Book Reviews

The Standardization of Manufacturing

From the American System to Mass Production, 1800–1932. The Development of Manufacturing Technology in the United States. DAVID A. HOUNSHELL. Johns Hopkins University Press, Baltimore, 1984. xxiv, 411 pp., illus. $37.50. Studies in Industry and Society, 4.

David Hounshell's history of the evolution of American production methods has few rivals; in execution of the theme, it has none. This is not a conventional history of technology. Rather, the author focuses upon the use of the technology as a means of achieving the production goals of management.

Hounshell carefully documents the development, transfer, and modification of the technology of the manufacture of interchangeable parts from firm to firm and industry to industry. Beginning with the handicraft production of muskets in the early 19th century, his story concludes with Henry Ford's Model T, in which standardization was carried to the *n*th degree, and the introduction of the Model A. Along the way, he analyzes the role played by this technology in the sewing machine industry, in woodworking, in reaper manufacture by McCormick, and in the bicycle industry and how the technology was adapted.

The book opens with a discussion of the "American System of Manufactures," a distinctive production technique developed by American manufacturers sometime before the middle of the 19th century. Americans economized on the use of high-wage labor by substituting specialized machines wherever possible and minimized reliance upon scarce skilled labor by the minute division of tasks. What emerged was a product with a high degree of uniformity and standardization. And uniformity held out the promise of interchangeability of parts. To many, indeed, the American System was and is synonymous with the interchangeability of parts.

Interchangeability was, however, to prove an elusive goal. Although the American System was quite widespread before the Civil War, parts of the products of many leading American manufacturers could not be interchanged until much later. Singer sewing machines, for example, were still hand-fitted until the mid-1870's, with serial numbers stamped on critical parts so that the machines could be reassembled, or rather refitted, after hardening and finishing. A series of excellent technical photographs and Hounshell's own field trials support his argument.

Hounshell explains the failure to achieve interchangeability by distinguishing between the American System and what he calls "armory practice." Armories attained the goal through the use of jigs and gauges derived from models and a rigid policy of inspection. Only after firms using the American System adopted these practices were parts interchangeable. Thus, McCormick reaper parts were not interchangeable until 1880, when Lewis Wilkinson, who had an extensive background in New England armory practice, was hired as superintendent. Although Wilkinson stayed only a short time with McCormick, Cyrus McCormick, Jr., who had served as his assistant, institutionalized the new techniques. Firms such as Wheeler and Wilson and Willcox and Gibbs that had achieved the goal much earlier and more rapidly had close contact with New England armories.

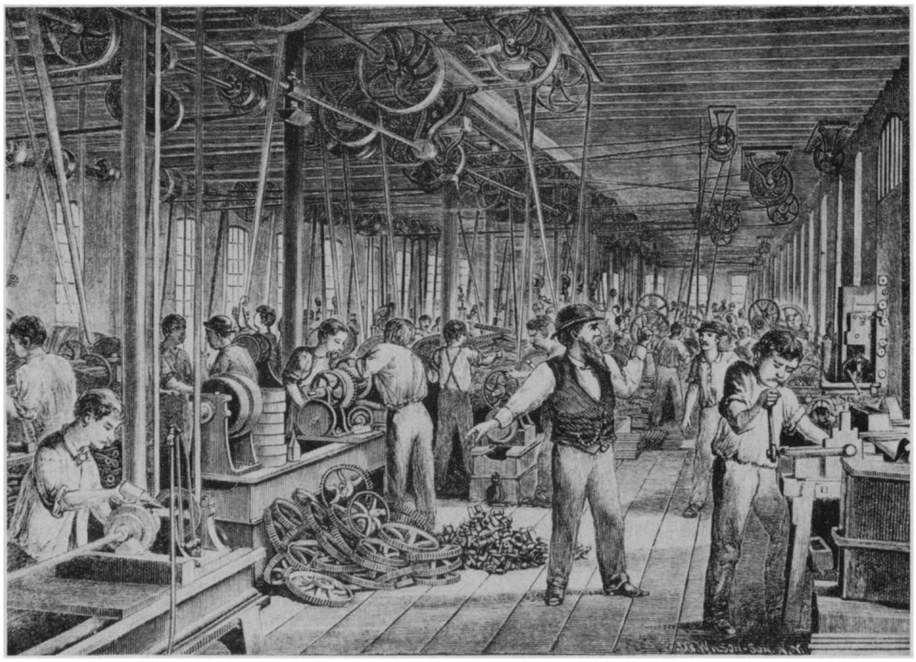
"Punching Out Needle Eyes, Wheeler and Wilson Manufacturing Company, 1879. A series of small, hand-operated machines were used to manufacture sewing machine needles. Two of the most difficult operations included punching out the eye and grooving the needle. The final step of straightening the needles was done by hand with a hammer." [*Scientific American* 3 May 1879; Eleutherian Mills Historical Library. From *From the American System to Mass Production, 1800–1932*]

Armories sought interchangeable parts because that was what the military wanted. The idea originated in France and spread to America through French military participation in the American Revolution and through the championing of the work of the French arsenal inspector general, Honoré Blanc, by Thomas Jefferson, then U.S. ambassador to France. However, as Eli Whitney was to discover, it was easier to conceive of interchangeable parts and their virtues than to manufacture them. Before the middle of the century, only the federal arsenals and a few of their contractors had achieved truly interchangeable parts, and then only because cost was no obstacle.

Although Singer was slow to adopt mass production techniques for their sewing machines, they were in the vanguard when it came to manufacturing wooden cases for them. Relying primarily upon comparatively scanty archival sources, Hounshell demonstrates that the sewing machine cabinet industry was among the first to attain the goal of mass production. It did so by adapting the product to suit production techniques that were more energy-intensive. For example, it pioneered the use of built-up veneers that could be shaped and glued under heat and pressure.

The widespread realization of mass production through interchangeability in metals manufacture, however, took longer. It seems likely that some of the delay stemmed from the New England armory tradition. Gun parts were drop-forged and then machined to obtain a satisfactory fit. This process was relatively slow and expensive. Throughput was limited until a new process, sheet metal stamping, could be developed. It is significant that the pioneer in this development, the Western Wheel Works, a bicycle manufacturer and comparative latecomer to the industry, had no tradition of armory practice. Through sheet metal stamping mass production of metal products was, at last, feasible.

There remained, however, one serious impediment to the widespread implementation of mass production—assembly. Mass production required mass assembly. The assembly line, introduced by Ford in 1913, was to prove one solu-



"Lathe and Press Room of the McCormick Factory, 1885. Note the clutter of the aisles and the materials handling methods." [*Illustrated Annual Catalogue*, McCormick Machines, McCormick Harvesting Machine Company, 1885; McCormick Collection, State Historical Society of Wisconsin. From *From the American System to Mass Production, 1800–1932*]

tion to the problem. It had dramatic positive effects upon productivity and equally dramatic, but negative, effects upon workers' job satisfaction. The assembly line represented a further step in the de-skilling of the work force that began with the American System.

Almost 90 pages, or about a quarter of the text, are devoted to two chapters on Ford. One deals with the evolution of the assembly line, the other with the switchover to the Model A. In the former, Hounshell discusses Henry Ford's experiments with his own brand of scientific management, Fordism, to shape production methods and the assembly line to achieve production goals with the Model T. The latter chapter, however, breaks with the theme of the book. The focus is no longer interchangeable parts and mass production, but rather Fordism, the personnel involved in the introduction of the Model A, and the production problems that Ford experienced as a result. Consequently, the reader is left unsure whether Ford's problems in 1928 are intended as providing grounds for a general indictment of the mass production system or seen as just a reflection of arrangements at Ford.

Neither the theme nor the form of the study is maintained in the concluding chapter, "The ethos of mass production and its critics." It does not advance the author's argument, nor does it summarize it; rather, it is an examination of what popular culture had to say about mass production together with a brief digression on the application of that technique to prefabricated housing. This chapter also provides the justification for the study's terminal date, 1932. This was when Diego Rivera painted his wall murals, *Detroit Industry*, at the Detroit Institute of Arts. I would have preferred that the author condense both this chapter and the preceding chapter on Fordism as part of a new concluding chapter. Nevertheless, both the armchair historian and the specialist in the history of technology will find this a highly readable and most informative work.

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Earth History

The Chemical Evolution of the Atmosphere and Oceans. HEINRICH D. HOLLAND. Princeton University Press, Princeton, N.J., 1984. xii, 583 pp., illus. $75; paper, $24.50. Princeton Series in Geochemistry.

The continuity of life during the past 3.8 billion years "is a consequence of the relative dullness of Earth history, of the rarity and relatively small magnitude of disruptive events such as asteroid impacts, of the variety of physical and chemical control mechanisms that have tended to maintain the status quo." With these words Holland summarizes his basically uniformitarian outlook on Earth history. The physical environment at Earth's surface changed radically and rapidly during the first half billion years after Earth's formation, during which time the atmosphere formed and the oceans grew to nearly their present size. Since that time atmospheric pO_2 has risen and pCO_2 has declined while the chemistry of seawater has remained remarkably constant. Holland supports this thesis with voluminous quantities of data on the chemical and isotopic composition of evaporates, shales, iron formations, paleosols, uraninites, and various other types of sedimentary rocks. Very few of these data are easy to interpret, however. Thus, despite the clarity with which the arguments are presented, this book will probably provoke considerably more controversy than Holland's very useful companion volume on the chemistry of the present ocean-atmosphere system.

The first four chapters of the book deal with the period from the beginning of the accretion process until the formation of the oldest rocks. Holland uses thermodynamic arguments to show that the oxidation state of volatiles released from Earth's interior depends critically upon the abundance of elemental iron in the crust and upper mantle. In accordance with recent work on the dynamics of accretion, Holland proposes that core formation occurred early, so that any highly reduced primitive atmosphere must have been extremely short-lived. Thermodynamic arguments are also used to estimate the partitioning of volatiles between the atmosphere and the (molten) mantle during the accretion phase. Very little atmospheric water vapor is predicted because of its high solubility in silicate melts, but as much as one-third of Earth's total CO_2 inventory may have been present in the gas phase at the close of accretion. These latter conclusions appear somewhat weak, since it is not clear to what extent equilibrium would have been maintained during the accretion process. Holland's fondness for thermodynamics is again apparent in his discussion of primitive atmosphere composition, despite his acknowledgement that atmospheric chemistry is controlled primarily by kinetic processes.

The next four chapters, which deal mostly with the time period from 3.9 to 0.6 billion years before the present, cover a wide range of topics, including the implications of observed weathering patterns for atmospheric pCO_2, the interaction of seawater with hot mid-ocean