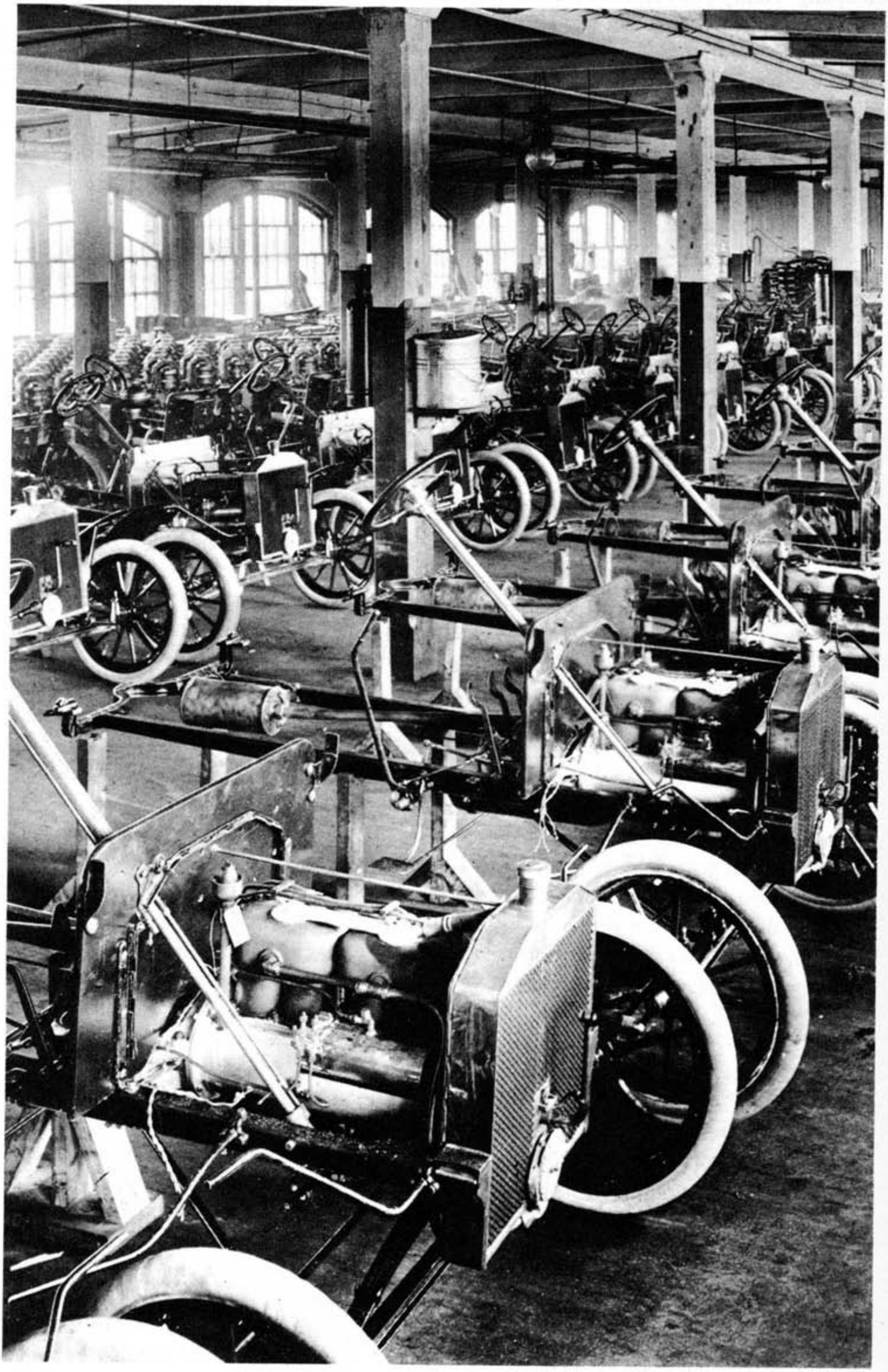

CHAPTER 6

The Ford Motor Company & the Rise of Mass Production in America

Mass production is not merely quantity production, for this may be had with none of the requisites of mass production. Nor is it merely machine production, which also may exist without any resemblance to mass production. Mass production is the focussing upon a manufacturing project of the principles of power, accuracy, economy, system, continuity, and speed.
—Henry Ford, "Mass Production," *Encyclopaedia Britannica* (1926)

Henry Ford had no ideas on mass production. He wanted to build a lot of autos. He was determined but, like everyone else at that time, he didn't know how. In later years he was glorified as the originator of the mass production idea. Far from it; he just grew into it, like the rest of us. The essential tools and the final assembly line with its many integrated feeders resulted from an organization which was continually experimenting and improvising to get better production.
—Charles Sorensen, *My Forty Years with Ford* (1956)

Ford did not have to spend his life, like Oliver Evans, furthering ideas ungrasped by his contemporaries. He may have had the same indomitable energy; but he also had the advantage of coming not at the start but at the end of the mechanistic phase. Success does not depend on genius or energy alone, but on the extent to which one's contemporaries have been prepared by what has gone before.
—Siegfried Giedion, *Mechanization Takes Command* (1948)

Perhaps more than any other historian, Siegfried Giedion has placed the work of Henry Ford, or more correctly the Ford Motor Company, in an appropriate context of technological development. Giedion recognized the important prior developments in production of interchangeable parts, the idea of continuous flow, the rise of an efficiency movement, and the rich suggestion of Chicago slaughterhouse "disassembly" lines. From Giedion's perspective, Ford comes at the end of a long historical process which, in a Hegelian sense, becomes recognizable only at the end, when ever-unfolding historical reason makes itself known.[1] Although this interpretation of Ford deserves careful attention, it underestimates the singular importance of the changes made at the Ford factory in 1913 and 1914 (as well as how they came about) and the way these changes were rapidly diffused throughout the Western world. Both the *act* of mass-producing the Model T Ford and the rapid *diffusion of the techniques* by which it was mass-produced had a profound impact on the twentieth century. Fordism, a word coined to identify the Ford production system and its concomitant labor system, changed the world.[2]

This chapter examines the rise of mass production at the Ford Motor Company between 1908 and 1915. While concentrating on originality at Ford, it also emphasizes the prior developments upon which Ford depended. By contrasting Ford methods with those of Singer, McCormick, and Pope the role of the Ford Motor Company in the rise of mass production technology in America can be properly assessed. Finally, this chapter briefly considers the means by which knowledge of Ford methods diffused rapidly throughout the American technical community.

Mass production at the Ford Motor Company was rooted in the Model T idea and the fruition of that idea. Established in 1903, the Ford Motor Company was Henry Ford's third attempt at automobile manufacture. Not controlled by Ford until 1907, the company sold a number of medium-priced automobiles including the Models A, B, C, F, K, N, R, and S. By 1906, it had become apparent to Henry Ford that, in light of the existing and potential demand for automobiles in the United States, the "greatest need today is a light, low-priced car with an up-to-date engine of ample horsepower, and built of the very best material. . . . It must be powerful enough for American roads and capable of carrying its passengers anywhere that a horse-drawn vehicle will go without the driver being afraid of ruining his car."[3] According to many Ford experts, the Model N possessed some of these characteristics and could rightly be seen as the forerunner of the Model T.[4] Henry Ford, however, found enough fault with the N to decide that a new model was needed, one that would be larger and more powerful but still be called "light" and sell for less than the Model N. Ford battled with other company directors about the desirability of a new model, but when he acquired controlling stock in the Ford Motor Company in 1907, the debate ceased.

Henry Ford ordered that a separate area at the Detroit factory be set aside for the design of what became the Model T, and he started his best mechanics to work on that design. Together, Henry Ford, C. Harold Wills, Joseph Galamb, C. J. Smith, Charles Sorensen, and others arrived at a mechanical synthesis which, if not consciously designed to be, would become a "car for the masses."[5] It fulfilled Henry Ford's vague 1906 prescription for the "most needed" automobile design. A simple block, cast in one piece, provided the foundation for the twenty-horsepower, magneto-fired engine. The engine drove a planetary transmission with two forward speeds and a reverse, which were operated by foot pedals. A liberal use of vanadium-alloyed steel, along with some common-sense structural design, provided the Model T chassis with the desired strength, durability, and lightness. Altogether, the T fulfilled Henry Ford's mandate for simplicity of design and repair. It was destined also to fulfill the *Nation*'s prophecy that "as soon as a standard cheap car can be produced, of a simple type that does not require mechanical aptitude in the operator, and that may be run inexpensively, there will be no limit to the automobile market." The world, according to *Harper's Weekly,* stood perched awaiting a car and a manufacturer for the masses: "There is no doubt . . . that the man who can successfully

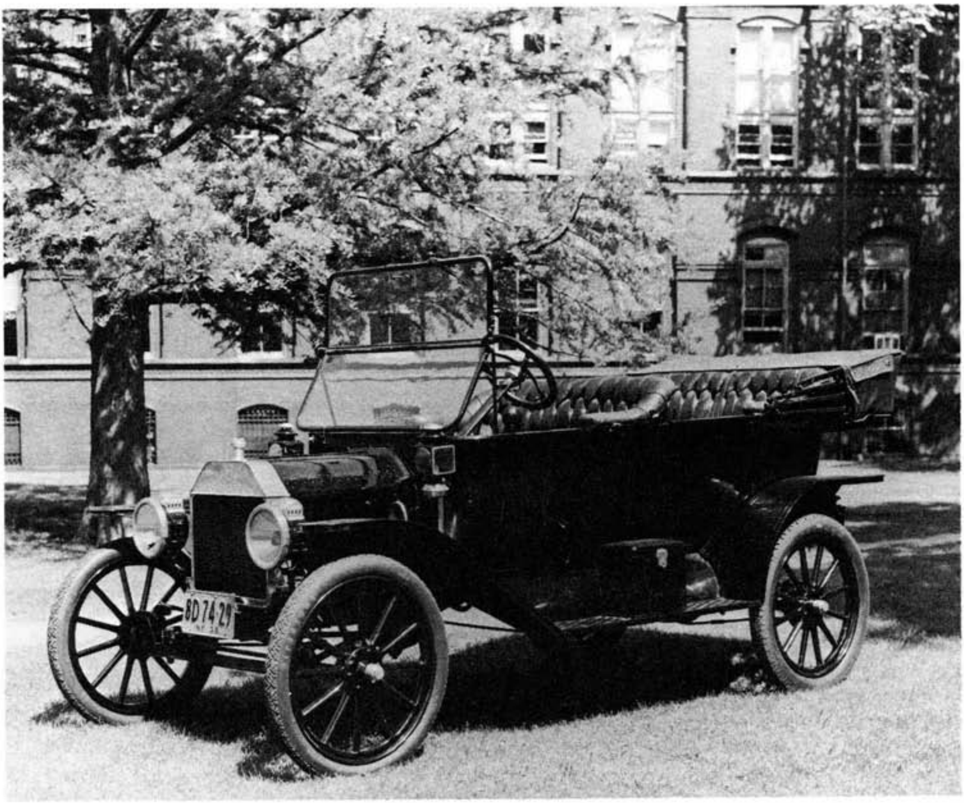

FIGURE 6.1. Model T Ford, 1913. Ford Motor Company produced the Model T from 1908 to 1927; some 15 million cars and trucks were made. (National Museum of American History, Smithsonian Institution Neg. No. 44002.)

solve this knotty problem and produce a car that will be entirely sufficient mechanically, and whose price will be within reach of the millions who cannot yet afford automobiles, will not only grow rich but be considered a public benefactor as well.''[6] When the Model T left the Ford Motor Company experimental room in 1908, it met all of these mechanical demands. Through an alignment of circumstances that would have been difficult to predict, Henry Ford and the Ford Motor Company put the car within reach of those millions of Americans. (See Figure 6.1.)

Allan Nevins and Frank Hill record the response by Ford agents to the first announcement about the Model T, made March 19, 1908. One agent wrote, ''We have rubbed our eyes several times to make sure we were not dreaming''; another exclaimed, ''It is without doubt the greatest creation in automobiles ever placed before a people and it means that this circular alone will flood your factory with orders.'' Even before the factory had turned out a single product, agents had ordered fifteen thousand of the new Model T's.[7] From the beginning of Model T production until the end of World War I the Ford Motor Company, its factory, and its output of automobiles grew dramatically.

An alchemy of circumstances allowed for this growth. The roots of many of these circumstances are found in Henry Ford's business philosophy and its application by the Ford company's financial wizard, James Couzens. The company was financed from within, and after Henry Ford gained control he followed a policy that dictated against taking money out of the company through large dividends (or even large salaries for its top people). The massive profits that began to accrue were consistently plowed back. At the time, as in hindsight, it seemed that the Ford Motor Company did not want to make money as much as it wanted to build cars. With unquestioned financial stability and without any set notions about how automobiles should be made (that is, about the actual manufacturing processes), Henry Ford allowed an extensive amount of experimentation to be carried out in the factory and a surprising rate of scrapping processes and machine tools when they did not suit the immediate fancy of his production engineers. Ford had attracted to his factory a core of perhaps a dozen or a dozen and half young, gifted mechanics, none of whom had developed set ways of doing things. Encouraged by Ford, this group carried out production experiments and worked out fresh ideas in gauging, fixture design, machine tool design and placement, factory layout, quality control, and materials handling. Had the factory been rooted in a definite manufacturing tradition, such as Yankee armory practice or even "western" practice as exemplified by the Western Wheel Works, the Ford company might never have furnished cars for the masses. In a sense, the Ford production engineers took what was best from each approach to manufacture and overcame limitations to these methods by adding their own brand of production techniques. When they were finished, they had created—in Allan Nevins's words—a lever to move the world.

Until about two years before the introduction of the Model T the factory of the Ford Motor Company resembled more closely a poorly equipped job shop than a well-planned manufacturing establishment. Originally working in rented shops, the Ford Motor Company built its own factory in 1904 on Piquette Avenue in Detroit. The three-story plant, 402 × 52 feet, hardly matched the nearby Packard factory or that of Ransom Olds in Lansing. Because the company purchased most of its parts, the Piquette Avenue plant was designed for automobile assembly rather than for accommodating machine tools in large quantities. What tools the company possessed were general machines, operated by hard-to-find skilled machinists. Production during the first year at Piquette—1,745 automobiles—exceeded slightly that at the old factory in 1903–4. On the third floor, preassembled engines, frames, and bodies were put together into complete automobiles by teams of workmen. Perhaps fifteen such teams worked at different assembly stations, each demarcated by various piles of parts and by wooden stands upon which the cars were assembled. This method of automobile manufacture continued until the end of 1905, when Henry Ford joined with James Couzens to form the Ford Manufacturing Company as a means of obtaining control of the Ford Motor Company and as a mechanism to begin manufacture of parts for the recently introduced Model N, the light, four-cylinder runabout which Ford planned to sell for $500.[8] The organization and staffing of the Ford Manufacturing Company (consolidated with the Ford Motor Company early in 1907) laid the foundation, or more accurately, established the precedents for the rise of mass production at Ford in the early years of the following decade.

Rather than setting up to produce Model N engines and small parts in the Ford Motor Company's Piquette plant, the Ford Manufacturing Company rented a factory on Bellevue Avenue in Detroit and began to equip the shop. In purchasing machine tools Henry Ford came in contact with Walter E. Flanders, a machine tool salesman whom Charles Sorensen regarded as a "roistering genius."[9] Rather than a genius, Flanders was simply a genuine Yankee mechanic, a breed unknown to the young machinists around the Ford shops. A native of Vermont, Flanders had mastered the machinist's trade almost before he reached manhood and had witnessed quantity manufacture as an employee of the Singer Manufacturing Company. Before selling machine tools for Potter & Johnson, Landis Tool Company, and Manning, Maxwell & Moore (at the same time), the Yankee had built tools for the Landis company, one of the important pioneers in precision automotive grinding. Through his salesmanship, Flanders helped shape the approach to engine manufacture at the Ford Bellevue plant. He then suggested to Henry Ford that he hire Max F. Wollering to superintend the plant. Although young, Wollering proved to be the most competent manufacturing mechanic Ford had yet hired. Within a short span of years he had been employed by International Harvester as a toolbuilder and superintendent of gas engine production and by the Hoffman Hinge and Foundry Company of Cleveland, Ohio.[10] Wollering began at the Ford plant in the spring of 1906, and by August of that year Henry Ford had attracted Flanders to fill the post of overall production manager for the two companies.

In planning for the large-scale production of the Model N, Henry Ford caught for the first time that age-old New England contagion for interchangeability. Perhaps Flanders had passed it on to him. In an oral history interview conducted in the early 1950s, Max Wollering said that the common belief that Flanders had played a critical role in bringing the idea of interchangeability of parts into the Ford Motor Company was "all hooey." "There was nothing new [about interchangeability] to me," Wollering contended, "but it might have been new to the Ford Motor Company because they were not in a position to have much experience along that line." Whatever the origin of the idea, he emphasized that Henry Ford firmly grasped the importance—if not the techniques—of achieving interchangeability. "One of Mr. Ford's strong points was interchangeability of parts," Wollering said later. "He realized as well as any other manufacturer realized that in order to create great quantity of production, your interchangeability must be fine and unique in order to accomplish the rapid assembly of units. There can't be much hand work or fitting if you are going to accomplish great things." As Wollering reiterated, Ford "stressed that point very, very much."[11]

"We are making 40,000 cylinders," the Ford company advertised, "10,000 engines, 40,000 wheels, 20,000 axles, 10,000 bodies, 10,000 of every part that goes into the car . . . all *exactly alike*."[12] Although he advertised uniformity before his factory had actually achieved it, Henry Ford essentially gave Wollering and Flanders carte blanche to fulfill that which he had promised. When Wollering began his tenure he set the mechanics under him designing and building fixtures, jigs, and gauges for all the parts made at the Bellevue plant (devices he called "farmer tools" because with them he asserted that he could make a farmboy turn out work as good as that of a first-class mechanic). Wollering supervised the heads of each of seven departments: block, crankcases, and axles; bushings and small parts; engine assembly; second floor machinery; toolmaking; engine testing; and overall inspection.[13]

Flanders's arrival four months later initiated changes in machine tool placement, production departments, and materials purchasing policy. The Yankee mechanic placed machine tools according to sequential operations on various parts rather than by the types of machine (such as milling machines all in one department).[14] If hardening or softening or any such nonmachining operation needed to be carried out during this sequence, Flanders placed a furnace or whatever in the correct sequential location if possible. With regard to machining operations, Flanders impressed upon Ford and all the mechanics at the factory the desirability of interchangeable parts and the notion that absolute in-

FIGURE 6.2. Static Assembly, Model N, Ford Motor Company Piquette Avenue Factory, 1906. The cramped condition of the Piquette Avenue factory would soon lead Henry Ford to expand the plant in 1907 and build the Highland Park plant, which opened in 1910. (Henry Ford Museum, The Edison Institute. Neg. No. 833-37306.)

terchangeability would become imperative in high-volume production. Flanders, as well as Wollering, also showed the Ford production mechanics the productivity gains possible through the use of special- or single-purpose machine tools. In October 1906, the Vermonter wrote a policy statement for manufacturing operations at Ford which dictated long-term purchasing of materials while at the same time requiring the supplier to carry the inventory. Flanders demanded that the factory keep on hand only a ten-day supply of these materials.[15] Being a bold fellow, he even made suggestions to Ford about sales policy. Charles Sorensen aptly summarized Flanders's contributions to the Ford company, saying that he "created greater awareness that the motorcar business is a fusion of three arts—the art of buying materials, the art of production, and the art of selling." Clearly, as Sorensen recognized, Flanders—particularly in his rearrangement of machine tools—"headed us toward mass production."[16] (See Figure 6.2.)

The consolidation of the two Ford companies in 1907 and the enlargement of the Piquette Avenue factory allowed the company to move all of its machinery out of the Bellevue plant into the enlarged works. This move also allowed Flanders and Wollering additional opportunity to refine machine tool placement and the flow of materials throughout the factory. Perhaps at this time simple gravity slides (not unlike rain gutters) were installed in the factory between machine tools to move parts from one machining operation to another, thus expediting the flow of materials.[17]

Walter Flanders remained at Ford less than two years. Accepting a more attractive offer with the Wayne Automobile Company, he also took with him Max Wollering and Ford's advertising manager, LeRoy Pelletier.[18] In hindsight, it appears that Flanders stayed at the Ford Motor Company just long enough to introduce the fundamentals of an admittedly modern version of New England armory practice to the handful of young mechanics Ford had assembled. Had he remained longer he might have indoctrinated them with the belief that this approach was the one best way to manufacture cars. For the next three years the Ford engineers elaborated the basic principles shown them by Flanders, but eventually they moved beyond Flanders, taking only what suited them.

Henry Ford possessed an uncommon gift—or was unusually lucky—in attracting to his company well-educated mechanics who believed that "work was play."[19] C. Harold Wills, Oscar Bornholdt, Carl Emde, Peter E. Martin, Charles Sorensen, and August Degener, among others, formed the backbone of the Ford production team, a backbone given strength by Flanders's and Wollering's brief residence at the Ford factory. Draftsman, toolmaker, and better-than-amateur metallurgist, Harold Wills played a major role in Ford automobile design and factory layout from 1902 until after Highland Park was built. After Flanders left, Ford put Wills nominally in charge of manufacturing operations and machine tool procurement. Wills left these duties almost completely to "Pete" Martin and "Cast-iron Charlie" Sorensen. Henry Ford despised job titles, but Martin functioned as the factory superintendent and Sorensen as his assistant. According to Sorensen, Martin oversaw production while he worked at "production organization and development." Ford had hired both men shortly before Flanders arrived; Martin eventually became general superintendent and a vice-president of the Ford Motor Company while Sorensen became the mastermind behind Ford production plants in Europe, the River Rouge, and the Willow Run bomber factory. Carl Emde, a technically trained German immigrant, assisted Oscar Bornholdt in tool design and construction. Again, Ford had hired both machinists before 1906. Their contact with Flanders and Wollering proved very fertile. When Bornholdt left Ford in early April 1913, Emde took charge of tool design. By this date the Ford shops had arrived at a distinctive approach to machine tool, jig, and fixture design that clearly showed the marks of Bornholdt and Emde. Even before the Ford Motor Company was formed, Henry Ford hired August Degener as a draftsman. By the time the Highland Park factory opened in 1910, "Gus" had become the superintendent for inspection.[20]

Because Flanders left shortly after the company had announced the Model T—and long before it had actually produced one—this team of mechanics suddenly became responsible for "tooling up" for Model T manufacture. They faced more pressing problems than Flanders had encountered because of the rapidly rising demand for the Model T. When Flanders wrote his policy memorandum of October 1906, he called for the production of 11,500 automobiles (in three models) during the year from October 1906 to September 1907. Actual production reached only about 8,250. Nevins argued that quantity production at the Ford Motor Company began in the fall of 1907, but during the year previous to June 16, 1909, the factory turned out only 10,660 automobiles, less than a 30 percent increase from the 1906–7 period.[21] Table 6.1 shows the rapid rise in sales and the decrease in price of the Model T from its beginning in 1908 until 1916.

To P. E. Martin and Charles Sorensen fell the chief responsibility of getting the Model

TABLE 6.1. MANUFACTURING AND MARKETING OF MODEL T FORDS, 1908–1916

Calendar Year	Retail Price (Touring Car)	Total Model T Production	Total Model T Sales
1908	$850	n.a.	5,986
1909	950	13,840	12,292
1910	780	20,727	19,293
1911	690	53,488	40,402
1912	600	82,388	78,611
1913	550	189,088	182,809
1914	490	230,788	260,720
1915	440	394,788	355,276
1916	360	585,388	577,036

Sources: Columns 2 and 4: United States Board of Tax Appeals Reports, vol. 11, p. 1116, as reprinted in Alfred D. Chandler, Jr., *Giant Enterprise*, p. 33; column 3: my compilation based on monthly production reports, Ford Archives.

T into production. Although preparations may have seemed frenzied at times, the two superintendents, with toolbuilders Bornholdt and Emde, approached production methodically. As Henry Leland had done with Willcox & Gibbs sewing machines and Singer had done with its machines, the Ford production men wrote out operations sheets.[22] These detailed the machining operations on various parts, the requisite material inputs, and the necessary tools, fixtures, and gauges (all of which were numbered and referenced to drawings of parts) and suggested how the factory ought to be laid out according to the sequential structure delineated on paper. Preparation of these sheets brought order and clarity to what might have been a chaotic effort to produce the new model. In detailing requirements in machine tools the sheets also suggested possibilities for the design of entirely new machines. Rather than hardening into rigid policy statements, the operations sheets served as guides to production and materials procurement.

With information from operations sheets, Sorensen rearranged machine tools for Model T engine production, following the practice of sequential machining operations that Flanders had suggested.[23] The engine of the Model T differed significantly from that of the N, consisting of a single-cast block and a magneto rather than two castings (each with two cylinders) and a battery-fired ignition system. Sorensen's ability as a patternmaker was clearly established by his solution to the problem of making a one-piece block. More important, he demonstrated his ability to bring original ideas to overall production when he recommended to Ford that stamping techniques rather than usual casting methods be employed for making crankcases.

Sorensen knew about steel stamping methods because he had grown up in Buffalo, New York, where the John R. Keim stamping company made bicycle crank hangers and other bicycle parts. According to his reminiscences, Sorensen had often prowled around the scrap pile at the Keim plant, picking up pieces that only a boy would find useful. Not long before Sorensen initially advocated pressed steel crankcases, William Smith, part-owner and superintendent of the Keim mills, had called at the Ford factory and suggested that Ford's rear axle housings could be made of pressed steel. Henry Ford encouraged both Sorensen and Smith. Soon Harold Wills and Sorensen went to Buffalo to see the Keim plant. Smith and his team of engineers made a suitable rear axle housing for the

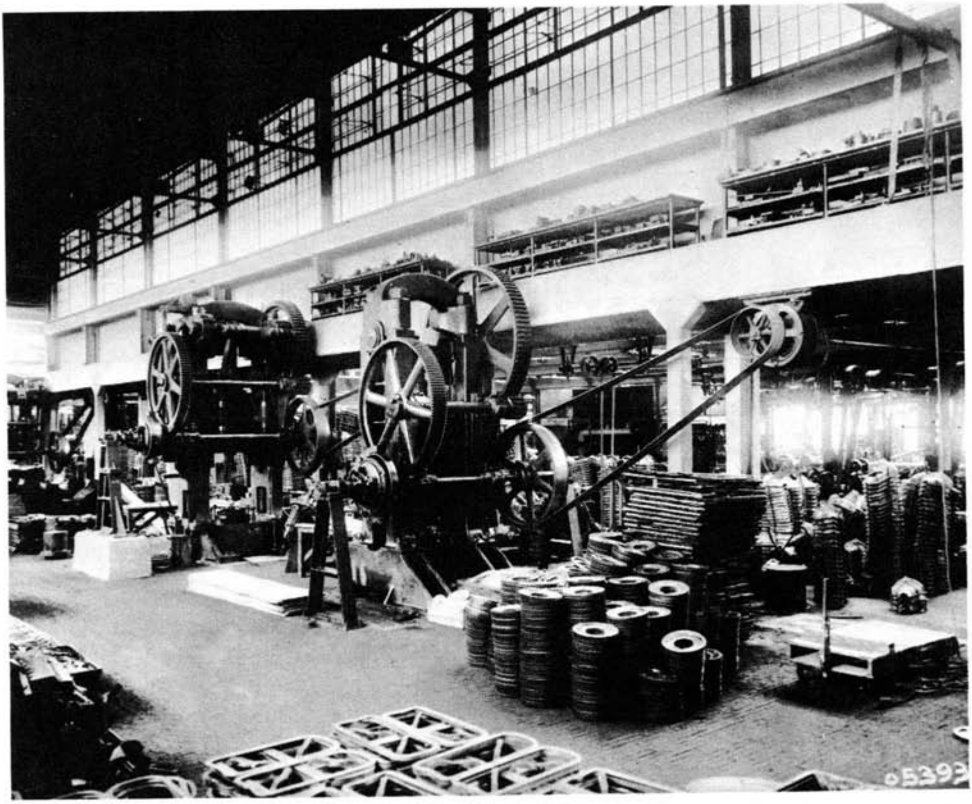

FIGURE 6.3. Punch Press Operations, Highland Park Factory, 1913. Much of Ford's punch press machinery came from the John R. Keim Company of Buffalo, which Ford purchased in 1911 and moved to Detroit. At the far right, stacks of Model T transmission covers and crankcases are visible. (Henry Ford Museum, The Edison Institute. Neg. No. 0-6341.)

Model T and offered them at a cheaper price than cast ones. Before Model T products proceeded too far, Sorensen (with Ford's approval) adopted the use of pressed steel parts wherever possible—crankcase, axle housing, transmission case. Ford purchased the Keim company in 1911 and moved it to Detroit. (See Figures 6.3 and 6.4.)

With the company's equipment also came a group of talented engineers who played a decisive role in the development of mass production at Highland Park. This group included William Smith (who continued engineering work), John R. Lee (who became Ford's welfare department head), William Knudsen (who directed Ford's assembly plant operations in other American cities and eventually became the president of General Motors), Charles Morgana (who worked with Carl Emde as the Ford machine tool purchaser and conveyor of specifications for capital equipment), John Findlater (a diemaker who became Ford's master of presswork), and E. A. Walters (who succeeded Findlater in 1919 as the chief expert in presswork).[24]

While the company's production engineers and machinists worked out details of manufacturing the Model T and Fred Diehl devised a materials purchasing system along the lines suggested by Walter Flanders, Henry Ford and James Couzens concentrated on plans to construct a new factory in which the car for the masses would be built. In 1906, before

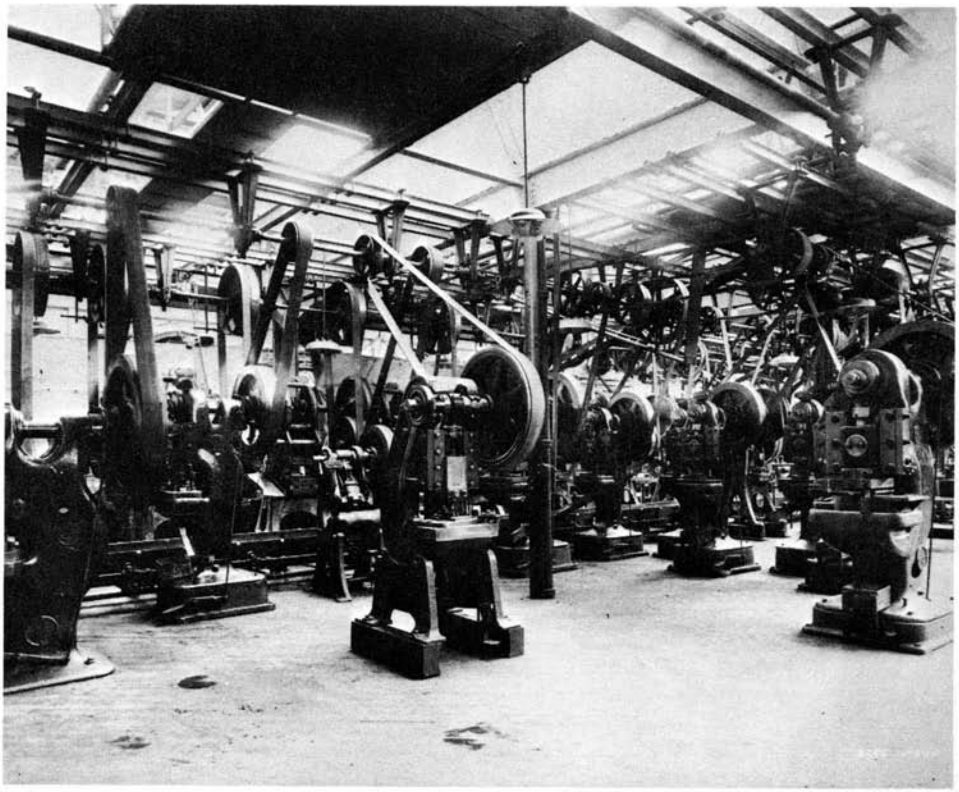

FIGURE 6.4. Punch Press Operations, Highland Park Factory, 1913. (Henry Ford Museum, The Edison Institute. Neg. No. 833-2295.)

the design of the Model T had been completed, Ford had purchased a sixty-acre tract of land at Highland Park on the northern edge of Detroit and had begun work with architects on the proposed factory. Although neither Ford's biographers nor Ford company pioneers mentions Flanders in connection with the Highland Park factory design, the Yankee must have at least told Ford how he would build a factory if he were in Ford's place. Ford, Couzens, Flanders, and others clearly recognized that the Piquette Avenue factory, even when enlarged, was inadequate for the growing production of Model N's and that anticipated for the Model T. Not long after Flanders left Ford he professed that in order for less expensive automobiles "to equal in quality cars now selling at $700 to $900, it is not only necessary to build them in tremendous quantities, but to build and equip factories for the economical manufacture of every part."[25] With large profits pouring into Ford's enterprise, it seemed natural to think about erecting a substantial factory along the lines envisioned by Flanders. The directors of the company approved the expenditure of a quarter of a million dollars in mid-1908. The factory opened formally on New Year's Day 1910, although construction at Highland Park continued throughout the next half-dozen years until the sixty acres would hold no more buildings.[26] (See Figure 6.5.)

The design of the Highland Park factory allowed architect Albert Kahn to elaborate upon work he had started in 1905, when at age thirty-six he designed a new factory for the Packard Motor Car Company, a "daylight factory" of extensive windows set in rein-

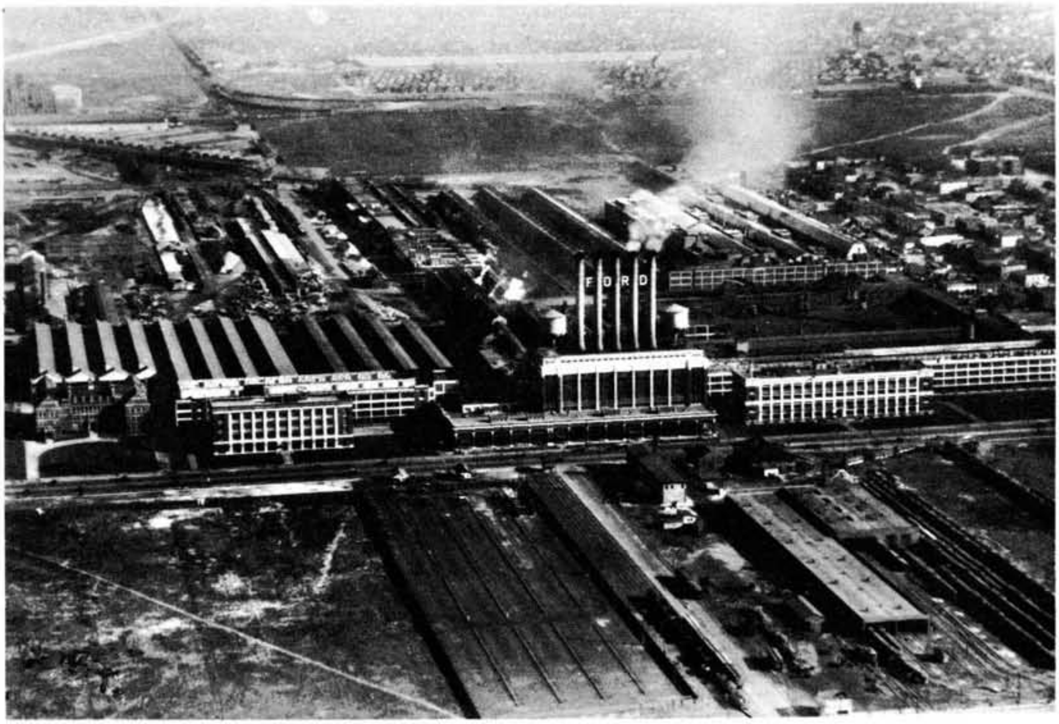

FIGURE 6.5. Highland Park Factory, 1923. This aerial photograph was taken at the peak of Highland Park's production. The 8,000-horsepower power plant is in the center of the photograph and the sawtoothed roof of the machining area is visible at the left. This area was connected by a glass-enclosed craneway to a four-story building 865 feet long and 75 feet wide. (Henry Ford Museum, The Edison Institute. Neg. No. 833-34974.)

forced concrete. The principal structure at Highland Park consisted of a four-story building 865 feet in length and 75 feet in width with some fifty thousand square feet of glass (roughly 75 percent of wall area). In a matter of months Kahn placed beside this structure a single-story building with a sawtooth glass roof, 840 × 140 feet, which served as the principal machine shop. Kahn connected these buildings with an impressive, glass-enclosed craneway, 860 × 57 feet. The main building as well as the machine shop opened completely into the craneway on all floors so materials could be moved with ease from one building to the other through the craneway. This craneway would serve as the major distribution point for all raw materials that made up the Model T.[27]

P. E. Martin and Charles Sorensen laid out careful plans for a smooth move into the new factory. Henry Ford simplified their plans in 1909, when he announced that the Ford Motor Company would henceforth make only the Model T and that the runabout, touring car, town car, and delivery car would all consist of identical chassis.[28] Now the plant superintendents no longer had to worry about transferring the Model N production equipment. Besides freeing the usable machine tools, Ford's decision allowed Martin, Sorensen, Emde, and Bornholdt to initiate the design, construction, or procurement of large numbers or special- or single-purpose machine tools. This is what the American system of manufactures was all about. Before moving machine tools to Highland Park, Sorensen and Martin drew up layout boards—scaled figures showing the correct placement of the machinery. They numbered each machine site and then attached brass plates to the machine tools at the Piquette factory. With these plans, the company's millwrights easily designed the electrically driven shafting at the new Highland Park works and correctly placed the machinery. When Highland Park began production, department by department, it was, as Sorensen later wrote, a "progressive" but not a "fully integrated operation."[29] During the next four years Sorensen and his fellow production engineers would effect profound changes at the "Crystal Palace" factory.

In the period between the opening of Highland Park (January 1, 1910) and the installation of the first assembly line (April 1, 1913) the work of the tool department, the move of the Keim pressed steel plant to Detroit, and the six- to tenfold expansion of output (depending on how one counts) distinguish manufacture of the Model T. Historians of the Ford Motor Company, when talking about factory operations, usually make immediate reference to what they and others have called the "classic" work by Horace Lucien Arnold and Fay Leone Faurote, *Ford Methods and the Ford Shops* (1915).[30] Although the work is a classic, few historians have fully understood it, and none has placed it in the context of another series of articles on the Ford factory, written by Fred Colvin in the *American Machinist* in 1913.[31] In many ways the Colvin series surpassed that of Arnold and Faurote in that it gave better details about the machine tools and the fixture and gauging system at the Ford factory. Colvin also compared and contrasted the Ford methods with those of other leading shops, and he grappled with the meaning of large-scale production. Most important, however, the *American Machinist* series described Ford factory operations immediately before the dawn of the assembly line, thus allowing us to see how far Sorensen and others had carried Walter Flanders's Yankee notions and how, once moving assembly was tried, those notions that dealt with assembly were suddenly scrapped.

When Fred Colvin visited the Ford Motor Company plant in the spring of 1913,[32] he was impressed by the way Ford engineers had concentrated on the "principles of power, accuracy, economy, system, continuity, and speed"—Henry Ford's elements of mass production. Noting that Ford manufactured over half the entire United States output of cars, Colvin suggested, "We think of 200,000 automobiles in a single season as being unheard of, if not impossible, as we can hardly imagine such an output. . . . We lose all sense of proportion, and we get to the point where we are quite as ready to accept a million as the proper figure as the paltry(?) 200,000." The well-known technical journalist tried to suggest the meaning of such an output. A million lamps; eight hundred thousand wheels and tires; ninety thousand tons of steel; four hundred thousand cowhides; 6 million pounds of hair for seats; and about 2 million square feet of glass went into the year's production. A complete Model T emerged from the factory every forty seconds of the working day. Five trains of forty cars each left the factory daily, loaded with finished automobiles. In a span of five years the company had gone from producing about six thousand Model T's to roughly two hundred thousand and had lowered costs. "What more could the greatest high priest of efficiency expect?" Colvin asked.[33] Unknown to Colvin, a month before these words appeared in print the priests of efficiency at Ford had made their first experiment with an assembly line.

The power plant at Highland Park, designed by Ford's construction engineer, Edward Gray, and built by the company, consisted of a three thousand-horsepower gas engine, which turned direct current generating equipment. Power was distributed throughout the factory by electric motors, which drove units of line shafting and belting. When Colvin toured the factory, construction was nearing completion on an additional five thousand-horsepower gas engine. The increasing output of Model T's demanded power of this magnitude.[34]

"The Ford testing method is unique and simple," Colvin wrote when he assessed standards of accuracy at Highland Park.[35] Every critical part of the Model T was machined in standard fixtures and checked by standard gauges both during and after the operation sequence. With proper attention by the tool department and the inspection department, the factory maintained essential accuracy. When a unit such as the engine, the transmission, or the rear axle assembly was put together, its bearings were checked with an electric motor. Unlike most automakers, Ford did not run its engine before assembly into the chassis. Not until the car was ready to leave the factory was the engine started. The company did not road-test any Model T. Sorensen, Martin, and others maintained that if parts were made correctly and put together correctly, the end product would be correct.

Principles of economy abounded at the Ford factory. Colvin suggested that the ever-declining price of the Model T served as a testimonial to these principles. He cited numerous instances of economy at Highland Park, all of which were tied to the principles of system, continuity, and speed so evident there. Establishing a theme that would be picked up by other journalists such as Arnold and Faurote, Colvin emphasized the close grouping of machine tools and how this economy of space militated against letting work accumulate in the aisles and made imperative a smooth flow of work throughout the banks of machine tools.[36]

Not long after the Highland Park plant had opened, a newsman from the *Detroit Journal* described the salient feature of the Ford production process as "System, system, system!"[37] In his *American Machinist* series, Fred Colvin reiterated this theme. Only the word "system" could be used to describe the way Fred Diehl purchased materials, their distribution throughout the factory from the main craneway, and the method the company used to handle finished stock. But Colvin was more impressed by the placement of machine tools: "So thoroughly is the sequence of operations followed that we not only find drilling machines sandwiched in between heavy millers and even punch presses, but also carbonizing furnaces and babbitting equipment in the midst of the machines. This reduces the handling of work to the minimum; for, when a piece has reached the carbonizing stage, it has also arrived at the furnace which carbonizes it, and, in case of work to be finished by grinding, the grinders are within easy reach when it comes from the carbonizing treatment."[38] Ford's machine tool expert, Oscar Bornholdt, had likened this sequential operations setup to "the making of tin cans." "At the Ford plant," Bornholdt wrote, "the machines are arranged very much like the tin-can machines"—one right after the other.[39]

Sorensen and Martin had devised a work-scheduling system for the factory. From experience, the average output of each machine tool was recorded and served as the basis for scheduling. If output of a certain class of machine tools in a department was rated at, say, one hundred pieces per machine per day and there were five such machines, total average output would be five hundred pieces. If the production schedule for a single day called for only four hundred pieces, the scheduling system dictated that one machine be shut down while the others turned out their full day's average. Special timekeepers monitored how closely the departments kept to their production schedules.[40] Largely through such systematization, the Ford engineers maintained continuity in the input and output of materials at a calculated rate.

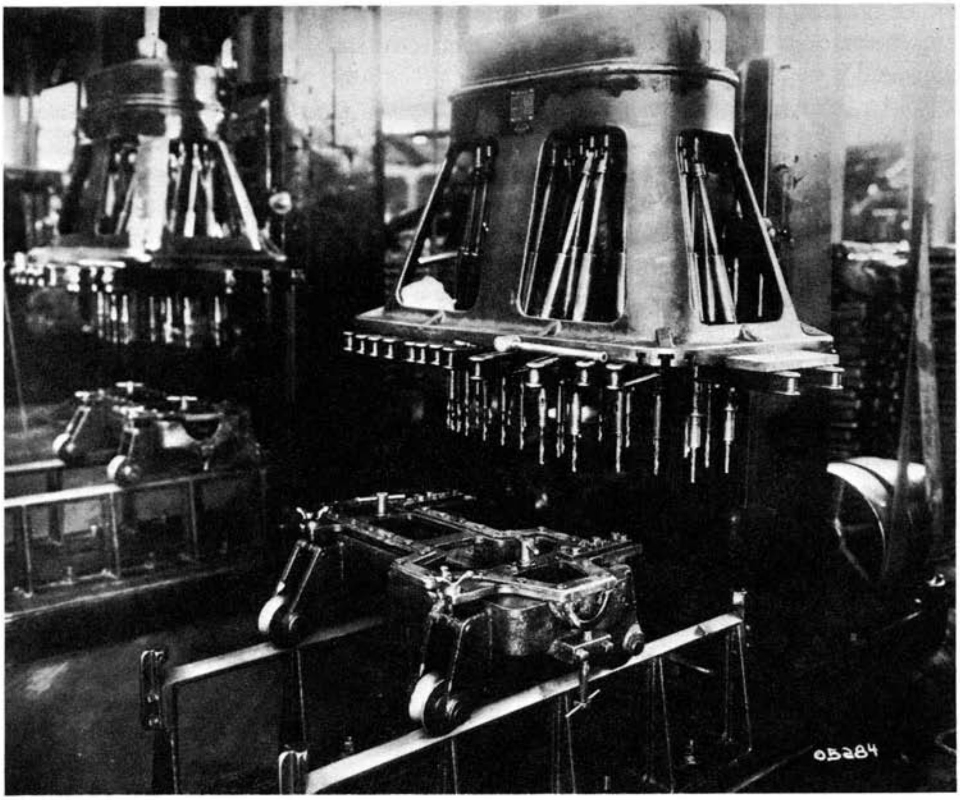

FIGURE 6.6. Quick-Change Fixture for Crankcase Drilling, 1913. This photograph is one of many examples that Fred Colvin used to illustrate the way Ford machine tool designers had built speed into manufacturing operations at Highland Park. The crankcase was quickly loaded into the fixture and then the entire assembly was rolled under the multiple spindle drill press. (Henry Ford Museum, The Edison Institute. Neg. No. 0-6342.)

The principle of speed was apparent to Colvin everywhere he turned in the Ford plant. He stressed, however, that the most impressive application of the principle was in the design of fixtures and gauges by Oscar Bornholdt, Carl Emde, and others in the tool department. The bulk of Colvin's series concerns the design and use of these devices, whose speed, accuracy, and simplicity epitomized the entire Ford production process. (See Figure 6.6.)

The Ford tool experts designed almost all of the fixtures and gauges so that they could be used by unskilled machine tenders. Simplicity, therefore, was an important concern, yet in certain instances this succumbed to the more important considerations of speed and accuracy. Excited by the rationality of absolute interchangeability of parts and painfully aware of the problems created by noninterchangeability in the troublesome assembly process, Ford's production engineers placed accuracy at the top of the list in fixture and machine tool design requirements. By 1913 Emde and others had achieved simplicity and speed in most of their design work without sacrificing accuracy. This achievement deeply impressed Fred Colvin, who had studied many of the leading factories in the United States. For example, the Ford team engineered milling machine fixtures and tables that

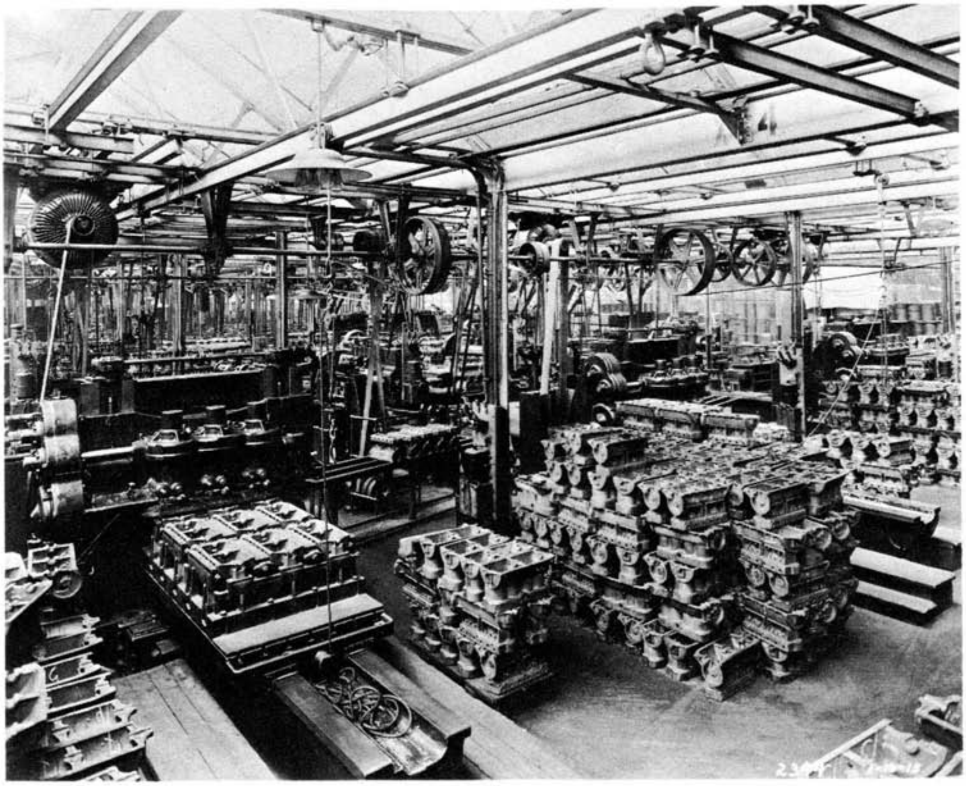

FIGURE 6.7. Machining Engine Blocks, 1915. Ford used multiple head milling machines to machine the blocks and the heads of the Model T engine. Special, easily loaded fixtures held fifteen blocks at a time for accurate machining. (Henry Ford Museum, The Edison Institute. Neg. No. 0-3927.)

held fifteen engine blocks at a time, each easily snapped into place and held rigidly, and similar devices for holding thirty cylinder heads at once. (See Figure 6.7.) Colvin marveled that when brought together the head and block would hold compression with only a plain gasket and without customary—and time-consuming—joint scraping.[41] Readers interested in more details about Ford fixture design should consult the almost countless examples given by Colvin in his series of articles.

Ford tool design depended on a subtle but important interplay with the machine tool industry. Charles Sorensen suggested that Ford men designed all the new machine tools at Highland Park, built a prototype for each, and then relied upon commercial toolbuilders to supply additional machines. He recalled that when Charles Morgana sent out specifications for a Ford-designed machine tool to machine tool manufacturers, the latter often came back to Morgana saying that there must have been an error because the machine could not do what it was supposed to do. Morgana would then show the toolbuilders that no mistake had been made because the Ford-designed and Ford-built prototype could indeed turn out the specified number of units within the specified limits of precision. "So it went on with the thousand pieces of machinery that we bought," concluded Sorensen.[42]

Sorensen no doubt claimed too much in saying that the Ford Motor Company's tool

FIGURE 6.8. Ford Crankshaft Grinding Machines, 1915. Developments in grinding technology, such as the machinery for grinding crankshafts, played an important part in the achievement of accurately machined automobile parts. (Henry Ford Museum, The Edison Institute. Neg. No. 833-2296.)

department designed and built at least one of each kind of machine tool in the Ford factory. The Ford team built many of the special machines used for Model T production, but as Ford machine tool purchaser A. M. Wibel maintained, the company relied heavily on midwestern toolbuilders such as Foote-Burt, Ingersoll, and Cincinnati Milling Machine for initial construction, if not design.[43] Unfortunately, we know less about the general development of machine tools between 1900 and 1915 than for the entire nineteenth century, so any assessment of the state of the art must be tentative.[44] One can only speculate that improvements in the accuracy and speed of machine tools during this period, which resulted largely from metallurgical development and greater rigidity, provided a critical component in Ford's—and the entire automobile industry's—rapid expansion of production capability. In view of the assembly problems at the Singer Manufacturing Company caused by inaccurately machined parts one cannot overemphasize Ford's insistence on accuracy. In Chapter 2 the question was raised of whether in the 1870s and 1880s high-volume, economical production of accurate parts was technologically possible. By 1913, when Colvin wrote the series in the *American Machinist* and when Ford

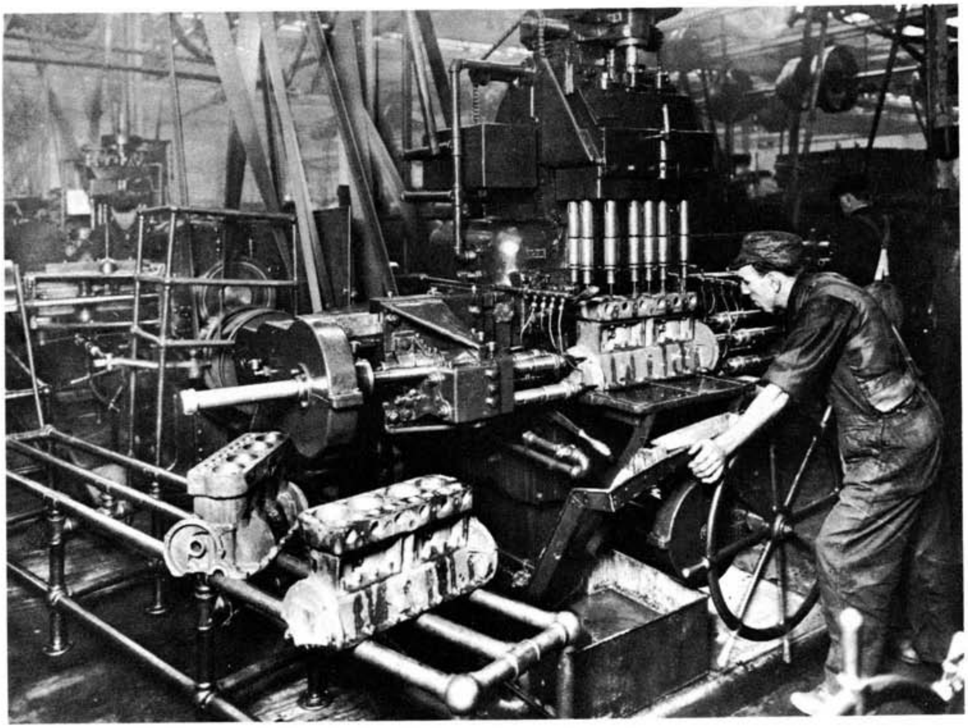

FIGURE 6.9. Drilling and Reaming Engine Block, 1913. This is one example of multiple spindle drilling and reaming machinery designed to machine the Model T engine block. (Henry Ford Museum, The Edison Institute, Neg. No. 833-219.)

initiated line assembly techniques, the machine tool industry was capable—perhaps for the first time—of manufacturing machines that could turn out large amounts of consistently accurate work.[45] (See Figure 6.8.) From the time the Ford Motor Company moved into the Highland Park factory, its production engineers and its principal owner did not compromise on this issue. As will be seen, this accuracy provided the rock upon which mass production of the Model T was based. Nevins quotes an authority on the automobile industry who argued that the "Ford machinery was the best in the world, everybody knew it."[46]

Henry Ford's determination to produce only the Model T provided his engineers the perfect opportunity to install single-purpose machine tools. The engine department, for example, relied extensively on such machines. Emde's department built special block and head spotting machines, which faced, or machined, the bearing points that were used for locating these parts in subsequent machining operations. Special machines bored out the cylinders and the combustion chambers of the head. Another machine tool drilled at one time forty-five holes in four sides of the block. (See Figure 6.9.) Colvin pointed out that "these spindles are non-adjustable so far as location is concerned." The Ford engine tools provided examples "of the single-purpose machine carried to the limit." Other special-purpose engine tools included a drilling machine for babbitt bearing anchor holes, other types of drilling machines, and broaching machines for valve stem bushings. These examples could be multiplied by the number of other partsmaking departments.[47]

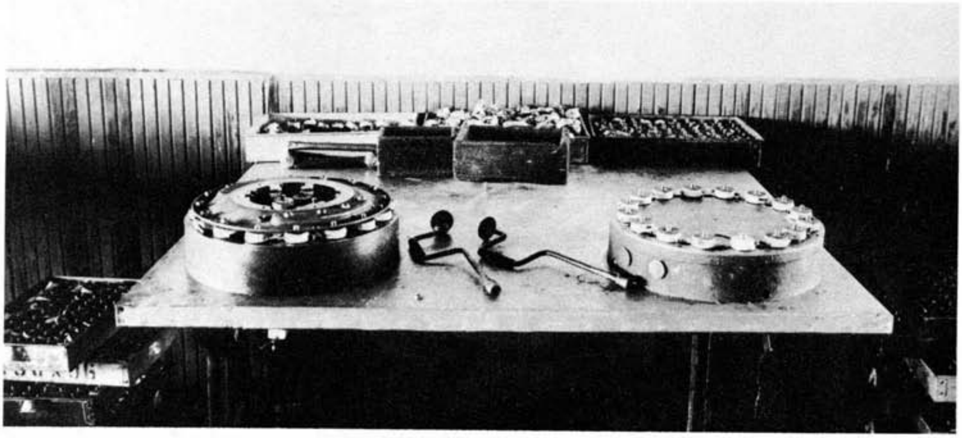

FIGURE 6.10. Magneto Coil Assembly, Highland Park, 1913. (Henry Ford Museum, The Edison Institute. Neg. No. 0-6337.)

Henry Ford's and his production engineers' constant experimentation with new production methods and their willingness to scrap processes and tools are perhaps best illustrated in pressed steel work. Ford had adopted the use of stamped steel rear axle housings, a process developed in Buffalo by the John R. Keim company. Ford purchased the company and moved its machinery and its leading mechanics to Highland Park in 1911. Not long after setting up at the "Crystal Palace," the old Keim team and the Ford engineers scrapped the rear axle housing stamping process after they developed a superior process that involved flaring out the ends of drawn steel tubing and riveting them to a malleable cast-iron differential housing.[48] The Keim mechanics found other applications for punching, pressing, and stamping, however, such as setting three shafts for transmission gears in the flywheel by a single punching operation.[49] As Colvin pointed out, machine tools and other production processes were constantly undergoing examination and change at Ford. This was clearly the case with processes by which the Ford automobile was put together.

Assembly of Model T components and the entire automobile greatly impressed the *American Machinist* writer. He wrote that after he had watched the entire assembly process he could "see that the production of 800 cars a day is not merely guesswork."[50] Colvin detailed either in the text or through photographs the motor assembly department, rear axle assembly, magneto assembly, radiator assembly, and finally the overall assembly. Ford engineers had set up simple workbenches for putting together the field windings of the magneto. (See Figure 6.10.) At the back of each bench and on its sides, small bins held the various parts that made up the field assembly. A workman stood at the worktable, putting together the parts of this important subassembly.[51] For assembling engines, Ford engineers also used workbenches, but instead of being located against a wall, the engine assembly benches were placed in the open so that men could work on both sides of them. (See Figure 6.11.) Parts bins were placed in the middle of the tables, easily reached from either side.[52] Colvin emphasized that there was no fitting—and therefore no fitters—in any Ford assembling department.[53] The rear axle assembling department relied upon assembly stands almost identical to those used in many New England shops, particularly the Pope Manufacturing Company during the bicycle craze of the 1890s. (See Figure

FIGURE 6.11. Engine Assembly, Highland Park, 1913. Individual workmen assembled entire engines by themselves. Unlike most of the photographs used by Fred Colvin in 1913, the original print of engine assembly no longer survives in the Ford Archives. (*American Machinist*, June 12, 1913. Eleutherian Mills Historical Library.)

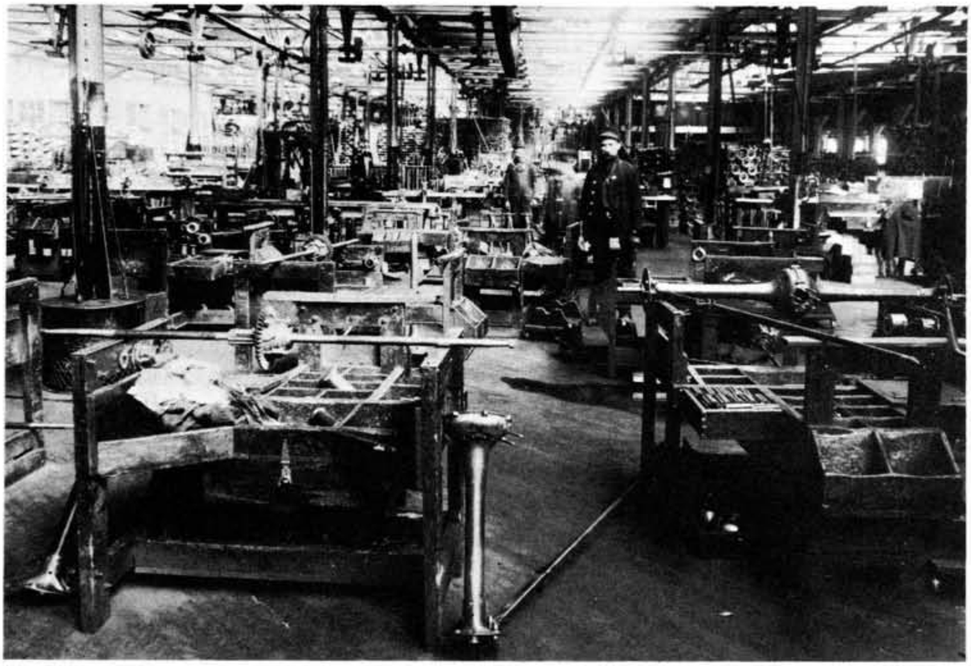

FIGURE 6.12. Rear Axle Assembly Stands, Highland Park, 1913. Individual workmen assembled rear axles entirely by themselves at these stands. (Henry Ford Museum, The Edison Institute. Neg. No. 0-6336.)

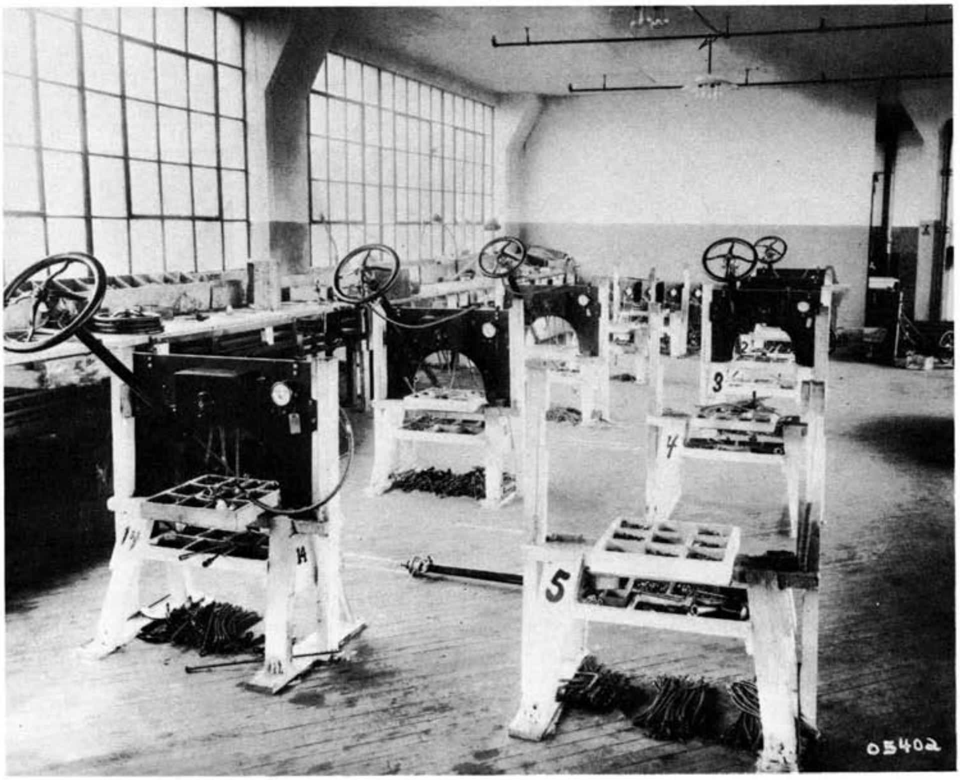

FIGURE 6.13. Dashboard Assembly Stands, Highland Park, 1913. (Henry Ford Museum, The Edison Institute. Neg. No. 0-6335.)

6.12.) These stands provided the necessary open work area and also held the parts in bins conveniently reached by workmen. The stands were placed far enough apart so that hand trucks could move material to and from them. As with other subassemblies, individual workmen performed the entire process of rear axle assembly. Colvin said that the design of the stand "show[s] that motion study has been carefully looked into, whether it is called by that name or not."[54] Faced with laborious threading of radiator fins and tubes together, production engineers designed a simple mechanism that pushed ninety-five tubes through the holes in the strips or fins in a single stroke. After mechanized core assembly was completed, however, the remainder of radiator assembly consisted chiefly of laborious hand soldering of the core to the tank and to the frame.[55] (See Figure 6.13 for dashboard assembly.)

"It is impossible to give an adequate description of the general assembly of the Ford automobiles, as this could only be done with a modern moving-picture machine," wrote Colvin about the final assembly process. "As in the machining department the keynote of the whole work is simplicity, even to the *assembling horses* or *stands* shown."[56] (See Figure 6.14.) Laborers distributed the necessary parts at each station and timed their deliveries so that they reached the station shortly before the parts were needed. While the automobile frames remained static upon the horses, dynamic assembly teams or gangs moved from station to station down the row. Each gang had been programmed to perform

FIGURE 6.14. Static Assembly of Model T Chassis, 1913. Unfortunately, the moving assembly gangs were not included in the photograph. (Henry Ford Museum, The Edison Institute. Neg. No. 0-1267.)

a specific task or series of tasks. Colvin pointed out that this method resembled that used at the Baldwin Locomotive Works and other shops. When carefully orchestrated—as the Ford assembly team was—the method worked well.[57] One might imagine, however, that problems of correct delivery of materials and of assembly gangs not keeping within their time limits (and therefore getting into each others' way) plagued the Ford factory. These problems were soon eliminated.

In "moving the work to the men," the fundamental tenet of the assembly line, the Ford engineers found a method to speed up the slow men and slow down the fast men. The assembly line would bring regularity to the Ford factory, a regularity almost as dependable as the rising of the sun. With the installation of the assembly line and the extension of its dynamism to all phases of factory operations, the Ford production engineers wrought true mass production.

It has generally been assumed that because Nevins and Hill were given complete access to the Ford Motor Company archives and because Nevins was usually a careful scholar, their account of the development of the assembly line is, if not definitive, at least accurate in its broad outlines. The authors maintain that employment of conveyor systems and gravity slides throughout the Ford factory led almost naturally to the assembly line. Pointing out that "no contemporaneous documentary record of the great innovation exists," Nevins and Hill turned to the recollections of the Ford pioneers, made some forty years after the event.[58] Some of these former employees suggested that conveyor systems

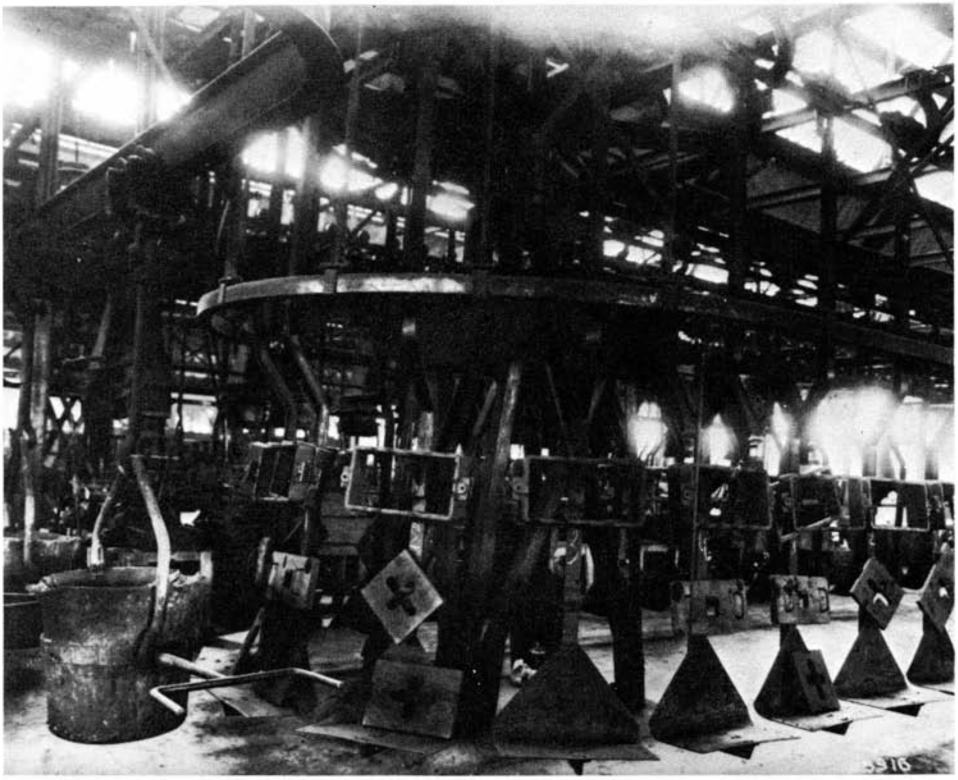

FIGURE 6.15. Ford Foundry Mold Conveyors, 1913. Molds were carried around on the platforms (lower foreground) past bull ladles from which molten iron was poured. (Henry Ford Museum, The Edison Institute. Neg. No. 0-6338.)

and gravity slides had been in use well before April 1, 1913, and that their elaboration eventually led Sorensen et al. to install an assembly line in the magneto department, which in turn led to lines in the engine assembly department, the rear and front axle assembly departments, and finally to chassis assembly.

Although they were aware of the Colvin series of articles in *American Machinist,* Nevins and Hill ignored the contemporaneous evidence—particularly pictorial evidence—in this gold mine of information. Colvin spent ten days at Highland Park perhaps less than two months before the first experiments were conducted on a magneto assembly line.[59] Throughout his articles, Colvin mentions and documents with photographs piles of parts and hand trucks that carried these parts through the factory. Nowhere does he mention conveyors or gravity slides, and none appears in any photograph. Fred Colvin was too keen an observer, too much an advocate of smooth flow of materials, to overlook gravity slides, gravity rollers, and conveyor systems. He does document fully a monorail system, which moved large trays or platforms of work throughout the factory. This materials handling system was typical of many shops, but the conveyor systems and gravity slides that show up in the photographs of the Ford factory in 1914 and 1915 were different.[60] It appears, therefore, that conveyors and gravity slides were adopted either immediately before the assembly line experiments or resulted from the "work in motion" principle

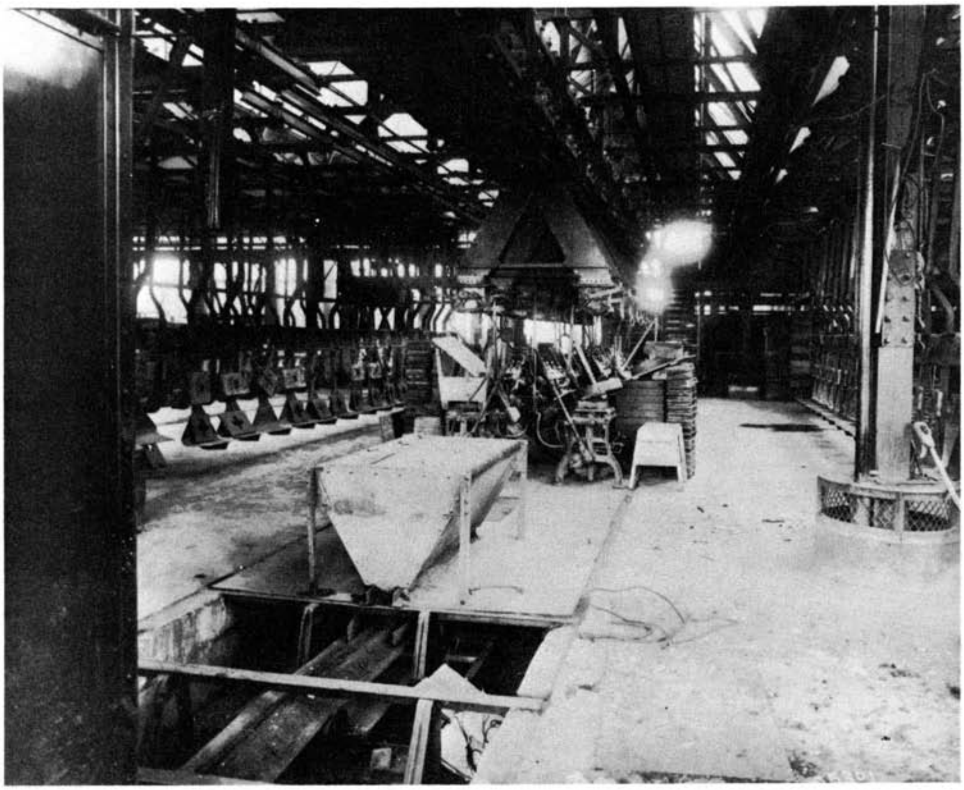

FIGURE 6.16. Molding Machines, Ford Foundry, 1913. In the center of this photograph are shown molding machines and the hoppers that fed them. Sand-conveying machinery appears in the left foreground. (Henry Ford Museum, The Edison Institute. Neg. No. 0-6339.)

brought to life by the assembly line. The latter view seems more likely. In any case, these two elements of mass production fed on each other; by 1915 both had reached a maturity unknown in 1913.

In his reminiscences, Charles Sorensen claimed that the idea of an assembly line occurred to him in 1908 and that on consecutive Sundays in July of that year, he, Henry Ford, Harold Wills, P. E. Martin, and Charles Lewis, an assembly foreman, laid out a crude chassis assembly line. Wills and Martin rejected the idea out of hand, Sorensen remarked, and it was buried in the rush to open the new Highland Park plant.[61] Although perhaps apocryphal, Sorensen's account suggests that the Ford engineers had been concerned about the problem of assembly. Faced in 1913 with the task of putting together almost two hundred thousand Model T Fords, however, Wills and Martin consented to more extensive experiments.

Sorensen did play a major role in the development of the assembly line.[62] He contributed his expertise in patternmaking and foundry work to the operations of the Highland Park foundry. In February 1913, a conveyor-type mold carrier began operation in the foundry. (See Figures 6.15 and 6.16.) The mold carrier moved past molding machines (at which point the completed molds were set on the carrier) and around past a bull ladle which allowed for continuous pouring of molten iron. (The engine blocks, however,

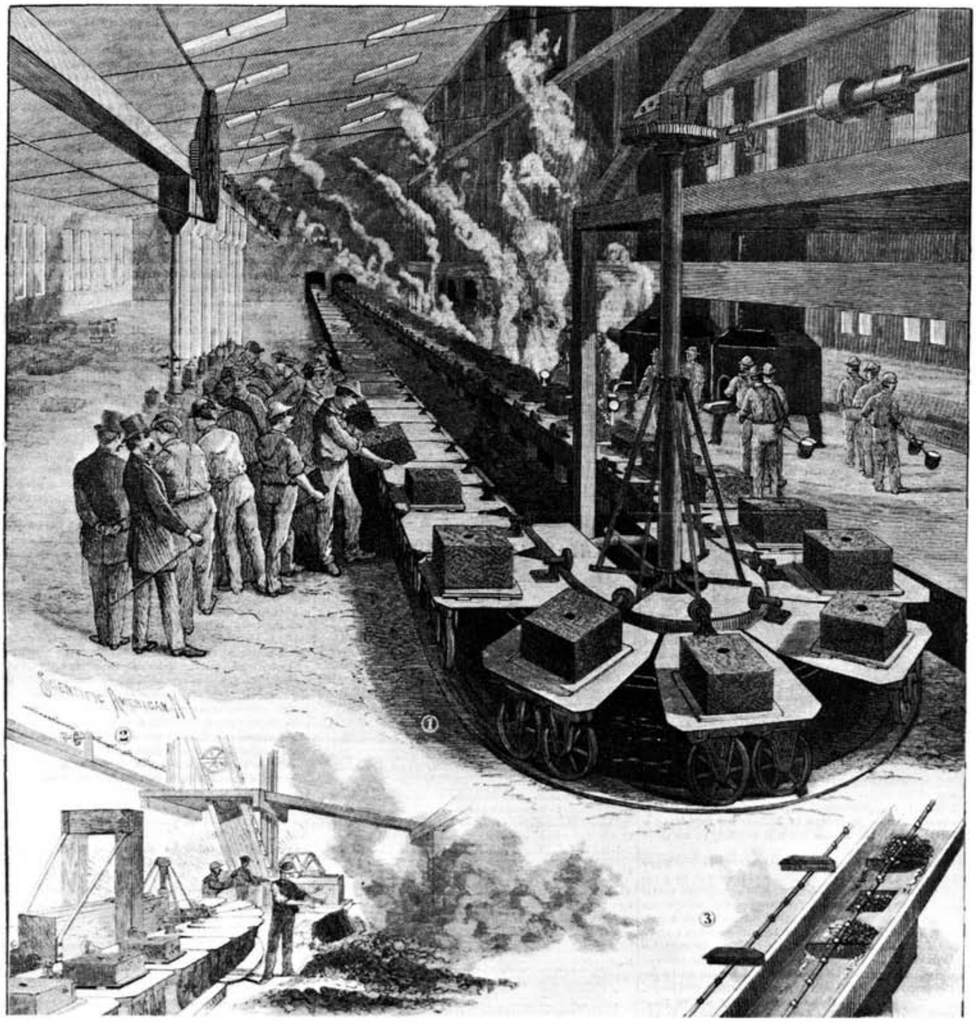

FIGURE 6.17. Westinghouse Foundry, 1890. A conveyor system (1) carries machine-made molds past pourers. Men break open the molds after sufficient cooling (2). The sand conveying system is illustrated in (3). (*Scientific American*, June 14, 1890. Eleutherian Mills Historical Library.)

continued to be laid out on a pouring floor rather than being put on the carrier.) As early as 1890, the Westinghouse Airbrake Company had devised a similar mold carrier. (See Figure 6.17.) Integral to both the Westinghouse and the Ford mold carriers was a conveying system that moved sand from the spot where the molds were taken off the carrier and shaken open to a sand-mixing operation and thence to hoppers above the molding machines.[63] This system eliminated wheelbarrows and almost all hand shoveling. The productivity of the Ford foundry astonished technical journalists. Rough calculations show that although the Ford foundry had half the area of Singer's Elizabethport foundry (in 1880), it poured daily more than ten times the amount of iron. By 1914, ten continuous-pouring mold carriers had been installed at Highland Park.

In addition to the mechanized foundry of Westinghouse Airbrake, developments out-side metalworking practice played on the minds of Ford production men. Three industries in particular seemed to provide models of efficient and smooth materials handling. In his autobiography, written in collaboration with Samuel Crowther, Henry Ford suggested that the "disassembly" lines of Chicago meatpackers served as a model for "flow production" at the Ford factory.[64] (See Figures 6.18 and 6.19.) Packing houses had come to public attention with the 1906 publication of Upton Sinclair's *The Jungle,* which described their operations in vivid detail. William Klann, head of the engine department at Ford, recalled that he had toured Swift's Chicago slaughterhouse and had then suggested to superintendent P. E. Martin, "If they can kill pigs and cows that way, we can build cars that way and build motors that way."[65] Klann also stressed that the Ford flow production also drew upon the mechanical conveying system of both the flour milling and brewing industries.

In 1904, the year before he joined the Ford Motor Company, Klann worked as a machinist repairing grain elevators and other mechanical conveyors in breweries for the Huetteman & Cramer Machine Company of Detroit. Klann claimed that both breweries and foundries used essentially the same hoppers and conveyors to feed those hoppers for, respectively, malting and moldmaking. Huetteman & Cramer made this equipment. Klann recalled that a fellow employee at Huetteman & Cramer, who also later worked for Ford, first interested Henry Ford in mechanical materials handling "by showing him a catalogue" of foundry and brewing conveyors and hoppers.[66] Although relatively new in foundry practice, mechanized conveyance had been used in breweries soon after Oliver Evans developed his automatic flour mill in the late eighteenth century.[67] (See Figure 6.20.)

Since the days Evans first operated his automatic flour mill on Red Clay Creek in northern Delaware, the flour milling industry had used and continued to refine his system of mechanical conveyance. Minneapolis had become the flour milling capital of the world by the late nineteenth century, and many informed people were well aware of the sophistication of automatic materials handling equipment in these mills. Indeed, the American system of milling was an object of pride in the United States at this time.[68] Ford production men should have at least heard about these mills. Certainly William Klann had. Klann summed up the importance of all three of these industries: "We combined our ideas on the Huetteman & Cramer grain [conveying] machine[ry] experience, and the brewing experience and the Chicago stockyard. They all gave us ideas for our own conveyors."[69] Yet another process technology may have influenced the Ford production men.

Ford's principal machine tool expert, Oscar C. Bornholdt, had in 1913 compared the sequential arrangement of machine tools at the Ford factory to the layout of food canning machinery. An earlier—and striking—illustration of a successful mechanized cannery in Chicago shows that not only were canning machines arranged sequentially but that they were linked by automatic conveyance systems that brought the work to the worker.[70] The illustration is richly suggestive. (See Figure 6.21.) If Bornholdt had established in his own mind an analogy between Ford's machine tools and canning machinery, there is no reason to doubt that he did not make and exploit a similar analogy between materials flow at the Ford factory and the movement of cans in a food-processing facility. Moreover, Klann's tour of a Chicago meatpacking plant could have easily included a cannery. If Bornholdt had seen a mechanized cannery, it is reasonable to assume that other key Ford employees were familiar with similar systems.

The unquestioned success of the mechanization of the Ford foundry, as well as the rich suggestions of meatpacking, milling, brewing, and canning, touched off a burst of experi-

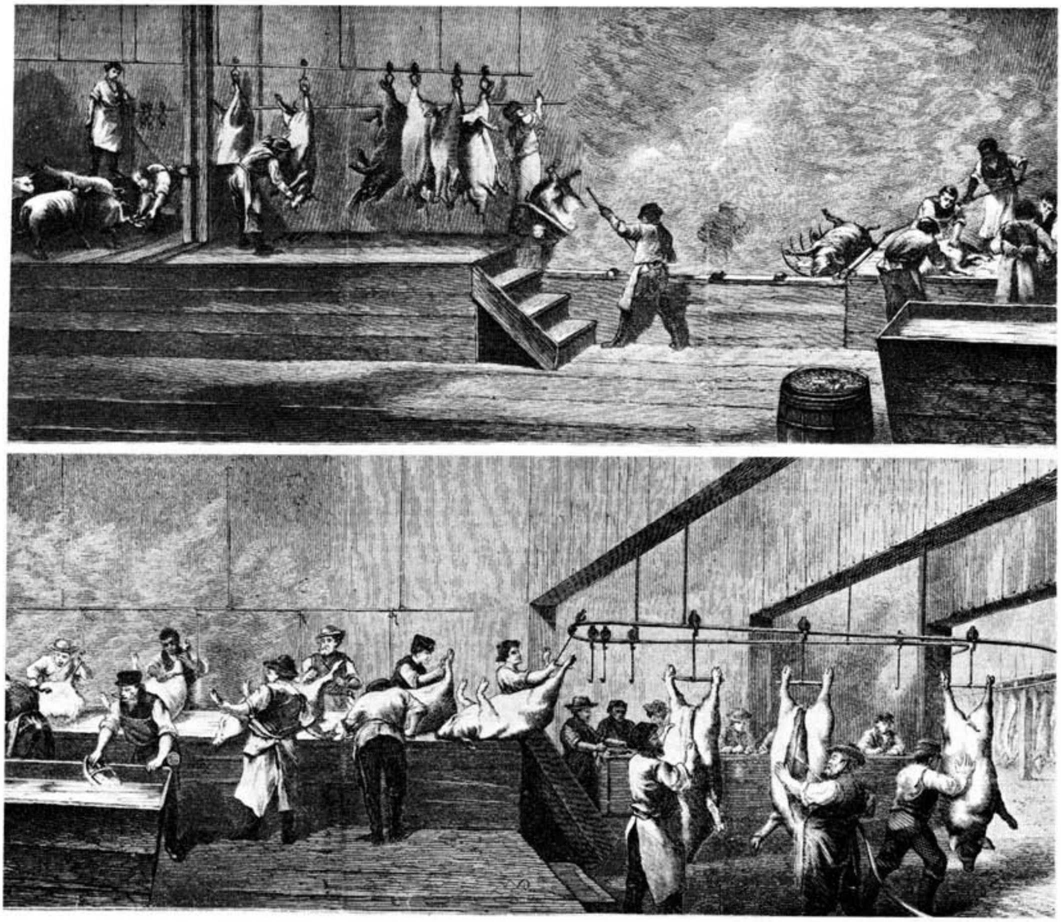

FIGURE 6.18. "Disassembly" Line, Slaughterhouse, 1873. An early example of "flow" production, slaughterhouses such as this one began first in Cincinnati and later became famous in Chicago, the "hog-butcherer of the world," in the era of Henry Ford. (*Harper's Weekly*, September 6, 1873. Eleutherian Mills Historical Library.)

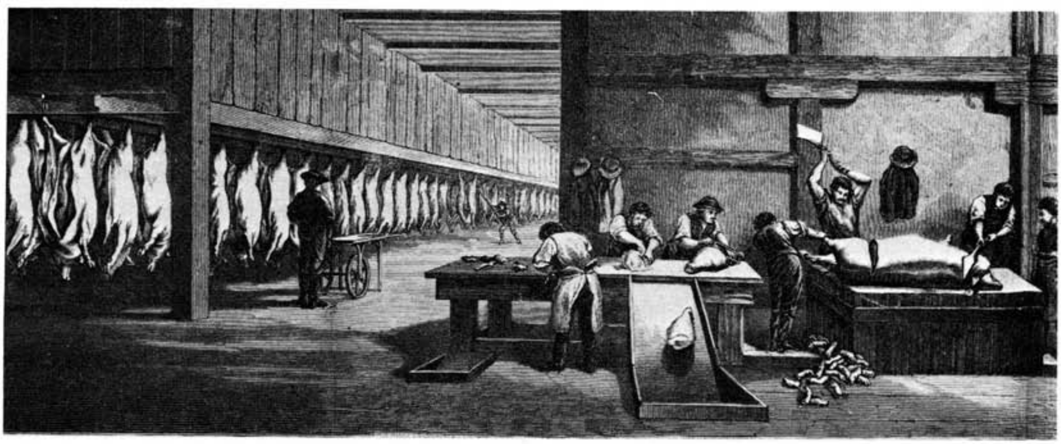

FIGURE 6.19. "Disassembly" Line, Slaughterhouse, 1873. Note the ham traveling down the gravity slide. (*Harper's Weekly*, September 6, 1873. Eleutherian Mills Historical Library.)

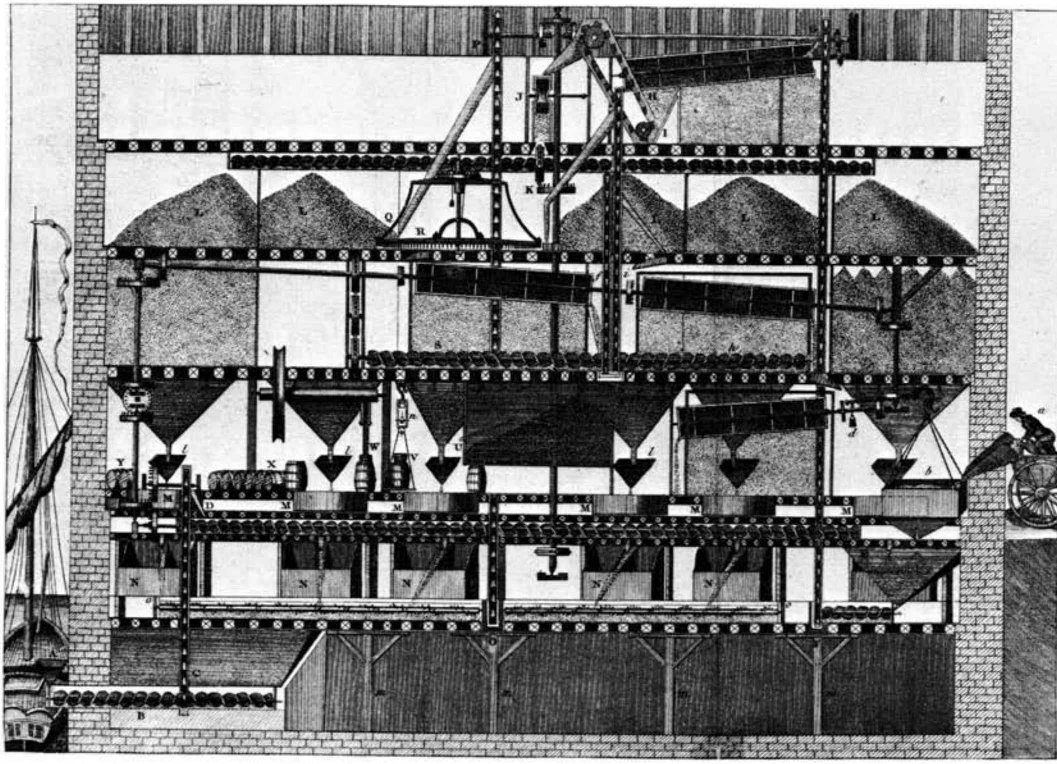

FIGURE 6.20. Evans's Automatic Flour Mill, Occoquan, Virginia, 1795. Conveying devices carry wheat from either wagon or boat through all the steps of screening, grinding, and bolting. (*Annales des arts et manufactures*, 1802. Eleutherian Mills Historical Library.)

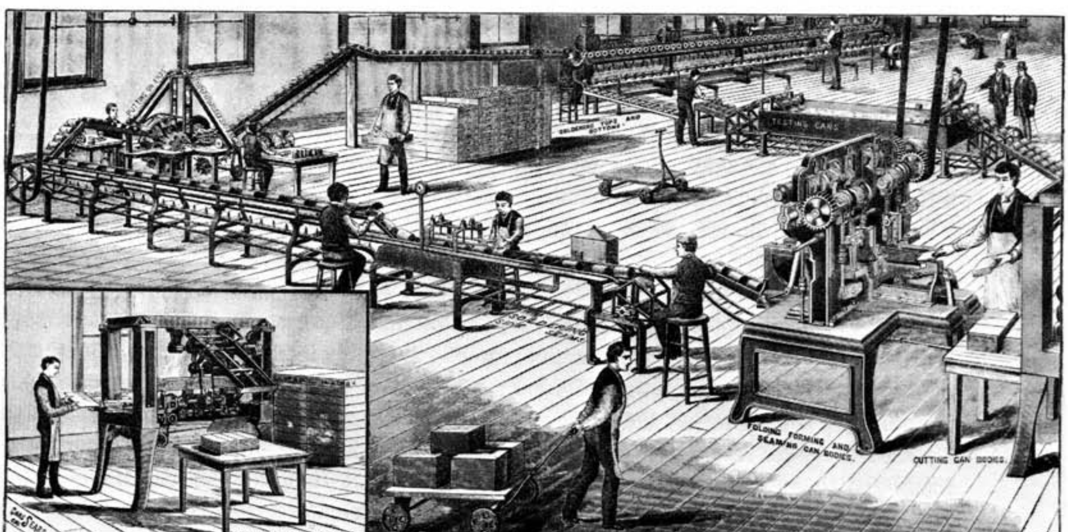

FIGURE 6.21. Norton's Automatic Canmaking Machinery, 1885. This can line, distinguished by special-purpose machinery and a conveyor system, was the creation of Edwin Norton, who later organized both the American Can Company in 1901 and the Continental Can Company in 1904. (*American Machinist*, July 14, 1885. Eleutherian Mills Historical Library.)

mentation and change at the factory in which every*thing* was put in motion and every *man* brought to a halt. Sorensen claims—and Nevins and Hill corroborate—that he designed a conveyor system for moving radiator work through the machining and assembly processes. He creates confusion, however, by adding that the radiator conveyor took finished radiators all the "way to the assembly line."[71] There was no chassis assembly line until August 1913. If Sorensen did install a radiator conveyor system before the magneto assembly line installation of April 1, 1913, he must have done so in February or March. Fred Colvin visited the factory sometime between January and "the spring of 1913." Had the radiator conveyor been installed or even partially installed, Colvin would have noted it, for he treats in detail the production and assembly of radiators in one of his articles.[72]

This discussion is not solely for the purpose of quibbling with Nevins's and Hill's details of the development of the assembly line. As already noted, these authors suggest that the installation of conveyor systems in radiator assembly and in engine assembly, as well as all the supposed gravity slides and gravity rollers in the machine shop, brought Sorensen et al. logically to the assembly line. All of the contemporary evidence, however, especially that in Colvin's lengthy series on Ford methods, suggests the contrary. No doubt the foundry conveyor system encouraged the Ford engineers to try the magneto assembly line, but it was the rapid rise of the assembly line that brought about the immediate installation of conveyor systems wherever they could be installed. Whatever its origin, its importance is that the Ford production experts were bringing about such rapid-fire changes that none of them could keep straight which came first, the assembly line or mechanized conveyance. Only a devoted diarist could have kept these changes straight, and none of the Ford men was a diarist. They were too busy. (See Figure 6.22.) The adoption and elaboration by Ford of sequential arrangement of machine tools and the dynamism of the foundry's mold carrier may have led logically to full-scale mechanized conveyance and assembly lines, but Nevins's metaphor or rivulets flowing into streams flowing into great rivers is inappropriate.[73] With the speed, magnitude, and impact of change at Ford, this was the Deluge, the Great Flood, which wiped out all former notions of how things ought to be moved and assembled.

As with the question of whether conveyors and work slides or the assembly line came first, there is ambiguity about exactly when and where the assembly line was first implemented at Highland Park. The standard account of Allan Nevins quite rightly relied heavily upon the work of Horace Arnold, which was written about a year after the innovation took place. But Nevins also drew upon the oral history interview of William Klann, who was the foreman of motor assembly at Ford in 1913. Klann's reminiscences are among the most extensive and vividly detailed of any of the Ford Motor Company employees who worked during the Model T era and who were interviewed for the commissioned history of the company. By combining the accounts of Arnold and Klann, Nevins concluded that the first attempt at moving assembly took place in the magneto coil department under the direction of James Purdy. But in discussing the results of this experiment, the historian cited the productivity figures reported by Arnold for the flywheel magneto assembly. Nevins obviously confused the magneto coil assembly, a flat metal disk that supported sixteen coils and was mounted rigidly on the rear of the engine block, and the flywheel magneto, a flywheel with sixteen V-shaped permanent magnets bolted on its front side. Elsewhere in the first volume of his study of Ford, he reproduced a photograph of workmen assembling the magnets onto the flywheel and called this the "first magneto assembly line."[74] (See Figure 6.23.)

Even when this distinction is kept in mind, however, confusion and contradiction

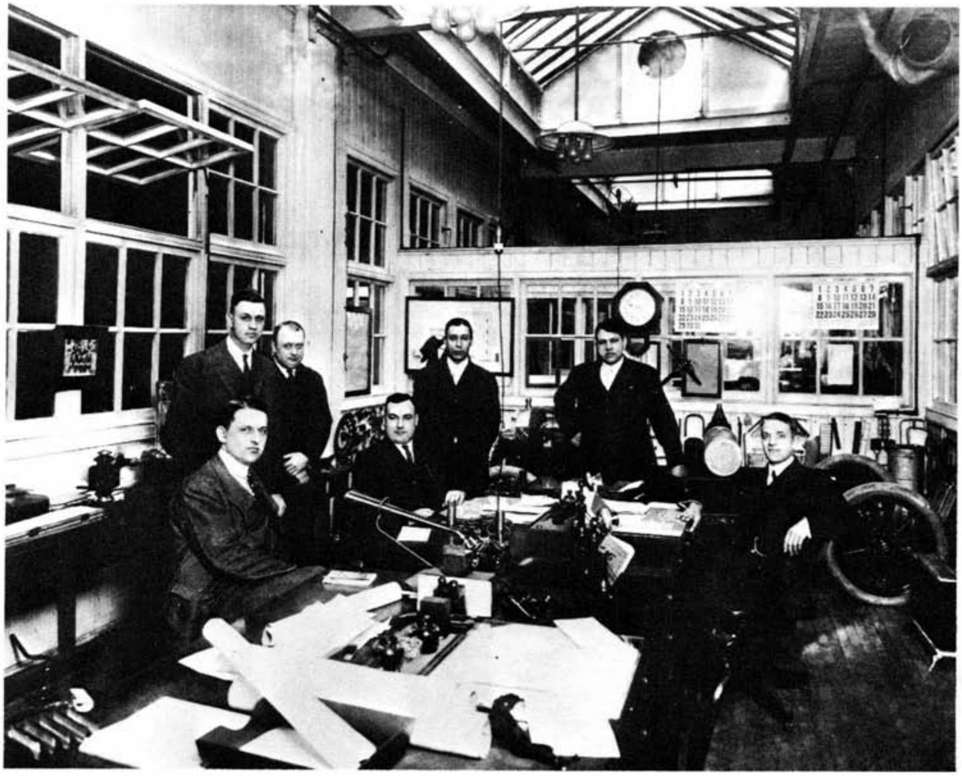

FIGURE 6.22. Some of the Principal Creators of Mass Production at Ford Motor Company, 1913. This is the superintendent's office at the Highland Park factory. Seated (left to right): Charles Sorensen, P. E. Martin, and C. Harold Wills. Standing directly behind Sorensen is Clarence W. Avery. Note the Model T chassis in the rear of the office. (Henry Ford Museum, The Edison Institute. Neg. No. 833-697.)

prevail. Arnold's account contains inconsistencies which are perplexing to the historian. In the same work he gave both April 1 and May 1 as the date of the first subassembly line. More important, he included a photograph captioned "West End of Flywheel-Magneto Assembling Line: This is the first of the Ford sliding assembly lines." (See Figure 6.24.) Yet this picture shows the transmission mechanism being assembled rather than the assembly of the sixteen permanent magnets onto the flywheel. Fred Colvin later reproduced the same photograph and correctly labeled it "Assembling the Transmissions."[75]

In his oral history interview, Klann was asked specifically about the first Ford subassembly line. Obviously having examined Arnold's account of this development, Klann repeatedly and adamantly argued that the magneto coil assembly was the first to be put on a moving line basis and that moving line assembly of the permanent magnets onto the flywheel actually followed placing the engine assembly and the transmission gear and clutch assembly on a moving line.[76] Because he was the foreman of engine assembly in 1913 and because his command of detail was so evident when he was interviewed in the early 1950s, Klann's account is persuasive. Yet it conflicts with nearly contemporaneous evidence. Specifically, a photograph of magneto coil assembly operations which Arnold

FIGURE 6.23. "The First Magneto Assembly Line," 1913. This is a photograph of what Allan Nevins, among many other historians, called the first magneto assembly line. In his text, Nevins said that the magneto coil assembly was the first subassembly to be put on a line basis, but this illustration shows assembly of the flywheel magneto, the other half of the entire Model T magneto. (Henry Ford Museum, The Edison Institute. Neg. No. 833-167.)

first reproduced in April of 1914 calls Klann's account into question for it shows procedures that clearly precede the assembly line.[77] It is possible that Arnold used an outdated photograph, but it is not probable given the immediacy of the other photographs he used to illustrate his articles.

The historian, therefore, is left with trying to resolve conflicting evidence, some generated a year after the fact and some forty years later. Arnold's and Klann's respective accounts of the first, critical subassembly line at Ford cannot be satisfactorily reconciled. Arnold's account with its substantial data on productivity gains achieved with the moving assembly of the flywheel magneto ultimately stands as the most convincing.[78] The anomaly of the photograph showing transmission assembly on the "first of the Ford sliding assembly lines" can be explained away in a number of ways which need not detain us. What is important is that whichever subassembly came first—magneto coil, permanent magnet, or transmission—the development of the assembly line at Ford was so swift and powerful that it defied accurate, unambiguous, timely documentation by the Ford Motor

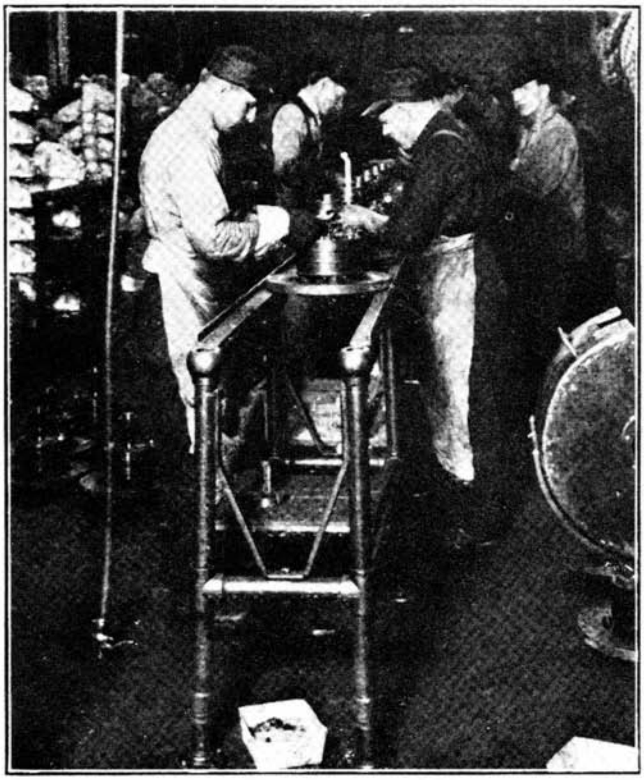

FIGURE 6.24. Assembling Transmissions on What Horace Arnold Called "the first of the Ford sliding assembly lines," 1913. Despite the caption, workers are assembling transmissions on the back half of the flywheel. After completion of this operation, the flywheel was flipped over, ready for assembly of sixteen permanent magnets. (See Figure 6.23). Note the pipe nipples at the bottom of the frame used to raise the height of the line because workers complained of backaches suffered from stooping. (*Engineering Magazine*, July 1914. Eleutherian Mills Historical Library.)

Company and its employees.[79] Within a year of the first line, virtually every assembly operation at Ford had been put on a moving line basis, and those early ones had been radically revised. No better example exists than the one that Horace Arnold called the first Ford assembly line.

On April 1, 1913, workers in the Ford flywheel magneto assembling department stood for the first time beside a long, waist-high row of flywheels that rested on smooth, sliding surfaces on a pipe frame. No longer did the men stand at individual workbenches, each putting together an entire flywheel magneto assembly from the many parts (including sixteen permanent magnets, their supports and clamps, sixteen bolts, and other miscellaneous parts). This was no April Fool's joke. The workers had been instructed by the foreman to place one particular part in the assembly or perhaps start a few nuts or even just tighten them and then push the flywheel down the row to the next worker. Having pushed it down eighteen or perhaps thirty-six inches, the workers repeated the same process, over and over, nine hours, over and over. Martin, Sorensen, Emde, and others had designed what may have been the first automobile assembly line, which somehow seemed another step in the years of development at Ford yet somehow suddenly dropped out of the sky. Even before the end of that day, some of the engineers sensed that they had made a fundamental breakthrough. Others remained skeptical. Twenty-nine workers who had each assembled 35 or 40 magnetos per day at the benches (or about one every twenty minutes) put together 1,188 of them on the line (or roughly one every thirteen minutes and ten seconds per person). There were problems, to be sure. The workers complained about aching backs because of stooping over the line; raising the work level six or eight inches would solve that problem. (See Figure 6.24.) Some workers seemed to drag their heels while others appeared to work too fast. Although a piece rate system would probably eliminate the slow ones, the engineers knew that Henry Ford would never tolerate such a system. Soon they found that by moving magnetos at a set rate with a chain, they could set the pace of the workers: speed up the slow ones, restrain the quick. Within the next year, by raising the height of the line, moving the flywheels with a continuous chain, and lowering the number of workers to fourteen, the engineers achieved an output of 1,335 flywheel magnetos in an eight-hour day—five man-minutes compared to the original twenty.[80]

One can only imagine how excited the Ford production engineers were about the problems and possibilities of the assembly line. It became an object of study not only by Martin, Sorensen, and Emde but also by the heads of other assembling departments. Almost immediately after seeing the flywheel magneto assembly line, William Klann, head of the engine assembly, received permission to build an engine assembly line. The rush to implement such a line—beginning with putting the crankshaft in the engine block—led to an accident on the second day of operation which injured a workman seriously enough to bring James Couzens into the factory to inspect this "Goldberg job." Couzens wanted to call a halt to Klann's experiments. But when Klann assured Martin and Sorensen that the line "could be made foolproof," he received their permission to continue. Klann recalled that he started the line again the next day after adding certain safety devices to keep the engines from falling off the conveyors. "In a few weeks we had the job licked," Klann boasted. Arnold wrote that new attempts were not made until November 1913. In any case, productivity gains were enormous.[81] Klann and the Ford production engineers also turned to transmission assembly.

The Model T's transmission consisted of three distinct subassemblies: the transmission mechanism, the flywheel magneto assembly, and the transmission cover. Assembly of the transmission mechanism onto the back side of the flywheel was put on the line soon after the line had been built for the permanent magnets onto the front side of the flywheel. (Or, if one believes Klann, this was done first.) Beginning with the flywheel, workers added the triple gears, the driven gear, three drums, and the numerous parts of the clutch to form a complete subassembly. This line was developed so that when the transmission mechanism was completed, the flywheel was simply flipped over, ready for the magnets to be installed further down the line.[82]

In June 1913, Klann changed transmission cover assembly into a line operation. On this subassembly, the production engineer had to resort to flat-top metal tables instead of rail slides because the shape of the cover did not lend itself to rails. Line operation immediately brought cover assembly time down from eighteen man-minutes to nine minutes and twelve seconds. As Klann pointed out about the adoption of line assembly techniques, "There wasn't any discussion on whether this would work. You couldn't go wrong because the first one worked all right."[83]

By November 1913, Klann, Emde, and others put the entire engine assembly—made up of several subassemblies—on an integrated assembly line. (See Figures 6.25 and 6.26.) This was not one long line but two lines at right angles with several machine tools, babbitting ovens, and other miscellaneous machinery interspersed. Engine line assembly proved to be a matter of constant experiment and refinement. As Klann remarked, "We monkeyed with that thing all kinds of ways before we got it to work on a moving line."[84] By the time Klann and his colleagues had gotten "all of the kinks" worked out, lowering engine assembly from 594 man-minutes to 226 man-minutes,[85] Charles Sorensen and his assistant Clarence W. Avery had tried moving line assembly principles on the chassis. This operation became, in the public's mind, "the" assembly line.

Horace Arnold described the Ford chassis assembly line as "a highly impressive spectacle to beholders of every class, technical or non-technical." Charles Sorensen called it "the most spectacular one." Sorensen may have imagined such a spectacle in 1908 and may have even tried to realize it. But in August 1913 the apparent success of the flywheel magneto line and the unqualified productivity gains of the engine and transmission assembly lines led Sorensen and others to begin experimentation with chassis assembly. Sorensen was not to be denied this time. Appointed directly by Henry Ford, Sorensen's assistant Clarence Avery (who had been Edsel Ford's manual training teacher in high school) proved to be a decisive factor in the success of the assembly line at Ford. As Avery said in 1929, "It was my good fortune to have [been assigned] the problem of developing the first continuous automobile assembly line."[86] Avery was a bright, well-educated young man who had wanted to get out of teaching into the "real world" of manufacturing. When assigned to him by Ford, Sorensen had instructed Avery to master conceptually every manufacturing operation at Highland Park.[87] After eight months of study, Avery was ready to help Sorensen. As Fred Colvin had pointed out in the *American Machinist,* stationary chassis assembly at Ford was not a matter of guesswork. With several assembly gangs moving up and down the rows of chassis and with delivery of parts at each station demanding correct scheduling, the orchestration of the assembly process had required motion and time studies (albeit perhaps elementary ones) to avoid chaos.[88] It was from these studies or from this knowledge about how long certain operations took that Sorensen and Avery laid out the basic plans of the first chassis assembly lines.

The use of time and motion studies for the layout of the final or chassis assembly line at Ford raises an important question: To what extent did Taylorism or scientific management or any other contemporary form of systematic management shape or influence the developments at Ford's Highland Park factory? The Ford Motor Company, after all, arose in the era when Taylorism was approaching the height of its influence. The widely publicized *Eastern Rate* case (1910) and the publication of Frederick W. Taylor's *Principles of Scientific Management* (1911) occurred just before the innovations at Highland Park, and it is natural to assume that there was a connection. Whether that was in fact the case, however, is by no means certain, because the contemporary sources are not adequate to assure a definitive answer. In addressing this issue, the initial problem is arriving at a reasonable definition of Taylorism or systematic management.

If by Taylorism we mean rationalization through the analysis of work (time and motion studies to eliminate wasteful motions) and the "scientific" selection of workmen for prescribed tasks, then we can agree with the recent judgment of Stephen Meyer III that Ford engineers "Taylorized" the Highland Park factory. Indeed, this was the conclusion of Allan Nevins in his standard work on Henry Ford and the Ford Motor Company. Ford's engineers, Nevins suggested, "had doubtlessly caught some of his [Frederick W. Tay-

FIGURE 6.25. Part of Engine Assembly Line Operations, Highland Park, 1915. (Henry Ford Museum, The Edison Institute. Neg. No. 833-2346.)

lor's] ideas.'' Moreover, Nevins wrote that Clarence Avery, who was clearly critical in the development of the moving chassis assembly line, had ''kept in touch with the ideas of men like Frederick W. Taylor.'' Meyer generalized by arguing that ''Ford managers and engineers may not have followed a specific program [of systematic or scientific management], but they surely followed general principles.''[89]

Unquestionably, Ford engineers standardized work routines at Highland Park after they analyzed jobs and work flow patterns. With the widespread use of special-purpose machine tools at Ford, the engineers hired semiskilled and unskilled workers to operate these machines (scientific selection of workmen, as Taylor called it). As early as 1912 or 1913, the Ford factory had a time study department, although some Ford employees later recalled that it was first known as the work standards department.[90] The very idea of establishing work standards—how much output a manufacturer could expect from a certain machine tool, a work process, or a series of processes if labor did a fair day's work—is the very heart of Taylorism in particular and systematic management in general. Moreover, in the Ford factory, there was a clear division of labor between management and workers along the lines advocated by Taylor in his *Principles of Scientific Management* (for example, machine tenders did not perform any maintenance on their machines but left this to specialists).[91]

Despite these facts, there is much reason to doubt that Taylorism contributed signifi-

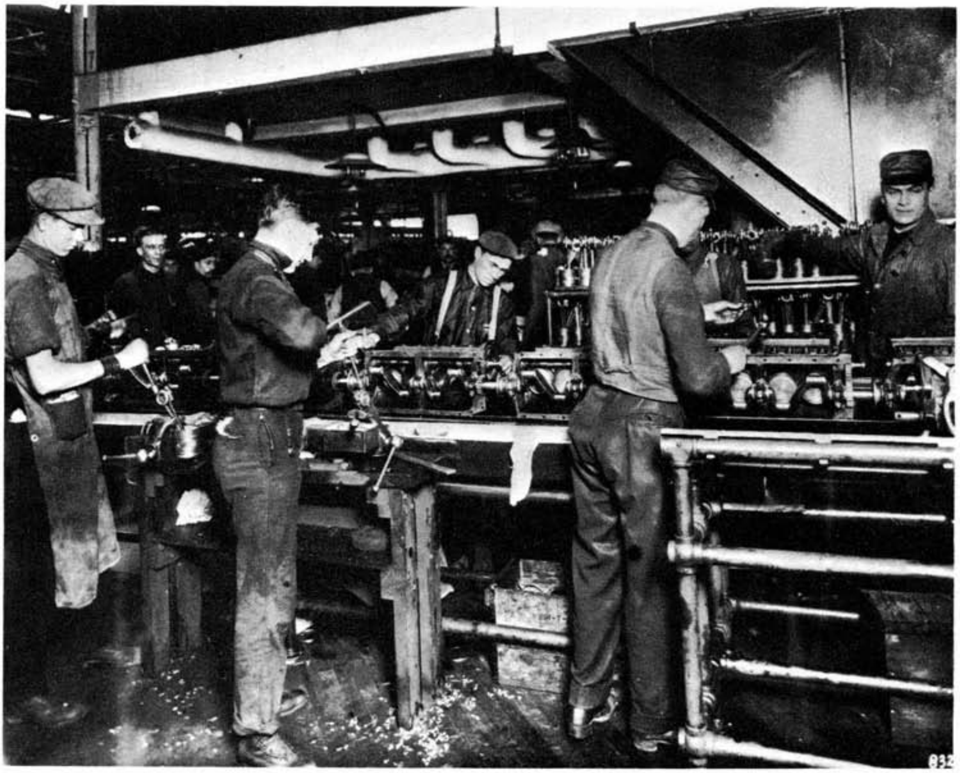

FIGURE 6.26. Installing Pistons in Model T Engines, Highland Park, ca. 1914. (Henry Ford Museum, The Edison Institute. Neg. No. 833-832.)

cantly to the new assembly system at Highland Park. Henry Ford himself claimed that the Ford Motor Company had not relied on Taylorism or any other system of management. As Horace Arnold noted in 1914, "In reply to a direct question he [Henry Ford] disclaimed any systematic theory of organization or administration, or any dependence upon scientific management."[92]

Four months before he died, Frederick W. Taylor spoke in Detroit to some six hundred superintendents and foremen of "leading" manufacturers of the city. In reflecting upon his experience in Detroit, Taylor proudly declared that the manufacturers there "were endeavoring to introduce the principles of scientific management into their business and that they were meeting with large success." This especially interested Taylor because it was "almost the first instance, in which a group of manufacturers had undertaken to install the principles of scientific management without the aid of experts." According to Allan Nevins, however, many of those who heard Taylor saw the matter differently. They argued that "several Detroit manufacturers had anticipated his ideas."[93] The Ford Motor Company could have been "Taylorized" without Taylor.

By focusing on those elements of the Highland Park factory that were Taylorized, one runs the danger of misjudging the fundamental differences between the Ford philosophy (Fordism) and that of Taylor (Taylorism). It was Henry Ford himself, or, more accurately his ghostwriter, who pointed up these differences. To explain his system, Taylor often resorted to his tale about Schmidt, the scientifically selected worker who was told how to

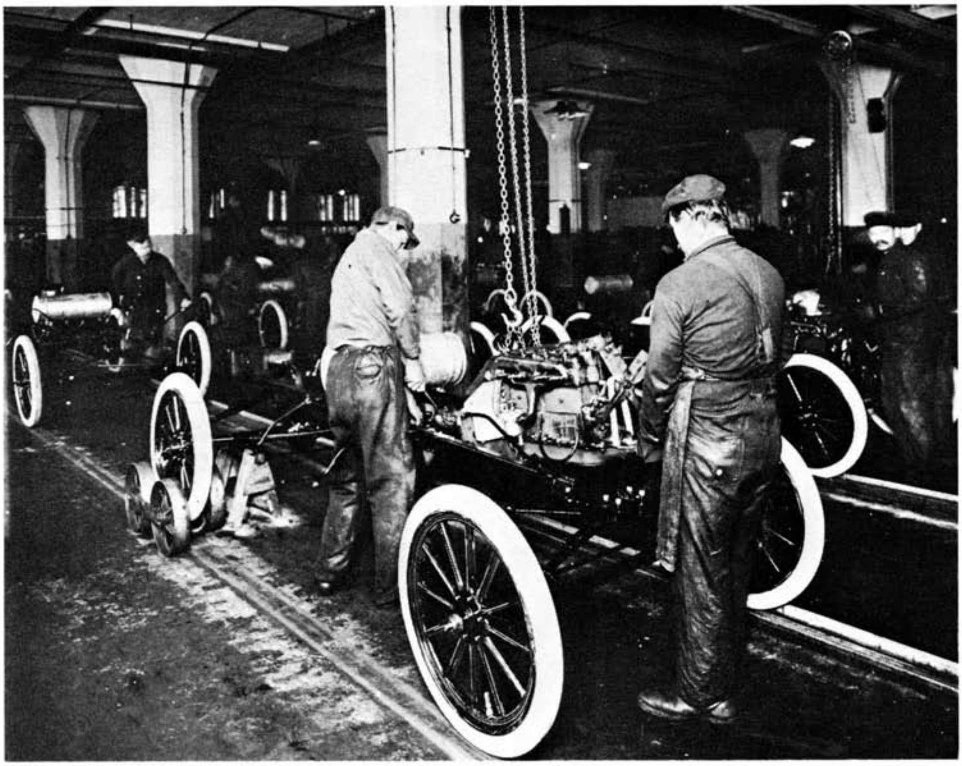

FIGURE 6.27. Engine Drop, Final Assembly Line, Highland Park, 1913. Careful study of this photograph suggests that at least three assembly lines were in operation and that chassis were still being pushed by hand along a single track with the aid of dollys. (Henry Ford Museum, The Edison Institute. Neg. No. 833-198.)

load pig iron scientifically (that is, after time and motion studies had been carried out) and was placed on an incentive wage system. Previously, Schmidt had hand carried each day twelve and a half tons of pig iron up a ramp and dumped it into a railroad car. But after he underwent the magic of scientific management, Schmidt was able to hand carry forty-seven and a half tons of the ninety-two-pound pigs each day. The Taylor approach was to assume that the job of loading pig iron was a given; the task of scientific management was to improve the efficiency of the pig iron carrier. Ford's production experts saw the problem differently. Why, they asked, should pig iron be hand loaded? Could this not be done by some mechanical means? (Ford engineers would later ask why one had to bother with pig iron at all. Why not pour castings directly out of the blast furnace and dispense entirely with handling and reheating pigs?)[94]

The Ford approach was to eliminate labor by machinery, not, as the Taylorites customarily did, to take a given production process and improve the efficiency of the workers through time and motion study and a differential piecerate system of payment (or some such work incentive). Taylor took production hardware as a given and sought revisions in labor processes and the organization of work; Ford engineers mechanized work processes and found workers to feed and tend their machines. Though time and motion studies may have been employed in the setup of the machine or machine process, the machine ulti-

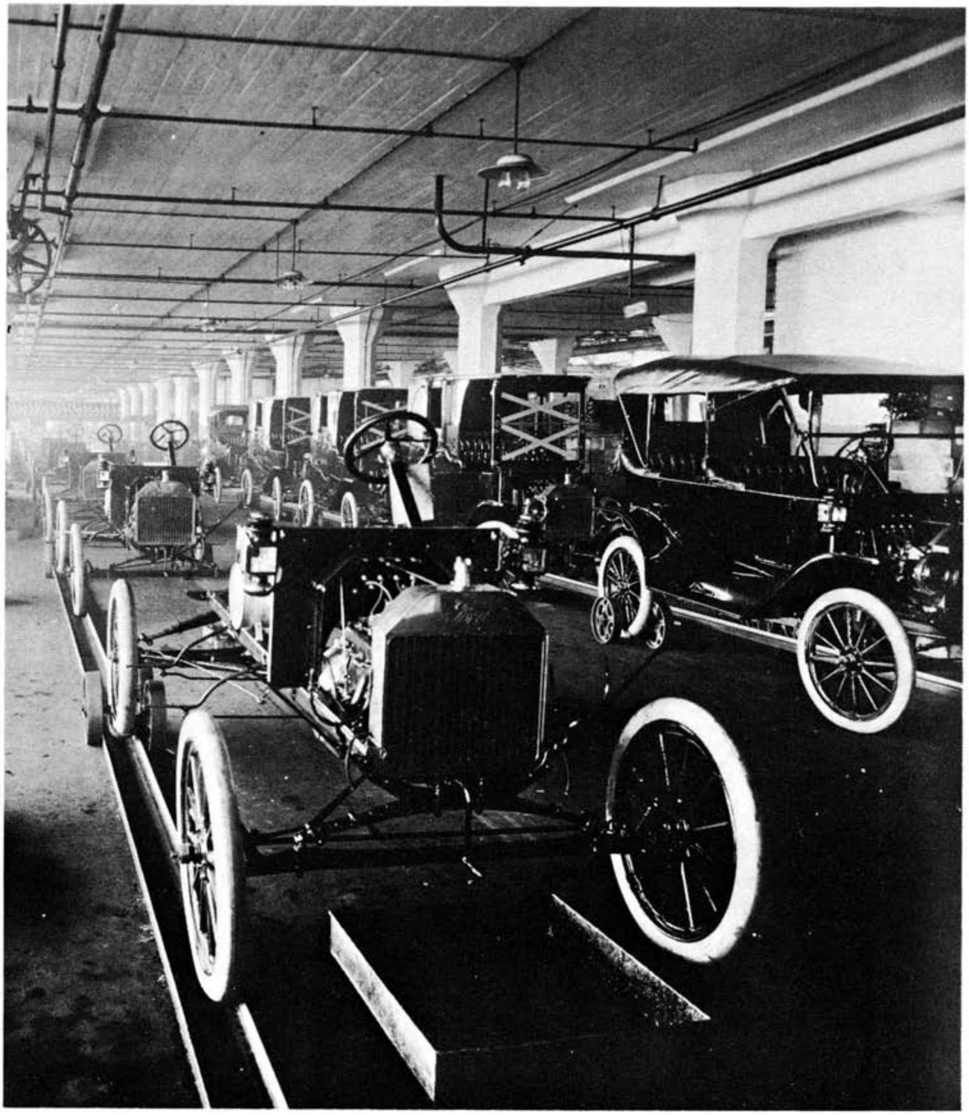

FIGURE 6.28. End of the Line, Highland Park, 1913. As in Figure 6.27, final assembly operations had not yet been put on the "chain system" when this photograph was taken. Note that Model T car bodies are being put on the chassis on one of the assembly lines. Those not receiving bodies were destined for rail shipment without bodies. (Henry Ford Museum, The Edison Institute. Neg. No. 0-3342.)

mately set the pace of work at Ford, not a piecerate or an established standard for a "fair day's work." This was the essence of the assembly line and all the machinery that fed it. While depending upon certain elements of Taylorism in its fundamentals, the Ford assembly line departed radically from the ideas of Taylor and his followers.[95]

The first attempt at line assembly in August 1913 was crude but phenomenally successful in increasing productivity. At one end of a long open space in the Highland Park

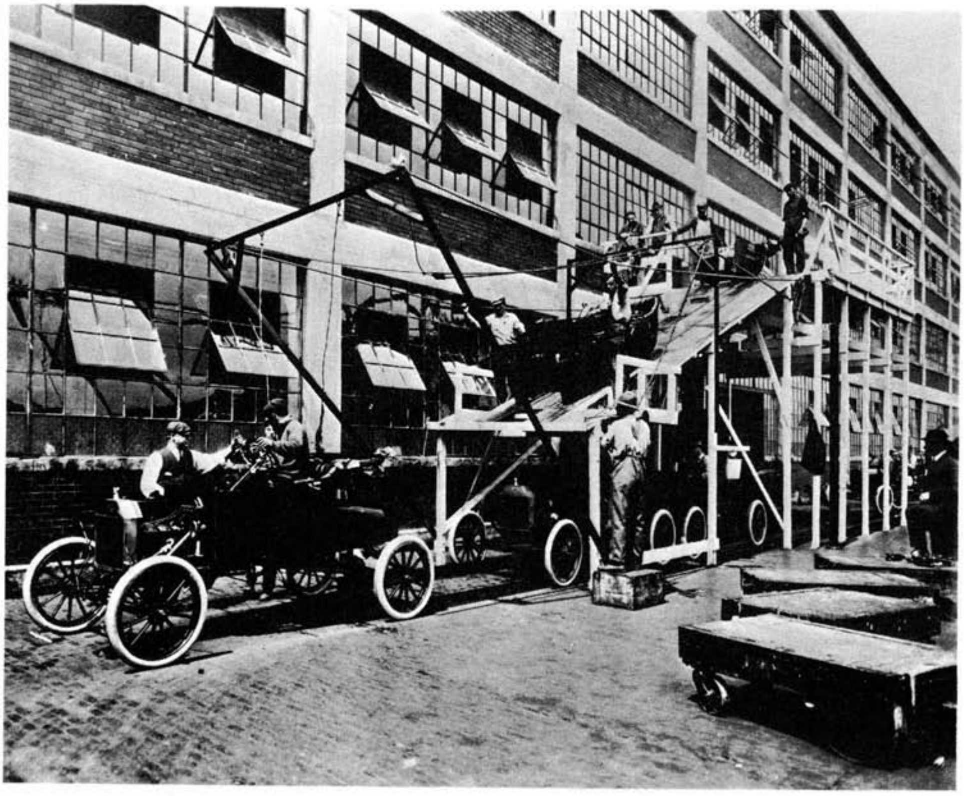

FIGURE 6.29. Body Drop, Highland Park, 1913. Many historians have argued that this photograph depicts how Model T bodies were first put on the chassis once the assembly line was developed. James O'Connor, who was a foreman for the Highland Park assembly line from 1913 to 1927, argued persuasively in the 1950s that this body chute was used only to drop bodies temporarily onto the chassis to haul them to the loading dock where the chassis, fenders, and bodies were packed separately into boxcars for shipment. Note that the car with the body on it does not have fenders, which lends great credence to O'Connor's statement, as does comparison with Figure 6.28. (Henry Ford Museum, The Edison Institute. Neg. No. 833-917.)

factory, the Ford engineers put a windlass and stretched out a rope 250 feet down the open space. Based on their knowledge about optimal installation times for various chassis components, the engineers placed these components at different intervals along the path. Whereas the man-hour figure had been slightly under twelve and a half with static assembly, the first assembly line attempt (in which six assemblers followed the slowly moving chassis as it made its way past the various components) reduced the figure to five and five-sixths man-hours.

Experiments continued. (See Figures 6.27–6.31.) On October 7, 140 assemblers had been placed along a 150-foot line. Man-hour figures dropped to slightly less than three hours per chassis. By December, Avery and those working with him had extended the line to 300 feet and had increased the assembly force to 177 men. Time: two hours, thirty-eight minutes. After Christmas, 191 men worked along the 300-foot line but pushed the assembly along by hand. Man-hour time increased rather than dropped. Sixteen days later, the engineers had installed a line on which the car was carried along by an endless

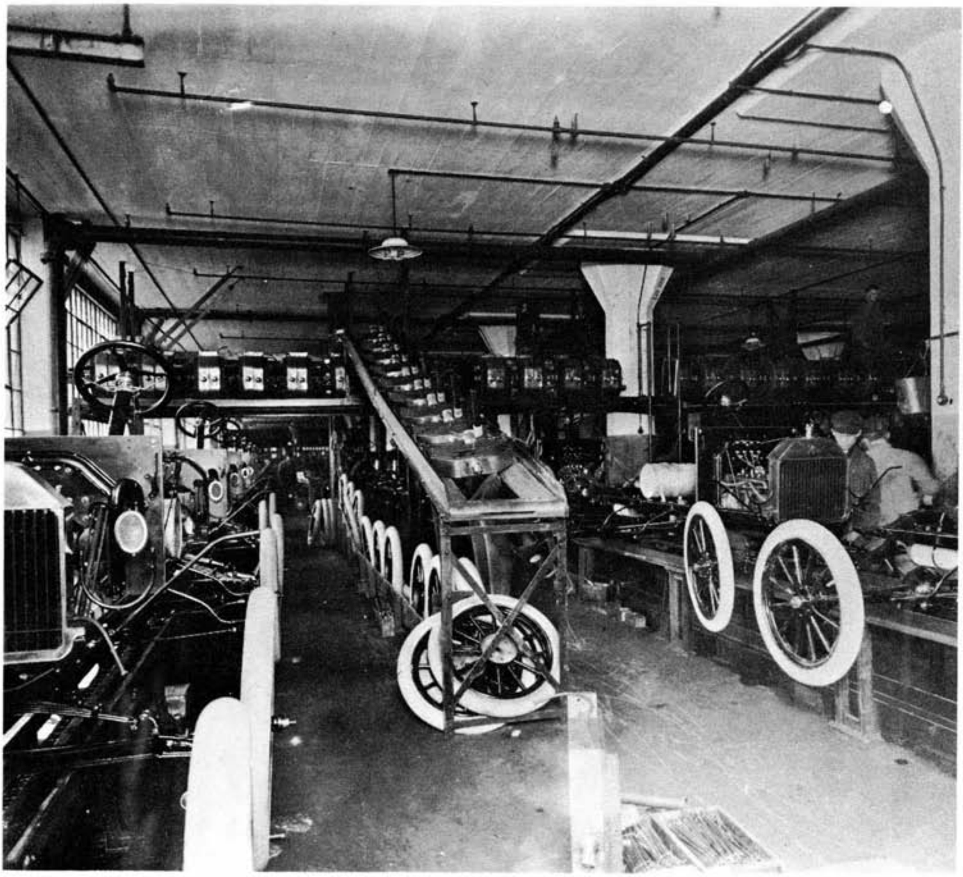

FIGURE 6.30. Radiator and Wheel Chutes, Final Assembly Line, Highland Park, 1914. By this time the final assembly line had been put on the "chain system" (see lower left), which controlled the forward progress of the chassis. The frame not only served to carry the chain but also to raise the height of work to a more comfortable level. (Henry Ford Museum, The Edison Institute. Neg. No. 833-895.)

chain. In the next four months, lines were raised, lowered, speeded up, slowed down. Men were added and taken off. As Charles Sorensen wrote, all of "this called for patient timing and rearrangement until the flow of parts and the speed and intervals along the assembly line meshed into a perfectly synchronized operation."[96] By the end of April 1914, three lines were fully in operation, and the workmen along them put together 1,212 chassis assemblies in eight hours, which worked out to ninety-three man-minutes. (See Figure 6.32.) Assembly figures became consistently predictable. Horace Arnold noted the effects of these developments: "Very naturally this unbelievable reduction in chassis-assembling labor costs gave pause to the Ford engineering staff, and led to serious search for other labor-reduction opportunities in the Ford shops, regardless of precedents and traditions of the trade at large."[97]

Experiment and refinement continued on the existing subassembly lines. These adjustments provided productivity gains comparable to those achieved with chassis assembly

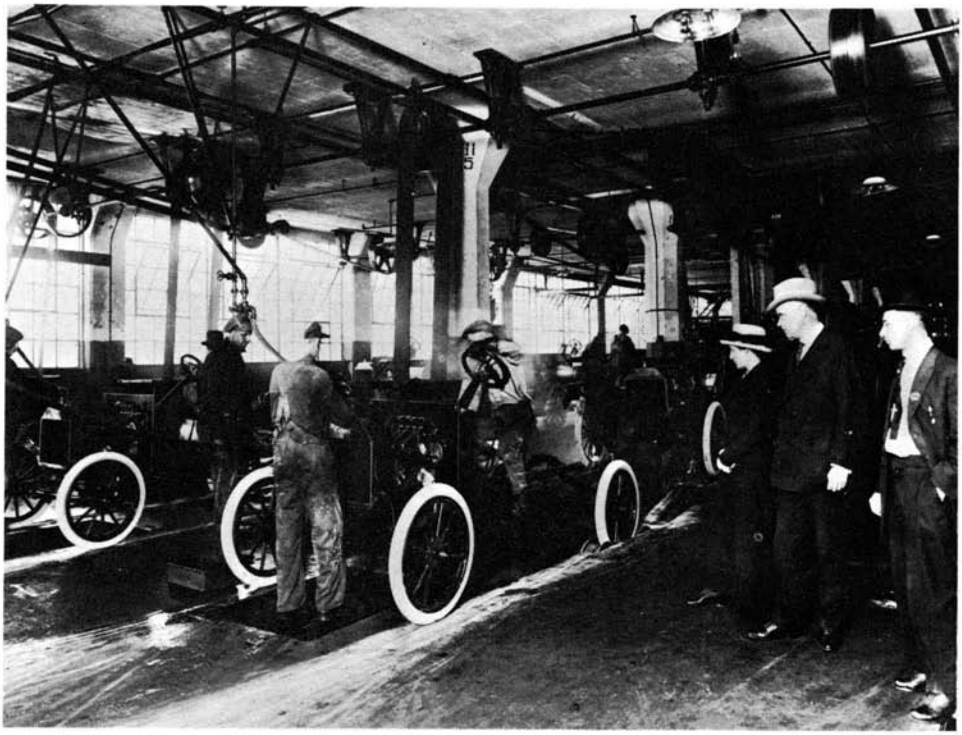

FIGURE 6.31. Driving Off the Assembly Line, Highland Park, 1914. At the end of the line, workmen filled the radiator and started the engine before driving off the line. (Henry Ford Museum, The Edison Institute. Neg. No. 833-997.)

and led the company to adopt entirely new lines. On June 1, 1914, chain-driven assembly lines began to roll out front axle assemblies. These reduced assembly time from 150 minutes (a January 1, 1913, figure) to 26½ minutes (July 13, 1914). Other subassemblies followed.[98] (See Figures 6.33–6.35.) All of the assembly stands over which Fred Colvin had marveled only months before and which were characteristically Yankee had been taken to the scrap pile.

The Ford engineers next designed and installed conveyor systems to feed these hungry lines. As Arnold wrote in July 1914, "Besides these almost unbelievable reductions in assembling time [wrought by the assembly line], the Ford shops are now making equally surprising gains by the installation of component-carrying slides, or ways, on which components in process of finishing slide by gravity from the hand of one operation-performing workman to the hand of the next operator."[99] Reductions in labor costs were thus achieved by assembly lines, conveyor systems, gravity slides, and the like along with the Ford system of machining, which had removed virtually all skill requirements for operation and whose fixtures and gauges allowed foremen to demand speed. But these great achievements had wrought serious labor problems at the Ford factory. Henry Ford's five-dollar day was an attempt to eliminate these problems.

Although the motives behind the five-dollar day are rooted in a sort of industrial beneficence on Henry Ford's part and a consciousness on James Couzens's part that such a wage and profit-sharing system would pay for itself in free advertising, the five-dollar

FIGURE 6.32. General View of "The Line," Highland Park, 1914. When Horace Arnold toured the Highland Park factory in 1914 and wrote of the assembly line that assembled a car in ninety-three man-minutes, this is the line of which he was speaking. (Henry Ford Museum, The Edison Institute. Neg. No. 833-987.)

day must be seen as the last step or link in the development of mass production. During 1913 the labor turnover rate at the Ford factory had soared to a phenomenal figure. Keith Sward points out that turnover in 1913 reached 380 percent: "So great was labor's distaste for the new machine system that toward the close of 1913 every time the company wanted to add 100 men to its factory personnel, it was necessary to hire 963."[100] Not only did this burden the administrative machinery at Highland Park, but it also affected the operations within the factory. High turnover was also accompanied by growing signs of unionization at the Ford factory. Other Detroit automakers had already experienced strikes. The Ford management sought to relieve these pressures by carrying out labor reforms in 1913.

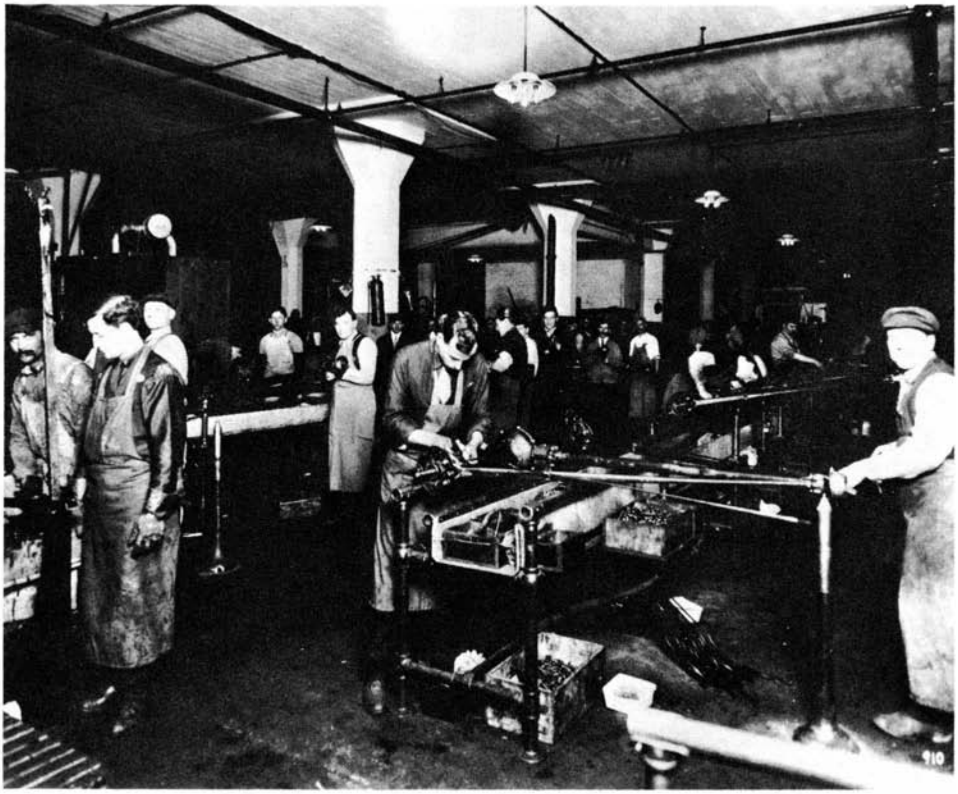

FIGURE 6.33. Rear Axle Assembly Line, Highland Park, 1914. (Henry Ford Museum, The Edison Institute. Neg. No. 833-910.)

Jobs were reevaluated and brought into parity with each other. The company gave special raises to efficient employees. And finally, an across-the-board pay increase, averaging 13 percent, was announced on October 1, 1913. The company set $2.34 as the minimum daily wage for every employee.

These reforms, however, did not stem the rising tide of labor problems. The growth in output of the factory, the installation and rigorous improvement in the efficiency of assembly lines in three different departments, and the promise of one being installed in every department added additional force, swelling the tide of labor turnover and dissatisfaction higher and higher in the final months of 1913. Attempting to reward workers who had stayed with the company for three years or more, the Ford directors gave a 10 percent bonus on December 31, 1913. Out of some 15,000 employees only 640 qualified for the bonus, a figure that indicates the extent of worker turnover. The following day, or perhaps a few days later, Henry Ford, James Couzens, P. E. Martin, Charles Sorensen, Harold Wills, John R. Lee (the personnel department head), and Norval Hawkins (the sales manager) met, discussed the labor problems, and considered increasing daily earnings (wages and "shared" profits) to $3.00, $3.50, $4.00, $4.50, $4.75, or $5.00. Ford had clearly become concerned about the inequity between the salaries and profits of directors (as well as the salaries and bonuses paid to the production experts) and the wages earned by the majority of workers in the factory. The turnover rate, the signs of unionization, and

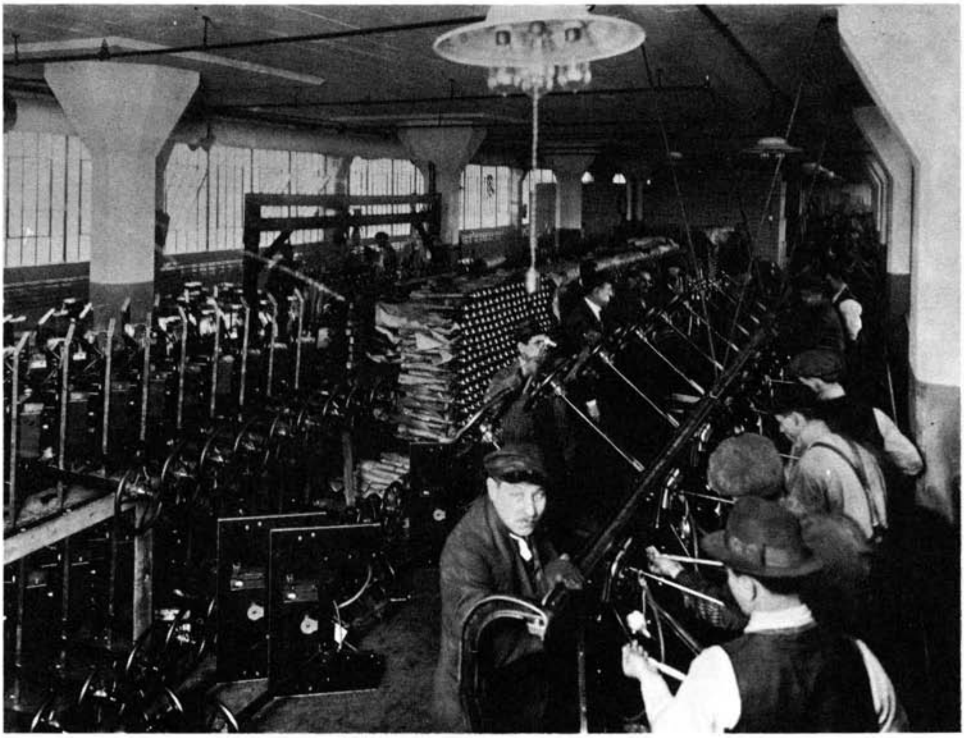

FIGURE 6.34. Dashboard Assembly Line, Highland Park, 1914. Contrast this with Figure 6.13. (Henry Ford Museum, The Edison Institute. Neg. No. 833-326.)

the manifest inequity of income combined in Ford's mind (and Couzens's) to produce a quick solution to all three. Ford, Couzens, and Horace Rackham (a director of the company) met on January 5, 1914, and adopted the five-dollar day. Since Ford owned controlling stock, the meeting was pro forma. Couzens had been convinced of the desirability of the plan—perhaps he had engineered it—so he and Ford encouraged Rackham to make the vote unanimous. Couzens got his free advertising, Ford his hero-worship, "acceptable" workers extraordinarily high earnings.[101] The basic psychology of the plan, however, and its basic effect were that now the company could ask its workers to become for eight hours a day a part of the production machine that the Ford engineers had designed and refined during the past four years.

The five-dollar day assured the company that the essential human appendages to this machine would always be present. This "bonding" effect of extremely high earnings was evident within a month after Ford announced it. As an anonymous housewife of a Ford assembly line worker wrote to Henry Ford on January 23, 1914, "The chain system you have is a *slave driver! My God!*, Mr. Ford. My husband has come home & thrown himself down & won't eat his supper—so done out! Can't it be remedied? . . . That $5 a day is a blessing—a bigger one than you know but *oh* they earn it."[102] As part of the five-dollar day scheme, Henry Ford also scaled up the paternalistic operations of the Ford sociological department, which determined if workers qualified for profit-sharing by investigating their private lives—an extra burden on top of those already imposed by Ford production technology.[103]

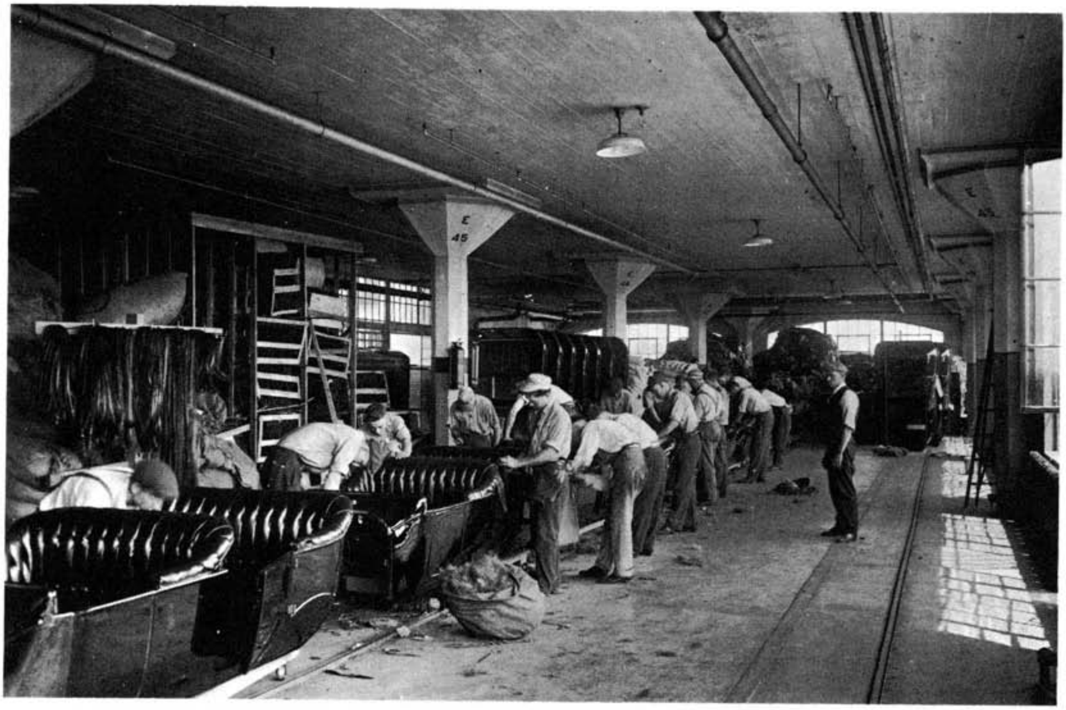

FIGURE 6.35. Upholstery Line, Highland Park, 1916. Even skilled processes such as upholstery were put on a moving line basis at the Ford Motor Company's Highland Park Factory. (Ford Motor Company.)

The story of mass production at the Ford Motor Company was not something that only historians of a later generation would delve into and try to understand. Henry Ford's contemporaries, many of whom were competitors, closely watched the doings at Highland Park, attempting to understand and emulate the revolutionary developments. Henry Ford encouraged their interest. Unlike the Singer Manufacturing Company, the Ford company was completely open about its organizational structure, its sales, and its production methods—at least after Henry Ford was satisfied that his company was on the road to mass production.[104] As Horace Arnold wrote in 1914, "The Ford company is willing to have any part of its commercial, managerial or mechanical practice given full and unrestricted publicity in print."[105] Ford engineers had no skeleton closets in their factory. Proud of their work, they were anxious to have technical journalists tour the shops and write extensive articles about Ford methods. When Horace Arnold was writing the series of articles for *Engineering Magazine* Henry Ford himself devoted attention to the author. Fay Faurote experienced the same cooperation and developed a friendship with Ford over the next fifteen years.

As a consequence of Ford's openness, Ford production technology diffused rapidly throughout American manufacturing. The *American Machinist* series of 1913, *Engineering Magazine*'s series of 1914 and 1915 (which resulted in Arnold's and Faurote's *Ford Methods and the Ford Shops*), a series in *Iron Age* in 1912–13, and occasional but incisive articles in *Machinery* were the primary agents of this diffusion.[106] One can thumb through the pages of these and other technical and trade periodicals in the days after the assembly line appeared in print and find automobile companies that were trying moving line assembly techniques even though they made only one or two thousand cars.[107] Manufacturers of other products also tried the assembly line. Within a decade, many household appliances such as vacuum sweepers and even radios were assembled on a conveyor system.[108] The Ford Motor Company educated the American technical community in the ways of mass production.

Yet exactly one year after the first assembly line experiments at Ford Motor Company, Reginald McIntosh Cleveland wrote an article titled "How Many Automobiles Can America Buy?" Although writers such as Edward A. Rumely and Harry Franklin Porter celebrated Henry Ford, because of his insistence on standardization, as "The Manufacturer of Tomorrow," Cleveland pointed out that already the American automobile industry had succumbed to "the fetish of 'The New Model.'" Manufacturers had resorted to this "creed" in order to sell cars. Ford dogmatically resisted this practice. Through standardization of design and the resulting development of mass production technology, Ford demonstrated a "big lesson" to the entire automobile industry.[109] Yet eventually—long after other manufacturers would have predicted—Ford himself had to resort to model change in order to keep his company from complete collapse. This change came after some fifteen million Model T's had been produced. By this time, Ford production technology had become so highly specialized that the changeover to a new model, the A, brought unimagined problems for the Ford Motor Company. The working out of these problems over a five-year period brought Ford into a new era of mass production technology, that of the annual model change, which demanded "flexible mass production." This was part of what Charles F. Kettering called "the new necessity."[110]