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Albert Churella. *From Steam to Diesel: Managerial Customs and Organizational Capabilities in the Twentieth-Century American Locomotive Industry.* Princeton: Princeton University Press, 1998. viii + 215 pp. \$45.00 (cloth), ISBN 978-0-691-02776-0.

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It is a commonplace of twentieth century industrial and railway history that the steam locomotive (and the firms producing it) fell before the diesel challenge, which delivered a technologically and economically more efficient form of motive power, promoted by two of America's leading corporations, General Motors and later General Electric, enterprises which dominate locomotive provision to this day. The great virtue of Albert Churella's slender, but satisfying study is his sustained effort to probe beneath this truism to expose the complex and contingent interactions which underlay diesel's triumph and the business cultures which sustained steam traction's construction and utilization. Churella (Ohio State University) also makes appealing arguments for individual agency and interpersonal relations within/between giant firms as key elements in framing the transition, notes the role of legislation and government contracts at critical moments, and documents innovators' persistent stumbling as they sought to design and market standardized diesel locomotives. Thus *From Steam to Diesel* represents a welcome achievement in business and technological history, valuably complementing John Brown's recent *Baldwin Locomotive Works* (Johns Hopkins, 1995), which analyzes the nation's leading nineteenth century railway engine builders, closing at just about the point (c. 1910) at which Churella takes up the story's threads.

Constructing locomotives long necessitated that enterprise owners and managers have the steely resolve to take the long view of markets and as well, a generous flexibility in meeting their clients' diverse needs for equipment. Demand for producers' goods fluctuated wildly, then as now, seeming perennially to be either overheated or "dead." Railways routinely clustered their orders, creating backlogs and delays, or deferred upgrades and replacements, thus forcing workforce and financial retrenchments. Moreover, the roads' superintendents of motive power held quite definite notions about the design characteristics of the locomotives necessary for different terrains, climates, or levels of use

intensity. Building engines in response to these variations made Baldwin, American Locomotive (ALCo, the outcome of a turn-of-the-century merger) and Lima (a perennial trailer, focused on market niches) virtuosos in the custom and small batch fabrication of complex mechanical goods. In tandem they developed a sectoral culture of steam propulsion shared by generations of railway managers and employees, batteries of product-specific workplace skills, and commitments to particular "ways of seeing" and addressing technical problems and evaluating locomotives' adequacy. Each of these assets became a liability as dieselization gained a foothold.

In theory, diesel engines had powerful advantages over steam, not least their ability to achieve "thermal efficiencies" vastly higher (yielding lower fuel costs) than the older technology. Diesels needed no water supplies, had lower repair expenses, generated more startup force per horsepower and could, through dynamic braking, ease trains' passage on long downgrades. In practice, however, into the 1920s, diesels were far too heavy for railway use, achieving early success chiefly in "marine applications" (pp. 14-17). Moreover, no experimental design could reliably transmit the engine's power directly to traction wheels, an obstacle resolved by using the diesel to drive electric motors of the sort GE and Westinghouse had created for streetcars and interurbans. Freed of the need for electrical power line contacts (and hence of the huge costs for erecting and maintaining these) and encouraged by legislation banning steam locomotives from New York and Baltimore, both companies ventured into diesel-electric production, GE in alliance with ALCo (using diesels from Ingersoll Rand) and Westinghouse with Baldwin. Yet it was Harold Hamilton's new-start, Electro-Motive, that forged ahead. For years, EM, clearly an early virtual corporation, "did not manufacture anything" (32). Rather Hamilton created a design boutique for self-propelled railcars, commissioning components and subcontracting their assembly. Rather than incrementally shifting designs to include "learning by us-

ing” improvements, EM froze its designs, reaped “substantial production efficiencies,” then consolidated accumulated feedback insights periodically into new models. When the Big Two sidelined their diesel efforts, EM picked up a roster of their able engineers and made some 500 railcars by 1930, but the Depression emptied order books, threatening a collapse.

Here Churella turns to the contingent sequence of interactions which brought EM into General Motors’ orbit and set it on a rocky path to challenge steam traction. In the late 20s, Charles Kettering, GM’s research director, promoted experiments in using diesels for highway vehicles, quickly finding that “metallurgy had not yet caught up with diesel engine technology” (p. 38). Once the economy slumped, Alfred Sloan pressed “Ket” to save on R&D costs by buying an experienced diesel engine maker. The Winton company, acquired in 1930, had worked with EM extensively; and Hamilton soon befriended Kettering, turning his attention to the potential of locomotive diesels and to aiding EM’s stalled engine-development plans. As an effort to promote GM diesels by having models designed for Navy contracts power the company’s 1933 Chicago World’s Fair display was flopping badly (“the only part of that engine that worked well was the dipstick”), Hamilton and his ally Ralph Budd (head of the Chicago, Burlington and Quincy) persuaded Sloan and Kettering to install diesels as drivers for the CB&Q’s new streamlined “train-set” for the Chicago-Denver run. A second failure would have been disastrous, but in 1934 the “Zephyr” stunned everyone, accelerating so rapidly on a test run that its tail lights fell off. Cheap to operate, fast and reliable, this luxury passenger train created a national sensation which surely helped Kettering extract a half-million from Sloan late that year for expanding diesel engine research, then vastly more in 1935 for what became a huge locomotive production plant at LaGrange, IL. In all this, the key players’ interpersonal networks of trust and confidence and their un-involvement with the “steam culture” proved crucial.

If this sounds like the run-up to rapid success, Churella supplies a cautionary “Not so fast.” Motive power men at most railways derided diesels, even resisting their use as yard-switchers, where their facility in starting and stopping could be valuable. EM salesmen thus approached railroad financial officers with reams of data showing diesels’ cost-savings and began landing orders. Second, the Zephyr-style three or four car passenger train-sets were a dead end, as cars could not be added. Instead, EM had to design independent passenger diesels to supplement the smaller switchers, then proceed to the big stuff, freight-hauling locomotives. Third,

railroad workers knew nothing about diesel maintenance and repair, hence, the makers had to develop extensive training programs, after-sale service linkages, and inventories of replacement parts for rapid delivery. GM’s deep pockets were crucial here, for absent system investments Churella estimates totaling between \$17 and \$25 million, the diesel campaign may well have floundered, even in the face of a vast locomotive replacement market (40,000 engines, perhaps \$4 billion over the long term). One further competitive advantage was that EM, which became a General Motors division, could mobilize the GM Acceptance Corporation’s resources to arrange monthly payment plans for railroads, just as GMAC did for citizens buying Chevrolets. Last, even into recent years, design failures in new models of these immensely complex machines (ca. 50-60,000 parts) occurred repeatedly. Yet it is clear that transferring elements of GM’s auto manufacturing approach to locomotive building, even if full mass production remained elusive, was a winning strategy, especially when contrasted with the stumbling efforts of the steam engine makers.

The three steam locomotive leaders at first denied the relevance of diesels to railway needs, then squandered opportunities to adapt their facilities, engineering practices, and work routines to producing them. All eventually fashioned diesel locomotives that ranged from dreadful to barely adequate when put in use by railroads that had long cherished their steam-powered drivers. Each attempted to use product diversification strategies (making all sorts of specialized capital goods), but failed to thrive for reasons that another research project might explore. ALCo, the least awful diesel builder, remained in the postwar engine market in large part because railways were anxious about EMD’s monopoly potential. Once General Electric, which had supplied ALCo its electrical components, entered the diesel trade in the 1960s with better models, ALCo quickly faded from sight. Churella rapidly surveys GE’s challenge to EMD in closing passages; by 1993 the “newcomer” (which had traction experience from before 1900) was outselling EMD two engines to one and GM “contemplated exiting [the] industry.” In response, EMD “allowed its customers greater control over the design and manufacturing process,” (p. 139) a step back toward the specialty production format which its standard models had helped erase in the century’s middle decades. Whether this move indicates desperation or represents tactical ingenuity lies outside the author’s boundaries, of course.

In sum, this is an engaging study of the transformation of a specialty production trade into a standard-product industry, though one which remains vulner-

able to the vicissitudes all capital goods sectors face. Churella's tale, to be sure, does not neatly conform to "organizational synthesis" templates, which he regards as "giv[ing] too little weight to historical actors" (p. 151). Rather, he urges readers to consider the interplay between enterprise structure/strategy considerations and those anchored in shared industrial cultures, technological and personal networks, and state activities, which, together with far broader phenomena (depressions, wars), deploy the challenges enterprises must face and create those shifts and surprises that inspire both the manage-

rial and the historical imagination. (I know convention mandates that I offer something critical about this work –OK, the index is inadequate...) This book is well worth the attention of economic/business historians and their students.

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