work and task organization, and the integration of the entire plant."[10]

Not surprisingly much of the innovation in the Ford plants has been attributed to the company's decision to produce a single model. Industrial journalist H.F. Porter, wrote that the production of a single model allowed managers and engineers to devote their complete attention to the machines, materials and work routines; the Model T's "unlimited run" resulted in a "free hand in the selecting and developing machinery, special tools, dies, and men." "Nothing," Porter continued, "is quite so demoralizing to the smooth commercial operation of a factory as incessant changes in design. Even small changes at the beginning of the season occasion much confusion for weeks or months; meanwhile, production is curtailed and costs go skyward."[11] Fay Faurote, in 1926, stated that the success of Ford's economies in production could be "attributed to quantity production which, in turn, could be attributed to the fact that only a single model was manufactured."[12]

After the decision to build only one model, came experimentation with, and introduction of, the automatic specialized machines. Intense mechanization in the Ford shops became crucial to the success of Fordism. Its importance stemmed from the fact that individual machines were equipped with highly specialized fixtures and jigs that allowed the worker to insert the part to be worked on without making adjustments. Some machines were standard, general purpose machines fitted with special jigs by Ford men. Others, like the multiple screw driving machine, were specially designed by Ford engineers and manufactured by machine tool companies. The screw driving machine allowed the worker to throw the screws "at random into the pans of hoppers at the top of the magazines." The machine placed and installed the screws, leaving the worker nothing to do but turn the handle to move the work through the machine. While the worker operated the machine, his helper removed the previous piece from the rack where it fell when completed.[13]

Like the standard model, specialized machines had been introduced before the company moved into the new shop. But because the new shop was planned for specialized machines, their effectiveness proved far greater than before. Moreover, the increased speed and efficiency of handling provided conditions in which the machines could work to their full capacity. As O.J. Abell described movement in the machine shop in 1915: "So far as possible the piece is kept from touching the floor or from accumulating in receptables during a series of consecutive operations in any department. The system had advanced far beyond methods in the old shop.[14]

Economic use of the machines depended on the scale of the factory. One of Ford's engineers explained that most of the machines could not be used by small manufacturers because they were available only if purchased in quantity. What is more, some of the machines were so expensive that few companies could afford them.[15] Another engineer explained that specialized and high speed machines played an important part in the development of Ford's system but that in order to build the special machines "you've got to have mass production or it will break you; it's so expensive."[16]

In the early days of mass production, most auto manufacturers did not have large enough output to warrant using the machines that Ford used. However, the boom in demand for automobiles in the 1910s gave other companies the means with which to employ some of Ford's economies of scale. By the mid 1920s descriptions of other companies sounded much like those of the Ford Motor Company. In a 1926 Wall Street Journal article, for example, the Hudson Company was described as turning out more engines per hour than Ford. The company had completely adopted Ford's practice of investing in expensive machines that "saved one minute per gear" resulting in large yearly savings. Hudson also adopted Ford's materials handling methods, moving materials quickly to avoid keeping a stock room.[17]

Perhaps the single most dramatic innovation, the moving line changed priorities in the factory such that timing and coordination of all movement became the single most important management task. Consequently, layout and materials handling loomed more important in the new shop than they had been in almost any factory. Layout and handling both addressed the same problem--how to reduce the amount of time and labor spent in moving materials around the factory. Time was, in the end, the problem to overcome and Henry Ford seemed to be obsessed with it. Workers were constantly prodded to use time well, as a typical reminder in The Ford Man, the company paper, read:

> Time is the Most Valuable Thing in the World
>
> Shorten the time required to perform an operation. To save one minute in each hour worked means a saving of 1.6% in the wage bill. True efficiency means making every Minute count.[18]

With every decision, the engineers intended to reduce the time required to produce a car. By 1913 much had already been achieved. As

Arnold and Faurote wrote "it is of record that in the old Piquette Avenue days, previous to the time when any attempts at Ford shops systematization were made and chaos reigned supreme, the first systematizer found that Ford [engine] travelled no less than 4,000 feet in course of finishing, a distance now reduced to about 334."[19] This was achieved even before the moving line system had been perfected.

The engineers first changed the position of machines on the shop floor. They were concerned, in the words of one structural engineer, with the "laying out of the work." Cummings told the society of engineers that layout, so central to the new theories of production, was the most important part of the engineers' work--"to give the greatest economy with the least expenditure of effort."[20]

According to a 1917 article in Automobile Topics, automobile output had been doubled in many plants by rearranging the shop floor and providing an adequate supply of materials "properly timed in their arrival at the machines."[21] But as the Ford Motor Company learned, such rearrangement and timing was no simple task. Nothing short of building the new shop could achieve the desired results in materials handling. Plant rearrangement and mechanization of materials handling dominated the design strategy of the new shop. The company considered those two improvements so important that they guided the planning and design not only of the new shop, but also Ford's next factory, the River Rouge plant.

As important as layout was, it was constrained by the line shafts that distributed mechanical power throughout the plant. Few machines ran on individual motors even as late as 1918. Usually medium sized electric engines provided power for a bank of machines and the troublesome shafting and belting transferred the power to the individual machines. The shafts and belts not only made layout difficult but also created safety problems and generally interfered with movement through the shop floor. In the words of a plant engineer "you had to lay your departments out to utilize the line shaft overhead that drives the machine."[22]

Even though restricted by the use of shafting and belting, layout did much to improve materials transportation through the factory. Continuing the method used in the old shop, engineers placed machines in the new shop as close together as possible to keep necessary transportation between machines to a minimum. But the timing demands of the moving line required more than good plant layout. Mechanized materials handling, the major technological innovation in the new shop, helped to meet the timing needs and represented a major contribution to the development of the rational factory. Materials handling became the key to assuring that mass production would work. The old manual methods of moving parts, materials, and assemblies in process, created so many bottle-necks that the moving line would not have been able to live up to its capabilities.

Most of the handling in the old shop had been manual. That is, laborers moved parts, raw materials, and assemblies in process around the factory; assemblers, as well as other production workers, often had to carry their work from the last worker's station to their own. Manual handling created several problems for mass production. Most important, it was slow and unpredictable. Because it depended on human beings, instead of machines, the movement was not as easy to control as the later mechanized system. It was inefficient because it used so many men whose tasks conceivably could be eliminated. With the moving line, the well-timed and predictable delivery of materials and parts was essential. The assembly lines moved at a certain pace and without a supply of parts the line could not go on. In the new shop most handling was mechanized though some manual handling remained.

In the new shop the cranes were planned as a primary handling source. Railroad cars pulled right into the craneway which, conveniently located between the two factory buildings, allowed the cranes to lift goods from the ground to loading platforms for both buildings. So many platforms jutting out into the craneway from the sides of the buildings that no work station was very far from the materials. This method greatly reduced the amount of slow and troublesome carrying of materials around the factory. However, much of the remaining horizontal transportation--the movement across factory floors as contrasted to vertical movement from one floor to another--still depended on the pushers and shovers to deliver parts and materials to the appropriate work stations but the manual handling merely supplemented the mechanical. During the planning of the new shop, some experts had predicted that manual handling would become almost obsolete with its completion. Though that prediction proved wrong, manual handling was nonetheless greatly reduced.[23]

In addition to the cranes, the new shop made full use of gravity slides, conveyors, and rollways. Conflicting reports about the origin of these moving devices leaves several questions unanswered. It is difficult to date the introduction of gravity slides. David Hounshell argues that neither gravity slides nor conveyors existed in the Ford Motor Company operations before the first experiments with the assembly line in 1913. He bases his argument, in which he disagrees with much previous writing, on an important set of articles written in 1913. The articles, written by Fred Colvin, a knowledgeable industrial journalist, contain no mention of conveyors or gravity slides, though they cover nearly every other important feature of the plant. Hounshell discredits other accounts that are largely based on oral histories done in the 1950s. There is however, another set of interviews from 1926 that were part of an extensive research project known as the Additional Tax Case. The probable accuracy of these interviews is much greater than the 1950 oral histories. Scattered through the 1926 interviews are indications that conveyors and gravity slides did exist before 1913. It is possible that some experimentation with slides and conveyors took place before 1913. But Hounshell is undoubtedly justified in his position that if they were in widespread use in 1913 Colvin would have described them.[24]

Nevertheless, the date of introduction is less important here than the use to which slides and conveyors were put in the new shop. The slides, troughs, and conveyors were the technologies that provided the base on which the new system of materials handling was built. The introduction of each new technology meant less manual handling and more automatic delivery.

Slides, conveyors, and rollways were built in many ways for different jobs. They varied in shape, length, width, and function. A slide might carry a finished piece just a few feet to the inspector or it might be twenty feet long and hold the work of several men. Some slides carried work from one man to another; some moved work to the next work area, sometimes even to the next floor. Conveyor belts brought work to the worker and took it away. (illustrations)

Ford engineers eagerly employed conveyors and moving overhead lines to move parts and materials as they made every effort to rationalize materials handling. The Ford Motor Company's position in the early debate about conveyors was clear. Ford engineers stood strongly behind the position that "conveyors should be installed wherever they will displace enough hand labor to pay for the investment."[25] Ford engineers clearly believed that they met that criterion. The in-house publication Ford Industries reported that "the day the first big conveyor went into operation seventy men were released by the transportation department for other work."[26] Other companies, less convinced of the utility of conveyors, argued that "in many cases material can be conveyed in crates or boxes on trucks and elevators with great economy." "In general, the critics argued, "the efficiency of conveyors is apt to be overstated."[27] The critics were proven wrong as company after company adopted conveyors, and production in most enterprises underwent transformation similar to that in the Ford Motor Company.

Moving conveyor belts constituted an important part of the company's new plan to rationalize production. In 1914 when the new shop was finished Ford engineers knew that the moving conveyor would become one of the most important time saving tools in the factory. Several years later, a company spokesman wrote that:

> conveyors on which assembly or other work is done are carefully timed to insure an even output and thus act as a governor on the rate of production. The rate of speed at which they move is the result of a careful time study of each operation which determines the rate at which any piece of work should be done without crowding men or machines beyond their efficient capacity. To have them move too slowly is sheer waste.

> Correct timing conserves the energy of the men by holding them at a uniform pace without allowing them to exceed it. It results in a better and more uniform quality of workmanship and also enables the company to determine with accuracy the number of hours of labor that go into each car and every part. This permits the factory to figure its production requirements months in advance and to regulate the flow of raw materials through the plant in such a manner that there is neither a shortage nor a surplus.[28]

Not all auto companies, however, immediately adopted the moving assembly line. In 1916, three years after Ford announced successful experiments with the moving assembly line and after production rates in many companies had soared with the widespread use of the moving line, at least two prominent companies continued to use group assembly. The companies, Cadillac and Chalmers, continued with the old methods perhaps because they competed only on quality of product rather than price. They too, however, eventually turned to the moving line.

Even with all of the mechanical handling devices, much manual handling remained. At the new shop, pushers and shovers continued to deliver parts and materials to the individual stations employing the standard loading boxes described in chapter four. Boxes of parts were placed along the lines for both easy access by the worker and easy view of the foreman who had to ensure a constant supply of parts.

Like other changes in the Ford factories, mechanization of handling would speed up delivery of materials, in addition to exerting new control over work. Mechanization of handling differed from mechanization of other jobs. When engineers mechanized the jobs of skilled machinists they created an entirely new job that an unskilled person with no experience could perform. The job became standardized and very controllable. Mechanizing handling eliminated many jobs, but the remaining transport jobs were unchanged. Those jobs continued to be difficult to standardize and control to the extent that the company viewed desirable. Though materials handling was an unskilled job, its mechanization and standardization became important to the success of Fordism.

Though considered one of the first of the rational factories, Highland Park's new shop operated under the constraints of two related and obvious holdovers from earlier factory plans--the six-story buildings rather than a single-story building and the use of group driven machines instead of individual motor drives.

Why did Ford's engineers build a six-story building at a time when many engineers and industrial architects advocated single-story buildings for low building costs and production efficiency? In 1914, mechanized materials handling was still in its infancy; with conveyors in the early stages of innovation their potential was still uncertain. It was safer, therefore, to expect any one conveyor to move materials and assemblies a few hundred feet at most. If the Highland Park plant had been spread out on one floor the building would have extended thousands of feet in each direction. Early conveyors did not have the capacity to cover such distances. At the same time, elevators and craneways were designed for vertical movement, they were fast, efficient, and reliable. Thus, the six-story building was perfect for mechanized handling as it existed in 1914.

It seems that Ford's plant engineers continued to think about power and power transmission in an uncharacteristically old-fashioned way. At a time when many companies were moving to individual drive machines that eliminated shafts and belting, the Ford Motor Company continued to use the group drive principle that perpetuated the use of shafts and belting. This adherence to obsolete ideas about power might help to explain the continued use of the six-story building design. In earlier periods when a factory ran off water or steam power, a tall, narrow building was best for efficient mechanical power distribution.

Work in the Rational Factory

Rationalization changed almost everything in the factory. Work in Highland Park no longer resembled any other experience in a worker's life. Once the beginning bell rang, work took on an unnatural regularity. The assembly line required absolute conformity and workers essentially became like one of the machines. The worker made no decisions and was discouraged from thinking about how to do his job. Company hiring policy continued to favor workers with no previous exerience. Ford and his engineers seemed to believe that the perfect worker would be as obedient as the machines.

In writing about efforts to introduce Taylorism in Watertown Arsenal in 1908, Hugh Aitken described rationalized production as consisting of more than merely technological innovations. The factory represented an organization with established hierarchies, patterns of behavior, and systems of control, and introducing Taylorism in Watertown Arsenal necessitated widespread changes in the old patterns; "there in microcosm were all the stresses of an industrial society exposed to constant revolution in technology and organization."[29] Aitken's observation is as pertinent to the transformation of the auto industry with the coming of Fordism as it was to the arsenal a few years earlier. However, unlike the arsenal where worker opposition to Taylorism resulted in the congressional ban of time study from companies holding Army contracts, Ford workers had no channels for complaint and had little choice but to cooperate with the new methods or find another job.[30]

The advances made in rationalizing production in Ford's new shop had significant consequences for workers in the factory. Many of the changes began in the old shop and progressed quickly in the new shop. The most obvious and startling change in the entire factory was speed. Not only the speed of the assembly line, but the speed of every moving person or object in the plant. When workers moved from one place to another, they were instructed to move fast. Laborers who moved parts were ordered to go faster. And every worker on a sub-assembly line worked as fast as the line dictated. The Ford factory combined scientific management with a finely tuned machine. Not only were workers expected to produce at a certain rate in order to earn a day's wages, they had no choice but to work at the pace dictated by the machine.

All of these changes in the factory did more than solve the engineering problems of materials handling, they also had a substantial and significant influence on the workers. Each new factory building increasingly embodied modern ideas about production and the concomittant concerns with management procedures and control of workers. Through a new concern about plant layout, the closer placement and specialization of machines meant that the men had little discretionary time. Earlier, when they assembled automobiles at their own benches, workers controlled their own speed and could linger over a particular operation. In the modern factory, the new layout eliminated the last vestiges of autonomy and independence in their work. As one worker in Ford's Chicago plant described his work:

> Along with [the assembly line] was the other bad treatment and the fear psychoses which was developed. I worked, for example, about 40 to 50 feet from a water fountain and during the summer you would work 8:00 to noon and 12:30 to 4:30 and never be able to get over this 40 to 50 feet to get a drink of water. If you did the assembly line would move so fast you would be behind and it would be impossible to catch up. I have seen people go to the washroom and get fired when they came back because their job was behind.31

Individual workers complained about the speed, and unions (though there was no strong union in the industry in the 1910s) defended the rights of workers to control their own work. The protest over speed arose from several quarters. The most straightforward was the harsh effect of the production speed on workers' health. A nervous condition dubbed "Forditis" was attributed to the constant pressure to keep up with the pace of the line.[32] Workers' wives even complained to the company that their husbands were overworked and physically exhausted after a day's labor.

Speed of the line was connected with other changes in the actual work performed in the plant. Rationalizing the new shop required fundamental changes in the role of workers in the plant. "Workers by millions in mills and factories are being shaped to meet the demands of these rigid machines," wrote Charles Reitell.[32] Jobs that had once required the skills of an experienced mechanic could now be performed by any one of the new "specialists." Specialists were machine tenders who knew how to perform one operation on a machine with a specialized jig. The jobs required no previous experience and a new worker could typically learn the job in less than one day. According to a 1917 survey, by the that year over fifty-five percent of Ford's workforce were specialists. Assemblers, a second semi-skilled position, made up most of the balance of the productive work force. Stephen Meyer has described the two deskilled jobs as the "foundations of the automobile industry," representative of "the new type of worker in industry."[51]

The new jobs demanded no mental activity from the worker. In fact, the less thinking workers did the better Ford liked it. Instead, the new work required manual dexterity, alertness, watchfulness, rhythmic and monotonous activies, coupled with a lessening of much of the older physical requirements[35] rather than a knowledge of machines and the experience of earlier workers. Agility and quickness in handling parts, both large and small, became the definition of skill.[36] The shift away from skilled jobs, of course, led to the decline in numbers of skilled workers in the factory. Though some of the skilled workers remained in capacities such as designing machines and fixtures, most left and some accepted demotion to specialist. The new skill requirements, or lack thereof, also led to a preference for younger workers. Young men could perform the new operations better than old ones. In the earlier factory young men had to serve years as apprentices and older men were valued for their experience. The rational factory reversed the situation. For the most part, jobs in the rationalized auto factory had been transformed from skilled, semi-skilled, and unskilled to the technical jobs (design, planning, scheduling, and routing), the supervisors (clerks, inspectors, foremen), and machine tenders. The automatic machinery and mechanized handling equipment leveled wages by eliminating the highest and lowest paid workers.

Rationalization also affected the make-up of the work force. As skilled workers left the company unskilled immigrants usually replaced them. One supervisor later recalled having men of fourteen different nationalities in one department.[37] Turnover became one of the company's most significant problems. In the rational factory labor turnover increased rapidly. (As noted earlier turnover reached almost 400 percent at Ford in 1913) The inventions that allowed inexperienced workers to build cars also allowed them to change jobs as often as they liked.[38] Though turnover created disruption, the company never worried about finding enough workers to operate the machines. David Montgomery has suggested that the jobless became "an indispensable part of rationalized industry,"[39] thus keeping an ever-ready supply of workers outside the factory gates.

In the rational factory, Ford's engineers eroded the control once held by skilled workers by virtue of their knowledge and experience. Ford simplified each job so that any man off the street could replace the skilled man. With a large labor pool at the company's door few single workers risked opposing the system. In such a factory, close supervision was absolutely essential for work to proceed as expected, for workers had no personal incentive to get work done. The factory was now filled with workers without a tradition of craftsmanship. They worked for money only.

Workers tried to assert some personal control in the rational factory in two ways. Borrowing from earlier days, they continued with soldiering practices to slow down production. This became more and more difficult as it became easier to identify the source of slow-downs. Slow-downs had to be planned and executed more carefully than ever before.

More important was the second method--unionization. Early efforts to organize the auto industry met with repeated difficulties. Disputes over jurisdiction characterized much of the early history. Growing from similar problems in the carriage industry, individual craft unions (e.g. painters, carpenters, etc.) competed with the Carriage Workers who represented all workers in the industry.

These fights intensified in the young auto industry in the battles between the AFL and CIO. But even when jurisdictional agreements were settled the UAW faced trouble with the character of the rational factory. The rational factory contained an ironic twist in the relationship between the union and the company. On one hand it was easy for a small group of workers to stop the flow of production through much of the plant because of the interconnectedness of each process. On the other hand, the very large plants of unskilled and semi-skilled workers were hard to organize: the workers had no craft tradition to tie them together and communication between departments proved difficult.

As production was rationalized the need grew for careful supervision of workers and for the final checking of pieces. "In the new Ford plant," writes Stephen Meyer, "the foreman's duties were more circumscribed and he had assistant foremen, sub-foremen (straw bosses), clerks, inspectors, and others to assist him."[40] The new system required the keeping of vastly increased records, resulting in the employment of many clerks.

As productive work was made more tedious, close supervision became necessary to assure any quality control. In one way the foreman's job became easier. The new jobs meant that workers had no reason to wander around the shop floor. Because the jobs allowed no worker judgement the foreman could "easily detect 'work' activities not necessary to the business at hand."[41] Likewise foremen from other departments could monitor movement through the factory because he would know whether or not a worker had reason to be in a particular place.

The new management system resulted in a reduction in the foreman's power. Like the guidelines of Taylorism, the individual foreman in the Ford factory could not hire or fire workers, nor could he assign work. These functions were moved to the planning department to be performed by someone with a broad view of the entire factory. Departments were no longer the province of the foreman. Much of his job--decision making about to get production out--was usurped by engineers in the planning department. Thus, he lost status as he lost power to make decisions and became just another worker. His job was reduced to enforcing speed and quality of production.[42]

Rationalization instilled in managers the confidence that a certain number of cars could be produced every day. The moving assembly line gave the production department the capability "to say how many cars it can build in a given time, for it knows how fast the conveyor chain moves, and how many chassis can be put on the track."[43] It also measured labor effort measurable.

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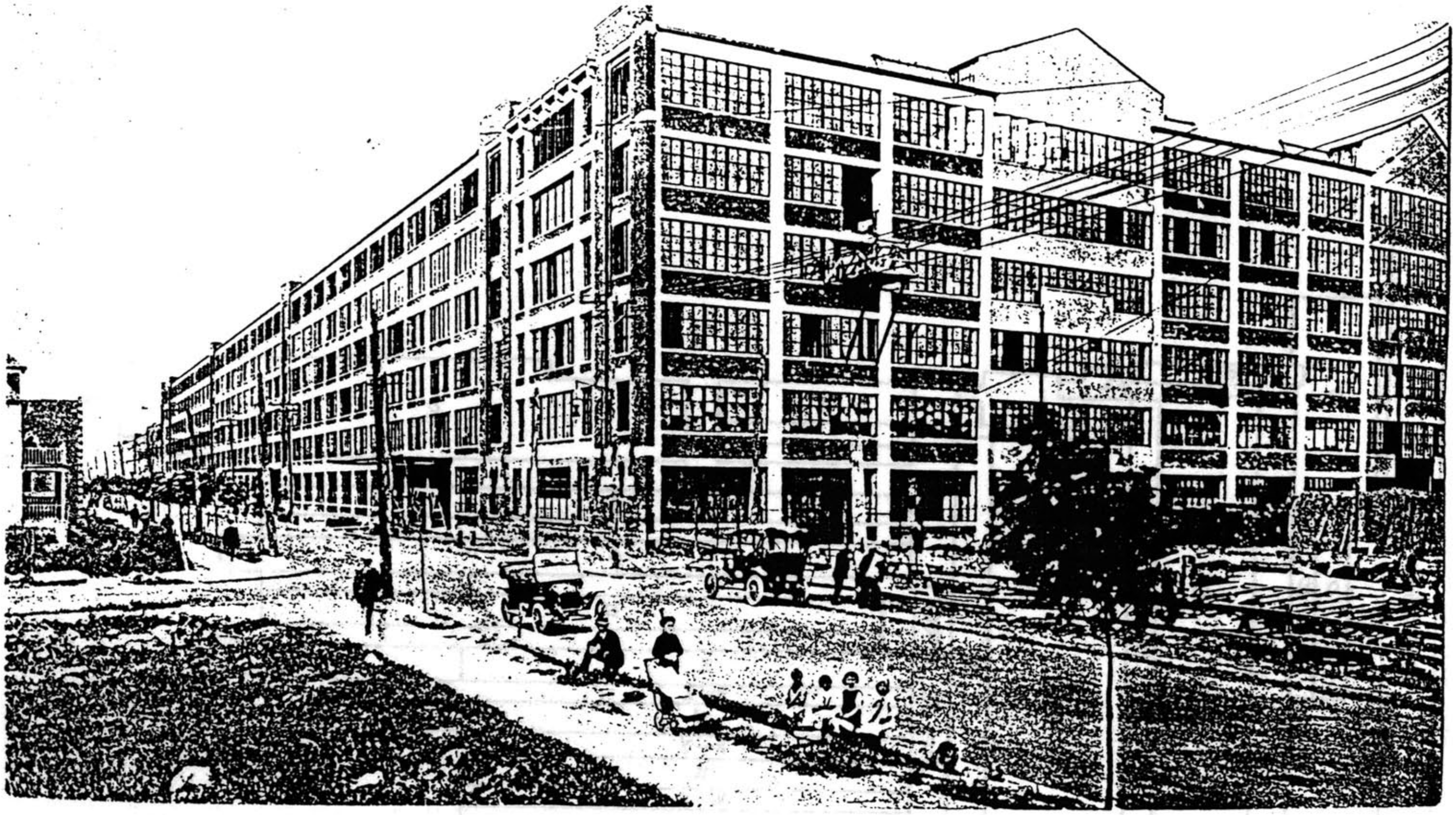
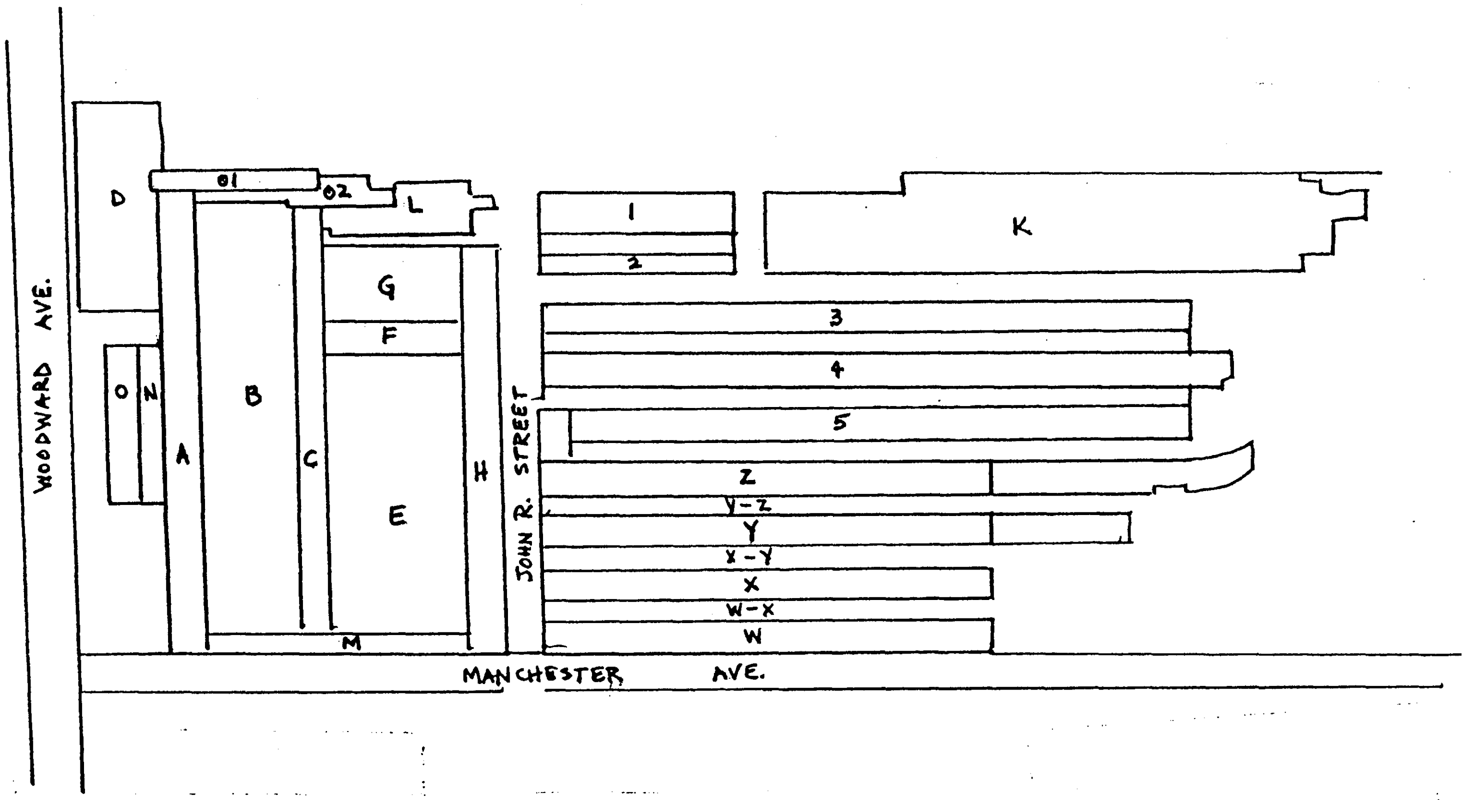
Construction at Highland Park continued through the 1930s as operations were added and production expanded. It seemed that the Ford Motor Company had an insatiable need for space. Only a year after the company moved into the new shop one report read that "some of the buildings are now overcrowded and will, in the course of another year, need additions, mostly on account of the heavy increase of service work."[44]

Highland Park's new shop provides a good example of the changes taking place in factory design and construction. Twentieth century mass production methods presented a new set of problems for the manufacturer, the architect, and the engineer. Greater volumes of production required larger spaces than ever before, new machines were heavier and, when in operation, set up a steady vibration which could prove hazardous to the building and to the worker. Perhaps most important was the increasing dedication to the modern production ideal--to produce large quantities quickly.



Highland Park's New Shop seen from rear of building. From FMC Archives.

The New Shop's craneway. From FMC Archives

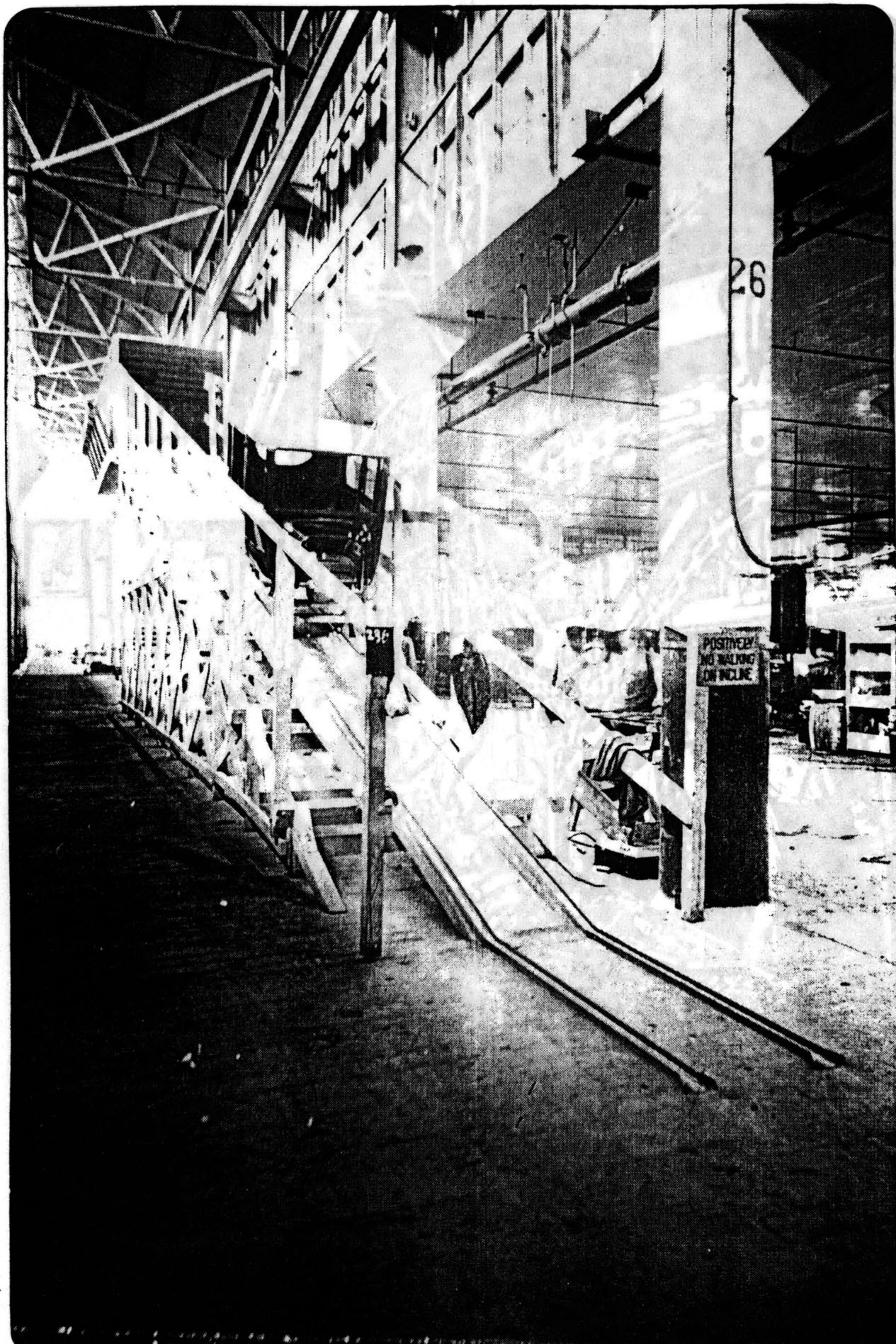


A. 4-story Factory Bldg
B. 1-story Machine Shop
C. 1-story Craneway
D. 5-story Power House
E. 1-story Machine Shop
F. 1-story Craneway
H. 4-story Factory Bldg
K. Foundry

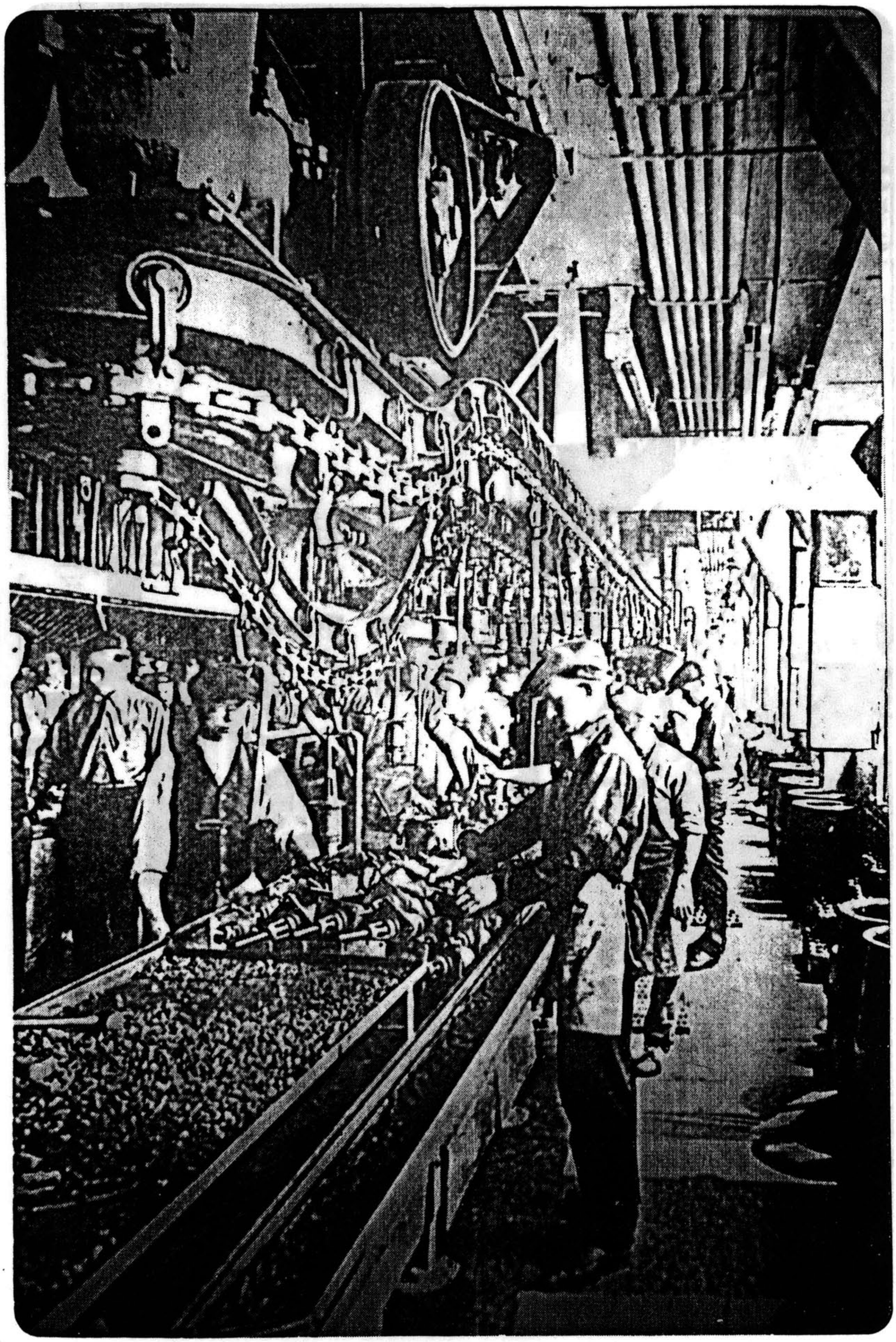
L. Gas Producer and Refrig. Plant
M. 4-story Factory Bldg
N. Garage
O. 4-story Admin Bldg
W,X,Y,Z. 6-story Factory Bldg
W-X,X-Y,Y-Z, 6-story Craneway
01.Coal Bunker & Conveyor

02. Unloading Dock
1. Heat Treat Bldg
2. Heat Treat Bldg
3. Forge Shop
4. Forge Shop
5. Factory & Storeroom (1-story)

Diagram of the Highland Park including the New Shop buildings, taken from plans in Insurance Appraisal, FMC Archives.



Model T body on slide in craneway area in the New Shop. FMC Archives.



Overhead conveyors in the New Shop. From FMC Archives.

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Chapter Five

Experiment in Industrial Control: Ford's River Rouge Plant from 1919 to 1935

> The experienced observer [sees each Rouge operation as] part of a huge machine--he sees each unit as a carefully designed gear which meshes with other gears and operates in synchronism with them, the whole forming one huge, perfectly-timed, smoothly operating industrial machine of almost unbelievable efficiency.1

Ford and his engineers believed that the River Rouge plant would be the perfect industrial machine. It would, they believed, overcome the limitations of the Highland Park plant, particularly the latter's inconvenient transportation facilities and lack of space for expansion. Highland Park, though as modern and efficient as any factory of the day, simply could not satisfy Ford's plans for expansion. The auto industry had grown at a phenomenal pace and technological change created new possibilities for fast, high volume production. The industry, and especially Ford, was responsible for introducing mass production and the assembly line, dramatically changing the way work was done in the factory. Ford's River Rouge plant would reflect the industry's unprecedented growth and change.

The Rouge River is connected to Lake Michigan by the Detroit River. In 1915 when Henry Ford bought the site, undeveloped land lay on either side of th river much of which had been farm land. The Dearborn area by 1920, however, began to experience the suburbanization process. Suburbs--both anglo-American and immigrant--surrounded the plant site; the proximity of a potential work force enhanced the desirability of the site for Ford.

Though the basic Ford manufacturing idea of bringing the work to the man and machine was developed at Highland Park, the plant depended on an insecure foundation--that iron and steel must come in from outside. Because of its inland location the plant was inland it depended solely on rail transportation which slowed down delivery of the materials. Residential and commercial activities had built up during the 1920s, thus surrounding the Ford plant, limiting available land for expansion.[2] Consequently, the company had little choice but to relocate in order to carry out planned expansion.

Not long after Highland Park's new shop construction began in 1914, the Ford Motor Company purchased more than 600 acres (shortly thereafter increased to over 1000) on the Rouge River. Henry Ford had personally bought several thousand acres a few years earlier. He sold it to the company in 1916. Ford envisioned a new kind of factory on the banks of the Rouge. It would not only be a large suburban factory, its buildings and their arrangement would also be unlike other factories. When completed, even the casual observer could see that the River Rouge plant was different, because of its size and many diveerse operations it looked more like an industrial city than a factory. The plant covered an area so great that by the 1950s it had an internal set of roads nearly 80 miles long and over 100 miles of railroad track for carrying parts and materials between buildings, enhancing the image of an industrial city.[3]

Another metaphor--the fortress or walled city--befits the Rouge. The plant is almost impenetrable, bounded on two sides by railroad tracks on the third side by the river. The plant is completely fenced on all of its landward sides. According to a company memo "all entrances to the main part of the Rouge are guarded when they are open and traffice is restricted to authorized vehicles and pedestrians.

There is also a fence between the Fordson yard and the parking lots and bus terminals no the east side of Miller Road and a guarded pedestrian overpass to the main part of the Rouge from the parking lots across Miler Road. There are other fences within the main part of the Rouge restricting pedestrians and vehicles to the use of guarded gates.[4]

The Rouge is located in an industrial suburb very different from the Highland Park community. On the streets surrounding the Highland Park plant one would have found a lively commercial area along with dense urban residential neighborhoods. The area, in Sam Bass Warner's terms, was a walking neighborhood. Employees walked to work in Highland Park and any pedestrian had easy access to the plant whose gates whose gats opened right onto the sidewalk. This created a closeness between the residents and the plant that disappeared in later factories. One notable example of the effect of Highland Park's location involved union organizing efforts. In 1913, when IWW members began efforts to organize the plant, Ford workers listened to union speeches outside during their lunch break. When police dispersed the unionists from Ford's gates they merely relocated down the block in an empty lot. This kind of contact was nearly impossible at the Rouge.[5]

The vast differences between the two plants is also apparent in comparisons of the power houses--a symbol of progress and strength. Highland Park's power house had been built as a showplace. Not only did the stacks hold up the FORD logo but the building's location beside a sidewalk on a busy street invited passersby to admire the sparkling generators and beautiful tiles and fittings of the powerhouse. The Rouge's power house with far greater capacity than its predecessor, was just another one of the plant's buildings. The eight stacks must have symbolized the plant's importance to visitors but it did not support the company name. In fact the Rouge could be identified by the uninitiated only by a sign at the gate that prevented visitors from freely entering the grounds. Perhaps Ford presumed that everyone would know the identity of the huge plant along the Rouge River, or perhaps by 1920 he did not care as much about advertising.

World War I and the B Building

Ford and his engineers decided on the Rouge site as a solution to several problems facing the growing company--water transportation through the Great Lakes would reduce high shipping costs and make delivery of raw materials more efficient, the Rouge River would provide water necessary for proposed materials processing plants, and the site was large enough for tremendous expansion.

The River Rouge plant became the largest factory in the world and one of the most expensive industrial experiments of all times. The location and design decisions were clearly motivated by technological and economic concerns and the size of the plant reveals the administrative decision to increase centralization efforts. Henry Ford also looked at Dearborn as a community where he could exercise more influence than he had in Highland Park. Ford and the company bought huge tracts of land in Dearborn, land that eventually became sites for additional company facilities, the Edison Institute, Henry Ford hospital, and Dearborn Inn. The company also made plans for worker housing in Dearborn but the plans were never carried out. Dearborn essentially became a Ford town.(see David Lewis)

The Rouge land was cheap, according to Charles Sorensen, Henry Ford paid $700,000 for the whole site[6]; I have not been able to verify this through archival records] because the land was swampy and the river at that point was too shallow to be very useful to major transportation.

All accounts of the beginnings of the Rouge plant date the land purchase at 1915. However, the Company's corporate papers contain no mention of the purchase until November 2, 1916.[7] Two reports dated November 13, 1916 cast doubt on the 1915 date as they compare the desirability of the Rouge site over one on the Detroit river. The reports by William B. Mayo, one of the company's main engineers, and Julian Kennedy, the Pittsburgh engineer who would design the plant's blast furnaces, both recommended that the company choose the Rouge River location for the site of the new plant. The reports reveal some of the thoughts about the company's plans and also more general ideas of good industrial planning. They suggest that no final decision had yet been made regarding the land purchase. One wonders, however, how opern the engineers really were to other sites considering Henry Ford's large holdings on the Rouge River.

Mayo wrote that "strictly from an engineering point of view" the Detroit River location would have slight advantages for a blast furnace but that taken as a whole the River Rouge site had many more advantages. He stated the reasons for seeking a new site. In order to construct a

> blast furnace, with connecting foundry, steel plant, and motor manufacturing plant that would be different and better than any existing plant of a similar kind and to be of such highly specialized construction to be more economical than anything yet devised, and to this end it was necessary to pick out a location that would embrace all the necessary essentials from both the civic and the engineering viewpoint and, in addition, be so located as to have easy connection with the existing plant at

Highland Park."[8]

Kennedy's report supported Mayo's. He also believed the Rouge location to be the largest convenient site near Detroit. Speaking as an expert he explained that "it has been the universal experience of successful iron and steel works that sites which are thought to be extremely ample at the outset are found in a few years, to be entirely inadequate and more land has to be acquired...so that the only safe way is to start with an acreage which seems absurdly large."[9]

Mayo wrote with enthusiasm about the Rouge site. In addition to its suitability for blast furnaces, he believed that the site would allow easy access for the delivery of raw materials. He also pointed out the convenience of the location for workers, and the site's proximity to "the largest labor sections in the City of Detroit." One of the most interesting of Mayo's arguments in favor of the site discusses the image of the new plant. Because of the "very large number of visitors" it was important to pay attention to "how well everything is done and as to its cleanliness and sanitary standards...that of all other things the location should be such that as near as possible a spotless town appearance could be attained both in regards to the plant and to its surroundings, with a country-like atmosphere and yet close to the city." In his report Mayo seemed able to capture the plant's future greatness.

Even though the Ford Motor Company was one of the fastest growing companies in America, Mayo's enthusiasm for the new industrial village undoubtedly stemmed in part from the very favorable business climate in the years before the U.S entry into World War I. The mid 1910s were profitable years and brought significant growth to American industry.

The decline in European manufacturing improved the commercial markets in the U.S. and abroad. Not only did American goods enjoy the absence of European competition, but many American industries produced directly for the war effort. As David Kennedy has written, "in war and in peace [businessmen] pressed their oportunities."[10] In addition to the built-in advantages of a war overseas, business prosperred from the pro-business policies of the Wilson administration. The prospects of the booming war economy must have had some influence on Ford's decision to buy a piece of land as large as the River Rouge site.

The Rouge site had one expensive problem--the river at that point was too shallow for freight ships. In December 1916, presumably at the behest of the Ford Motor Company, the Army Corps of Engineers wrote the first of several reports on "improving" the Rouge River. Major H. Burgess of the Corps reported that inquiries to owners of Rouge River property had been made and a public hearing held to obtain the views of all interested parties. "The result of the inquires," wrote Burgess, "has been to develop the fact that the demand for further improvement of the River Rouge is due primarily to the location of a large industrial plant by the Ford Motor Company." Burgess repeatedly acknowledged that the real beneficiary of the Corps' work on the river would be the Ford Motor Company but based on older precedents he argued that the improved river would provide a public good. The public benefits would grow from increased employment (the new plant promised to employ at least 15,000), harbor frontage would be increased, the improved river would encourage other industries to locate on the river bank which would, in turn, bring greater commercial activity to the Great Lakes (an estimated increase of 30,000,000 tons), the increase of freight traffic would be of general benefit to the city, and the turning (to be constructed by private concerns) would be open to the public. Burgess clearly supported the Corps' involvement with Rouge improvements. At one point in his report he writes what sounds like a justification to anticipated criticism of his recommendation.

> It has not been the practice of the Government to assist in the construction of private slips, but it is believed that the conversion of the Rouge River into a slip will be of sufficient general benefit to cause it to be considered differently from other dock improvements. It is understood that in the past it has been considered proper to add to the harbor frontage of important cities at the expense of the General Government.[11]

The division engineer opposed the improvement, arguing that the proposal work would be "in the interests of one company and not worthy of being undertaken by the United States."[12] Nevertheless, an agreement was reached in which the Corps of Engineers would widen the channel from an irregular width ranging from 300 feet to 175 feet to an even width of 200 feet and dredge it to a depth of 21 feet, as well as assuming responsibility for yearly maintenance. The estimated cost was $495,000 plus $5,000 yearly for maintanance. In turn, the Rouge River property owners, namely Ford, would donate land needed for widening and build the turning basin that would allow the large ships to turn around for their return trip to the Great Lakes.

Work began at the Rouge in 1917 with installation of cranes, digging of a well for the blast furnace, and the beginning of the blast furnace construction. In 1918 plant construction experienced a surge when the United States Navy contracted with the Ford Motor Company to build Eagle boats for the World War. The boats were needed after President Wilson declared the end of American neutrality in the war. Henry Ford promised to build 112 submarine chasers within a year and he believed that he could build them as fast as he did Model Ts. Ford's proposal was unique in the ship building world for no one had ever tried to build ships using mass production. Ultimately, the attempt failed.[13]

In December 1917 Henry Ford wrote to Josephus Daniels, Secretary of the Navy making an unsolicited bid to build the Eagle boats. Ford's letter contained three promises that would later cause him trouble. First, he stated confidently that his workers could easily be trained to build boats; second, that he would build the boats at an almost completed plant in Newark, New Jersey; and third, that he would accept no profits from the work.[14]

Instead of using the New Jersey plant, Ford ordered the construction of a new building on the Rouge River site and billed the government $3,500,000 for it. Six months after the signing of the original contract a second contract was drawn up allowing the company to build a second plant at Kearny, New Jersey at a cost of $2,500,000, to be paid by the government. In addition to the buildings, many other plant improvements were charged to the Navy account, such as roads, railroad tracks, and sewage systems. The total bill came to about $10,000,000.[15]

The timing of the Eagle contract proved suspiciously convenient to Ford in light of the events of the previous year. In 1916 John and Horace Dodge filed suit against the Ford Motor Company and Henry Ford accusing Ford of using stockholders' dividends to expand the plant and to lower the price of the Model T. The suit asked that "the defendants distribute as dividends 75 percent of the company's cash surplus, or about $39,000,000."[16] In October 1917, the minority stockholders obtained a restraining order to keep the company from continuing expansion at the Rouge site and thereby spending the contested money.

The Dodge Brothers accused Henry Ford of deliberately witholding dividends and of using the money to create a monopoly on cheap cars. Though they did not explicitly argue that he wanted to hurt the Dodge Brothers Company commercially, the implication was clear.[17]

Less than two months after the issuance of the restraining order Henry Ford wrote to Daniels with his offer to build Eagle boats. Ford surely hoped that a government contract would help him to win the case, and at the very least, to nullify the restraining order. Ford and Daniels reached an informal agreement before the official contract was signed in March 1918. The government contract gave Ford the wherewithal he needed to begin plans for the new plant. The Navy would pay for the new plant, but moreover, Ford could argue that the war effort needed the new plant, thereby circumventing the restraining order. Though the order was lifted several months later, the Navy contract allowed Ford to metaphorically snub his nose at the Dodge brothers and the courts and proceed as planned with the new factory. Even without the Eagle contract the company would have built the plant but the timing gave Ford a symbolic victory plus the advantage of beginning construction while under the restraining order.

The government contract also helped the company's financial situation. The court ruled in favor of the Dodge brothers, in February 1919 the Michigan Supreme Court handed down a decision that the company owed its stockholders $19,000,000 plus interest.[18] Only$1,900,000 went to outside owners since Henry Ford owned most of the stock. But the situation angered Ford enough that he decided to buy out all of the other stockholders to ensure that they could never again keep him from reinvesting the company's profits. The buyout cost him $105,000,000.

Not even Henry Ford had that amount of cash on hand. He borrowed $60,000,000 and the company liquidated as much of its inventory as possible.[19] Without the buyout the Rouge might never have become what it was, for undoubtedly the stockholders would have continued to object to the reinvestment of profits into the plant.

In the end the United States had paid for the beginnings of the River Rouge plant and had allowed Ford to accumulate a work force that was then in place to begin work in the new auto factory.

Construction on the plant's first factory building, the "B Building" (presumably short for Boat Building) reached completion in 1919. One of the largest factory buildings built by that time, it measured 1700 by 300 feet, almost the size of twelve football fields. Constantly improving construction technologies enabled industrial engineers to design larger and larger building. New management skills along with the rapid advancements in materials handling made efficient operations possible in such a large building. Like the Highland Park plant, the building's walls had large window areas, a feature that continued in plant design through the 1920s (illust). Unlike any of Ford's earlier factories, the building was designed to stand separate from all subsequent buildings at the Rouge plant.

Construction of the B building signaled the break from the traditional mill design. Though in planning the new shop, Ford engineers had abandoned traditional layout patterns and introduced revolutionary materials handling devices, in the end the actual buildings only thinly disguised the classic dimensions and appearance of the mill building.

Though the B building retained the basic, rectangular shape of the textile mill, its dimensions make any such comparison superficial. With the old technological constraints gone, industrial engineers took advantage of new freedoms to build factories to fit production processes rather than building technologies. The creation of a new model factory proved a slow process, however, and one sees the gradual transition from mill building to modern factory at the Rouge plant. The B building is clearly represented the beginning of that process where the mill building was stretched out far beyond the imagination of the early mill builders while maintaining its multiple stories.

Because the B building's original function was ship fabrication, the three story interior was open with no floors, to allow the ship to pass through the building. An Engineering News-Record article[20] explained that the original building design created problems. "The buildings were designed before the manufacturing method fully evolved, and subsequently it was found that some different set-ups might have been employed to a greater advantage. Initially the company took the view that continuous conveyor-assembly production could be applied to ship building. Further study showed that this was not practicable...Step by step movement was installed instead." Charles Sorensen explained in his autobiography that the building was really designed for the ultimate plan of auto manufacturing and assembly.[21]

Post-War Activities

The last Eagle boat left the B Building on September 3, 1919.[22] As the final boat moved through the building in the process of completion, workmen rebuilt the building behind it. The Ford Man reported that "as [the boats] are moved down the line from operation to operation, the installation of equipment for the building of Ford [Model T] bodies is taking place. Already the first three operations in the north end of the building are being transformed from a boat to a body building institution.[23] According to William Pioch, the chief tool designer, "the first, second, and third floors were added after the Eagle boats went out. There were three lines going down through there for the boats. We kept the middle line open as a crane bay and the two slides were filled up with floors."[24] The company predicted that over 4,000 bodies would be produced daily to supply to the Highland Park plant. Body manufacturing, previously done by Fisher Body and O.I. Beaudetter of Detroit, was the first step toward the company's goal of integrated self-contained production.[25] A few years later the B Building also housed production of Fordson tractors.

The company wasted no time in moving from war-time to peace-time production. In 1919, several operations began--Model T body production, the coke ovens were started, the saw mills cut their first wood.

At first, the company planned to make iron for the castings used in the Model T. The blast furnaces were one of the original reasons given for the decision to expand to another site. Ford's engineers explained that the Highland Park plant was not only too small for two furnaces, but that a large amount of water would be needed, which was not available at the Highland Park plant.

Blast furnaces were especially important to the company for production of the T's single-cast engine block. In writing about the T, Michael Mahoney pointed out the irony of Ford's method of engine fabrication. Casting rather than forging the engine resulted in a product less refined, though more serviceable than those of other cars. Mahoney argues that one might expect the cruder cast engine to be less expensive when compared to the more sophisticated, high performance engines. But, to the contrary, the cast engine required a more expensive set-up. Casting required a foundry rather than a machine shop and a stamping press and annealing furnace rather than a blacksmith and forge.[26] Thus, in this case at least, the cheaper the car, the more expensive the factory. The new blast furnaces would make the production of iron and the cast engine blocks faster and cheaper.

The first blast furnace began making iron in 1920 and it did not take long before management realized that a steel mill would be an important addition to the company's works. Charles Sorensen, who became Henry Ford's right hand man, wrote that the company sold scrap iron for $8 a ton and spent more than that in handling it. The scrap iron could feasibly go right into a steel mill saving money in several ways. But to Ford, the ability to control his own supply of steel was even more important than saving a few dollars on scrap iron.[27] The ability to produce steel became especially important after the war when steel was scarce and auto companies competed for the available stock. As usual Ford did not play exactly the same game as everybody else. Instead of trying to outmanuever other companies for the available steel, he simply built his own steel mill.

The blast furnaces and steel mill represented only the beginnings of the vast Rouge processing facilities. Over the next five years, from 1917 to 1922, the company built several more processing plants. These included a glass plant, a paper mill, a cement plant, a rubber plant, a leather plant, and a textile mill. Ford took a radical step when he decided to incorporate materials processing into the production operations. But the next decision was even more unconventional--the acquisition of coal fields, forests, and rubber plantations to provide every raw material that went into the Model T.

In the early 1920s the company acquired close to one million acres of forest in northern Michigan, ore mines in Michigan, coal mines in Kentucky and West Virginia, and a rubber plantation in Brazil.[28] Wood from the forests was turned into Model T bodies. The blast furnace made ore into iron, and coal went into the steel mill. Most exotic of all, Brazilian rubber became tires. The company also experimented with making artificial rubber from soybeans for use in steering wheels.

Behind the decision to invest in materials processing lay Henry Ford's frustration and distrust of suppliers. Undependable suppliers and their costly materials had angered him in the past, and he believed that he could supply and process materials cheaper than he could buy them. Furthermore, by controlling sources, important materials would never be withheld due to shortages or their prices raised.

Control over raw materials added a new dimension to the company. By building processing facilities, and acquiring the sources of the materials, the Ford Motor Company entered its phase as, what David Lewis has called, an industrial empire. With his empire, Ford was fulfilling his dream of the totally self-sufficient plant by adding control over all raw materials and their processing, creating the first integrated automobile company.

Henry Ford's obsession with eliminating unnecessary costs led to campaigns to rid the company of all possible waste. The results showed up in additional materials processing. In order to use the by-products of one process, another was installed. Already mentioned was the slag from the blast furnaces being turned into steel. The scrap from the saw mill and textile mill was turned into cardboard and paper for plant use. And blast furnace slag ended up as cement that the company used for all plant building construction.[29]

Not until 1927, with the introduction of the Model A and the transfer of final assembly to the Rouge, did the plant become the absolute center of Ford Motor Company production. Before 1927 the Rouge was considered primarily as a feeder plant to Highland Park. A 1924 company publication described the Rouge as the plant that "deals primarily in raw materials." (Ford Industries, 1924, p.9)

Corporate Centralization

By building the Rouge plant the company expanded its centralization efforts and added processing facilities that eventually completed the company's vertical integration. The large site attests to Ford's long range plans for centralizing the growing company.

At first glance the company's earlier decisions to establish branch assembly plants might seem to imply an interest in decentralization. The company publication even supports such an idea when, in 1924, an article appeared stating "the Ford policy in general is for the decentralization of industry but River Rouge is an exception."[30] Highland Park produced Model T components and shipped the unassembled pieces to assembly plants around the country. More unassembled cars fit into a railroad car than assembled ones, resulting in dramatic transportation savings. This, however was not real decentralization.

Another experiment that many scholars have mistaken as an attempt at decentralization was the Ford Village Industries. In seventeen villages around Michigan, Henry Ford experimented with small scale manufacturing operations operated by local farmers during the seasons when they could not work their fields. The village industries ranged in size from twelve workers at Nankin Mills to 738 at Ypsilanti.[32] They met varying degrees of success but after Henry Ford died the company discontinued the program, implying that serious cost accounting left the small plants in the red. During Henry Ford's life he refused to discuss the profitability of his experiment.[33]

Though physically decentralized, Ford's supervision made the village industries just another piece of the larger centralized system. Furthermore, the experiment apparently was not part of the company's commercial planning. All evidence suggests that the company considered it a pet project of Ford's and that his death ended the experiment.

With the exception of these examples of physical decentralization, the Ford Motor Company must be considered a highly centralized company. To see how centralized it was, one can compare the company to its main competitor, General Motors. GM and Ford are almost ideal types of opposite business schemes. GM retained the divisions that arose naturally from the purchase of many small companies. For several years the adminstration did not follow the activities of the separate divisions; each set its own price and production policies.[34] Even when the company reorganized in the early 1920s each division remained semi-autonomous, with only decisions like price and model being made by the executive committee.

The differences between the two types of management strategies are apparent in other examples. Ford produced one model aimed at a particular market for eighteen years. When the market forced the company to develop a new model, it produced only one different model. At the same time, GM had several models aimed at a range of markets and the models changed almost yearly.

The men who ran the two companies also differed. Obviously Henry Ford ran the Ford Motor Company with the assistance of a few faithful engineers. Ford insisted that he, himself, be consulted on all decisions of any significance. Whether or not one should actually consult him varied, but more stories are told about erring on the side of not asking him. He knew the industry as well as anyone in the business and he knew his company better than most presidents could know an enterprise of such magnitude. Lastly, after the 1920 buyout, Ford owned virtually all of the stock. Ford's profile provides an almost humorous contrast to the presidents and executive committee of General Motors. After "Willy" Durant left GM in 1920 the successive presidents knew little or nothing about automobile production as Sloan admitted in his memoirs.[35] Instead they were men who knew about business.

To those who view the branch plants and the village industries as decentralizing efforts, the Rouge and the vast investment in centralization are confusing. The Rouge, especially when completed, was the antithesis of decentralization. It would have, in one location, the facilities to process every material and manufacture every component used in an automobile. At the Rouge Henry Ford's dream literally came true--that raw material went in one side of the plant and a complete automobile came out the other.

Though in the end Ford's centralized company would prove the loser and GM the winner, centralization served the Ford Motor Company well in the beginning. Henry Ford quickly discovered that larger is cheaper, and if done right, it is also faster. A master of cost accounting he knew how to use economies of scale. He knew that by shaving a few minutes from an operation he could save a few pennies; the pennies, multiplied by the thousands of cars produced, eventually resulted in great savings. As John Van Deventer, the industrial journalist, wrote, "in an organizaion tuned up to the production pitch of the Ford Motor Company, minutes are measured in terms of thousands of dollars."[36]

Plant Layout and Materials Handling

Contrasted with the company's administration, the physical layout of the Rouge was less centralized than other plants. The multiple story buildings of earlier plants, including Highland Park, had been arranged with adjoining walls, or grouped around a central yard. The layout at the Rouge resembled neither of those models. To the outsider the Rouge must have looked like an almost random placement of huge buildings. The buildings at Highland Park had been placed contiguously to save time and expense of materials handling, a strategy that proved successful in speeding transportation. The arrangement created another problem though, and one not easily solved by technological innovation. The problem was expansion. With buildings so tightly arranged, each department had to be carefully planned and if more machines or operations were added many departments had to be shifted. This became a very time consuming and expensive operation. When planning the Rouge, ease of expansion became a major concern for the engineers in charge of layout. By organizing the plant into distinctly separate buildings they assured the economy and potential of future growth. An editor of Iron Age wrote in 1918 that "[at the Rouge] practically all construction is being laid out with a view of 100% expansion when necessary."[37] Engineers of the Ford Motor Company, more than their counterparts in any other auto company, had reason to believe that the almost absurd amount of space allowed for future expansion was necessary. The enormous size of the Rouge site reflects the fact that the company had grown so much, so fast, that the engineers must have anticipated unlimited growth. One can imagine the thrill felt by Ford's engineers in planning the Rouge. They had the opportunity to expand their success at Highland Park as they developed new ideas on an unprecedented scale. Here was a company with seemingly unlimited capital resources headed by a man willing to try almost any new idea.

Decentralization of the plant layout is also apparent in considering the administration building. The first administrative offices at the Rouge were located in the Wash and Locker Building. Originally planned as a facility for workers to clean-up, Sorensen converted it into office space shortly after the building was completed. From these offices, on the plant site, Sorensen ran the Rouge. In 1928, the year after the introduction of the Model A, when the Rouge became the primary production facility of the company, a new administration building was completed. The new building was located a couple of miles away from the plant. Though not far from the plant "as the crow flies" several sets of railroad tracks and a large parcel of land separated the plant and the administrative building. Of course each manufacturing building continued to have a supervisors office, but the company was run from the new, detached building.

The separation represented several things. Henry Ford increasingly delegated the running of the company to his son, Edsel, and to Charles Sorensen. More importantly, the company's continued expansion required an ever larger administrative and clerical staff for which physically proximaty to the plant was unnecessary. Yet, what was the advantage of placing the administrative offices completely away from the site? The absence of the plant engineering department's records makes it difficult to explain the separation with certainty, but informed conjecture can help. The administrative offices at Highland Park were in a separate building but next to the rest of the plant. Though physically close, the offices and the plant received very different treatment. The administration building, for example, housed the only dining room at Highland Park in addition to the building's beautiful features. And of course, office workers wore white collars rather than blue ones. The buildings reflected the differences between office work and manufacturing. Furthermore, increased labor conflicts by 1926, the year construction began on the adminstration building, increased the inherent tensions. Consequently, Ford probably believed it better to have the offices at a safe distance from the plant. General industrial advice also suggested the separation of the two functions.[39]

Other companies preceded Ford in the separation of administration from manufacturing. The split represented the increasing professionalization of management, the new high leve managers had less to do with the day to day operations of manufacturing. It also reflects the incrasing managerial and clerical staff and the distinction between shop floor managers and business managers. By the 1920s companies like Ford could not survive by simply making a good product. The marketing and financial decisions determined success as often as the manufacturing oerations, and many companies seemed to feel proximity to the rest of the business community more important than closeness to the factory. Consequently, many companies moved their offices even farther from production than Ford. General Motors and Fisher Body both hired Albert Kahn to design elaborate office buildings in Detroit's New Center.[40] The Ford Motor Company subsequently built a new skyscraper to house administrative offices even farther away from the plant than the original building, it does, however, remain in Dearborn.

Like Highland Park, the Rouge had its chroniclers. In 1922 and 1923 the Industrial Management ran a ten part series written by John Van Deventer, entitles "Ford Principles and Practice at River Rouge." He documented nearly every process and building existing at the time. A decade later the editor of Mill and Factory wrote an equally extensive but more superficial series on the plant. Much of the following discussion is taken from those articles.[41]

Construction at the Rouge began with the huge bins for raw materials storage and the travelling bridge cranes that loaded and unloaded the bins.(illust) Work on the first blast furnace also began in 1917. Construction on the materials processing facilities stopped in 1918 when the B Building was started and boat production consumed time and energy allotted to the Rouge for the next year. (The company was involved in more than boat building on behalf of the war effort. The Highland Park plant produced trucks, tanks, and helmets for American and Allied troops.) After the war a building campaign began that did not stop until the mid 1940s, with a brief break in construction during the Depression years. Except for the B Building, all of the buildings during the first few years were constructed for processing raw materials--blast furnace, foundry, cement plant, power house, and by-products building. Many small buildings were constructed as support for the processing plants--breakers building, screening station, pulverizing building, and others.

The huge processing facilities added to the need for a plant layout different from Highland park. They had different requirements, most notably for water and space. Because the processing facilities were the first constructed they helped to establish the pattern for future layout.

When construction finally stopped in the 1940s the Rouge contained almost one hundred separate buildings. These included all of the buildings one would expect to find--press shop, motor building, tool and die shop, steel mill, tire plant, etc.--as well as many that would be surprising to even the experienced engineer--box factory, paper mill, waste heat power plant, benzol lab, and the soy bean extractor building.

The shift to single-story buildings constituted another change in plant planning policy that added to the new layout configuration. By 1922 single-story plants had become at least an unofficial company policy of plant construction. In responding to an inquiry about plant design E.G. Liebold, Henry Ford's secretary, wrote "we find that a one-story building for factory purposes with saw-tooth construction is about the most efficient and obviates elevator service and transferring materials up and down."[42]

The Rouge was by no means the first plant to contain single-story buildings. Many engineers had argued for years for the efficiency and economy of one-story plants. Single-story buildings, they argued cost less to build and provided more flexible manufacturing space. The problem with single-story plants, however, had been the difficulty in finding efficient methods by which to move materials. In the Highland Park plant Ford's engineers had discovered that vertical transportation was easier than horizontal, given the state of mechanical handling knowledge.

The diffuse plant layout and single-story buildings were acceptable to the efficiency minded company only because of the constantly improved system of materials handling. Materials handling developed to new heights at the Rouge. Every department was equipped with mechanical handling devices and every shop and building connected by a network of overhead monorails and conveyors.[43] According to Van Deventer, the development of the Rouge's "integrated manufacturing" depended largely on transportation. Integrated manufacturing, he wrote, "ushers in a new era of mechanical handling, announc[ing] the beginning of the exit from industry of manual lifting and shop pedestrianism, and sounds the death knoll of the wheelbarrow and shovel."[44] The continuous flow that characterized the system eliminated "any possibility of loafing or soldiering on the job when each operator is faced with the necessity of keeping up with the procession or else seeing his stock piled up to a point where it become distinctly noticeable by the immediate management."[45]

The idea of process and transportation provided the key to operations at the Rouge. In preceding decades engineers had improved individual production machines so much that the cost of fabrication became a small part of the total cost of production. "The center of thought in the modern plant is therefore no longer the individual machine but the process," wrote Van Deventer. "The biggest cost savings of today and tomorrow are likely to come from moving rather from making. This is the decade of mechanical transportation."[46]

Engineers at the Rouge designed many different types of materials handling technologies, consisting primarily of expansions on ideas first developed at Highland Park. The moving conveyors, cranes, monorails, railroads of earlier days persisted and were joined by overhead conveyors, the high line and others. The moving conveyor continued to be a prominent feature of the company's operation. (illust) As it was improved and extended to more departments it continued to speed production and eliminate workers just as it had at Highland Park. An unsigned letter to Sorensen in 1929 described the most recent cuts:

> I cabled you today, stating that we had eliminated over 400 men in the B Building, with the installation of various conveyor systems thoughout the different departments. In the torque tube department, the conveyor from the department to the shipping dock, has been completed and is in operation, eliminating 20 men for handling stock. The brake plate conveyor from this department to the loading dock completed, eliminating 80 men. The differential gear case forging balcony and conveyor for same from this department to the dock, has been completed and in operation, eliminating 20 men....In the steel Mill, the front radius rod conveyor has been completed and in operation, eliminating 20 men. The cold heading conveyor for handling cold heading wire and finished parts will be put in operation Monday, 40 men will be eliminated.[47]

At the Rouge, engineers succeeded in almost eliminating hand trucking. Although Barclay lists it as one of many methods still in use in 1936, hand trucking played a small role by then.[48] The transportation around the shop floor, previously done by the hand trucks, was transferred to standard full-size, gas-powered trucks. On the "upper floors of the B building one sees "a truck loaded with tools, jigs, fixtures, or supplies, running along the broad aisles, stopping at certain points to unload goods and at others to pick up materials." Furthermore, the aisles are compared to streets in a "small but busy town."[49]

Overhead conveyors, made possible in the Rouge after the elimination of belting, played the greatest role in eliminating hand trucking. As indicated in chapter four, shop floor layout and movement around the floor was hampered by the belting needed to power the machines. At the Rouge, individual motors provided the power to most machines and group drive powered a few of the smaller machines. By eliminating belting, pulleys, and overhead shafting, plant engineers opened the space above the machines, making the installation of the new conveyors possible.

Overhead conveyors became an important part of the Rouge production system. They maintained a constant supply of parts for the worker, eliminating the necessity of storing parts at each work station and more importantly, eliminated the trucking of parts. The overhead conveyors, thus, improved reliability and speed of production.

Machine placement in the Rouge shops resembled the layout schemes originated at Highland Pak. Machines were placed closer than in more conventional shops, so close that "a man who is accustomed to the space usually allowed between machines...would say that the River Rouge departments were crowded and congested."[50] Van Deventer explained the company's rationale--

> Under the usual operating conditions in the average plant a machine operator is required to take many steps that have been eliminated at the River Rouge where 'the work moves and the men stand still.' An old time machinist might feel himself decidedly cramped if confined to the space alltted him in this machine shop. Inasmuch as the majority of operators at River Rouge, however, are specialists who perhaps have never even seen a

> machine tool before their employment by the Ford Company, they have no precedents or ingrained hapits with respect to tool operation and they soon become accustomed to carrying on their operations in the space provided.[51]

The tight machine arrangement did not escape criticism, however. He may not have expressed this view while working for Ford, but years later William Pioch criticized the layout practice.

> It was a good idea but it didn't work out too good...because the machines were in so tight that sometimes if we had to move a machine, we'd have to move four or five different machines to get that one out.[52]

Engineers at the Rouge designed a vast network of railroad tracks and roads to carry materials and the "unusual High Line" that served as a major transport system throughout the plant. The High Line was a forty foot high concrete structure resembling a viaduct, wide enough to carry five railroad tracks, John Van Deventer called it the "backbone of the plant." "The two principle functions of the High Line," wrote the journalist, "are active storage and distribution."[53]

The High Line was a unique materials handling method. Similar to the craneways of the Highland Park plant, it provided semi-automatic delivery of parts and materials to several buildings. Like the craneways, it handled the heavy materials and transported raw materials to and from the huge storage bins. To that end, the line was equipped with hoppers and gravity unloading devices which were moved by a remote control system.[54] In keeping with its anti-waste philosophy, the company turned the area under the High Line into a one-story building housing service shops, storage, and repair stations.

In addition to the High Line, the Detroit, Toledo, and Ironton railroad as well as the internal system of railroads and roads moved heavy materials. Like the arrangement at Highland Park, railroad cars could be brought right into many of the buildings, thus facilitating deliveries. According to Hartley W. Barclay, editor of Mill and Factory, "the new River Rouge plant includes the largest completely mechanized installation of handling equipment ever installed in any industrial enterprise."[55]

Much of the work at the Rouge consisted of processing and other heavy work like that in the foundry and press shop. Consequently, handling facilities had greater demands than at Highland Park. The handling of coal through the plant provides a good example. A travelling bridge crane lifted the coal from storage bins at the ore docks and dumped it in the railroad cars on the High Line. The High Line carried the coal from the ore docks and dumped it on an enclosed conveyor. The conveyor carried the coal in to the Pulverizer Building where it was crushed to be fed into the coke ovens or oilers of the Power House by another conveyor.[56]

Operations at the Rouge gradually began to include manufacturing in addition to the processing, heavy work, and partial assembly. In 1924 completion of three buildings significantly changed things at the Rouge. The buildings--the Motor Plant, Press Building, and Spring and Upset Building--marked the beginnings of the company's total move from Highland Park to the Rouge. Ford Industries published the official explanation for the move:

> Whenever production warrants it the practice of bringing the machine to the part rather than the part to the machine is followed. Eighteen Highland Park departments are being moved to the Rouge in order that all operations from the melting of ore to the final assembly of the motor may be made continuous. It is easier to move the machine to the Rouge plant than to bring castings to Highland Park in constantly increasing numbers.57

The company's big move to the Rouge finalized the policy of corporate centralization. The expense and technological sophistication of the plant speaks to more than centralization, however; it reflects Henry Ford's emphasis on production methods and quality of product. Though Henry Ford himself, proved a masterful publicity manager, throughout his life he encouraged technological innovation over marketing. His thinking, as embodied in the Ford Motor Company, lies behind the construction of a complex like the Rouge.

The Ford Motor Company tradition becomes clearer when contrasted with General Motors. The GM approach, in contrast to the Ford Motor Company, concentrated energies on financial and legal skills rather than production and mechanical skills. GM, instead of building a company by virtue of mechanical know-how, collected together small companies along with their engineers and mechanics.

The Ford Motor Company's emergence as a successful company came relatively early in auto history. Ford "made it" largely because he produced a cheap, good quality car. This "first stage" of auto history, as Alfred Chandler has called it, depended on mechanical invention and innovation. The Ford Motor Company continued to operate as though it remained in that first stage for several decades. The construction of the Rouge reflects that thinking. The organization of General Motors, on the other hand, occurred during the "second stage" of auto history, best characterized by competition through marketing.

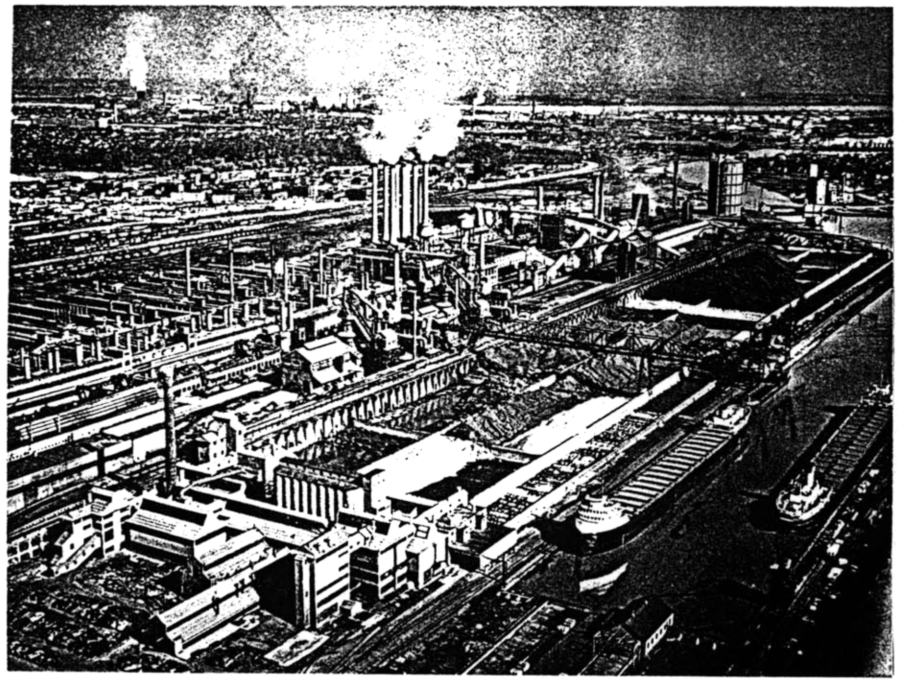
The Model T, Ford's foremost success, stood at the center of plans for the Rouge plant. Model T sales, however, began to fall in the mid 1920s. But plant expansion continued as though the company would only the single model forever. The entire complex was designed around building only the Model T.

Finally, in 1926, Henry Ford realized the necessity of a model change. Once design engineers prepared the new model, it took the company six months to retool for Model A production. This period of retooling exposed all of the problems with the Ford system. First, the single model production meant that the entire plant closed down during the changeover. Second, because the Rouge had been built solely for Model T production, it had built into it an inflexibility that substantially slowed the retooling process.

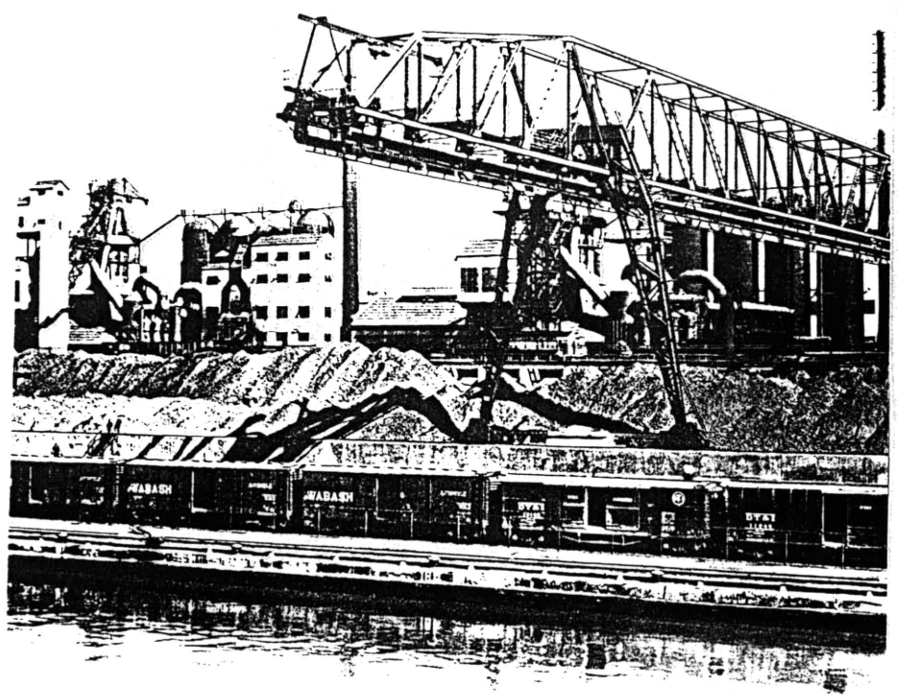
During the changeover the company moved many operations, including final assembly, from Highland Park to the Rouge. At the same time several innovations were added. The October 1927 Ford News proudly announced that "radical advances have been made in the body department. Not a single body truck will be employed either in building a body or in transferring it to the assembly line. From first to last the body will be handled by conveyors, hoists, elevators, and transfer tables."[58] Further improvements included some rearrangement of departments to facilitate delivery of stock. The motor assembly line was joined with the main assembly line and assembly line practice was improved to allow assembling of several different body types on the same line.[59] The changeover proved to be very costly to the company. Not only was the actual expense greater than it would have been in a company organized differently, but Ford business stopped completely during the changeover and GM took over the market lead and succeeded in keeping it. Ford continued to believe his single model strategy was best but the market forced him diversify--even innovators become wedded to their own traditions.

In 1932 the company introduced the V-8 engine and, in 1939, the

Mercury, but the Ford Motor Company found diversification difficult. The organization that Ford built around the Model T tacitly excluding the innovative, creative elements required for new product development. This is in contrast to GM, a company "as diversified as Ford was unified." Chandler accurately characterizes the Rouge as a brilliant technological success but unsuccessful as a business venture.[60]



Aerial view of the River Rouge plant. FMC Archives.



Storage bins and loading crane at River Rouge plant. FMC Archives.

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60. Alfred Chandler, Giant Enterprise (NY: Harcourt, Brace, and World, 1964), 301.

Conclusion

In 1927 the Ford Motor Company commissioned Charles Sheeler to produce a series of documentary photographs of the River Rouge plant. Sheeler had already earned recognition for his urban and rural landscapes, but his industrial landscapes would become his most famous artistic achievement. The Rouge photos though, were hardly documentary. Instead they reflected Sheeler's almost romantic vision of industry. Sheeler's photos of the Rouge depict a clean and orderly plant, void of heavy industry's smoke and grime. To achieve that mood Sheeler chose isolated views, views that created an abstract and almost beautiful image of the plant. His photographs, like his later paintings, belied the reality of the factory; they make the viewer forget the noise, the heat, and most of all the smells that emanated from the plant.

Around 1930 Sheeler began to use his photographs as the basis for a series of paintings. In the paintings he presents the plant in a cold romanticism; "it is the industrial landscape pastoralized," removed of "the frenzied movement and clamor we associate with the industrial scene," as Leo Marx has written about "American Landscape."[1] Clean, efficient buildings, commanding of order and respect fill Sheeler's canvases. He achieved that impression by simplifying the scenes, by stripping the factory of its complexity. Sheeler painted only major forms, and to enhance the pastoral impression he painted them in pastels. He left out the clutter of the real factory and, perhaps most revealing, he left out the workers--his fascination was for the machine, not the workers. By visually removing the workers, Sheeler produced his own version of the rational factory, the factory that operated just like a machine, a factory in which workers were important only as hidden pieces of the machine.

Sheeler's quiet landscapes provide concrete images for John Van Deventer's description of the plant:

> I have said that the first impression of the River Rouge is of vastness and complexity. The second impression is that of motionless quiet. Unless one enters a building, there does not seem to be much going on. One does not see many people in the yards, perhaps the reasons being that space is so vast that men are less noticeable. As a matter of fact comparatively few men are required outside the buildings because of the extent to which mechanical transportation has been developed.2

Sheeler, like many Americans of his day, seemed to revere "the machine." His art glorifies the factory much like earlier artists paid homage to the church. In fact, the caption beneath one photograph of the Rouge, published in Vanity Fair in 1928, referred to the plant in religious terms -- "an American altar of the God-objective of Mass Production," and a "Mecca toward which the pious journey for prayer." A few years earlier Van Deventer, similarly praised the plant and Henry Ford. He wrote:

> Steam and power from the water, glass from the sand, ore and coal from the cliffs, limestone from the gray rocks and lumber from the trees.--and thus the motor car and tractor.
> Henry Ford has brought the hand of God and the hand of Man closer together at River Rouge than they have ever been brought in any other industrial undertaking.3

Sheeler personally believed that "industry, with its emphasis on utility, efficiency, and progress best expressed American life."[4] He wrote that "every age manifests the nature of its content by some external form of evidence." He believed that, with the decline of religious beliefs, industry had become the focus for the major belief system. Consequently, the factory took on new symbolic importance.[5]

In addition to the actual images he created, Sheeler's titles further disclosed his ideas about the factory. "American Landscape," "Classic Landscape," "Ballet Mechanique," and "City Interior," suggest that Sheeler believed industrial environments to be more than places for production. His titles imbue the images with a significance beyond manufacturing, the factory became a major cultural symbol. Sheeler's landscapes, as an expression of an American attitude, speak volumes about changes in thinking about the factory. Compared to the negative literary images of the eighteenth and nineteenth century factories, Sheeler's visual depictions of the River Rouge plant embody an enthusiasm for industry, reflecting the impact of an industrial society on American attitudes. He captured the growing belief in industry as the Messiah for modern society and in the factory its physical representation.

In 1931 Edsel Ford contracted with the Mexican artist, Diego Rivera, to paint murals with an industrial theme in the courtyard of the Detroit Institute of Art. Like Sheeler, Rivera was fascinated with the River Rouge plant and chose it as the subject for his murals. Also like Sheeler, Rivera considered modern factories important as architecture and as a cultural symbol. He wrote that "in all the constructions of man's past--pyramids, Roman roads and aqueducts, cathedrals and palaces, there is nothing to equal these [factories]."[6]

The resemblance between the two men stops with their common respect for industry and technology. Rivera's murals, in contrast to Sheeler's landscapes, step inside the buildings of the Rouge plant to the teeming world of auto production and workers. The murals depict a voluptuous Rouge, in contrast to the cool detached crispness of Sheeler's paintings. Rivera painted the machines with sensuous, soft, curved edges. His panels are filled with people, in contrast to Sheelers humanless exterior images. Rivera portrayed workers and machines, though for him workers remained the most vital force in the factory.

Rivera believed in the importance of the factory in modern life, placing industrial buildings, machine-design, and engineering in positions loftier than any other accomplishments in all of history. But unlike Sheeler, Rivera saw the worker as the center of, and the power behind, the great machine.[7] In focusing on people in the factory, his murals suggest a negative side of factory life. He depicts the machines as larger than life, as dominating the men around them and dictating the pace of work. The activity in the mural is almost too much for the viewer to comprehend. In stark contrast to Sheeler's serene landscape, Rivera's Rouge is frenetic, reminding the observer of the Forditis suffered by workers in the early days of the assembly line.

The two artists depicted different realities of the modern rational factory. Both images have their own truths. To Sheeler, the Rouge represented the rational factory, one with little need for workers. He perceived the ideal toward which industrial engineers worked. Rivera, on the other hand, recognized some of the consequences of that ideal. He saw the relationship of the modern factory to history, to the environment, and to workers.

It was fitting that both artists portrayed Ford's River Rouge plant, at the time the most modern of factories. The Rouge was the culmination of three decades of experimentation with factory planning and design. It represented the direction in which modern industry would move, both in building style and production methods; it was a harbinger of things to come. Above all, it reflected the growing recognition of the importance of factory organization. The Ford Motor Company, and other companies, looked to the redesign and reorganization of the factory as a way to facilitate the perfection of assembly line production and as a way to better manage workers. The new factory layout, the assembly line, and the division of labor allowed managers to maintain closer watch over workers.

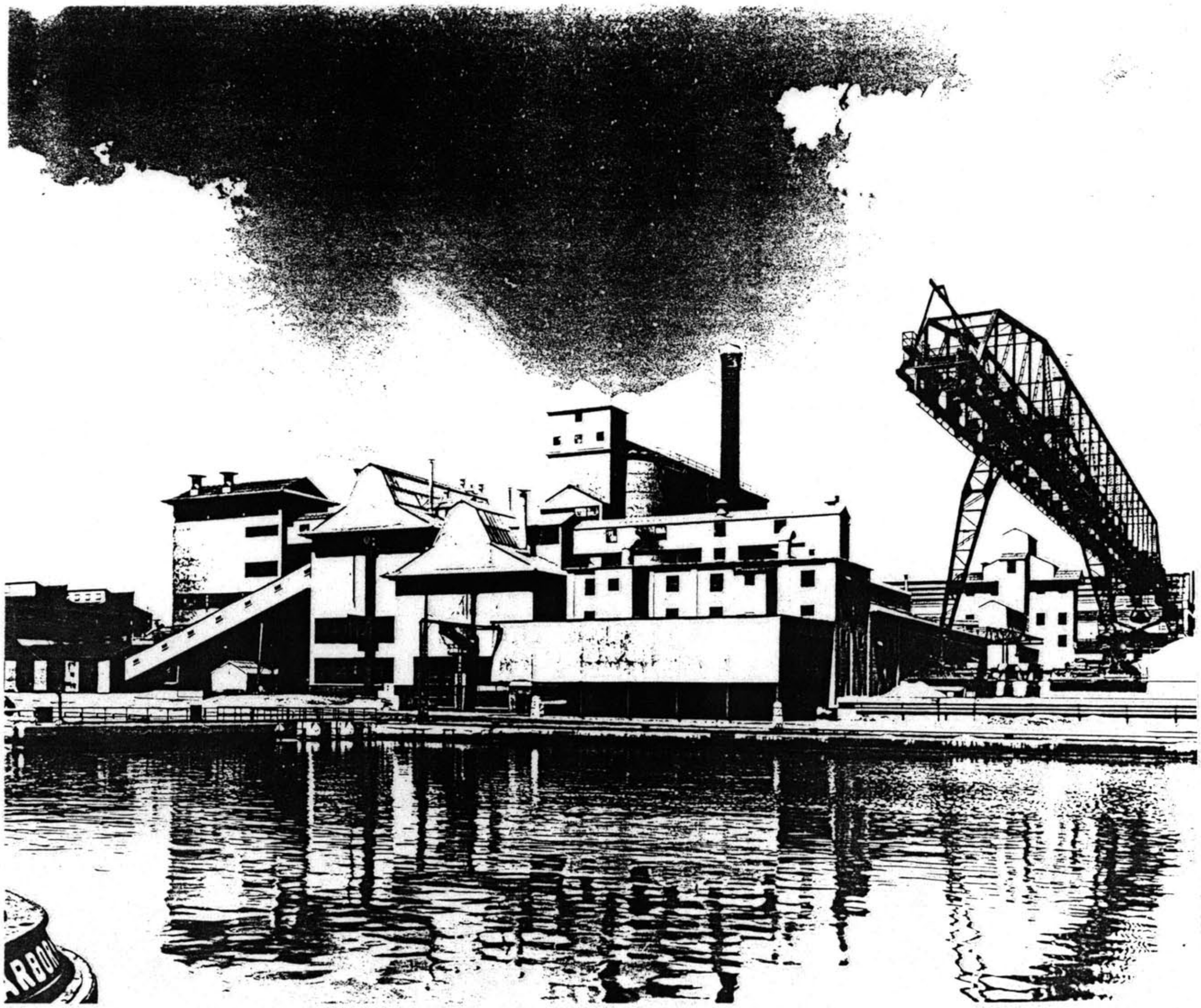
Improvements in production technology in the early twentieth century had increased the potential for faster production and larger volume. That potential could be realized, however, only with major reorganization of the factory. The Ford Motor Company, more than most companies, addressed the problems of organization by designing new factories at each stage in the development of mass production. At Ford, one sees a group of engineers trying to figure out how to organize mass production and to find the best factory for it. Each of the company's factories should be viewed as more than additional space, it should be seen as a critical point in the development of Ford's production system.

The Piquette Avenue plant represented the company's first expansion. Its builders clearly copied the nineteenth century mill building style and the company's production process at that time, differed little from nineteenth century production. Highland Park's old and new shops were transitional buildings--they embodied characteristics of both nineteenth and twentieth century factories. The old shop represented the introduction of the Model T and the first attempts to improve materials handling. The new shop represented the beginning of the rational factory, a factory planned to fit the production process rather than the constraints of building technology or power transmission. The River Rouge plant undoubtedly introduced the modern factory to world; the modern factory combined rational factory planning with modern production and construction technology. It demonstrated to American industry that technology and know-how had reached the level needed to organize a large, totally integrated manufacturing enterprise.

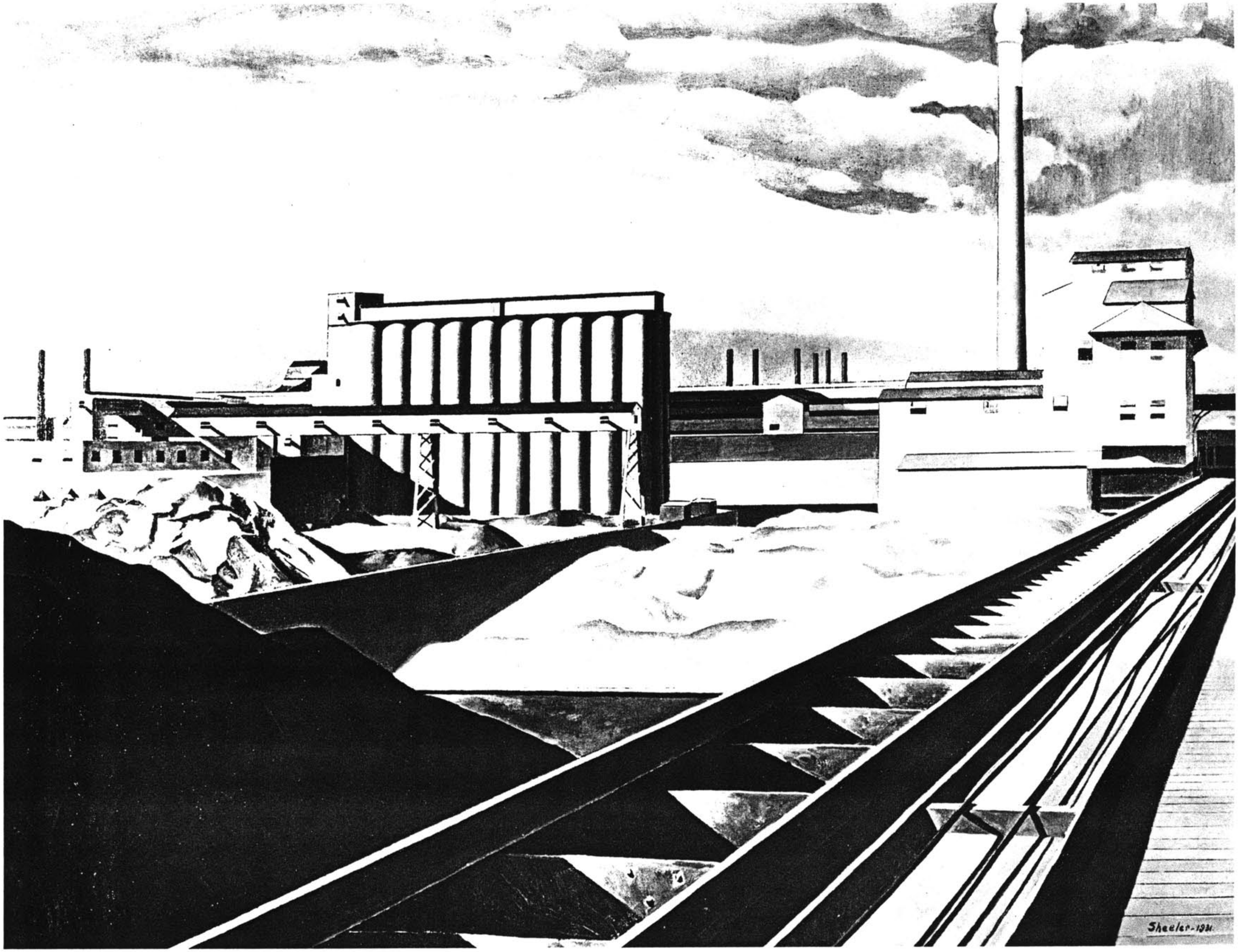
At a level of analysis more general than the individual company, we can see the impact of factory reorganization on the entire auto industry. Ford's success resulted, in large part, from the systematization that paralleled improvements in factory design. Ford's success marked the beginning of the centralization of the entire auto industry. By the time the Rouge was built the dozens of small companies had begun to feel the squeeze of the large companies. Mechanization and centralization made it impossible for companies with small capital to compete, they could not install the systems that had allowed the large companies to reduce their prices so much.

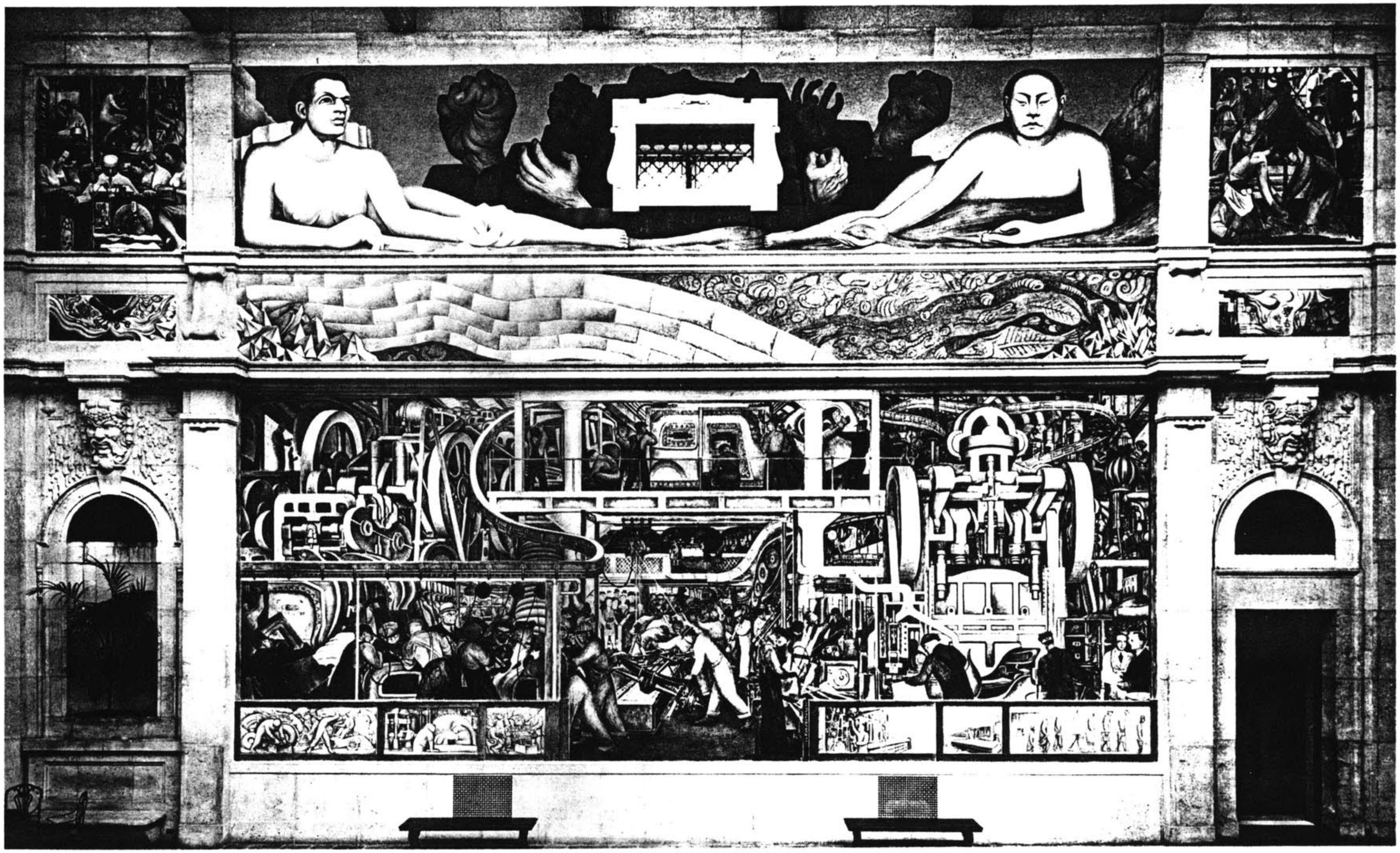
The rational factory had a profound impact on the worker. It heralded the stage in industrialization in which the factory was removed another step from non-work life. The rational factory--the moving assembly line, combined with the mechanization of nearly all materials handling and other work--turned the factory into a mechanical wonder that left the worker with few authorized freedoms. Managers and engineers used factory planning and design to confront the increasingly complicated task of organizing and controlling growing numbers of workers, machines, and materials in one place.

By 1930 industrial engineers made significant progress in factory planning and design. Mechanized materials handling systems and automated machinery, plus the elimination of belting for transmission of power had freed engineers to layout the shop floor in the most efficient manner. That freedom, coupled with reinforced concrete and steel construction, opened vast possibilities for the design of factories. Mechanized materials handling, more than the other innovations, allowed production engineers to chart every necessary movement in the factory. With such control over details, industrial engineers succeeded in making everything in the factory merely a cog in the master machine.



Charles Sheeler, photograph of Cement Plant and boat slip.


Sheeler-1931



Notes: Conclusion

1. Leo Marx, Machine in the Garden (NY: Oxford University Press, 1964), 355-56.

2. John Van Deventer, "Links in a Complete Industrial Chain," Industrial Management, Sept. 1922, 137.

3. Van Deventer, 131.

4. J.J. Jacobs, "The Rouge in 1927," The Rouge (Detroit: Detroit Institute of Arts, 1978), 11.

5. Papers of Charles Sheeler, NSh 1, frame 101, Archives of American Art, Smithsonian.

6. Bertram Wolfe, Diego Rivera, His Life and Times (NY, 1939), 313.

7. Linda Downs, "The Rouge in 1932," The Rouge.