

*Ingenious Yankees: The Rise of the American System of Manufactures in the Private Sector.*  
By Donald R. Hoke. New York: Columbia University Press, 1990.

Until recent years, the history of technology used to be written, and taught, for its own sake and almost completely isolated from economic and social history. Who among us has not had his eyes glaze over at tedious recitations of the technology of the flying shuttle, or the power loom, or the open-hearth process? The treatment was tedious because treated in isolation; about all we were told of the economic effects was that these machines improved productivity and lowered costs.

This tiresome tradition came to a sudden end with the arrival of the fascinating and crucially important work of David A. Hounshell, *From the American System to Mass Production, 1800-1932* (1984), which created a new paradigm dominating the field of American technological history. Hounshell's achievement was to integrate technological with economic and social history, and bring us, for the first time, a genuine history of the development of mass production. Thus, for example, in his pioneering history of the bicycle industry of the 1890s, Hounshell showed that the bicycle was, in two ways, a critical prelude to the invention and development of the automobile because, (1) the bicycle taught consumers the possibility and the joy of individual, mobile transportation (in contrast to the mass transportation between fixed points essential to the railroad); and (2) it taught bicycle makers the technology of the wheel, the tire, and the axle. It is no accident that the first automobiles were made in bicycle shops.

But there was one troublesome aspect to this new paradigm, one that conspicuously did not fit with an economist's knowledge of the market economy and the way it operates as compared to government. Based on his own work and on the contemporaneous studies of Merritt Roe Smith, Hounshell asserted that the fountainhead of mass production was U.S. government armories. Operated by government

and with government as their only customer, the federal armories, beginning particularly in the late 1840s, were able to give full sway to the "technological enthusiasm" of engineers, and, *heedless of cost*, could develop mass production of firearms with perfectly interchangeable parts. This aesthetically pleasing but costly method of manufacture gradually spread its way from the public sector to private mass production. Thus, modern mass production was a creation of government typically heedless of cost rather than of private entrepreneurs functioning in a market economy.

But now comes Donald Hoke, in this exciting and highly significant work, to upset completely the Hounshell-Smith picture of "Armory Practice" as the key to the development of mass production in America. While building upon Hounshell's work, Dr. Hoke stands Hounshell on his head. Hoke makes it clear that he is an old friend and colleague of Hounshell's: both of them emerging from the remarkable economic history and history of technology program of the Hagley Foundation and the University of Delaware. Hoke demonstrates conclusively that, long before Armory Practice, mass production was brought to American industry by the remarkable engineer-entrepreneur, Eli Terry. As early as 1807, Terry, an ingenious Connecticut Yankee, created a wooden movement clock industry, as a mass produced clock with interchangeable parts, completely superseding the old hand crafted clock. In 1814, Terry delivered another shock to the clock industry, by creating the highly successful wooden movement shelf clock, as compared to the "hang-up" clocks previously dominant. In contrast to the highly costly arms manufacture, Terry's clock process was adopted precisely because it drastically *lowered* costs, and could thus be sold at a very low price and create a new mass consumer market for clocks that had previously been a luxury item for the wealthy.

One of the keys to this private mass production, which Hoke shows was to become the rule throughout American industry, was that the parts were not *perfectly* interchangeable, an inordinately rigid and expensive procedure. Instead, the wooden clocks and private manufacturing in later industries, were *designed* to be not "perfect" but adjustable, with built in adjustable elements such as screws, which allowed the parts to be fitted in each unit at the final assembly. Thus, interchangeability was not "perfect," but as much as necessary. This built-in flexibility allowed mass production to cut costs; for, in contrast to government operation, the emphasis by Terry and later private producers, was on cutting costs of manufacture and on easy use by the consumer. Hence, Terry and his successors were driven, not just by technological enthusiasm, but by such enthusiasm

intimately combined with a continuing quest to make products more cheaply and to render them more usable by the consumer. All this development was made possible by close cooperation between engineers and entrepreneurs; in this way, technology was always advanced in close collaboration with private, profit-seeking entrepreneurs for the benefit of the mass of consumers.

The next great case of mass production was the axe handle industry, developed in the 1830s and 1840s, also in Connecticut, by the creative engineer, Elisha K. Root, in collaboration with the far-seeing entrepreneur, Samuel W. Collins. Once again, the key was profit-seeking and cutting costs, and in the case of Root, in an integrated, systems approach. And rather than this mass production being influenced by Armory Practice, it was the Colt armory that hired Root, eminent from his development of axe handle factories, to manage its arms production at the end of the late 1840s. Thus, the major influence was, contrary to Hounshell, not so much from Armory Practice to private industry, as the other way around.

Donald Hoke goes on to study two other prominent cases beginning around the Civil War and also relatively neglected by historians: the intricately precise typewriter industry, and watch manufacturing as established by the Waltham Watch Company at Waltham, Massachusetts. In all cases he found the same pattern: emphasis on profit-seeking through cost-cutting and the development of a mass market; adjustable rather than "perfect" interchangeability; and collaboration between engineers and entrepreneurs. Not only that: In each and every case, Hoke found that not only was the industry private, but that there was virtually no reliance on government subsidies, or even on government contracts or purchases. The American System of mass production was private and market-oriented through and through.

Why have David Hounshell and other previous historians missed the boat so badly? Why, in particular, was the great pioneer Eli Terry virtually unknown before resurrected by Donald Hoke? Hoke's hypothesis is that Hounshell and the others have been deficient as antiquarian engineers: that is, they work solely from documentation and never from close study of the three-dimensional, old *objects* themselves. Hoke shows that Hounshell shows pictures of the objects produced in the nineteenth century only to illustrate his story, not as objects of study themselves. Hence, Hounshell and the others get the story wrong. Hoke, steeped in antiquarian engineering and in its journals, and therefore in close study of the objects themselves, was able to avoid this error.

In sum, *Ingenious Yankees* is a superb book, providing a new paradigm of American technological history consonant with sound

economics, based on thorough scholarship and a deep study of the produced objects themselves. It combines sparkling writing, bursting with the excitement of his paradigm discovery, with meticulous detail on the specific engineering innovations and their broader significance. There are also fascinating nuggets of insight that I hope Hoke or others will pursue further. Thus, Hoke finds absolutely no labor strife in these private mass production industries, despite their often rapid technological change. This harmony contrasts, for example, with the bitterness of many craftsmen working in the Harpers Ferry Armory. It is very possible that the technological force-feeding of government operation created more resentment than the cost- and customer-conscious collaboration between entrepreneurs and engineers. Hoke also notes the fundamental error of those historians who wail about mass-production workers being reduced to skillless machine operatives, deprived of the high skills of their craftsmen-fathers. Hoke replies that, not only did mass production create many more jobs, but that the new mass production required and developed many *new* skills, including invention, production, maintenance, and repair. The new skills were different from those of craftsmen, but the skills were still extensive.

Hoke also makes some telling points about later periods in American history. He shows that even Henry Ford was engaging in misleading bravado when he proclaimed that there were "no fitters" in this mass production; on the contrary, even automobiles needed adjustments and fitting. Even on Hounshell's own turf of the bicycle industry, Hoke shows that Alexander Pope's bicycle factory was not nearly as Armory Practice oriented as Hounshell claims, that his machine tools were adjustable rather than "perfect" and that Pope's increasingly successful competitors after the mid-1880s were even farther removed from Armory Practice.

With the appearance of *Ingenious Yankees*, the history of technology has become more deeply scholarly, focusing at last on the profound study of the actual three-dimensional technological objects, and at the same time, becoming integrated with social and economic history as well as with the teachings of economic theory. In his preface, Hoke quotes the eminent historian of medieval technology Lynn White, Jr. that "the history of technology is, emphatically, fun." In the hands of Donald Hoke, at least, it certainly is.

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