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Corporate response to technological change: Dieselization and the American railway locomotive industry during the twentieth century. (Volumes I and II)

Churella, Albert John, Ph.D.
The Ohio State University, 1994

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CORPORATE RESPONSE TO TECHNOLOGICAL CHANGE:
DIESELIZATION AND THE AMERICAN RAILWAY LOCOMOTIVE
INDUSTRY DURING THE TWENTIETH CENTURY

Volume I

DISSERTATION

Presented in Partial Fulfillment of
the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

Albert John Churella, B.A., M.A.

The Ohio State University
1994

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INTRODUCTION

Hurtling through the night it came, two hundred tons of steam and steel, driving wheels tall as a person, headlight piercing the nighttime gloom. As distance narrowed, rails began to flex and sing, ground shake under the power of three thousand horses. As the train rushed by, the wisps of steam that rolled through the air were matched by the haunting cry of the whistle, echoing off the distant hills. Then it was gone, an apparition seemingly more alive than machinery could ever be, more powerful and majestic than its creators could have possibly imagined.

In 1935, it was possible to observe this scene in virtually every part of the United States, for everywhere that steel rails reached, so too did the steel behemoths known as steam locomotives. At the time they were the largest and most powerful pieces of machinery ever to move on land. Steam locomotives pulled virtually every passenger and every piece of freight
that moved by rail, as they had done for the past hundred years. Most children, and a good many adults as well, cherished no greater ambition than to be appointed the engineer of a steam locomotive, guiding a train across the steel rails that bound America together.

Little more than twenty years later, steam locomotives were a rare sight on American railroads. Most could be seen in long lines in railroad graveyards, fires cold, whistles silent, their fitness for future service belied by the one-word death sentence — "scrap" — chalked on their sides.

By 1955, diesel locomotives ruled American railroads. Diesels lacked the romance of steam, but they cut costs and improved performance in ways that not even the most modern steam locomotive could match. And so, within two decades, steam locomotives disappeared from American railroads. At the same time, new companies came to dominate the diesel locomotive industry, sweeping away the steam locomotive producers just as quickly and just as powerfully as an express train rushing onward into the dark and unforgiving night.

The dieselization revolution that swept through the American railroad industry in the decade following World
War II changed forever the structure of the locomotive industry in the United States. Three companies with extensive experience in locomotive design and construction had long controlled the production of steam locomotives -- the American Locomotive Company (ALCo), the Baldwin Locomotive Works, and the Lima Locomotive Works. Although all three firms initially produced diesel locomotives, they had abandoned locomotive production by the late 1960's. After that date, the market was controlled by two companies that had never steam locomotives, General Motors and General Electric.

The transition from steam to diesel locomotive production thus offers an example of a complete turnover of firms within a single major industry, an event unique in modern American business history. As a part of this turnover, the size and profitability of both ALCo and Baldwin plummeted. In 1917, the two companies were ranked at #52 and #62, respectively, among the 200 largest industrial corporations in the United States. By 1948, their rankings had fallen to #145 and #143, and continued to decline in the years that followed. With only two exceptions (Great Western Sugar and Willys-Overland) no industrial corporations in the history of
American business fell so far, so fast. No major industry was as devastated by technological change as was the steam locomotive industry.¹

My dissertation focuses on the failure of three established, successful steam locomotive builders to acquire and maintain a share of a $4 billion market (to replace all of the steam locomotives in the United States with diesels) and the concurrent ability of two new entrants to capture that market.

INDUSTRY DEVELOPMENT

Although diesel engines were developed in the 1890's, their successful application to railroad locomotives dates to the third decade of the twentieth century. A series of noise and smoke ordinances passed by the City of New York in the mid-1920's helped create a market for these still highly experimental diesel-electric locomotives. The early locomotives were generally built by a consortium of companies, each

providing its own particular area of expertise. Because of their high first cost and low power, locomotives of this type were suitable only for enclosed spaces or highly populated areas where steam locomotives could not operate. Nevertheless, they allowed builders to improve significantly diesel locomotive technology.

By the mid-1930's, diesel locomotives were sufficiently powerful and reliable to begin displacing steam locomotives from certain assignments. Dieselization occurred in three stages. Railroads first dieselized yard-switching assignments, primarily because they required these locomotives for service virtually twenty-four hours a day. Diesel switchers stopped only for refueling, but steam locomotives, which required frequent servicing and constant maintenance, were out of service for much longer periods of time. Because long-distance passenger assignments required clean and reliable motive power, they were the next duty to be turned over to diesels, followed by over-the-road freight assignments. The dieselization of American railroads was largely complete by the mid-1950's -- a remarkable achievement, considering the vast sums that railroads had invested in steam locomotives.
Between 1930 and 1969, six firms built virtually all of the diesels produced in the United States. General Motors, the latest and most successful entrant, used its experience with automotive internal combustion engines to enter the field in 1930. In that year, GM acquired the Winton Engine Company and the Electro-Motive Company, two established producers of diesel engines and gasoline-powered railcars. In 1935, Electro-Motive built an integrated diesel locomotive production facility at La Grange, Illinois, on the outskirts of Chicago. In 1941, the company became the Electro-Motive Division of General Motors (EMD). By 1945, EMD was the acknowledged leader of the American diesel locomotive industry.²

The American Locomotive Company (ALCo) was incorporated in 1901 as a consolidation of ten smaller

locomotive builders. This firm introduced the first commercially viable diesel locomotive in 1926, but failed to exploit fully its early lead. ALCo acquired the McIntosh and Seymour Company, an established producer of diesel engines, in 1929. By 1941, ALCo was the second-largest producer of diesel locomotives in the United States. ALCo continued to produce steam locomotives until 1948, when the company shifted entirely to the production of diesels.³

General Electric experimented with gasoline and diesel-power railroad equipment as early as the 1910's. The company built small diesel locomotives for industrial and export markets during the 1930's and 1940's while simultaneously supplying electrical equipment for ALCo diesels. GE entered the large diesel locomotive market in 1960, and quickly outpaced ALCo, its former

Baldwin, the oldest and largest producer of steam locomotives, built experimental diesels as early as 1922. Like ALCo, Baldwin failed to exploit its early lead, primarily because of Board Chairman Samuel Vauclain's abiding faith in steam locomotives. Although Baldwin purchased De La Vergne, a producer of diesel engines in 1931, the company did not introduce a standard line of diesel locomotives until 1939. Baldwin merged with the much smaller Lima-Hamilton Corporation in 1950 and ended locomotive production six years later. 

Fairbanks-Morse expanded its line of railroad equipment and gasoline engines to include diesel engines in 1922. The company produced its first, custom-built, locomotive at its Beloit, Wisconsin, facility in 1939.

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and offered a standardized line of diesel locomotives between 1944 and 1957. Fairbanks-Morse never became a leading company in the diesel locomotive field, however. 

Although the Lima Locomotive Works was a marginal producer of specialized locomotive designs during the early twentieth century, by 1940, it had acquired a reputation as an innovative producer of high-quality steam locomotives. Lima was unable to transfer this success in steam locomotive production to the diesel locomotive industry. Executives at Lima waited too long to begin diesel locomotive production and failed to realize that their company lacked the capital necessary to exploit this emerging market. As such, Lima's 1950 merger with Baldwin marked the end of locomotive production at the former company.

The three companies -- ALCo, Baldwin, and Lima -- that produced both steam and diesel locomotives discovered, too late, that vast differences in manufacturing, 

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marketing and management existed between the two industries. As a result, they failed to invest in new manufacturing facilities, equipment, and adequate diesel locomotive designs, failed to create aggressive marketing campaigns and establish post-sale support services, and failed to redefine managerial objectives to allow for more effective diesel locomotive production and distribution. This comprehensive failure prevented ALCo and Baldwin from establishing what business historian Alfred D. Chandler, Jr., refers to as "first mover advantages" — the barriers to entry created by the first firm in an emerging industry to make a combined investment in manufacturing, marketing and management.7

Technology and manufacturing methods were much different in diesel locomotive production than they had been in the steam locomotive industry. Although theoretically simple, the steam locomotive was in actuality a complex machine. Fuel, burned in the firebox, created hot air that flowed through tubes in the boiler, thus converting water in the boiler into steam. This steam collected in a steam dome atop the

7Chandler, Scale and Scope, 34-5, 597-605.
boiler and was then piped to the cylinders. Steam entering the cylinders propelled pistons that were connected to a system of linkages known as valve gear. This valve gear converted the reciprocating motion of the pistons to the rotary motion of the wheels.

Until the very end of steam locomotive production in the late 1940's, all steam locomotives were custom-built by skilled craftsmen familiar with traditional metalworking techniques such as foundrywork and machining. Individual railroad customers were largely responsible for locomotive designs, basing these on the curves, grades, weight and clearance restrictions, and power requirements of their particular railroad or operating district. Because of these specialized design requirements, only a small number of locomotives were built to each design -- usually no more than twenty or thirty -- and standardization produced no corresponding economies of scale.

The one attempt at standardization in the locomotive industry occurred during World War I, when the United States Railroad Administration developed standardized steam locomotive designs in the interest of wartime production efficiency. Although locomotives produced to these designs were generally satisfactory, the craft nature of steam locomotive manufacture resulted in only minor production efficiencies and, after the war, railroads renewed their demands for
Since railroads approached locomotive builders with their orders, and since railroads were generally loyal to a single supplier of steam locomotives, executives at ALCo, Baldwin, and Lima had little incentive to develop marketing campaigns. Post-sales support services held little interest for steam locomotive industry executives, since railroads had extensive shop forces trained in the well-understood principles of steam locomotive maintenance; and after all, locomotive builders saw little need to guarantee the performance of locomotives that had largely been designed by the customers who purchased them.

Because manufacturing and marketing responsibilities were so frequently assumed by customers (the railroads) managerial capabilities in the steam locomotive industry were scantily developed. ALCo and customized locomotive designs. Because steam locomotives were largely custom-built to the specifications of individual railroads, locomotive builders rarely kept a large stock of spare parts in inventory. Instead, railroads too small to possess extensive foundry and machine shop facilities described or sent in the defective part, and a spare was either cast or machined from blueprints and patterns kept in a pattern vault. Steam locomotives were thus frequently idled for days or weeks while awaiting a single spare part.
Baldwin, although large companies, employed a unitary line-and-staff organizational structure until well after World War II, and boasted few middle managers. Top corporate executives understood that locomotive sales, like those in the rest of the capital goods industry, fluctuated erratically in a "feast-or-famine" pattern. These executives understood that a period of prosperity would inevitably be followed by a slump in orders that, at some unknown point in the future, would turn into a bonanza again. As a result, management, which had seen prosperity come and go at regular, if not altogether predictable, intervals, adopted a stay-the-course mentality that gave little credence to declines in business, believing them to be temporary rather than permanent.

Organizational requirements in the diesel locomotive industry were considerably different, however. Diesel locomotives typically consist of three main components -- the locomotive body, the diesel engine itself, and the generators, traction motors and other electrical equipment. Unlike a gasoline engine, which employs a spark to ignite a relatively low pressure fuel/air mixture, diesel engines compress a fuel/air
mixture to such great pressures that the fuel ignites, driving a piston housed in a cylinder. A generator then converts the mechanical energy of the moving pistons into electricity. This electricity in turn powers traction motors attached to the locomotive axles, thus propelling the locomotive.\(^9\)

The design and manufacture of diesel locomotive components required greater accuracy and closer tolerances than had been the case in steam locomotive production. While diesel locomotives were too large to be manufactured on an assembly-line basis, standardized designs allowed for a high degree of interchangeability among parts and subassemblies. Because such standardization lowered manufacturing costs to a considerable extent, railroads were forced to accept diesel locomotives that they had not designed. The declining role of the customer in the design process forced diesel locomotive builders, Electro-Motive foremost among them, to

\(^9\) Virtually all diesel-powered railroad locomotives in the United States after the late 1920's used electric transmissions, and thus should properly be called diesel-electric locomotives. For the purposes of this study, however, such locomotives will simply be referred to as "diesels."
guarantee the performance of their diesel locomotives. In addition, since railroad shop forces were unfamiliar with diesel locomotive technology, diesel locomotive manufacturers found it necessary to provide spare parts depots and rebuilding facilities, and also to train railroad employees in the proper techniques of diesel locomotive operation and maintenance. These expanded marketing capabilities, virtually unknown in the steam locomotive industry, were vital to success in the diesel locomotive market.

ALCo and Baldwin did not appreciate the differences between steam and diesel locomotive production and marketing until it was too late. The combination of radically different manufacturing and marketing techniques meant that the managerial structure of the steam locomotive firms was inadequate for diesel locomotive production. As this dissertation indicates, ALCo and Baldwin were constrained by the outdated beliefs and values of steam locomotive production, and were thus unable to modify their managerial skills rapidly enough to attain success in the diesel locomotive industry.
CONTEXT AND SCOPE OF THE DIESELIZATION STORY

In spite of widespread popular interest in railroads in general and steam locomotives in particular, little serious historical research has been conducted on the American locomotive industry during the twentieth century. The only recent scholarship concerning the diesel locomotive industry has come from Thomas Marx. Marx, an economic historian, addresses issues that are considerably different from those I study here. He offers a narrowly focused analysis of government antitrust policy in relation to two suits by the Justice Department against General Motors during the 1960's. Marx is not concerned with corporate decision-making processes or overall managerial responses to technological change. His primary interest lies in the realm of prescriptive macroeconomic policy analysis. In addition, Marx did not have access to the vast wealth of company records relating to individual firms now available.

able to historians. For example, Marx has not used the rich ALCo Collection at Syracuse University, the Barriger Collection at the St. Louis Mercantile Association Library, or the records at the General Motors Institute in Flint, Michigan. Robert Bingham uses the locomotive industry as a case study to develop an economic analysis of the theory of innovation. He does not place great emphasis on marketing or corporate culture; and, in addition, he wrote his dissertation in 1962, well before the modern competitive structure of the locomotive industry had emerged. Donald Park offers another economic analysis of innovation and the steam locomotive. Richard Hydell examines the process of dieselization from the perspective of one eastern railroad, the Erie. Other scholars have written on the development


and application of diesel engines themselves.\textsuperscript{14}

Most of the other secondary works that describe the locomotive industry are intended primarily for the rail-fan market. They contain many beautiful photographs and exhaustive amounts of detail concerning specific locomotive types, experimental models, and railroad assignments, but provide little historical analysis. Nevertheless, they sometimes provide information not readily available elsewhere. Three of the most useful are authored by John F. Kirkland.\textsuperscript{15} John Bonds Garmany has also written a valuable book on early diesel locomotives.\textsuperscript{16} To a large extent, these works suffer from a


common failing in that their primary focus is on the product rather than on the process. Naturally, the actual diesel locomotives themselves must figuratively and literally loom large in any discussion of the locomotive industry.

To business historians and historians of modern America, however, the methods by which these locomotives were manufactured, the way in which they were marketed, and the ability, or inability, of companies to manage the processes of manufacturing and marketing are all more important than the actual technology itself. Companies such as ALCo and Baldwin failed because innovations in their products were not matched by innovations in manufacturing, marketing, and management. An examination of the evolution of the diesel locomotive industry thus offers a window through which historians and business executives alike can attain a deeper understanding of the ways in which technological change, constrained by social and cultural values, can dramatically affect individual corporate success and national economic achievement.

In order to bring the broader implications of my work into sharper focus, I will first address the larger
questions and issues raised by this topic, introducing relevant historiography where appropriate. I will follow this with a brief overview of the structure of my entire dissertation.

First, the locomotive industry was and, to a lesser extent, remains an important segment of America's industrial economy. The United States has dominated the world market in diesel-electric locomotives since the 1930's, a situation that applies to few other industries. With the exception of Europe, Japan, and the former Soviet Union, railway traffic in much of the world is hauled by American diesel locomotives. In spite of this, the American locomotive industry has largely been ignored by historians. Scholars have devoted little attention to the railroad industry after the 1920's, save to describe the long process of decline caused by the development of automobiles, trucks, and airplanes. Few historians have examined the economic successes associated with railroads since that time. The diesel locomotive industry is one such success, at least for General Motors and General Electric.

Second, this dissertation delineates which responses to technological change proved most
successful. American locomotive builders employed a number of competitive strategies in response to the change in technology from steam to diesel motive power. These included joint ventures, such as that between ALCo and General Electric, horizontal combination, as in a merger between Lima and Baldwin, and vertical integration in the case of General Motors. This variety of organizational responses to technological change, in turn, relates to the larger issue of how established companies adapt, or fail to adapt, to technological, political, social, and economic changes.

Third, my dissertation looks at the extent to which corporate participation in the political process, especially at the federal level, was necessary to secure a strong competitive position within a particular industry. Historians, economists, and popular writers have often assumed that large firms, such as GM and GE, have an unusual degree of influence over government policy; and, if this was in fact the case, it may have given these two firms a competitive advantage over the older, more traditional locomotive builders. The actions of specific government agencies, such as the War Production Board, may also have had a lasting effect on the industry.
Fourth, my study offers the possibility of assessing the potential for large diversified firms to exploit technological innovation and thereby fulfill larger social and economic needs. The enormous financial and technical resources of GM and GE certainly facilitated their capture of the diesel locomotive market. Does firm size thus indicate that modern diversified firms are particularly efficient at exploiting technological innovations? Does the expansion of firms into related product lines increase competition, or does this process ultimately lead to a reduction in competition; and, if competition becomes muted, does this reduced participation in an industry result in economically or socially undesirable consequences? Did firms such as GM -- as the Justice Department alleged in the 1960's -- use their enormous financial resources to distort socially desirable economic patterns?

A fifth and related issue concerns the ongoing dialogue between historians who examine mass production, such as Chandler, and those who have turned their attention to smaller, more specialized producers of small-batch or custom-manufactured products. Because of their size and economic power, large industrial firms have
attracted a great deal of attention from business historians. Chandler, America's preeminent business historian, has written two books which are especially useful in understanding the processes by which large industrial corporations respond to technological change and the introduction of new products. His recent *Scale and Scope* discusses the creation of "first-mover" advantages. In Chandler's view, these advantages do not necessarily accrue to the first firm to offer a product or service. Instead, they are obtained by the first firm to make a three-pronged investment in production, distribution, and management. In an earlier work, *Strategy and Structure*, Chandler explains the development of the diversified, decentralized firm, noting that a firm's organizational structure typically derives from its corporate strategy.\(^\text{17}\)

While Chandler's works greatly increase our knowledge of industry structure and corporate decision-making

processes, other historians have correctly pointed out that Chandler's synthesis is not all-encompassing. It is too often easy to assume, for example, that corporations utilize a rational, linear strategy in order to respond to technological change. In the locomotive industry, at least, the decision-making process was much more complicated, even for firms like General Motors. In addition, Chandler downplays the significance of all-too-human managers. Top-level corporate executives have never operated in a vacuum, and their corporate cultures frequently have had overwhelming impacts on their responses to technological change -- and not always for the best. My own work thus introduces a human element, in the form of corporate culture, to Chandler's impressive achievements in institutional history.

Some economic and business historians have questioned the applicability of an organizational model based on the collective corporate experience of a handful of large mass-production firms. John N. Ingham has found that owners of smaller, specialized, independent steel mills in Pittsburgh retained a large degree of control over the economic and social affairs of their city well into the twentieth century, despite inroads by
absentee owners of large-batch mass-production steel firms. Particularly in light of recent financial catastrophes at several large corporations, scholars such as Philip Scranton, Michael Piore, and Charles Sabel have suggested that flexible batch production has served some companies well in the past, and might do so again in the future. Batch production, though less predictable than mass production, allows companies to alter rapidly their production and marketing capabilities in order to respond to changing customer demands. In a recent article Scranton correctly classifies the steam locomotive industry as a haven for flexible batch production.


20Philip Scranton, "Diversity in Diversity: Flexible Production and American Industrialization, 1880-1930," The Business History Review 65 (Spring, 1991), 27-90. Scranton notes that some industries derived greater benefit from flexible production than others. The machine tool industry, for example, enjoyed
had done well as batch producers during the early twentieth century, and were unwilling and, ultimately, unable to adjust to manufacturing techniques in the diesel locomotive industry -- techniques that more closely resembled mass production.

Sixth, my study addresses the relationship between technology and business strategy. Just as historians of technology have abandoned a narrow focus on artifacts themselves, they have also disavowed the simplistic notion that technological change is an irresistible force that in and of itself determines the fates of companies or nations. Instead, it is clear that the effects of technology must be examined in a broader social and cultural context, one that gives full reign to the often irrational and unscientific actions of the diverse range of individuals who put that technology to use. For example, in his *From the American System to Mass Production*, David Hounshell shows that some

a mutually beneficial cooperative competition as companies adapted their designs to meet specific customer requirements. The jewelry industry, however, was nearly wrecked by over-competition and price-gouging during the 1920's.
companies, such as Singer, employed the supposed benefits of standardization and mass production only as a last resort, when more conventional production techniques failed to keep pace with increased demand brought about by advanced marketing strategies.  

David Noble, in *America by Design* examines the development of a specialized cadre of professional engineers, and indicates that their actions have larger social implications than the mere success or failure of the business firm. 

The *Making of American Industrial Research*, by Leonard Reich, is an outstanding example of a recent interest in corporate research and development programs — programs that often forsook pure science in favor of the development of products to satisfy the marketing campaigns devised by senior corporate executives.

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23 Leonard S. Reich, *The Making of American Industrial Research: Science and Business at GE and Bell, 1876-1926* (Cambridge: The Cambridge University Press, 1985). For a clear example of the subservience of science to marketing, examine the development of Crisco, as told by Susan Strasser in Chapter 1 of *Satish-
Like other historians of technology, I would be remiss if I failed to place technological change in the locomotive industry within a broader social and cultural context. This is especially true because, as the next few hundred pages will demonstrate, the context, not the technology, is the real story. Briefly, it is my thesis that while a variety of factors, ranging from issues of technological transfer to instances of government action, influenced changing competitive patterns in the locomotive industry, endogenous factors, particularly the corporate culture of the locomotive producers, proved to be the determinant of success or failure in the industry.

The concept of corporate culture has attracted increasing interest during the last decade, particularly among business writers. Japan's economic success has often been attributed to that country's presumed strong organizational or corporate culture. Many American business executives are now exhorted to improve the corporate culture of their companies, and in so doing, *Faction Guaranteed: The Making of the American Mass Market* (New York: Pantheon Books, 1989).
create corporate success through unity of purpose. Too often, however, this emphasis on corporate culture in the modern business firm is seen as merely an encouragement for teamwork, conformity, and groupthink rather than a call for a deeper analysis of the belief systems of workers or managers and the ways in which those belief systems may be the cause of, rather than the cure for, corporate problems.\textsuperscript{24}

This present study may help to address some of these deficiencies. The definition of corporate culture

used here refers to the beliefs, attitudes, and values of company management, the way in which these beliefs were shaped by education and work experience, and the impact of the resulting values on corporate decision-making processes. The failure of the steam locomotive producers to penetrate successfully the diesel locomotive market provides a clear example of the perils of a strong corporate culture.

Simply put, executives at ALCo and Baldwin, through lifelong training and experience, developed a corporate culture that was virtually inseparable from the custom craft production of steam locomotives. This corporate culture allowed ALCo and Baldwin to dominate the steam locomotive industry and to gain respect throughout corporate America as successful, reliable, and well-managed firms. Paradoxically, the corporate culture that contributed to this success had become ossified by the 1920's, the managers caught in its snares unable to respond to growing evidence that the steam locomotive industry was headed for extinction. The very success of their corporate culture thus blinded executives at ALCo and Baldwin to the realities of technological change. At the same time, executives at Electro-Motive possessed
a corporate culture that, while not inherently "better" than that of ALCo and Baldwin, nonetheless recognized the applicability of the diesel locomotive and fostered its development.

Scholars are showing an increased interest in an examination of corporate culture from an historical perspective. Charles Delheim, in his research on Cadburys, shows how strong religious beliefs can shape a company culture and how that culture, in turn, can affect the performance of a company and the attitudes of its workers, even after the founders have departed the scene.25 Michael Rowlinson and John Hassard offer a different view of corporate culture at Cadburys, suggesting that religious values formed the centerpiece of a mythical corporate culture fabricated to ensure worker

loyalty. William R. Childs and David M. Vrooman point out the ability of powerful individuals to shape an organizational culture, especially if they are able to use symbolism that is potent and familiar to a variety of individuals both inside and outside an organization. Paul A. Tiffany shows that a "deeply embedded culture of distrust," shared by managers, workers, and government officials alike, had a disastrous effect on the postwar American steel industry. Mansel Blackford and Howard E. McCurdy make observations analogous to those in my study; namely, that seemingly capable and successful executives and bureaucrats can become so


enmeshed in a corporate culture that they are unable to adapt to new realities.²⁹ My own work adds to these already impressive beginnings by suggesting that a solid corporate culture — one that modern business executives might envy — can potentially be so unable to cope with technological change that it destroys the company it had done so much to create.

In short, my dissertation studies the response of the American locomotive industry to technological change and, by doing so, further illuminates the diverse responses of American business to the forces of change. The decline of established, respected, and profitable locomotive producers and the ascendancy and subsequent financial success of two new entrants into the field offers insights into the decline of established American industries and the rise of new industrial powers and new forms of economic endeavor.

My dissertation begins with an exploration of the early years of diesel engine and diesel locomotive development. The first two chapters discuss the origins and diffusion of diesel engine technology and examine the early efforts of various builders to apply internal combustion technology to railroad locomotion. Chapters 3 and 4 focus on the critical years of the 1930's. During this decade, Electro-Motive acquired a significant first-mover advantage in the diesel locomotive industry, while its principal competitors, ALCo and Baldwin, failed to make comparable investments in manufacturing and marketing capabilities. Chapter 5 illustrates that World War II and the federal production restrictions that accompanied it increased temporarily the ability of other locomotive producers to compete against EMD.

During the postwar period, as railroads rushed to dieselize, EMD and ALCo emerged as the dominant and, indeed, as the only viable producers in the industry. As events depicted in Chapter 6 make clear, however, ALCo, by failing to establish a first-mover advantage in the 1930's, was relegated to a secondary position in the industry during the postwar period. The end of the postwar dieselization rush resulted in the elimination
of marginal producers from the industry; and Chapter 7 shows how first Lima, then Baldwin, and finally Fairbanks-Morse were forced out of locomotive production. Chapter 8 discusses the entry of General Electric into the large diesel locomotive market in 1960, followed by that company’s rapid replacement of ALCo as the second-largest producer in the industry. While my dissertation focuses primarily on the domestic locomotive industry, the final chapter offers a case study of the involvement of American locomotive producers in foreign markets, with particular emphasis on production and sales in Canada and the countries of Latin America. While these markets potentially offered increased sales opportunities for ALCo and Baldwin in the diesel locomotive market, in reality the same competitive patterns prevailed abroad as in the United States.
CHAPTER I

THE ORIGINS OF THE DIESELIZATION REVOLUTION

The invention of the diesel engine predated its first viable application in railroad locomotives by more than a quarter of a century and attained widespread use only several decades after that. As is often the case with new technology, especially that which challenges the dominance of complex and long-established technological systems, the mere presence of the diesel engine was not enough to ensure its use. The railroad diesel engine gained widespread acceptance only after related advances in fuels, metallurgy, welding techniques, and electrical design had occurred. Paradoxically, its use was advanced by two very different, yet equally taxing, crises for American railroads, the Great Depression and World War II. Ultimately, however, diesel locomotives did not begin to emerge as a viable option until the absolute limits of existing steam locomotive technology had been reached.
During the 1920's, the impetus for diesel locomotive development came, not from companies in the steam locomotive industry, but rather from firms that produced internal-combustion railcars. ALCo, Baldwin, and Lima had no interest in the seemingly insignificant niche market for small railcars, yet these units offered a valuable testbed for the development of railroad diesel engines and related equipment. The companies that pioneered railcar design, particularly the Electro-Motive Corporation (EMC), possessed a corporate culture that was far different from that of the steam locomotive industry, one that favored experimentation and acknowledged the need for new developments in manufacturing and marketing capabilities. Harold Hamilton, EMC's founder, used his experience in the auto industry to create a corporate culture similar to that of General Motors, a situation that facilitated the interaction of those two firms after 1930.

RUDOLPH DIESEL AND EARLY DIESEL ENGINE DEVELOPMENT

Although this dissertation is not a study of the invention and development of the diesel engine, a brief
review of that process will provide a useful context for a discussion of later efforts to apply the diesel engine to railroad use.¹ Unlike the gasoline engine, which requires a spark to ignite the fuel and air mixture in the cylinder, a diesel relies on the enormous pressure created by the compression stroke of the piston to accomplish the same effect. It was not until the late 1800's that the engine began to assume its modern form, largely through the efforts of Dr. Rudolph Diesel.² After Diesel graduated -- at the top of his class -- from the Technische Hochschule in Munich in 1880, he

¹For the first half century after its invention, Dr. Rudolph Diesel's engine was usually referred to as the Diesel (capitalized) engine in his honor. More recently, it has been commonly referred to as the diesel (uncapitalized) engine. Except in the case of direct quotations, this work will use the latter version throughout. Even though railroad locomotives are often called "engines," the phrase "diesel engine" refers to the power plant alone, while a "diesel locomotive" includes the carbody, chassis, trucks, and other components necessary for railroad use.

²For more information on the career of Rudolph Diesel, see: Donald E. Thomas, Jr., Diesel: Technology and Society in Industrial Germany (Tuscaloosa: The University of Alabama Press, 1987). This book, part biography and part history of technology, discusses the growth of a new profession -- engineering -- and the resistance to this by older established professions. It also examines the role of engineers as agents of change and solvers of social problems.
began working on refrigeration equipment. He soon became intrigued with the high potential thermal efficiency (the portion of the potential energy in the fuel that is transformed into actual work) of the compression ignition engine. As Diesel well knew, steam engines wasted energy moving heat from the fire box to the boiler tubes, transferring that heat to the water in the boiler, then moving the steam thus produced to the cylinders, where it was converted into mechanical power. In internal combustion engines, however, all of the heat would be contained in the cylinder and immediately transformed into motion. Diesel initially believed that it would eventually be possible to attain an astronomical 73 percent efficiency. In practice, however, thermal efficiency for even the best diesel engines seldom exceeded 35 percent. Still, this was a substantial improvement over the 6-10 percent efficiency of the steam engine and the 18-22 percent efficiency of the gasoline engine.  

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3Speech by Charles Francis Kettering at the EMD Silver Anniversary, Chicago, October 24, 1947, General Motors Institute Alumni Foundation’s Collection of Industrial History, Flint, Michigan (hereafter referred to as GMI), 76-16.2; Scientific American 221:2 (August, 1969), 108-117; Fortune 38 (July, 1948), 76-81, 144-9; Harold L. Hamilton, "The Development of the Diesel
Diesel's interest in internal combustion began to bear fruit in the early 1890's. In 1892, Diesel patented his still-theoretical engine design. \(^4\) A year later, Diesel built a one-cylinder oil-fired engine that never ran. By 1897, Diesel had developed an engine that produced an encouraging 26 percent efficiency if and when it actually operated. In October of that year, Diesel sold the American and Canadian patent rights for his invention to brewer Adolphus Busch. American engineers tested the first commercially successful diesel engine in the United States in September, 1898, and later used it as a power plant in the St. Louis Locomotive,\(^*\) address to the Pacific Railway Club, Los Angeles, June 9, 1949, reprinted in Proceedings: The Journal of the Pacific Railway Club 33:2 (May, 1949), 5-22.

brewery. This development eventually led to the creation of the Busch-Sulzer Brothers Diesel Engine Company in 1911.5

Rudolph Diesel's collaboration with the other half of the Busch-Sulzer Company, the Winterthur, Switzerland firm, Messrs. Sulzer Brothers, resulted in the construction of the world's first diesel locomotive. Diesel, recognizing the potential for his engine in railroad service, joined with Sulzer and the Berlin firm of A. Klose to form the Society for Thermo-Locomotives in 1906. In the summer of 1912, the world's first diesel-powered locomotive made its debut on the Winterthur-Romanshorn Railroad in Switzerland. It was equipped with a 1,600-hp 4-cylinder Sulzer engine and a mechanical transmission. The locomotive was not a great success, largely because developments in the field of power transmission and regulation had not kept up with advances in the diesel engine itself.

5 John F. Kirkland, Dawn of The Diesel Age: The History of the Diesel Locomotive in America (Glendale, California: Interurban Press, 1983), 32, 36; Nelson C. Dezendorf, address at the annual dinner of the Traffic Club of St. Louis, St. Louis, January 15, 1947, AAR.
Advocates of the diesel engine in railroad service had more success with smaller, less powerful railcars. Unlike a locomotive, railcars were designed to pull only themselves or, when necessary, one or two unpowered "trailer" cars. Sulzer delivered its first railcars just prior to the outbreak of World War I in Europe. These units developed only 200 hp, and utilized more reliable electrical transmissions.*

World War I hampered European efforts at diesel locomotive development and allowed American firms to attain dominance in this field. German diesel engine expertise was redirected to serve military needs, primarily to provide power for dirigibles and submarines. German submarines, despite their many limitations, clearly demonstrated the potential for diesel engines. Furthermore, after the war, European railroads, which had higher traffic densities than their American counterparts, frequently found that it was more

*The first truly successful diesel railcars in Europe were those of the "Polar-Dena Express" in Sweden in 1913. Baldwin Locomotives 5:1 (July, 1926), 43-9; Engineering, December 26, 1952, 830-1.
economical to switch from steam locomotives to straight electrics, rather than to diesels.

Rudolph Diesel himself was no longer in a position to advocate the universal applicability of his engine. In September, 1913 he jumped, fell, or was pushed over the rail of a steamship plying the English Channel. To this day, the exact cause of his death remains unknown, but the fact that Diesel was enroute to London for a discussion with the British admiralty regarding submarine engines led to the widely held suspicion that the German government was responsible for the death of one of its own citizens. Given Diesel's chronic financial difficulties, it seems more likely that he committed suicide, however.7

In the meantime, Diesel's original patents expired in 1912, leaving the field open for other entrants. Several thousand diesel engines had been built between 1900 and 1914, indicating the presence of at least a modest demand for diesel engines. The easing of patent restrictions, combined with claims from Diesel and

7Baldwin Magazine 1:2 (2nd qtr., 1944), 10-15; Dezendorf, address at the annual dinner of the Traffic Club of St. Louis, St. Louis, January 15, 1947, AAR.
others that his engine would replace all other forms of
motive power, including steam and gasoline engines, led
to more than 100 companies entering the diesel engine
field during and immediately after World War I. Most
failed miserably, lacking capital and proper research
and development facilities. This rapid disenchantment
with diesel engines would have lasting repercussions in
the locomotive industry. The brief tenure of most
diesel engine producers convinced many builders, already
ardent supporters of steam locomotive technology, that
not only were diesels NOT universally applicable, but
that they were in fact almost universally INapplicable,
and thus suited for only a very few specialized niche
markets.8

In the years that followed, it became apparent that
diesels were indeed better suited to some applications
than to others. Most companies decided that automobile
diesels were a lost cause. Only the larger models of
buses and trucks could be adapted to diesel propulsion.
Powerplants and other large stationary applications

8 Dezendorf, "Diesel Engines or Gas Turbines for
Locomotives?"; Fortune 38 (July, 1948), 76-81, 144-9.
found it more economical to use coal or oil-fired steam turbines. Aircraft diesels showed promise, but were outpaced by faster technological advancements in gasoline engines. By the early 1920's, the success of diesel engines was evident only in marine applications. Only here, it was assumed, was the weight of a diesel engine not critical, and only here did higher thermal efficiency take precedence. Established locomotive builders, comfortable with steam locomotive technology, correctly assumed that they could not build a successful diesel locomotive solely by using existing technology. Furthermore, they had no interest in undertaking the research and development necessary to expand this technological envelope. Market conditions and the limitations of existing technology thus meshed with the established corporate cultures of the steam locomotive builders in a way that delayed the diffusion of diesel engine technology. The effort to apply this technology to railroad applications would not come from the locomotive builders, but would originate from different sources entirely.\(^9\)

\(^9\)Ibid.
RAILCARS AND INTERNAL-COMBUSTION ENGINES

As was the case in Europe, the motorized railcar provided the first opportunity for the internal combustion engine to prove itself in railroad service in the United States. The companies that built them found gasoline and, later, diesel engines better suited to their specialized requirements. In addition, railcar producers did not have the myopic devotion to steam power that characterized the established locomotive builders. The efforts of the railcar builders provided valuable experience for proponents of railroad dieselization and helped persuade many railroad executives that diesel power had merit.

During the early decades of the twentieth century, virtually all trains on the vast American railroad network were hauled by conventional steam locomotives pulling unpowered freight and passenger cars. This was a perfectly satisfactory arrangement on heavily travelled main lines but created problems on lightly travelled branches. The problem was particularly acute in the case of passenger service. Typical branch line
passenger trains consisted of a steam locomotive and one to three cars. Total crew size (six or more) often exceeded the daily passenger count. Such services rarely made money, and frequently were kept afloat only because of lucrative mail contracts. Average speed rarely exceeded 25 miles per hour, and passengers unfortunate enough to rely on such trains endured stifling summer travel, frigid winter journeys, and year-round noise, smoke, and cinders — a far cry from the crack limiteds that barrelled along the mainlines.

Naturally, railroad executives welcomed any developments that reduced the expenditures connected with the necessary evil of branchline passenger service, and therefore they encouraged the development of internal-combustion railcars. By the turn of the century, they realized that internal combustion engines could be applied to railroad equipment as well as to automobiles. Frequently, the initial impetus to apply such engines to railroad service came from the railroads themselves, and in no case was an established locomotive builder willing to sully itself with something so mundane as a railcar.

The first railcars used gasoline engines. In 1897, the Chicago-based Patton Motor Car Company introduced a
gasoline and battery powered railcar. This car was probably the first to use an electric transmission. Patton built nine similar cars between 1888 and 1893, but none of these was a great success. The Chicago, Burlington and Quincy Railroad built its own motor car a year later, but it was no more successful than its predecessors. In 1905, the Union Pacific Railroad assigned its superintendent of motive power and machinery, William R. McKeen, Jr., the task of building a railcar. This car, employing a 6-cylinder, 100-hp gasoline engine and a mechanical transmission, was completed in the railroad's Omaha shops in March, 1905. Its success prompted the Union Pacific to build 41 additional cars over the next three years.

After realizing that other railroads were interested in his idea, McKeen resigned from the railroad in July, 1908, in order to establish the McKeen Motor Car Company. This company's railcars, built to a standardized design that was virtually identical to the Union Pacific models, were nearly indestructible. Though most burned gasoline, some were designed to burn less-expensive diesel fuel or distillate, which was similar to kerosene. The 155 McKeen cars that entered railroad
service demonstrated that railroads could not easily afford to dismiss internal combustion.\textsuperscript{10}

The first decade of the new century also witnessed the entrance of General Electric into the railcar market. Whereas railroads such as the Union Pacific constructed railcars as a means of lowering operating expenses, GE saw this field as a logical extension of its railway electrical equipment line. GE built its first straight electric locomotive (for the Baltimore and Ohio) in 1895 and furnished a variety of components for electric streetcars and interurbans. GE, like its competitor Westinghouse, had hoped that American railroads would undertake widespread mainline electrification in the early years of the twentieth century. Primarily because of the enormous capital expenditures involved, however, electrification was generally restricted to long tunnels, underground stations, and

other areas where the smoke from steam locomotives created an operating hazard.¹¹

The failure of electric locomotive demand to materialize to the extent that had been expected caused GE to search for additional ways to utilize the organizational capabilities created to produce electric locomotives. In 1904, GE established a Gasoline Engine Department under the direction of Henri G. Chatain. In February, 1906, GE built its first motorcar, using a carbody provided by ALCo. The 65-foot, 65-ton car used a 160-hp British-made Wolseley gasoline engine, which lacked the necessary power. Befitting GE's electrical expertise, power was transmitted to the wheels via an electrical transmission. Two years later, GE built a second railcar that was much lighter (31 tons), and had a less powerful (100-hp) engine.

GE understood that electricity offered the best method of controlling internal-combustion railroad equipment. Mechanical transmissions, such as those used on the McKeen railcars, were difficult to regulate and suffered from frequent malfunctions. Hydraulic

¹¹Railway Age 142:16 (April 22, 1957), 32-6, 42.
transmissions, popular in Europe, proved unreliable in more rigorous American railroad applications. Electric transmissions allowed railcar operators to change directions easily and make subtle adjustments in speed.

Power generated by a gasoline or diesel engine first turned a generator that then supplied electricity to the traction motors that actually turned the wheels. This system of power transmission proved so reliable that it was applied to nearly all American railcars and diesel locomotives.

In 1911, GE began to consider the possibility of using diesel engines in its railcars, and established a research and development program for that purpose. At the same time, railcar development shifted from Schenectady, New York to Erie, Pennsylvania. By 1916, GE had developed a new 200-hp, 2-cycle, V-8 diesel engine, based on a Junkers aircraft engine. In 1917, the company used this engine, the Model GM50, to power an experimental locomotive, which was the first diesel locomotive built in the United States. Shortly thereafter, however, more lucrative war contracts persuaded GE to terminate research on gasoline-electric and diesel-electric railcars and locomotives for the next decade.
The company ended production of gasoline and diesel engines for railroad use in 1919, but continued to manufacture electrical equipment.\textsuperscript{12}

GE’s limited railcar production had greater significance for the company than the small number of units produced would indicate. Between 1906 and 1914, GE built 88 railcars, frequently using carbodies provided by the Watson Manufacturing Company of Springfield, Massachusetts. Most did not last long in railroad service, since they were overweight, underpowered, difficult to operate, and prone to frequent malfunctions.\textsuperscript{13}

Nevertheless, the railcar industry as a whole benefited from GE’s experiments with gasoline and diesel engines. The fact that a company as large as GE was willing to install gasoline and diesel engines in railroad equipment gave further credence to that form of motive power. Finally, GE’s brief railcar research and development


program gave valuable experience to individuals who later employed their talents at other firms.

Chief among these GE-trained employees was Richard Dilworth, who joined GE as a "machinist-electrician" in 1910. He was placed in charge of GE's railcar demonstration staff in 1911 and became a test engineer the following year. In 1913, he began working on GE's diesel engine project. Although Dilworth received less than one day of formal education during his lifetime, he acquired an excellent practical knowledge of electricity in the U. S. Navy. In the early 1920's he assisted Dr. Herman Lemp in his efforts to develop a simplified generator and traction motor control system. While at GE, he rapidly added a thorough knowledge of internal combustion engines to his repertoire. He had a lifelong interest in tinkering and experimentation -- while on assignment in the Philippines, he converted an engine to run on 90 proof gin! Although he left GE a few years after railcar development ended, he remained a staunch advocate of diesel railway traction and, as an employee of Electro-Motive, had an enormous impact on the development of the diesel-electric railroad locomotive. He served as EMC/EMD chief engineer from 1926 to 1948, at
which time he became engineering assistant to the vice-president in charge of EMD.\textsuperscript{14}

THE RAILCAR MARKET REVIVES IN THE 1920's

The 1920's witnessed a renewed interest in railcar technology. As automobiles and highways continued to improve, rural dwellers were no longer forced to travel by train. Automobiles provided flexibility and convenience for those who could afford them. Buses offered lower fares and faster and more comfortable service than railroads. Faced with rapidly declining patronage, railroads once again sought ways to reduce the expense of branchline passenger service.\textsuperscript{15} This time, however,


\textsuperscript{15}For a thorough analysis on how one railroad, the Southern Pacific, attempted to cope, albeit inadequately, with increased competition in passenger traffic during the interwar period, see: Gregory Thompson, "Misused Product Costing in the American Railroad Industry: Southern Pacific Passenger Service between the Wars," \textit{Business History Review} 63 (Autumn, 1989), 510-54; and Thompson, \textit{The Passenger Train in the Motor Age: California's Rail and Bus Industries, 1910-1941} (Columbus: The Ohio State University Press, 1993).
small, independent manufacturers, rather than railroads or large industrial corporations, played the leading role in railcar development.

A number of firms enjoyed limited success in the railcar industry during the 1920's. The Mack Truck Company, which produced 112 gasoline and diesel-powered railcars and locomotives between 1905 and 1959, saw its period of greatest activity in the 1920's. In December, 1924, the J. G. Brill Company introduced a new line of gasoline-mechanical railcars, though it shifted to the use of electric transmissions by 1926. Typical of the larger railcars of the period, the new Model 75 employed a 190-hp, 6-cylinder engine to power a 55-foot long, 27-ton car. A variety of other manufacturers also entered the field. For the most part, however, they simply modified existing bus and truck designs to operate on railroad tracks. These railbuses were small, uncomfortable, and ill-suited to the rigors of railroad operation.16

Of all the companies engaged in the production of railcars, the Cleveland-based Electro-Motive Company enjoyed the greatest success. Strictly speaking, EMC did not manufacture anything. Instead, the company consisted largely of draftsmen, who designed and contracted out the various railcar components to other companies, and sales agents, who marketed the finished product to railroads. These marketing capabilities proved to be EMC's greatest strength, an asset that carried over into its later locomotive production as a subsidiary of General Motors.\textsuperscript{17}

The Electro-Motive Company was largely the creation of Harold L. Hamilton. Hamilton, who was born in Little Shasta, California, in 1890, showed an early aptitude for things mechanical. At age eleven, he built his first engine, powered by steam, which exploded. He embarked on a career in railroading and by 1914 had advanced to the position of road foreman of engines for the Florida East Coast Railroad. In that year, he

\textsuperscript{17}The initials "EMC" refer to the company from its formation in 1922 to its reclassification as the Electromotive DIVISION of General Motors on January 1, 1941. EMC was a wholly owned subsidiary of GM between 1930 and 1940.
joined the White Automobile Company in Denver, working in both the engineering and sales departments.

Along with his various other duties at White, Hamilton led that company's rather haphazard efforts to adapt its highway vehicles to railroad use and gained valuable marketing experience in the process. In so doing, he gave careful study to both McKeen and GE railcars. His other tasks included teaching teamsters how to operate and maintain trucks, rather than horses. These instructional duties gave Hamilton valuable experience in marketing and in overcoming entrenched ideas regarding the most suitable form of motive power. For a short time during World War I, Hamilton served as a member of the Engineering Committee of the Army Motor Transport Corps. Hamilton thus lacked the generations of training and experience in steam technology that were represented by the managers of the established locomotive builders. Instead, he was more familiar with the limitations and the potential of internal combustion engines and had no vested interest in proving that gasoline and diesel engines could not be applied to railroad
service.\textsuperscript{18}

Although he was moving upward in the White organization — he became western wholesale manager in 1921 — Hamilton decided to cast his lot with the railcar industry. He resigned from White in mid-1922 and on August 31 of that year founded the Electro-Motive Engineering Corporation (he changed the name to the Electro-Motive Company in late 1923). Hamilton soon recruited Ernest Kuehn, Andrew and Tom Finigan, and Jimmie Hilton, four employees who had been part of GE's now-defunct railcar program. Richard Dilworth, after a stint in the U. S. Army Corps of Engineers during World War I and employment at GE after the war, joined EMC in 1926. Between 1922 and 1926, Dilworth had been GE's liaison with EMC and helped Hamilton solve the vexing problems associated with power transmission. Hamilton also acquired the services of Paul R. Turner, who had worked for White Motor Truck from 1918 to 1922. Turner joined EMC in that year, and established EMC's New York

\textsuperscript{18}White sold approximately fifteen railbuses in all, many of which experienced problems with their mechanical transmissions. \textit{Railway Age} 115:6 (August 7, 1943), 239-40; Reck, \textit{On Time}, 11-14.
office in 1925. He later became eastern regional manager, then director of sales.19

Based on his experience with White railbuses and McKeen railcars, Hamilton concluded that mechanical transmissions were too unreliable and difficult to control to be used successfully in railroad service. Accordingly, EMC contacted Westinghouse and GE, the only firms with the financial resources and technical expertise necessary to develop reliable electric transmissions. The former company’s offer to develop electrical equipment at EMC’s expense was clearly unacceptable, given EMC’s limited financial resources. GE, however, was willing to finance a research and development program, provided that it could sell the resulting products to any company it wished. Unfortunately for EMC, the early GE traction motors were a major disappointment and required continued refinements. By the

late 1920's, EMC was using electrical equipment supplied by both GE and Westinghouse.\textsuperscript{20}

As was the case with electrical equipment, EMC subcontracted the construction of the carbodies and the final assembly of the railcars, although virtually all design work was done by EMC engineers. The St. Louis Car Company built the largest portion, about 40 percent, of EMC's railcars. Other builders included the Pullman Company, the Osgood-Bradley Car Shops, the Standard Steel Car Company, and the Bethlehem Steel Company. In order to reduce weight as much as possible, these cars had a smaller cross-section than conventional passenger cars, and had a substantially lower roofline. EMC continued this type of carbody design well into the 1930's.\textsuperscript{21}

While EMC purchased electrical equipment and car­bodies from a variety of manufacturers, it remained


\textsuperscript{21} Berge and Loftus, Diesel Motor Trains, 7; Reck, On Time, 59.
loyal to one manufacturer, the Winton Engine Company, for its engines. While the Winton Company traced its origins to the late nineteenth century, its involvement in diesel engine research began in 1911, when Alexander Winton installed gasoline engines in his yacht La Belle. A year later, he established the Winton Gas Engine and Manufacturing Company in Cleveland. The company produced its first diesel engine in 1913, a 175-hp stationary model used to provide power for the Winton factory. By 1916, Winton had three sizes of marine diesel engines in production. One of these, the Model W-40, weighed 45 tons, yet produced only 450 hp, and was thus clearly far too heavy for railroad applications. Accordingly, EMC was restricted to the use of Winton gasoline engines.22

Winton steadily increased the power and reliability of its gasoline engines during the 1920's. Starting with a 175-hp engine in 1924, it boosted output to 220 hp in early 1925 and to 275 hp later that year. By

1927, Winton offered a 300-hp 6-cylinder and a 400-hp 8-cylinder engine for railcar service.

These early engines burned gasoline, but the increasing demand for this fuel, combined with rising gasoline taxes, lessened the cost savings of railcars and prompted Winton to explore the use of alternative fuels. In the late 1920's, EMC and Winton began a five-year cooperative research effort to develop a distillate engine. Distillate, similar to kerosene, was about one-fifth as expensive as gasoline. Although Dilworth, EMC's representative on the project, believed that the effort was not a great success, EMC was able to offer some railcars with distillate engines in the early 1930's. In 1928, EMC and Winton began a cooperative diesel engine research and development program, but at the time of its purchase by GM in 1930 EMC had concluded that diesel engines showed little promise for railcar applications.\textsuperscript{23}

Based on his experience with recalcitrant teamsters, EMC President Harold Hamilton realized that railroad operating and mechanical officials, who traditionally had the largest input in motive power purchases, would resist radical technological change. For shop crews, the advent of internal combustion engines forced them to master a wide variety of new skills and techniques. Mechanical departments in particular failed to understand the advantages of railcars in general and electric transmissions in particular. Furthermore, any innovation that reduced operating personnel from six to two was unlikely to be popular with train crews.

Accordingly, Hamilton instead approached top management officials, particularly those in the financial departments. These individuals understood the charts and figures that demonstrated how the replacement of a steam locomotive and cars with a railcar reduced operating expenses by more than half. Hamilton reasoned that "...we were going to sell these cars to the top management and work downward, as far as necessary, rather than up through the organization as was conventional. We were selling a product entirely on 'economy
and performance," which likewise was new and different."24

EMC's post-sale service policy also set it apart from its competitors and from the larger steam locomotive industry. Traditionally, after a builder delivered a steam locomotive to a railroad, that manufacturer no longer had any responsibility for its product. Provided that there was no defect in the locomotive's construction, its performance -- or lack thereof -- was the railroad's problem. Of course, the locomotive builders often sent observers to monitor the new locomotive's progress, but this practice was intended primarily to provide data for future locomotive designs. Should the locomotive steam poorly, have insufficient tractive effort, lack power on grades, ride roughly, cause excessive track damage or, as happened occasionally, blow up, the locomotive builder did not consider itself responsible.

EMC challenged this customer-driven marketing pattern on two counts. First, it supplied a largely standardized railcar, one that was designed with little input from individual railroads. Collective customer requests for alterations and improvements were incorporated en masse in periodic design changes, a process similar to that employed by GM in the auto industry. Second, in order to reassure railroad executives about purchasing a product that they had not helped to design, EMC was willing to guarantee the performance of its railcars. This policy did little to impress railroad mechanical employees, since, after all, less maintenance meant fewer workers. However, this new concept impressed top railroad executives, who probably were accustomed to something similar on the new automobiles that they were presumably able to buy at frequent intervals.25

The willingness of EMC to train railcar operators increased the company's sales. EMC's demonstration services reflected Hamilton's experience at White, where he created a service staff that was twice the size of

his sales staff. Just as teamsters had to be acclimated to the mysteries of the motor truck, steam locomotive engineers had to be taught how to operate railcars. Many of these engineers, particularly during the early years of EMC's operation, did not even have prior experience as automobile drivers. Again, engineer training had little counterpart in the world of steam locomotives. Locomotive builders provided no training; nor, for the most part, did railroads. Teenagers typically began as switchtenders and worked their way up through the ranks as brakemen, firemen, and finally engineers.²⁶

EMC executives discovered the necessity of pioneering new instructional techniques. Typically, an EMC field instructor travelled with every new railcar for at least thirty days. In addition to instructing engineers in the proper operating procedures, he also rode with the car in order to iron out any unexpected mechanical problems and make sure that the cars were being serviced correctly. This use of "riders" persisted well into the diesel locomotive era, when increasing reliability and improved railroad training programs made them

²⁶Reck, On Time, 44.
unnecessary. One example that illustrated the need for travelling instructors occurred with EMC's fourth railcar, sold to a Mexican railroad. The local service crew disabled the railcar when they mistook the engine exhaust port for a hose inlet, and proceeded to fill it with water.\textsuperscript{27}

The ability to provide spare parts rapidly also set EMC apart from the steam locomotive builders. Whereas railroads often had to cast or machine replacement components for their steam locomotives, EMC provided spare parts for its railcars. EMC's ability to do so was aided by its nearly rigid policy of standardization, which allowed the company to maintain parts interchangeability between units sold to many different railroads.

EMC's parts and service organization was largely the creation of H. B. Ellis, who joined the company in April, 1926, after having been service manager at White. Ellis established regional parts warehouses, which ensured that a railroad was usually able to receive a part within twenty-four hours of ordering it. This

\textsuperscript{27}Ibid., 45-6.
rapid service, in turn, was made possible by the unit exchange system, in which a railroad turned in a defective part and received a new one immediately, without waiting for the old part to be repaired. Most importantly, even though EMC was not itself a manufacturing firm, the company assumed responsibility for all of the parts used in its railcars, regardless of who manufactured them. By stocking and distributing parts manufactured by Winton and GE, EMC increased its revenues, enhanced customer loyalty, and reduced the likelihood that its suppliers would use their own sales and service network to begin to compete directly with EMC.28

These tactics clearly worked for EMC during the 1920's. After EMC delivered its first railcar in July, 1924, business increased steadily. The company sold more than 500 railcars over the next six years. By 1930, EMC had several hundred employees, mostly in the mechanical, engineering (drafting) sales and service departments. Between 1924 and 1930, EMC captured 84 percent of the railcar market. Given the fact that EMC

itself manufactured essentially nothing, its success was largely the result of its marketing abilities, especially its post-sale service and repair programs.\textsuperscript{29}

EMC soon found itself in a dead-end market, however. There were only a finite number of branchlines where railcars could be used to lower operating costs. In addition, fears that the cost of gasoline might increase, along with the limited success of the distillate and diesel engine development programs, further reduced the economic advantages of railcars. By 1930, then, the railcar market was largely saturated.\textsuperscript{30}

Furthermore, the railroads themselves were helping restrict the use of railcars. EMC had intended railcars to be fast and comfortable, and thus win passengers back from buses. Railroads, however, were impressed with the high power of EMC railcars, and began to use them like locomotives to pull short passenger, and sometimes even freight, trains. This use of railcars as locomotives --

\textsuperscript{29}Hamilton, "Historical Background and Notes on the Development of Electro-Motive," 19; Reck, On Time, 56.

which should have been a clear wake-up call to the steam locomotive builders -- often meant that these railcar "trains" were slower and less comfortable than the steam-powered trains that they replaced. As a result, branchline passenger traffic declined still further.31

In an attempt to expand its potential market, EMC built a prototype diesel-electric switching locomotive during the winter of 1929-30. The experiment was considered a failure, and the inadequate diesel engine was replaced by a gasoline power plant. Hamilton concluded that a proper diesel locomotive research and development program would cost at least $5 million, which was clearly well beyond EMC's meager financial resources.32

The onset of the Great Depression dealt the final blow to EMC. Fewer people were able to travel by train; and, in any case, railroads could no longer afford to invest in new equipment. EMC did secure a few sales early in the depression through a new financial plan


32 Ibid., 20; Hamilton, digest of remarks at the EMD Silver Anniversary Dinner, Chicago, October 24, 1947.
that, like many of its other innovations, it retained after its purchase by GM. Rather than selling its railcars, EMC rented them to the railroads, with the stipulation that rental payments would be less than the operating savings that the railcars were expected to create. This "can't-lose" policy also allowed the railroads to depreciate their newly acquired assets.\textsuperscript{33}

By 1930, railcars appeared to be a dead-end for EMC. In retrospect, however, the railcar experience allowed the company to develop the organizational skills, especially marketing, that enabled its successor, EMD, to dominate the diesel locomotive market in the decades that followed. These skills had their ultimate origin in the automobile industry, a characteristic that made EMC's corporate culture compatible with that developed by General Motors. In addition, as Hamilton believed, railcars "gave the railroads an appetite for the economies of internal combustion

\textsuperscript{33}Hamilton, "Historical Background and Notes on the Development of Electro-Motive," 22.
power.\textsuperscript{34} As shown in the following chapter, the established steam locomotive builders did not completely ignore the potential of internal combustion. However, their radically different corporate culture and organizational structure, rooted in nineteenth-century processes of production, prevented them from capitalizing on their decades of experience and dominance in the locomotive industry.

\textsuperscript{34}Ibid., 20; Hamilton, digest of remarks at the EMD Silver Anniversary Dinner, Chicago, October 24, 1947.
CHAPTER II
EARLY TRIALS AND LOST OPPORTUNITIES:
THE STEAM LOCOMOTIVE BUILDERS DURING THE 1920's

During the 1920's, as EMC became increasingly dominant in the railcar industry, two of the three established locomotive builders explored the possibilities of diesel locomotives. Because of their lifelong immersion in the techniques and culture of steam locomotive production, however, executives at ALCo and Baldwin viewed diesels as suitable for only a few specialized applications for which steam locomotives could not be used. Furthermore, they believed that diesels suffered from fixed, unalterable limitations, while at the same time ignoring evidence that their beloved steam locomotives were pressing against an unbreakable technological barrier. They failed to see the potential of diesels and thus never supported the research and development programs necessary to unlock that potential. Because of their myopic vision, executives at ALCo and Baldwin did not make investments in
new diesel locomotive production facilities and expanded marketing systems that might have ensured their success in the diesel locomotive industry. At the same time, because ALCo and Baldwin squandered their profits during the 1920's on excessive dividends, they lacked the resources necessary to undertake a comprehensive diesel locomotive development program during the 1930's. Thus, even though ALCo was credited with building the first commercially successful diesel-electric locomotive in the United States, that company failed to establish the production and marketing capabilities necessary to exploit this feat, and lost its potential for market leadership to EMC.

In spite of their size and seeming complexity, steam locomotives could be constructed fairly easily. Numerous builders produced small industrial steam locomotives; and some railroads, such as the massive Pennsylvania Railroad system, built locomotives in their own shops. However, only three firms produced large mainline steam locomotives for a variety of railroads on a regular basis. Baldwin traditionally held a leadership role in the industry, though it traded market dominance with ALCo at regular intervals. Lima was a
more marginal producer, often taking the overflow from its two larger rivals. Between 1920 and 1928, ALCo enjoyed a 47 percent market share, followed by Baldwin, with 39 percent, and Lima, with 14 percent.¹

THE BALDWIN LOCOMOTIVE WORKS AND THE MASTERY OF STEAM

Baldwin traced its earliest origins to 1819, when Matthias W. Baldwin opened a jewelry shop in Philadelphia. The Quakers who constituted a large portion of the city's population apparently believed that such finery was too ostentatious, and the business soon failed. Baldwin then built printing and bookbinding equipment, followed by a stationary steam engine. He built his first locomotive (a model for the Philadelphia Museum) in 1831, followed by a full-size locomotive a year later. By 1837, his company was building more than forty locomotives per year. Business boomed during the Civil War and the rapid expansion of the railroad network that followed.

¹Barron's, June 7, 1937, 9.
Baldwin grew rapidly during the late nineteenth and early twentieth centuries. Matthias Baldwin died in 1866, and the firm changed names at frequent intervals, but it remained a partnership, rather than a corporation. This did not change until 1909, when the firm, then called Burnham, Williams, & Company, was reborn as the Baldwin Locomotive Works, a corporation chartered in the state of Pennsylvania. Baldwin had produced more than 33,500 steam locomotives during its 78 years as a partnership and by 1910 employed some 19,000 workers and had a capacity to make 2,500 locomotives a year. This capacity was severely tested during World War I, when the company completed an average of seven locomotives per working day. The year 1918 saw 3,580 locomotives leave the Baldwin erecting shops. In spite of the war, Baldwin continued its gradual transfer of operations, begun in 1906, from Philadelphia to the nearby industrial suburb of Eddystone. This process was completed in June, 1928, just in time for the onset of the Great Depression and the collapse of the locomotive market.²

Ironically, in light of its later failure to realize the advantages of diesels, Baldwin had a consistent reputation as an innovative and progressive company during the nineteenth and early twentieth centuries. Matthias Baldwin advocated the use of interchangeable parts as early as 1839, although it is doubtful that such standardization was used to any great degree. In 1842, Baldwin introduced the flexible beam truck, a major advancement in locomotive stability. Baldwin was the first locomotive builder to introduce a two-shift workday. In 1891, Baldwin's general superintendent, Samuel Vauclain, developed the 4-cylinder compound locomotive, again a major advance in design. The company was the first in the industry to use hydraulic forges. In 1895, Baldwin, in cooperation with Westinghouse, was among the first to develop a mainline electric locomotive. During the late 1800's, Baldwin developed new locomotive designs that increased steadily the size, power, and efficiency of its locomotives and set new standards for
steam locomotive design.\textsuperscript{3}

In 1906, Baldwin, through its subsidiary, the Whitcomb Locomotive Company, produced what was generally acknowledged as "... the first successful gasoline locomotive built in this country."\textsuperscript{4} These gasoline-powered locomotives were too small for regular railroad use and were sold mainly to mines, quarries, and agricultural plantations. Baldwin executives failed to appreciate the larger potential of this form of motive power and kept Whitcomb's production geographically (the plant was located in Rochelle, Illinois) and organizationally separate from the rest of the Baldwin corporate structure.

During the late 1910's and throughout the 1920's, Baldwin gradually transferred steam locomotive production from cramped quarters in central Philadelphia to a new facility at Eddystone, south of the city. By June, 

\textsuperscript{3}\textit{Baldwin Locomotives} 9:4 (April, 1931), 3-15; 1934); \textit{Railway Age} 105:27 (December 31, 1938), 951, 954; 108:6 (February 10, 1934), 282-3.

\textsuperscript{4}Whitcomb began as a producer of coal mining machinery in 1878. Baldwin acquired a majority interest in the company, and made it a subsidiary in 1931. \textit{Baldwin Locomotives} 12:3 (January, 1934), 22-3 (quote).
1928, when Samuel Vauclain dedicated the new plant, Eddystone was probably the most advanced and efficient steam locomotive manufacturing facility in the world. Eddystone proved disappointing to Baldwin for two reasons, however. First, within less than a decade, diesel locomotive orders exceeded those for steam locomotives, and Eddystone, despite its modernity, was never designed to produce diesels. Second, the Great Depression soon plunged Baldwin into the worst financial crisis in its history as both orders and income plummeted. Except for the World War II years, Eddystone was a large and expensive white elephant.⁵

ALCo EMERGES FROM A COLLECTION OF SMALLER FIRMS

ALCo developed much as Baldwin had done. In January, 1848, Edward and Septimus Norris established the Schenectady Locomotive Engine Manufactory. The company, capitalized at $40,000, built one locomotive, then went bankrupt. In May, 1851, it was reborn as the

Schenectady Locomotive Works. As was the case at Baldwin, the business grew steadily during the last third of the nineteenth century. In 1873, for example, ALCo built 110 locomotives. The following year, largely as a result of the Panic of 1873, production plummeted to just 9 units -- a graphic illustration of the "feast or famine" nature of the locomotive industry.®

The locomotive industry participated in the great merger wave that occurred at the turn of the century, as firms sought to take advantage of economies of scale and avoid the rigors of "excess" competition. In June, 1901, Pliny Fisk organized The American Locomotive Company for the purpose of acquiring the assets of the Schenectady Locomotive Works and seven other small locomotive builders. These firms were the Rhode Island, Cooke, Brooks, Manchester, Pittsburgh, Richmond, and Dickson Locomotive Works. The company acquired stock in the Montreal Locomotive Works in 1902 and in the Rodgers

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Locomotive Company three years later. ALCo merged with the latter firm in 1909. The most important component of the new company was the Schenectady plant. ALCo later used this facility for the production of all of the diesel locomotives that it manufactured in the United States.  

LIMA SURVIVES AS A MARGINAL PRODUCER

The origins of the Lima Locomotive works date to 1869, when George Harper, Frederick Agerter, Jesse M. Coe, George W. Disman, and John Carnes -- all from Upper Sandusky, Ohio -- established Carnes, Harper, and Company to manufacture threshing machines, portable

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7Report of Appraisers, Supreme Court of the State of New York, in the matter of the applications of Samuel Posen, Clara Berdon, Belle Kuller, Edgar Scott, et al., 1944, AAR; "Manufacturing Capabilities, Alco Products, Inc., Latrobe, Pa.,” 1963(?), The American Locomotive Company Collection at the George Arents Research Library, Syracuse University, Syracuse, New York (hereafter referred to as the ALCo Collection), Box 11; Commercial and Financial Chronicle, October 29, 1945, 2010; Railway Age, 103:14 (October 2, 1937), 468-9; 105:25 (December 17, 1938), 889, 897; 106:14 (April 8, 1939), 627-8.
sawmills, and stationary steam engines. This company was reincorporated as the Lima Machine Works in 1877, just prior to a decrease in thresher and sawmill demand in the late 1870's. The owners were receptive to an 1880 proposal by Ephriam Shay, a Michigan lumberman, to build an experimental locomotive for use in the logging industry. This type of locomotive, which Shay patented in 1881, used a geared drive system to negotiate steeper grades and sharper curves than conventional rod locomotives could accommodate. Although its top speed rarely exceeded ten miles per hour, the power and rugged dependability of the Shay guaranteed it a market in logging, mining, and quarrying operations. Lima acquired all patent rights to the Shay, and produced approximately 2,761 of this type of engine between 1880 and 1945.

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8 I presented some of this information, in a modified form, at the Spring, 1992 meeting of the Ohio Academy of History at Dayton, Ohio, in a paper entitled: "Lima Locomotive Works and the Dieselization Revolution, 1930-1950: Corporate Response to Technological Change."

9 Ira P. Carnes, "To the President, Officers, and Employees of the Lima Locomotive & Machine Co.," 1912, Records of the Lima Locomotive Works, Allen County Historical Society, Lima, Ohio (hereafter referred to as the ACHS Collection); "BLH Observes 100th Year," Lima News, February 23, 1969; Richard J. Cook, "Lima: 100 Years of Steam and Steel," Railroad Model Craftsman,
Lima sought other sources of business when changing conditions in the mining and logging industries caused a decline in the demand for Shay locomotives after the early 1920's. Earlier in the century, the company had formed a number of subsidiaries for this purpose, including the A. C. W. Realty Company, the Gramm Motor Car Company, and the Lima Vacuum Machine Cleaning Company. None of these attempts at diversification was more than modestly successful. The Ohio Power Shovel Company, organized in 1928 as a wholly owned subsidiary of Lima, produced cranes, power shovels, and draglines. This company, which was reorganized as the Shovel and Crane Division of Lima in 1934, was profitable even during the Great Depression -- the locomotive division was December, 1969, 26-33. In 1903, Lima completed a new facility to fill an increasing number of orders for Shay locomotives. The plant was expanded in 1910, in 1912, and again between 1918 and 1920. In 1912, the company was reorganized as the Lima Locomotive Company and was again reorganized, in 1916, as the Lima Locomotive Works, Incorporated. (O. B. Schultz, "The History of the Lima Locomotive Works," a paper presented at a meeting of the Chicago Chapter of the Railway and Locomotive Historical Society, March 14, 1947, ACHS Collection, Box 889, 6-10). For more information on Shay locomotives, see: Michael Kock, The Shay Locomotive: Titan of the Timber (Denver: World Publishing, 1971).
not -- and outlasted locomotive production at the Lima facility by more than two decades. In addition to electric and steam powered cranes, Lima manufactured diesel-powered cranes for more than a decade before it applied the same power source to railroad locomotives.10

The Lima Locomotive Works also had a close working relationship with two companies that supplied many of the critical components for steam locomotives. A. L. White, who was then the president of Lima, organized the Ohio Steel Casting Company in 1907. It supplied the expensive, custom-made, steel castings that were essential to locomotive construction. The Franklin Railway Supply Company provided a wide range of parts and sub-assemblies for Lima locomotives. Two of its founders were Joel S. Coffin and Samuel G. Allen, both of whom served as presidents of Lima. Although these close working arrangements guaranteed a timely supply of critical components, this system was less efficient than

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vertical integration. In addition, the reliance of these companies on continued steam locomotive production gave Lima a strong incentive to continue to manufacture steam locomotives, rather than experiment with diesel locomotive production.\footnote{Leslie A. Floyd, "Lima and Manufacturing, 1850-1910" unpublished seminar paper, The Ohio State University, 1987, 23-24; Cook, "Lima: 100 Years of Steam and Steel," 30; Schultz, "History;" Lima Locomotive Works, 1931 annual report, 4; 1935 annual report, 5; 1939 annual report, 5. Joel S. Coffin was president of Lima from 1923 to 1931. He was succeeded by Samuel G. Allen, who served until he was replaced by John E. Dixon in 1939.}

During the early 1900's Lima produced a number of conventional steam locomotives similar to those manufactured by ALCo and Baldwin. Following a major plant expansion in 1922 and 1923 and the retirement of its last mortgage bonds in 1922, Lima began the development of a radically improved steam locomotive. Under the direction of W. E. Woodward, vice president in charge of engineering, Lima's engineers made dozens of improvements to conventional steam locomotive designs, greatly increasing efficiency and lowering fuel consumption. The Lima A-1 "Superpower" locomotive made its debut in 1925, and was well received by many railroads. Lima
produced 603 "Superpower" locomotives, in several variations, between 1925 and 1949. ALCo and Baldwin quickly copied many elements of "Superpower" technology, which remained state-of-the-art until the end of steam locomotive production in the United States.12

During the 1920's and 1930's, Lima made numerous other smaller contributions to steam locomotive technology. In spite of these technological innovations, Lima's steam locomotives remained custom-built products that were created by highly skilled craftsmen. For example, Lima issued a 21-page specification list for

12Hirsimaki, Lima: The History, 113, 136; Earle Davis, "60 Years of Lima Locomotives," Railroad Magazine, December, 1939, 21; Railway Age, 79:11 (September 12, 1925), 467-71; 81:3 (July 17, 1926), 101-2; C. B. Peck to A. Lane Cricher, July 9, 1925, Records of the Bureau of Foreign and Domestic Commerce, National Archives (Record Group 151, hereafter referred to as BFDC Records). Several Lima "Superpower" locomotives still exist, either preserved as static displays or used in excursion service. One such locomotive, built for the Southern Pacific in 1936, was used for the Bicentennial Freedom Train forty years later. (Richard K. Wright, America's Bicentennial Queen - Engine 4449, (Oakhurst, California: Wright Enterprises, 1975), 28-34, in ACHS Collection). For more information on Lima's "Superpower" locomotives, see: Richard J. Cook, Superpower Steam Locomotives (San Marino, California: Golden West Books, 1966) and Eugene L. Hendleston and Thomas W. Dixon, The Allegheny: Lima's Finest (Edmonds, Washington: Hundman Publishing, 1982).
one type A-1 locomotive. During 1929 and 1930, 118 separate pieces of correspondence were involved in the bid specifications for nine locomotives for the Chicago, Minneapolis, and Omaha Railroad. Each time a railroad placed an order, no matter how small, new specifications had to be established, new blueprints drawn, new patterns made, machines altered, and craftsmen retrained. This process prevented Lima and the other steam locomotive builders from enjoying significant economies of scale. In 1939, an observer wrote that Lima had a "pride in craftsmanship that has never been sacrificed to a conveyor belt..." — but it was the conveyor belt that was even then allowing EMD to become the leading producer of diesel locomotives.¹³ Virtually all of Lima's

technological innovations and a great deal of its diversification were therefore based on its traditional, tested, and proven production of steam locomotives. When Lima engineers discussed recent improvements in locomotive technology, they rarely mentioned diesels.

In spite of this commitment to traditional steam locomotive technology, Lima did experiment with diesel locomotives. Lima built two small experimental gasoline-mechanical locomotives in 1909 or 1910. These were suitable only for light industrial switching and were not produced in quantity. Lima produced similar experimental models in 1929 and for a few years thereafter, but the Great Depression ended any plans the company may have had to continue production. The company also showed interest in diesel locomotive developments in England during the early 1930's. Lima, still actively involved in improving steam locomotives and feeling the effects of the depression, chose not to enter the diesel locomotive market.¹⁴

¹⁴Schultz, "History;" Hirsimaki, Lima: The History, 74, 184-7; John E. Dixon to W. Rodney Long, February 26, 1930 and January 22, 1931, BFDC Records. Hirsimaki (pp. 194-5) reports that Lima had several diesel-mechanical or diesel-electric locomotives under design between 1938 and 1940. I have found no confirmation of this in any other source, however.
THE LIMITS OF STEAM LOCOMOTIVE TECHNOLOGY

During the 1920's, the three steam locomotive builders reached the pinnacle of their success. Orders flowed in, and profits and dividends mounted. Domestic orders increased from a post-World War I low of 214 in 1919 to 1,998 in 1920. Orders peaked at 2,600 in 1922, then slowly declined until they reached 1,301 in 1926. This slow decline was followed by a sharp decrease in orders, to 734 in 1927 and 603 a year later. One last surge in demand occurred in 1929, when American railroads ordered 1,212 locomotives. During the 1920's export sales averaged approximately 220 locomotives per year. ALCo, Baldwin, and Lima were building the world's most advanced and powerful locomotives, the largest pieces of machinery yet built with the capability of moving on land. Still, although their executives refused to acknowledge it, the success of these three companies was fragile. By the late 1920's, these
builders had pushed the performance of the steam locomotive to its absolute outer limits.\textsuperscript{15}

The problem was basically one of physics. The limits of steam locomotive capabilities had a parallel in the field of aviation where, two decades later, airframe designers realized that piston-engined aircraft would never be able to fly at speeds much above 400 mph. There, the solution was a relatively simple one -- the replacement of propellers with jet engines -- and did not in any case render propeller-driven aircraft obsolete. The limitations of steam locomotives, however, called for a complete revision of railway motive power and rapidly caused the disappearance of steam from American railroads. It was not until the limitations of steam power became apparent that American railroads were willing to embrace the concept of dieselization.

One way to increase the power of a steam locomotive was simply to make it bigger, but therein lay the problem. Bigger also meant longer, wider, and heavier, and by the 1920's steam locomotives had reached the capacity

\textsuperscript{15} \textit{Railway Age} 88:1 (January 4, 1930), 79.
of railroads to support them. Track gauge was fixed and so too, for financial reasons, were the strength of bridges and the clearance of tunnels and trackside buildings. As it was, the adoption of a new class of motive power by a railroad generally required substantial additional expense for betterments to the physical plant. Multiple engines could be used for heavy trains, but each locomotive required a separate engine crew, who were usually unable to communicate with their counterparts on the rest of the train. Thus, by the mid-1920's locomotive designers could make only marginal improvements to steam locomotive performance, utilizing devices such as roller bearings, poppet valves, streamlining, and lightweight steel alloys for valve gear and other critical parts.

By this time, railroads were very interested in a rapidly accumulating body of data that suggested that the use of diesel locomotives might produce substantial savings over the costs of steam locomotives. As early as 1922, one railroad official, Julius Kruttschnitt of the Southern Pacific, inquired whether Baldwin, its traditional steam locomotive supplier, might be able to build a diesel freight locomotive. Baldwin declined,
claiming that all of their engineers and draftsmen were too busy designing new steam locomotives. Three years later, Kruttschnitt, in a paper delivered to the American Society of Mechanical Engineers, predicted that the replacement of steam locomotives by diesels would cut fuel costs by two-thirds.16

Other railroad officials echoed Kruttschnitt's interest in diesel locomotives. In January, 1923, at an address to the New England Railway Club, L. G. Coleman, assistant general manager of the Boston and Maine, complained that steam locomotives were inherently inefficient and called for further research into the possibilities of diesel locomotives. An August, 1925 editorial in Railway Age, the leading industry trade journal, discussed "... the outstanding advantages of this new form of motive power."17 And, in May, 1930, a report by the Committee on Diesel Locomotives at the International Railway Fuel Association Convention in


17 Railway Age 79:5 (August 1, 1925), 209 (quote).
Chicago showed that the use of diesels in switching service would lower operating costs from $7.70 to $5.09 per locomotive hour. General Electric later admitted that railroads demanded diesel transfer locomotives "... even before the manufacturers were in a position to supply units of sufficient capacity."  

Steam locomotives had numerous disadvantages compared to diesels. First, since their thermal efficiency was less than one-third that of diesels, steam locomotives required more fuel to do the same useful work. By the mid-1930's, it was well understood that diesel switchers could reduce fuel costs by 75 percent. The diesels placed in service in 1948 alone reduced railroad coal consumption by 10 million tons from the previous year. By 1954, diesels were saving railroads more than $600 million per year in fuel costs. These costs not only involved the expense of purchasing fuel for steam locomotives, but also that of transporting it to the

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^18Railway Age 74:3 (January 20, 1923), 241-3; 78:19 (April 11, 1925), 939-41; 88:19 (May 10, 1930), 1135; General Electric Review 40:9 (September, 1937), 421-8 (quote).
fueling facilities. The transportation of coal, of which the railroad industry was the largest industrial consumer, required vast fleets of hopper cars. One railroad official estimated that the elimination of this expense alone would be more than enough to pay for new diesel service facilities. Of course, diesels also required fuel, but in typical service one tankcar of diesel fuel was equivalent to eight cars of coal. In addition, diesels could travel much greater distances without refueling.¹⁹

Second, unlike diesels, steam locomotives required vast quantities of water. This was often difficult to obtain in the arid regions of the West. Wherever it came from, water often required demineralization before it could be used in locomotive boilers. Failure to do so could result in serious damage to the boiler and, in

extreme cases, explosions. In 1937, the Association of American Railroads estimated that American railroads spent $50 million per year on water provision and treatment. The Santa Fe, for example, used tank cars to haul more than 1 million gallons of water per day to the arid station at Ash Fork, Arizona. Not surprisingly, the Santa Fe was the first railroad to purchase large quantities of diesel freight locomotives. In addition, since steam locomotives could seldom travel more than 150 miles without filling their water tank, water stops increased both travel time and railroad congestion.20

Third, steam locomotives had higher repair costs than diesels. Because of their weight, high boiler pressures, enormous heat production, and large numbers of poorly fitting moving parts, steam locomotives literally shook themselves to pieces and had to be inspected and rebuilt at regular intervals. Every year, railroads spent approximately 25 percent of a steam locomotive's original cost on its maintenance. Various estimates showed the use of diesels to reduce repair

20 Railway Age, 118:12 (March 24, 1945), 541-2; Remarks of Ralph Budd at a luncheon given by Alfred P. Sloan, Jr., New York, October 28, 1937, AAR.
costs between 50 percent and 90 percent. In 1947, the Interstate Commerce Commission estimated that total dieselization would save the railroads $210 million per year in repair costs. This savings, combined with an estimated $340 million annual savings in fuel costs, would increase the railroad's rate of return between 3 percent and 5 percent. By 1958, diesel locomotives were saving American railroads more than $1 million a day in operating costs.\footnote{Railway Age 123:12 (September 20, 1947), 476-7; Railway Progress 12:2 (April, 1958), 32-43; Hamilton, remarks at luncheon given by Alfred P. Sloan, Jr., New York, October 28, 1937, AAR; GM-EMD, Fuel Oil for Diesel Locomotives, September 25, 1948, General Motors Institute Alumni Foundation's Collection of Industrial History, Flint, Michigan (hereafter referred to as GMI), folder 19/26; General Electric Review 40:9 (September, 1937), 421-8; American Locomotive Company, "Report of the Annual Meeting," April 19, 1949, ALCo Collection, box 6; GM Research Laboratories Division, Fuel Oil for Diesel Locomotives in Relation to the Supply of Petroleum, September 25, 1948, AAR.}

Because of their need for frequent maintenance, steam locomotives had a low degree of availability. Since they were often out of service while building up steam, dumping ashes, or being cleaned or repaired, steam locomotives were available for revenue-generating service only 50 percent to 70 percent of the time.
Railroads were typically forced to buy two locomotives for every one in constant service, a practice that substantially increased capital expenditures. Diesels, on the other hand, were often available as much as 95 percent of the time. In addition, since diesels needed less frequent servicing, they halved transit time, lengthened typical runs from 125 miles to 500 miles, and improved effective freight car utilization by a third.\(^2\)\(^2\)

Fifth, although steam locomotives usually exceeded diesels in brute horsepower, they had less tractive effort than diesels, especially at slow speeds.\(^2\)\(^3\)


\(^2\)\(^3\)Because tractive effort represents the actual power available to move trains, it offers a more useful indication of applied force than does horsepower. Tractive effort equals the total weight of the locomotive on its driving wheels multiplied by a coefficient of adhesion. The latter figure depends on the condition of the rail (i.e., wet, dry, oily, etc.) and varies little between steam and diesel locomotives. However, since steam locomotives carry much of their weight on unpowered lead and trailing trucks (necessary for the negotiation of curves and switches), the former figure is lower than that of diesels, which carry all of their weight on powered wheels. John A. Armstrong, The Railroad: What it is, What it Does (Omaha: The Simmons-
Furthermore, the horsepower of a steam locomotive increased as its speed increased, while that of a diesel locomotive remained constant at all speeds. These characteristics made the diesel especially suitable for switching service. At 10 mph, a 600-hp diesel switcher actually had more tractive effort than a 2,000-hp steam locomotive. A 6,000-hp steam locomotive could generate 135,000 pounds of tractive effort, while a diesel of identical horsepower had an output of 230,000 pounds.\(^{24}\)

Diesels offered a further advantage that no steam locomotive could emulate. Dynamic brakes, when used on trains travelling downgrade, caused the enormous inertia of the train to turn the diesel's traction motors into resistance generators. The heat that resulted was vented through grids on the locomotive's roof. This feature substantially reduced brake shoe wear. The Santa Fe estimated that diesels saved three-quarters of

\(^{24}\)Railway Age 96:19 (May 12, 1934), 685-9; Railway Progress 12:2 (April, 1958), 32-43; "Super Power for Super-Railroads," address by John W. Barriger III, before the Committee of the Coordinated Railway Mechanical Associations, Chicago, September 15, 1947, AAR.
a ton of brakeshoes on a single 4,500-mile round-trip of the *El Capitan*. The same railroad estimated that the use of steam locomotives forced it to spend $1 million per year on brakeshoe replacement. In addition, the lack of dynamic brakes forced steam-powered trains to stop at the head of a grade to laboriously set the retaining valves (i.e., partly apply the brakes) along the length of the train. They had to make further stops while descending the grade in order to cool their wheels. The extent to which this increased traffic congestion in mountainous terrain is indicated by the fact that many railroads shelved plans to install extensive double track after they acquired diesels.²⁵

Diesels offered a variety of other important advantages. They were less damaging to track and bridges than were steam locomotives and, as a result, dieselization allowed many railroads to reduce expenditures for capital improvements and routine maintenance.

to their physical plants. Diesels offered better visibility for train crews and greater protection in case of an accident. They produced smoother starts and gentler stops than steam locomotives and produced neither smoke nor cinders, all characteristics which made them highly suitable for passenger service. They were capable of higher sustained speeds and produced less of a fire hazard.

Diesels were by no means perfect, however. Disadvantages included their higher first cost (2-3 times the cost of a steam locomotive, per horsepower), their shorter life expectancy, and their need for new fuel and maintenance facilities. The cost of providing

\[\text{\textsuperscript{26}}\text{For example, at high speeds, the drivers of a large steam locomotive could bounce as much as 1-1/4 inches off the rail. Franklin M. Reck, \textit{On Time: The History of Electro-Motive Division of General Motors Corporation} (GM-EMD, 1948), 104.}\\
\text{\textsuperscript{27}}\text{Railway Age 100:19 (May 9, 1936), 763-6; 121:13 (September 28, 1946), 513; E. E. Chapman, "Operation of Steam vs. Diesel-Electric Locomotives," presented at the meeting of the American Society of Mechanical Engineers, Kansas City, Missouri, June 16-19, 1941, AAR; Diesel Engine Manufacturers Association, \textit{Diesel Locomotives}, 1945, AAR; EMD, "Conference Leader's Outline," subject II, unit 3, GMI, folder 76-1.59; Dezendorf, speech before the New York Society of Security Analysts, New York, June 1, 1951, AAR.}
facilities dedicated to diesel locomotive repair caused many railroads to delay experimentation with diesel locomotives, especially during the Great Depression. In addition, few railroad employees knew how to operate or repair diesel locomotives, and this deficiency would later give an edge to locomotive producers, such as EMC, that offered adequate training programs.

THE STEAM LOCOMOTIVE PRODUCERS IGNORE THE EMERGING DIESEL MARKET

The steam locomotive builders preferred to concentrate on the limitations of the diesel and largely ignored its potential. During the 1920's, they viewed diesel locomotive technology as fixed and immutable, believing that no amount of research and development would ever produce a successful mainline diesel freight locomotive. Some claimed that diesels could not be used at speeds much exceeding 10 mph, while others asserted that the excessive weight of existing diesel engines, designed largely for marine use, constituted an insurmountable barrier to locomotive applications. All believed that advances in steam locomotive technology
would more than keep pace with whatever developments might occur in the diesel industry.

Both ALCo and Baldwin made tentative entrances into the diesel locomotive industry during the 1920's. However, they continued to view the diesel as suitable for only a narrow range of applications where the "obvious" first choice -- the steam locomotive -- absolutely could not be used. As such, they failed -- as we shall see -- to develop the organizational strengths necessary to gain first mover advantages in the industry; and, in so doing, allowed a relative newcomer to overtake them.

ALCo SERVES AS A SUBCONTRACTOR OF DIESEL LOCOMOTIVES

ALCo's initial participation in the diesel locomotive industry was a direct response to the Kaufman Act, passed by the state of New York in 1923 and amended in 1924 and 1926, which banned steam locomotives from the entire city of New York. This legislation was the direct result of popular outcry over several terrible accidents in the smoke-filled tunnels under Manhattan Island. Because it encouraged the development of
experimental locomotive models, the Kaufman Act offers an example of the effect of government policy on technological development. Given the political and economic power of the railroad industry during the 1920's, this degree of legislative control is indeed remarkable.\(^\text{28}\)

The Kaufman Act provided a small initial market for diesel locomotives. The main lines into New York had already been converted to electric operation, but this capital-intensive option was simply not viable on more lightly travelled switching lines. Gasoline or diesel-powered locomotives were the only remaining alternative. Railroads that served the New York area, particularly the New York Central, thus approached the Ingersoll-Rand Company, an established producer of diesel engines, with a request to build a prototype diesel switching locomotive. The criteria for this locomotive, in descending order of importance, were: reliability, high potential

speed, low maintenance costs, minimal noise and smoke, good fuel economy, and "reasonable first cost." These specifications, which put reliability first and cost last, again should have been a clear indication to the steam locomotive builders that railroads were keenly interested in diesel locomotive development.²⁹

In 1921, the Ingersoll-Rand Company and General Electric agreed to develop jointly an experimental 300-hp diesel switching locomotive. This locomotive, which was completed in December, 1923, and given its first public demonstration two months later, performed well. The following year, ALCo became a part of the production consortium. At Schenectady, ALCo built the underframe and shell for a second experimental diesel locomotive. These components essentially constituted a large metal

²⁹In 1921, Ingersoll-Rand acquired the patent rights to the P-R engine, named for its developers, William T. Price, who later worked with Baldwin's subsidiary, De La Vergne, and George J. Rathburn. A modified version of this engine was used in early consortium locomotives. Railway Age 96:19 (May 12, 1934), 685-9; John F. Kirkland, Dawn of the Diesel Age: The History of the Diesel Locomotive in America (Glendale, California: Interurban Press, 1983), 37-8, 76. Chicago passed similar legislation in 1912, but gave the railroads until 1927 to comply, a time limit that was later extended to 1935.
box on wheels, which were the least technically sophisticated parts of the locomotive. Ingersoll-Rand built the diesel engine at its Phillipsburg, New Jersey, plant while GE supplied the traction motors, generator, and related electrical equipment, and assembled the various components at its Erie works. This hardly constituted integrated production.

After the first Ingersoll-Rand-GE-ALCo diesel switcher was delivered in July, 1925, this consortium built a variety of other locomotives, all of them largely experimental, during the following years. A 600-hp passenger locomotive was completed in 1927, followed by a 750-hp road freight diesel in 1928. In all, the Ingersoll-Rand-GE-ALCo consortium built thirty-three diesel locomotives between 1925 and 1931, hardly a pace that would lead to the rapid dieselization of American railroads. Ingersoll-Rand assumed all responsibility for marketing the new product, thus denying ALCo the opportunity to gain experience in this facet of the emerging diesel locomotive industry. ALCo's vulnerability was illustrated by a New York Central order for forty-four locomotives, the largest single diesel locomotive order prior to 1946. GE and Ingersoll-Rand
built these locomotives cooperatively, and no role was assigned to ALCo whatsoever.\textsuperscript{30}

The consortium began to dissolve in 1927, when GE decided to increase its share of the finished product by building its own locomotive bodies. Actual production began in 1928. GE continued to buy diesel engines from Ingersoll-Rand, as well as from other manufacturers, such as Cooper-Bessemer and Caterpillar. In 1929, GE reorganized its railway engineering department as the transportation engineering department, later to become the transportation equipment division. This new department, along with GE's airbrake department and industrial locomotive engineering department, was located in Erie. In 1937, Ingersoll-Rand withdrew from the railroad diesel engine market, having provided engines for 118 locomotives and two railcars.\textsuperscript{31}

\textsuperscript{30}Railway Age 76:23 (May 10, 1924), 1159; 83:19 (November 5, 1927), 890-1; 85:3 (July 21, 1928), 98-100; 86:12 (March 23, 1929), 663-7; Garmany, \textit{Southern Pacific Dieselization}, 74; Kirkland, \textit{Dawn of the Diesel Age}, 75, 86-8, 97.

In response to its loss of GE as a customer, ALCo decided to enter the diesel locomotive market on its own. In 1929, ALCo purchased the McIntosh and Seymour Company, which John E. McIntosh and James A. Seymour had incorporated in 1886 for the purpose of building small stationary steam engines. This firm had begun building diesels in 1913. These engines were designed for marine and stationary use, applications vastly different from those required by railroad locomotives. Accordingly, ALCo placed increased emphasis on locomotive diesel engines, although the company was still primarily interested in stationary diesel engines. The newly acquired McIntosh and Seymour facility at Auburn, New York, did ship some locomotive diesel engines to the Schenectady plant, however; and, in 1931, ALCo delivered the first diesel locomotive equipped with its own engine to the Jay Street Connecting Railroad in Brooklyn. ALCo produced only two of the three most vital components of these locomotives, the engines and the bodies, while it purchased the high-value electrical equipment from General Electric and Westinghouse.32

32 Dana T. Hughes, "A History of Schenectady Operations of Alco Products, Inc.," reprinted from the Schenectady Union-Star, April 22, 1955, ALCo Collection,
Although ALCo gained early experience, albeit in a limited manner, in diesel locomotive production, this experience did not ensure market dominance. The early ALCo-GE-Ingersoll-Rand consortium diesel locomotives were hailed by the trade press as the first commercially successful diesel locomotives to be produced in the United States. ALCo was unable to translate this early technological achievement into dominance of the diesel locomotive industry because it failed to establish modern diesel locomotive production facilities, failed to create a marketing system to support diesel locomotive sales, and failed to alter the steam locomotive-based corporate culture of top management. As a result, ALCo did not acquire the first-mover advantages that, as Alfred Chandler correctly states, will accrue to the

Box 11; "New Muscle in Diesels," reprinted from Alco Review Spring-Summer, 1959, ALCo Collection, Box 1; Alco Products Review, 5:2-3 (Spring/Summer, 1956), 15; American Locomotive Company, "Growing with Schenectady," 1948, AAR, 35; American Locomotive Company, "Light Locomotive Parts and General Products Catalog, #10057," no date, ACHS, box 897.
first company to make this triple investment in manufacturing, marketing, and management.\textsuperscript{33}

Baldwin downplays the significance of diesel locomotives

ALCo's failure to develop the organizational capabilities necessary to gain an early lead in the diesel locomotive industry during the 1920's pales in comparison to the inability of Baldwin to even attempt to penetrate this potential market. Despite the fact that its subsidiary, Whitcomb, had constructed some 1,230 gasoline-mechanical locomotives between 1910 and 1926, Baldwin officials believed that internal combustion had little application for mainline railroads. In addition, the company's failure to manage its subsidiaries effectively ensured that any potential manufacturing abilities were squandered.\textsuperscript{34}

Although Baldwin refused to accommodate the Southern Pacific's request for a diesel locomotive, it

\textsuperscript{33}Alfred D. Chandler, Jr., \textit{Scale and Scope: The Dynamics of Industrial Capitalism} (Cambridge: The Harvard University Press, 1990), 34-5.

\textsuperscript{34}Kirkland, \textit{Dawn of the Diesel Age}, 64.
built an experimental diesel-electric in 1925. This unit, which was similar to a locomotive built in Germany for the Russian Railways the year before, used a 12-cylinder engine rated at 1,000 hp. This was extremely powerful for locomotives of the period, but it quickly became apparent that the Knudsen Motor Corporation engine was too unreliable for railroad service. In 1929, Baldwin completed a second experimental locomotive, also of 1,000 hp, but employing a 6-cylinder Krupp engine. This locomotive was designed for switching service, a duty for which it was hideously overpowered. This locomotive, like its predecessor, was too temperamental for railroad use.

Both locomotives used Westinghouse electrical equipment; this was a natural collaboration, since Baldwin had been building the carbodies for Westinghouse straight electric locomotives for several decades. The fact that Samuel Vauclain served as both president of Baldwin and as a board member at Westinghouse reinforced this collaboration. Like ALCo, Baldwin thus produced the least technically sophisticated third of the locomotive and, like ALCo, failed to make necessary investments in marketing. Baldwin allowed Westinghouse to
market the finished locomotives, a tradition that had been established in the electric locomotive industry.\textsuperscript{35}

Baldwin's dependence on Westinghouse increased in 1929, when it signed an agreement allowing the latter company to build both the electrical equipment and the diesel engines for a new line of 400-hp and 800-hp diesel switchers. In reality, these were Westinghouse locomotives, with Baldwin acting only as an independent supplier. Westinghouse had formed a Railway Engineering Department at its East Pittsburgh works in 1926 and later that year acquired the U. S. production rights to the dirigible engines produced by the Glasgow firm of William Beardmore Company. Westinghouse completed its first locomotive in January, 1928, and formalized its agreement with Baldwin a year later. In 1930, Westinghouse transferred its locomotive production from East

Pittsburgh to its South Philadelphia facility, in order to be closer to the Baldwin factory at Eddystone.36

The Great Depression prevented the Westinghouse-Baldwin consortium from taking advantage of the dissolution of the Ingersoll-Rand-GE-ALCo consortium, as locomotive sales were considerably lower than expected. Between August of 1930 and early 1933, Westinghouse received no locomotive orders at all, and this convinced the company that its resources would be better spent elsewhere. In June, 1936, Westinghouse announced that it would no longer take orders for diesel locomotives or the Beardmore engines that powered them. During the period of Baldwin-Westinghouse collaboration, the two

36 By the early 1930's, Westinghouse offered a standardized line of four diesel engines for railroad use ranging from a 4-cylinder, 265-hp model to a 12-cylinder, 800-hp unit. The Beardmore engines, which were called "...an experiment, or rather a step in the development of the ultimate," were exceptionally light (16 pounds per horsepower), thanks to the use of aluminum alloys, but experienced frequent trouble with their fuel injectors. Railway Age 80:7 (February 13, 1926), 443-6; 84:23 (June 9, 1928), 1319-23 (quote); 86:14 (April 6, 1929), 787-90; 88:24 (June 14, 1930), 1427-9; 95:5 (July 29, 1933), 179-81; 95:16 (October 14, 1933), 531-3; 96:19 (May 12, 1934), 685-9; 97:7 (August 18, 1934), 199-200; Garmany, Southern Pacific Dieselization, 73; Kirkland, Dawn of the Diesel Age, 109-111, 119.
companies had produced twenty-six diesel locomotives — again, hardly a revolution in railroad motive power. 37

With Westinghouse no longer willing to supply diesel engines, Baldwin was forced to secure a new source of supply for this vital component. Baldwin had an opportunity to purchase the production rights to the Beardmore engines, but chose not to do so.

Instead, Baldwin acquired De La Vergne, an older producer of diesel engines, but one that had considerably less experience in the locomotive field. De La Vergne originated as a producer of refrigeration equipment, not of diesel engines. In 1880, John C. De La Vergne established the De La Vergne Refrigerating Machine Company, following successful research into ammonia-based cooling systems. Eleven years later, he acquired a license from an English company, Hornsby-Akroyd, to build an oil engine bearing their name. Many of these engines were sold to the U. S. Government for use in lighthouses, forts, and other military installations. Following De La Vergne’s death in 1896, the

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37 Kirkland, *Dawn of the Diesel Age*, 120, 126-7, 188.
company bought the rights to manufacture gasoline engines from the Koerting Gas Engine Company. That company's founder, a German national named Ernest Koerting, acquired control of De La Vergne in 1909. By 1912, the company had developed a reliable semi-diesel engine, the Model DH. In 1917, the Alien Property Commission seized the German-owned firm, and later sold it to William Cramp & Sons Ship & Engine Company. In 1922, De La Vergne introduced its first true diesel engine, the Model VG, which was designed mainly for pipeline pumping stations. Cramp & Sons left the shipbuilding industry in 1926, forming Cramp-Morris Industrials, an early conglomerate. A year later, it transferred its De La Vergne subsidiary from New York to Philadelphia. Based largely on its proximity to Eddystone, Baldwin purchased De La Vergne and the rest of Cramp-Morris Industrials in 1931.38

However, because diesel engines had no connection to steam locomotive production, Baldwin did not integrate De La Vergne with its locomotive division.

38Baldwin Locomotives 10:3 (January, 1932), 21-34.
Instead, it made De La Vergne a part of a subsidiary company, the Baldwin-Southwark Company, which was primarily a builder of hydraulic presses and stamping equipment. De La Vergne engine production was thus organizationally separate from the rest of the Baldwin organization. De La Vergne was not fully incorporated into the main Baldwin corporate structure until 1944; prior to that, De La Vergne had "sold" diesel locomotive engines to its parent company at cost.

Similarly, Whitcomb, also a Baldwin subsidiary, had made great advances in gasoline locomotive technology, having produced a powerful 450-hp locomotive for the Chicago, Burlington, and Quincy in 1932. Had Baldwin combined the strengths of these two subsidiaries, it might have created a formidable contender in the diesel locomotive industry. However, executives at Baldwin, like those at ALCo, lacked the entrepreneurial vision that would have allowed them to see the potential of the diesel locomotive market.

38Baldwin Locomotives 17:1 (July, 1938), 22-6; Railway Age 92:14 (April 2, 1932), 559-60; Kirkland, Dawn of the Diesel Age, 42, 48.
COMMON FAILINGS AT ALCo AND BALDWIN

In addition to their separate, individual failures in manufacturing, marketing, and management during the 1920's and early 1930's, several factors common to ALCo and Baldwin prevented them from making the necessary commitment to the diesel locomotive industry. First, during the boom years of World War I and the early 1920's, both ALCo and Baldwin failed to reinvest their massive profits in the firms. Lavish dividends seemed appropriate during the 1920's, when the steam locomotive producers enjoyed unprecedented prosperity. Nevertheless, given the feast-or-famine nature of the locomotive industry, executives like Vauclain, who had controlled Baldwin during the depression of the 1890's, should have understood the need to set aside funds to cover a future decline in orders. In addition, the boards of directors at ALCo and Baldwin continued to approve large dividends even after steam locomotive orders began to decline after the mid-1920's, a policy that contemporary financial analysts attributed to excessive greed.40

40 It is of course difficult to make direct comparisons between dividend policies at ALCo and Baldwin and those at GM and GE. Electro-Motive did not become a
ALCo was the worst offender but, ironically, avoided the insolvency that plagued Baldwin during the 1930's. Dividends on a share of ALCo common stock, with a market price of approximately $100, were $6.00 in 1924 and $18.00 in 1925. Between 1926 and 1929, after the post-World War locomotive boom had ended, ALCo paid $8.00 per share per year in dividends. At the same time, ALCo's net earnings were $7.45 per share in 1926, $4.80 per share in 1927, $1.92 per share in 1928, and $5.40 per share in 1929. Even though ALCo's earnings per share were only $1.41 in 1930, the company still managed to pay a $4.50 dividend. In 1937, a financial analyst correctly deduced that "As a consequence of those disbursements, American Locomotive stock for years was accorded an investment esteem not intrinsically

part of the GM corporate structure until 1930 and, even then, was incorporated as a small subsidiary whose profits paled in comparison with those of its parent. Similarly, only a minuscule portion of GE's corporate revenues originated in the locomotive industry. Nevertheless, both GM and GE put their profits in the auto and electrical equipment industries to good use during the 1920's and into the 1930's, primarily by investing in new plant and equipment and by diversifying into new product lines.
warranted." ALCo thus lacked the financial resources to modernize its plant, establish a diesel locomotive research and development program and reduce its top-heavy capitalization by buying back its large issue of 7 percent preferred stock.

Similarly, Baldwin gave away its earnings during the 1920's. The company paid out $34.4 million in dividends between 1918 and 1930. During this same period, Baldwin had net earnings of approximately $55 million. These dividends were particularly excessive, given the cyclical nature of the locomotive industry. Executives at Baldwin, like their counterparts at ALCo, understood that the feast of the early 1920's would eventually turn to famine. Although they could not possibly have anticipated the severity of the Great Depression, sound managerial techniques dictated that executives at the steam locomotive producers set aside a large reserve against an unavoidable future downturn in locomotive orders. Their failure to do so led to Baldwin's bankruptcy during the 1930's, and reduced the ability of both producers to establish adequate

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41 Barron's, June 7, 1937, 9 (quote).
organizational capabilities in the emerging diesel locomotive industry.  

Second, ALCo and Baldwin further diluted their financial resources by diversifying into complementary product lines. In addition to soaking up millions of dollars in cash, the reliance of these companies on continued steam locomotive production reinforced managerial reluctance to abandon or deemphasize that market. Between 1926 and 1930, in addition to McIntosh and Seymour, ALCo acquired the Railway Steel Spring Company, Heat Transfer Products, Inc., the Jackson Engineering Corporation, and 35 percent of the General Steel Castings Corporation. ALCo retained its controlling interest in the Montreal Locomotive Works and also maintained a close relationship with the Superheater Company -- one of whose founders, Samuel G. Allen, later served as ALCo's president.

Like ALCo, Baldwin diversified into closely related product lines. Baldwin acquired a controlling interest in the Midvale Company, a producer of steam locomotive forgings, ordinance, and structural steel, in 1926. Baldwin purchased the Southwark Foundry and Machine Company in 1929; and it retained its 32 percent interest in the General Steel Castings Corporation, which, among other products, supplied Baldwin with cast frames for steam locomotives and their tenders. The Standard Steel Works Company, owned since 1875, was another subsidiary more attuned to the demands of the steam locomotive than that of the diesel. In addition, Baldwin acted as the export agent for the American Tire Manufacturers Export Association (manufacturers of steel steam locomotive tires), the American Spring Manufacturers Export Association (locomotive springs), American Steel Foundries, the Commonwealth Sales Corporation (locomotive tender frames and castings), the Flannery Bolt Company (locomotive staybolts), the J. Faessler Manufacturing Company (locomotive siderod bushings), the Locomotive Equipment Division of Manning, Maxwell, and Moore, the Prime Manufacturing Company (steam locomotive parts), the Roberts and Schaefer Company (coaling and cinder removal
equipment), the Superheater Company, and the U. S. Metallic Packing Company (automatic bell ringers and sanders), among others.\textsuperscript{43} 

Because ALCo and Baldwin squandered their resources during the boom years of the 1920's, and because their limited organizational capabilities were so firmly centered around the production of steam locomotives and related components, they were ill-prepared to meet any challenge from an organization capable of making a combined investment in new manufacturing facilities and marketing networks, much less one with the financial resources of General Motors. Still, during the 1930's, both companies would have an opportunity to overcome 

\textsuperscript{43}By the mid-1930's ALCo operated plants at Schenectady (steam and diesel locomotives), Dunkirk, New York (Alco Products Division), Richmond, Virginia (steam locomotive parts and accessories), Auburn, New York (diesel engines), and Latrobe, Pennsylvania and Chicago Heights, Illinois (Railway Steel Spring Division). Baldwin had facilities at Eddystone, Nicetown, Pennsylvania (Midvale), Burnham, Pennsylvania (Standard Steel Works), Granite City, Illinois (General Steel Castings), and Rochelle, Illinois (Whitcomb). \textit{The Magazine of Wall Street}, 60:3 (May 22, 1937), 152-5, 192-3; \textit{Barron's}, June 7, 1937, 9; \textit{Railway Age}, 80:27 (June 5, 1926), 1501-2; 105:25 (December 17, 1938), 889, 897; 108:23 (June 8, 1940), 1011; \textit{Baldwin Locomotives} 1:4 (April, 1923), 24-6; 9:4 (April, 1931), 3-15; 20:1 (June, 1942), 33; \textit{Business Week}, June 8, 1946, 66-8; Germany, \textit{Southern Pacific Dieselization}, 73.
these errors. In that decade ALCo and Baldwin increased their ability to produce diesel locomotives by purchasing companies capable of supplying them with diesel engines. Given the limitations of existing diesel engine technology and the initial disinterest of GM in diesel locomotives, as the decade of the 1930's began, ALCo and Baldwin both still had the potential to become major participants in the diesel locomotive industry.
CHAPTER III
DIESELIZATION DONE RIGHT: GM AND EMC DURING THE 1930's

The diesel locomotive industry came of age during the 1930's. Between 1934, when the first streamlined diesel-powered passenger train made its appearance, and 1941 diesel locomotives proved themselves capable of handling the most rigorous railroad assignments. Dieselization occurred in three main stages. By 1935 most railroads accepted the superiority of diesels over steam locomotives in yard switching service. Passenger service was next to feel the effects of dieselization, ensuring that many luxury trains were diesel-powered by the late 1930's. When the United States went to war in December, 1941, railroads were just beginning to apply diesels to freight service. Depression-induced financial constraints prevented railroads from purchasing large numbers of diesels during the 1930's. In addition, many conservative railroads, especially those with a high percentage of coal traffic, adopted a wait-and-see attitude toward dieselization during the 1930's. As
a result, steam locomotives still comprised more than 90 percent of all locomotives in service on American railroads in 1940. Of more concern to locomotive producers, however, diesel locomotive orders exceeded those for steam locomotives nearly every year during the 1930's. Furthermore, because railroads often standardized on the models of only one builder, the company that acquired the largest market shares during the 1930's would establish a substantial first-mover advantage. That company was Electro-Motive.

In 1930, ALCo and Baldwin were strong, successful companies, while EMC faced market saturation and financial catastrophe. Ten years later, EMC was the dominant producer in the locomotive industry, and ALCo and Baldwin had lost forever any opportunity of catching up. Because of the financial support of General Motors, and, more importantly, because of its willingness to undertake a combined investment in manufacturing, marketing and management, EMC created an unstoppable first-mover advantage. EMC's managers, unlike their counterparts at ALCo and Baldwin, were not held back by an outdated steam locomotive-based corporate culture. They made significant investments in the development of
modern production facilities and equipment, as well as advanced locomotive designs during the 1930's. EMC's technology, products, and production methods did not create its market dominance, however. Instead, EMC's marketing capabilities, based on the experience of Hamilton and his colleagues, gave that company a crucial edge over ALCo and Baldwin.

The decade of the 1930's gave EMC the opportunity to combine its organizational strengths with the vast financial resources of General Motors. This marriage was initially unintentional, and it certainly did not guarantee EMC a dominant role in the diesel locomotive industry. In spite of GM's later claims to the contrary, its top management during the early 1930's showed little interest in the potential of diesel locomotives. Its initial involvement in this industry occurred as much from historical chance as from careful corporate planning.¹

¹I presented some of the material in this chapter, in a modified form, at a meeting of the Economic and Business Historical Society in Nashville, Tennessee, on April 24, 1993, in a paper entitled "Corporate Response to Technological Change: The Electro-Motive Division of General Motors During the 1930's."
GM SHOWS INTEREST IN DIESEL ENGINES DURING THE 1920's

Not surprisingly, GM's involvement in the diesel engine industry grew from its production of automobiles. Even in the early years of the twentieth century, diesel-engine advocates realized that the largest potential market for diesels lay in the motor vehicle industry. In 1921, GM engineer Carl E. Summers began the first diesel engine tests at that company, using a model from the Schwer Engine Company of Sandusky, Ohio. Results were not encouraging, and the testing program was soon dropped. The German firm Benz had greater success with a diesel-powered truck that it built in 1924. When Alfred P. Sloan, Jr., assumed the GM presidency in 1923, he placed greater emphasis on research and development and expansion into related product lines. The announcement that Packard had developed a diesel aircraft engine in the autumn of 1928 was enough to stir GM into action.²

After completing a lengthy study of various types of automotive gasolines in early 1928, Charles Francis Kettering, the director of GM's Research Laboratories, began to examine the feasibility of using diesel engines in trucks, buses, and automobiles. His research into gasoline, particularly that concerning the role of the anti-knocking compound tetraethyl lead, convinced Kettering that information on gasoline engine combustion should apply equally well to diesels. According to Kettering, "... a study of diesel engines seemed to be a direct supplement to the work which we had been doing in connection with Ethyl gasoline."

This fuel research was part of a larger GM diversification program, which included the 1925 purchase of referred to as GMI), 7, 35, 39.

3 In his book Boss Kettering (New York: Columbia University Press, 1983), Stuart W. Leslie provides an excellent in-depth study of the life and career of Charles Francis Kettering. Only a small portion of this book (pages 267-73) is devoted to diesel locomotives, an indication of the breadth of Kettering's interests and abilities.

the Yellow Truck and Coach Company and the 1929 acquisition of the Allison Engineering Company, a firm that had done some initial research on diesel airplane and dirigible engines. In addition, GM broadened its research to include fuels and metals, knowing full well that advancements in these fields would have applications in both diesel and gasoline powered vehicles.\(^5\)

Kettering found the diesel a difficult proposition. In 1928, he wrote to a colleague that "At the present time my opinion of the diesel engine is not fit to put in print."\(^6\) Kettering realized that the most significant of the many problems plaguing diesel engines were their excessive weight and their inadequate fuel injectors. The injector, which was designed to spray a fine mist of diesel fuel into the cylinders under high


pressure, frequently malfunctioned as a result of high temperatures, metal fatigue, and poor construction. In addition, Kettering realized that metallurgy had not yet caught up with diesel-engine technology. Because of their compression ignition, diesel engines typically operated with a cylinder pressure of 650 pounds per square inch, compared to 125 pounds for a gasoline engine using spark ignition. While gasoline engines had compression ratios of 6 to 1; diesels utilized compression ratios of 16 to 1. Without high-strength metal alloys, engine parts would therefore need to be very heavy to be strong, and this excessive weight was clearly unacceptable.7

During the late 1920’s, Kettering moved from theoretical research to actual experimentation with diesel engines. In March, 1928, Kettering began testing a single-cylinder Cummins diesel engine. A month later, he purchased a yacht, the first Olive K, which he used

as a floating test bed equipped with Bessemer diesel engines. This yacht, along with the Winton-powered second Olive K (launched in September, 1929), gave Kettering valuable information that was later put to good use in the redesign of the fuel injectors.\textsuperscript{8}

The onset of the Great Depression nearly terminated GM's brief foray in the field of diesel research. The crisis of confidence that plagued many companies after the stock market crash caused GM to suspend virtually all diesel research in November, 1929. Thanks to persistent lobbying by Kettering, research resumed a month later.

Anxious to avoid a long and expensive R&D program, GM president Alfred P. Sloan, Jr., put pressure on Kettering to purchase an established producer of diesel engines. During the second half of 1929, GM offered to buy the Treiber Diesel Engine Company for $200,000, but a disputed contract with the Consolidated Shipbuilding Company canceled the arrangement. GM also failed in its efforts to acquire the Cummins Engine Company.

\textsuperscript{8}\textit{"Research Report TI-8,"} 289-90, \textit{Fortune} 19 (March, 1939), 51.
Kettering succeeded on his third attempt, causing GM to purchase the small, inadequately managed, and technologically backward Winton Engine Company.  

GM had little interest in the engines produced by Winton. Instead, GM wanted to combine the technical experience of GM engineers with Winton's facilities. Diesel-engine modifications designed by GM engineers in Detroit would be constructed by Winton technicians in Cleveland. In fact, one of GM's main inducements for purchasing Winton was the proximity of that company's Cleveland headquarters to Detroit. When GM purchased the Winton Company in June, 1930, it established Winton as a wholly owned subsidiary. Charles Francis Kettering then sent his son Eugene to Cleveland to take charge of Winton's experimental diesel engine program.

After acquiring the company, Kettering and the other engineers at GM discovered, to their dismay, that

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Winton continued to follow its own agenda. Winton employees were used to custom fitting and loose tolerances between parts. GM engineers were horrified to discover that these workers frequently drilled holes in engines that were already partly assembled, leaving metal chips inside the engine. Even worse, when GM's research labs were ready to make the shift from four-cycle to lighter two-cycle engines in early 1932, Winton refused to follow its parent's lead. Winton's engineers continued have faith in the four-cycle principle and would not fully support the two-cycle engine until early 1934. Kettering complained that "You haven't got a man in Winton that wants to make a two-cycle engine so it will run." 11 By July, 1935, Kettering wrote of Winton that "As it is, they are going ahead building and selling more mistakes which will ultimately ruin our prospects," and that "The failure of Winton to [establish] an intelligent program of engineering progress affecting future models has been very disappointing." 12


Of the many changes that Kettering and the other GM engineers made to the Winton engines, two were especially important. The first was a redesign of the fuel injectors, which incorporated elements of both the GM and the Winton research programs. Many early fuel injectors used compressed air to force the fuel into the cylinders. These compressors wasted a large portion of the engine’s total horsepower, and the high pressure fuel lines often leaked — a dangerous problem near a hot engine. In 1928 and 1929, both the GM Research Laboratories and Carl Salisbury, chief engineer at Winton, were independently working on designs for a unit fuel injector. This injector "... combined all of the functions of metering, pressurizing and atomizing" of the fuel, and was a marked improvement over earlier systems.¹³ Winton had initially begun work on the unit injector at the insistence of EMC, whose engineers believed that existing injector designs would be ill-suited for that company’s proposed efforts to use distillate engines in its railcars.

Unfortunately, Winton simply did not have the manufacturing capabilities to produce the unit injector, which required tolerances of 1/10,000 of an inch. GM's Research Laboratories therefore combined the best features of the two injector designs. The injectors themselves were manufactured at GM's Research Laboratories until 1937, when production was transferred to the newly created Detroit Diesel Division.  

The second improvement made to the diesel engine by GM's Research Laboratories was the replacement of Winton's four-cycle design with a simpler, lighter two-cycle design. As was the case with the unit injector, GM's contribution largely involved refining and improving designs that already existed. The four-cycle engine was so named because the piston made four strokes for each revolution of the flywheel: a compression stroke, a power stroke, an intake stroke, and an exhaust stroke.  

followed by a power stroke, then an exhaust stroke, and finally an intake stroke. The two-cycle engine had only a compression/exhaust stroke, followed by a power/intake stroke. Kettering believed that the use of the two-stroke engine was the most effective way to reduce excess weight, and, to a certain extent, he was correct.

GM went too far, however, in asserting "... that the two-cycle lightweight diesel engine was entirely a development of General Motors research." As early as 1879, William Barnett and Sir Douglas Clerk had designed a two-cycle gasoline engine. Busch-Sulzer Brothers had already been producing two-cycle diesels for more than twenty years. By the early 1930's, most diesel engineers were familiar with the relative merits of two-cycle and four-cycle engines, generally assuming that the former were best suited to large engines, and the latter to small and medium size engines.


Furthermore, despite GM's claims that the two-cycle diesel was far superior to the four-cycle, in reality there was little difference between the two. Both were (and are) equally suited for railroad applications. Some railroads, such as the Burlington, gave preference to two-cycle diesels because they were better suited to fast lightweight passenger trains, a preference that would have important repercussions for EMC. Still, companies that used four-cycle engines, such as ALCo, Baldwin, and GE, were not inherently doomed by GM's "invention."

What did more to set GM apart from its rivals was that company's use of recently developed high strength metal alloys, its involvement in diesel fuel research, and its ability to produce engine parts to extremely close tolerances. In the diesel engine industry, marginal improvements in existing technology thus mattered more than radical technological innovations.¹⁷

¹⁷J. B. Hill to Lyman Delano, August 24, 1939, Louisville and Nashville Railroad Collection, University of Louisville (Record Group 123, hereafter referred to as the L&N Records), box 1, folder A-15113; "Research Report TI-8," 276; Boyd, "Advances in Engines and Fuels," 76-8.
Although GM was primarily interested in the motor-vehicle market for diesel engines, the company was unable to develop an adequate automobile or truck engine during the 1930's. And, during the first half of the decade, GM had no interest in the railroad diesel market.

Instead, much of the impetus for continued GM diesel development came from the American military, long a supporter of leading-edge technology. In November, 1932, the Navy ordered a single 12-cylinder diesel engine for consideration for possible use in submarines. By April, 1933, this engine, the Model 201, was providing fairly reliable results in tests. In November of that year, the Navy ordered sixteen diesel engines from Winton. Other orders followed, but the Navy's continued patronage depended on finding a quick solution to the problems at Winton.  

18 The Model 201 designation, like that of all subsequent GM diesel locomotive engines, was based on the cubic-inch displacement of each cylinder.

GM AND EMC SLOWLY CULTIVATE THE RAILROAD DIESEL MARKET

Largely absent from the early discussions that centered on resolving the disputes between GM and Winton over the Navy contracts was any mention of railroad diesel locomotives. Had GM purchased any diesel-engine producer other than Winton, it is unlikely that it would have produced a single diesel locomotive, much less become the industry leader. GM became an industry leader only because Winton's single largest customer happened to be the Electro-Motive Corporation.

GM purchased Electro-Motive only because that company provided a captive, if small, market for Winton engines, not because it planned a comprehensive diesel locomotive development program. EMC President Harold Hamilton later said that "After negotiations with

istory of the Cleveland Diesel Division (the corporate successor to Winton), ca. 1962, describes "close cooperation and study" between GM and Navy officials between 1933 and 1940, including, in 1934, the establishment of "the first Navy Training School for Diesel Specialists" at Cleveland Diesel (Winton). (untitled history, 11-12, GMI, folder 76-16.1).
officials of General Motors and the Winton Engine Co. had progressed toward a decision it became evident to General Motors that the Winton Engine Co.'s biggest customer was the Electro-Motive Corporation, and in those days it was almost a case of the tail wagging the dog."

By 1930, Hamilton realized that Electro-Motive could not survive as an independent company, particularly since it lacked the financial resources necessary to develop a reliable diesel switching locomotive, a sum that Hamilton estimated to be approximately $5 million. And, as Hamilton recalled in 1957, "the money itself would not have been enough. Winton didn't have the technological men and equipment required for development of the engine we needed. General Motors did." 

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Hamilton was not forced from power following the GM takeover, as is so often the case when large companies take over smaller ones. Hamilton remained president of GM's new Electro-Motive subsidiary; and, when that company was later incorporated into GM's corporate structure as the Electro-Motive DIVISION, Hamilton was elevated to the status of a GM vice-president. Throughout his career with Electro-Motive, both as an independent company and as an affiliate of GM, Hamilton remained a strong advocate for the use of diesel power in railroad locomotives -- a stronger advocate, in fact, than more senior GM executives such as Sloan.22

With the assurance of at least a small market for maritime diesel engines, Kettering and others examined the possibility of modifying the Navy engine for

22 To a certain extent Hamilton's career thus paralleled that of Sloan himself. Sloan joined the Hyatt Roller Bearing Company in 1895 and, during the next twenty years, helped the company to become an important supplier to the growing automobile industry. In 1916, William Durant, president of General Motors, purchased Hyatt and, recognizing Sloan's business acumen, invited him to serve as a GM vice president. After Durant lost control of GM to the DuPont interests, Sloan rose still higher in the GM organization. (Alfred P. Sloan, Jr., My Years With General Motors (New York: Doubleday, 1964), 17-26.
"generator sets and industrial use." No mention was made concerning railroad applications. By mid-1932, GM had decided to demonstrate the industrial utility of its diesel engines to the general public by using two 8-cylinder Model 201 diesel engines to provide power for the GM building at the 1933 World's Fair in Chicago. These engines, each of which provided 600 horsepower, performed adequately, but not spectacularly. Frantic night-time maintenance was often required in order to have at least one engine serviceable the following day, and spare parts flowed from Detroit and Cleveland to Chicago with annoying regularity. A "Summary Report of Operation of Winton Diesel Engines at [the] Century of Progress" listed eight pages of defects and their possible solutions and indicated that something went wrong with virtually everything on the engines at least once. Eugene Kettering said afterward that "the only part of that engine [sic] that worked well was the


dipstick."\textsuperscript{25}

In spite of these difficulties the general public was suitably impressed with the GM Chicago World's Fair diesel engines, but perhaps no one more so than Ralph Budd, president of the Chicago, Burlington, and Quincy Railroad. During the 1920's, the branchline-encumbered Burlington had been EMC's largest railcar customer. In September, 1932, Budd had begun to design a lightweight, streamlined train for the railroad's premier Chicago-to-Denver service. Among other design improvements, this train was to employ the shotwelding technique recently developed by the train's builder, the Edward G. Budd Manufacturing Company. The extensive use of aluminum and metal alloys, such as stainless steel, resulted in a train that weighed 219,000 pounds, compared to 809,000 pounds for conventional passenger equipment, and thus unintentionally brought it within the abilities of a diesel locomotive power plant.

Hamilton, on his own initiative, approached Budd with a proposal for a diesel-powered train, and took him

\textsuperscript{25}Sloan, \textit{My Years With General Motors}, 349 (quote).
to see the two World's Fair engines being built by Winton. Budd had originally intended for the train to be pulled by a streamlined steam or distillate locomotive, but, after seeing the Winton diesels, decided that he had to have an ultramodern diesel engine pulling his ultramodern train.26

Budd received a cool reception from Sloan, who believed that a frantic R&D program to place a largely untested diesel engine in a highly demanding railroad application would result in ignominious disaster. Budd, however, had a powerful ally in Hamilton's deeply held faith in the ultimate triumph of the diesel railway locomotive. In addition, Budd and Kettering enjoyed a close friendship, and the railroad president was described as "an admirer of Ket."27 One factor that may

26*Fortune* 38 (July, 1948), 76-81, 144-9; Ralph Budd, "Light-Weight Diesel-Electric Trains," *Civil Engineering* 8:9 (September, 1938), 592-5; Budd, remarks at EMD's silver anniversary dinner, Chicago, October 24, 1947, GMI, folder 76-16.2; Coverdale and Colpitts, Consulting Engineers, "Report on Light-Weight Trains of the Zephyr Type," January 15, 1935, AAR; *General Electric Review* 40:9 (September, 1937), 421-8.

have tipped the balance was the fact that Budd "... started the design and building of the train without having a prime mover to go in it, and I think it was the pressure of this outside influence which the Boss [Kettering] used very effectively with the people in General Motors." Eventualy, Budd, Hamilton, and Kettering were able to convince Sloan and other GM top management to provide a Model 201 diesel engine for the building of the Burlington Zephyr.

The train performed magnificently. On its test run, on April 17, 1934, an engineer who had never before operated a diesel locomotive took the Zephyr, in the space of six miles, from a dead stop to 108 miles per hour. The train accelerated so fast that oil sloshed up and out of its tank, so fast that the train's tail lights fell off. On its official first day of operation:

28 Nelson C. Dezendorf interview, The Kettering Archives, 1965 Oral History Project, April 6, 1961, GMI. It is interesting that even though Dezendorf served as a GM vice president in charge of EMD, he referred to his superiors as "the people in General Motors" -- a clear illustration of the tendency of EMC/EMD to distance itself from its corporate parent.

29 Speech by Ralph Budd at EMD's Silver Anniversary Dinner, Chicago, October 24, 1947.
operation, the Zephyr travelled the more than 1,000 miles from Denver to Chicago nonstop in thirteen hours and five minutes, thirteen hours faster than the previous record pace.\(^3\)

The Zephyr's long-term benefits were even more gratifying. The train cost only 31 cents per mile to operate, less than half the cost of a steam locomotive and conventional passenger equipment. The Zephyr's faster service caused passenger loads to increase by 50 percent. Its speed also increased the likelihood that the Burlington would receive and retain important mail contracts. More important, however, especially from EMC's standpoint, was the tremendous publicity that the train generated. On the day of its inaugural run, businesses closed and schools let out, in order that adults and children alike could watch the Zephyr, soon nicknamed "Little Zip," flash past at more than a hundred miles per hour. Because of its speed, its shiny

\(^3\)"Research Report TI-8," 200; Harlow H. Curtice, speech delivered at the American Institute of Consulting Engineers, New York, November 27, 1956, GMI, folder 83-1.9-60. GM engineers probably meant marker lamps when they described the missing "tail lights" -- no doubt they were more familiar with automotive jargon than that of the railroads.
stainless steel exterior, and because it did not look at all like a steam locomotive, the Zephyr drew crowds wherever it went. The popular press praised the Zephyr as an example of what American ingenuity could accomplish, even during the dark days of the Great Depression.31

Other railroads soon demanded passenger trains similar to the Zephyr. Although they could seldom afford to buy traditional steam locomotives during the depression, railroads were willing to expend considerable sums on these luxury trainsets because they reduced operating costs, increased publicity, and guaranteed capacity bookings, since the very rich were able to travel in luxury, no matter what the state of the economy. This new demand for lightweight trainsets was nothing short of salvation for EMC, which had sold only one railcar between June, 1932 and the beginning of 1934. EMC coordinated the production of thirteen

31 Stanley Berge and Donald L. Loftus, Diesel Motor Trains: An Economic Evaluation (Chicago: The Northwestern University School of Commerce, 1949), 9-10; Chicago, Burlington, and Quincy Railroad, response to Reconstruction Finance Corporation questionnaire, March 5, 1937, RFC records (Record Group 234), box 188.
trainsets over the next three years. As had been the case with its production of railcars during the 1920's, EMC allocated the production of components to others. Its parent, Winton, supplied the diesel engines, car-builders such as the Budd Company and the Pullman Company built the carbodies, while GE and Westinghouse furnished electrical equipment.32

First to be completed was the M-10,000 City of Salina for the Union Pacific. This three-car, largely aluminum trainset was capable of 110-mph speeds. Because the Union Pacific was willing to accept a 600-hp distillate engine, it was delivered in February, 1934, two months before the diesel-powered Zephyr was ready for tests. Like the Zephyr, it created an immediate public relations sensation. The City of Salina was soon followed by other trainsets on the Union Pacific: the five-car, diesel-powered M-10,001 (City of Portland) in October, 1934, and the M-10,002 (City of Los Angeles) and M-10,003 (City of San Francisco), both in service by June, 1936. The Boston and Maine took delivery of a

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three-car Zephyr clone, the Flying Yankee, in February, 1935. The Burlington received two larger Zephyrs for the Chicago-St. Paul run, as well as a Mark Twain Zephyr for service between St. Louis and Burlington, Iowa.  

These new luxury trainsets had their drawbacks, and they certainly would not provide a sustainable market for EMC. Since all units of the trainset were semi-permanently coupled, a minor problem in one car could disable an entire train. This lack of flexibility also prevented railroads from increasing or decreasing the length of the train in order to accommodate changing passenger demands. The custom-built trainsets were smaller than conventional equipment, and thus could not be intermixed with it. The unfortunate fact that the diesel engines and electrical equipment were by no means foolproof was illustrated by the Union Pacific, which, in addition to the regular train crew, assigned an electrician and a road foreman of engines to its trainsets.

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at all times. In addition, the high initial cost of these trainsets ensured that they would be used only on a few routes, where passengers would be willing to pay a premium for speed and luxury. Finally, these trains were ultimately victims of their own success. Because the public was so eager to ride them, demand increased to such an extent that their limited size proved insufficient. Railroads were thus forced to utilize conventional passenger equipment with full size diesel locomotives in order to maintain comparable schedules.34

The benefits of trainsets, especially to EMC, far outweighed these problems, however. While these trains increased the prestige and passenger revenues of the railroads that operated them, they also greatly increased the acceptance of diesel locomotives by American railroads. The favorable public response to these new diesel trains caused railroad managements to consider further diesel locomotive purchases. In addition, the presence of even one diesel locomotive on a particular railroad required the construction of

34General Electric Review 40:9 (September, 1937), 421-8; Berge and Loftus, Diesel Motor Trains, 21; Garmany, Southern Pacific Dieselization, 105.
specialized service and repair facilities, as well as the creation of shop forces trained in diesel locomotive maintenance. The presence of these facilities substantially lowered the effective cost of acquiring additional diesel units, a fact that EMC used to its advantage as the dieselization revolution accelerated.

The construction of these trainsets gave EMC itself a wealth of valuable experience that it later used in the construction of locomotives. In addition, this surge of new business, brief though it was, helped convince top GM executives that their tiny (EMC had a staff of no more than two dozen people at this time), largely forgotten subsidiary was neither useless nor moribund. The success of the Zephyr and its companions gave Hamilton and Kettering valuable ammunition in their efforts to convince GM to provide the funds for the development of a diesel engine specifically designed for locomotive service.  

GM COMMITS TO THE DIESEL LOCOMOTIVE INDUSTRY

In spite of these successes, Sloan, who preferred to concentrate on lucrative Navy contracts, nearly ended GM's involvement in the locomotive industry. The Model 201 engine had numerous defects, Winton was nearly as recalcitrant as it had been in 1930, and the custom-built nature of the early diesel locomotives plagued a company that did much to advance the cause of flexible mass production. Kettering recalled that "Mr. Sloan called me up one day [in late 1934] and he said 'Ket, we've got to throw this thing out.'" In response, Kettering asked for a $500,000 research appropriation to develop a new diesel engine for railroad use. He recalled that Sloan's response to this request was: "You know damn well well you can't build a locomotive for five hundred thousand dollars," to which Kettering replied: "No, but I think if you get that much in it,

you will be likely to finish it." Sloan described this incident in his autobiography, *My Years With General Motors*, but failed to mention that he almost terminated what would eventually become one of GM's most profitable subsidiaries.\(^{37}\)

Kettering persuaded Sloan that, rather than abandon the diesel locomotive market entirely, GM should design a new diesel engine specifically for locomotive use. His ability to do so thus marked the key turning point in GM's participation in the locomotive industry.

This decision to develop a diesel engine specifically for railroad use was contingent on Kettering's ability to resolve the chronic problems at Winton. After obtaining an initial $500,000 research appropriation, Kettering, during the second half of 1935, set up a series of monthly meetings to coordinate activities between the GM research labs, Winton, and Electro-Motive. In May, 1936, engineers from each of these three groups formed a Diesel Engine Products Study Group.

\(^{37}\)Address by Charles Francis Kettering before the employees of the Electromotive Division of General Motors, Chicago, June 13, 1950, GMI, folder 10/28 (quote); Sloan, *My Years With General Motors*, 350.
to develop engines for various commercial applications, especially for railroad locomotives. At the same time, Kettering increased his control over Winton by transferring their engineering department, including Carl Salisbury and Eugene Kettering, from Cleveland to Detroit. In July, 1936, GM's DELCo Products Division began a program to develop new generators and traction motors, based largely on GE designs.

The efforts of Kettering and his research staff led to the development, in 1938, of the Model 567 diesel engine. This engine, designed specifically for railroad use, weighed only twenty pounds per horsepower, a 90 percent reduction from the Winton Model W-40. In spite of the fact that the Model 567 was designed for locomotive use, GM vice president R. K. Evans, who was in charge of the various diesel engine divisions, believed that it would have "... even a greater volume of business in marine and stationary work than in locomotives." 38

Winton itself followed a path that was increasingly divergent from that of EMC. The Electro-Motive Company and the Winton Engine Corporation had been consolidated under the latter name on January 1, 1933. In November, 1934, it became the Winton Division of GM, and the Cleveland Diesel Engine Division in January, 1938. At the same time, GM also opened the first facilities of the new Detroit Diesel Engine Division, established in April, 1937. Simultaneously with its introduction of the Model 567 locomotive engine, GM announced plans to mass produce a wide range of smaller two-cycle diesel engines at Detroit and Cleveland. GM also established consolidated testing facilities in Detroit to accommodate Cleveland, Detroit, and La Grange. While EMC would market engines of 600 or more horsepower, Cleveland Diesel would sell the smaller engines through existing auto parts distributors.  

39 Automotive Industries 76 (May 1, 1937), 640; 78 (January 22, 1938), 95, 101; Railway Age 94:1 (January 7, 1933), 30; 104:5 (January 29, 1938), 232; Untitled history of the Cleveland Diesel Division, ca. 1962, GMI, folder 76-16.1, 4,8; "Research Report TI-8," 293.
While the research and development on the 567 engine and its related electrical equipment was progressing, EMC arranged for the construction of a variety of locomotives, primarily for testing purposes and additionally to demonstrate to the railroads that EMC offered more than just passenger trainsets. EMC's locomotive research and development program consisted of one engineer and two draftsmen, hardly a major financial commitment on the part of its parent company. GE, the St. Louis Car Company, and Bethlehem Steel built the carbodies of the twelve locomotives that were part of this project, while GE and Westinghouse furnished electrical equipment. A 2-unit 3,600-hp demonstration model was completed in June, 1935, and tested on various railroads. This locomotive, introduced more than four years before EMC's regular production freight locomotives, was the first truly successful diesel freight locomotive in the United States, and should have given ALCo and Baldwin clear notice that diesels were becoming as powerful and reliable as their steam locomotive counterparts.

EMC's experimental units soon gained favor with railroad executives. The 3,600-hp locomotive and similar demonstration units were sold to both the Santa
Fe and the Baltimore and Ohio. The Santa Fe units reduced the Chicago to Los Angeles running time of the Chief by 15 hours by operating at speeds of nearly 100 mph. Despite initial problems — one of the diesels pulling a train carrying Santa Fe President Samuel Bledsoe caught fire on a test run — the Santa Fe was extremely pleased with its new diesels. Given its early experience with diesels and its route through arid, isolated terrain, the Santa Fe soon assumed a leading role in the replacement of steam locomotives with diesels.40

The capstone of GM’s new commitment to the production of diesel locomotives was the construction of an entirely new facility for locomotive production at La Grange, Illinois, a suburb of Chicago. GM made the initial decision to build the facility in late 1934, with final approval occurring in January of the following year. Ground was broken on March 27, 1935, and the newly completed facility produced its first locomotive

fourteen months later. At first, the facility assembled, rather than manufactured, diesel locomotives, using engines built in Cleveland by Winton and electrical equipment produced by General Electric and other manufacturers. Gradually, as the plant was expanded from 205,000 square feet to 3.2 million square feet, it became a true manufacturing facility. In 1936, GM transferred the production of the Model 201 engine from the Winton facilities in Cleveland to Chicago. La Grange built its first Model 567 diesel engines in January, 1938, while the transmission department completed its first generators and traction motors in July of that year.\footnote{41}

One observer, watching the construction of La Grange, thought that "The production line will resemble that of a modern automobile plant," and, to a certain extent, this analogy held true.\footnote{42} Like an automobile assembly line, La Grange had a main "assembly line," the


\footnote{42}{Steel 97 (August 5, 1935), 16 (quote).}
erecting shop, with subassembly lines feeding into it. Because of the enormous size and weight of the locomotives, however, EMC was forced to modify its "assembly line" by "... bringing the tools to the job rather than taking the job to the tools." Small battery-powered trucks trundled back and forth, each carrying a box of tools, a box of electrical parts, and a box of miscellaneous parts. The plant had an on-site testing laboratory to control quality and to help compile data on fuels, lubricants, and new metal-working techniques.

Initially, EMC's La Grange plant manufactured 600-hp and 1,000-hp yard switchers. These were built to a standard design, but actual production methods were not standardized until World War II. The switchers built between 1935 and 1938 were equipped with Model 201 engines and GE electrical equipment; those built later used Model 567 engines and EMC-built electrical equipment. The introduction of yard switchers in 1935 was a wise choice. The economy was beginning to improve after the nadir of the Great Depression, yet railroads were

\[43\text{Burnham Finney, "Where Diesels are Railroaded," American Machinist 80 (April 22, 1936), 331-4 (quote).}\]
still anxious to take advantage of the economies offered by diesel switchers. Their high tractive effort at low speeds made diesels ideally suited for switching service, and the fact that they seldom strayed far from the yard made service, maintenance, and emergency repairs relatively easy. Assuming that they were used at least sixteen hours per day, diesel switchers were an excellent investment, usually repaying their initial cost in between two and four years.

The use of yard switchers, the first stage of dieselization, required the creation of service and repair facilities at major yards and cities along the railroad, and this in turn facilitated the second and third stages of dieselization -- the use of diesels in road passenger and later road freight service. Switchers also gave EMC valuable experience regarding diesel locomotive performance in actual operating conditions.44

44 Railway Age 96:19 (May 12, 1934), 685-9; GM-EMD, The Diesel Locomotive: Preface of a New Era, 16; Nelson C. Dezendorf, speech before the New York Society of Security Analysts, New York, June 1, 1951, AAR.
The production of standard switchers at La Grange prepared the railroads for the dieselization of the largest potential locomotive market, road freight units. Diesel switchers impressed railroad executives with their cost savings and they, far more than top GM management, urged EMC to build a freight locomotive. Since EMC was already producing road passenger locomotives (the E-series, introduced in 1937), it was a relatively simple matter to design a similar unit for road freight service.⁴⁵

EMC introduced the prototype for a 5,400-hp, 4-unit road freight locomotive in November, 1939. This locomotive, the first Model FT, was soon in demonstration service on the Santa Fe and, later, the Boston and Maine. In spite of the fact that its four 16-cylinder 1,350-hp engines provided less horsepower than many large steam locomotives, the FT had more tractive effort than any steam locomotive yet built. The Santa Fe in particular was so impressed that it purchased the demonstrator and soon placed an order for additional

The Santa Fe, which bought its first diesel switcher in February, 1935, and its first diesel road passenger unit in August of that year, rapidly became a regular EMC customer, although it occasionally purchased diesels from other builders. By March, 1941, four railroads, including the Santa Fe, the Southern Railway, and the Milwaukee Road, had placed orders for the FT.46

But the FT was by no means a perfect locomotive, even though it remained in production until 1945. Mechanical problems occurred with unacceptable frequency. In addition, while the 4-unit locomotive could be separated into two 2-unit locomotives, each with 2,700 horsepower, 1-unit and 3-unit combinations were more difficult, since half of the units lacked cabs and were semi-permanently coupled to their cab-equipped companions. This was done partly to save construction costs -- units with cabs and locomotive controls were more expensive -- and partly to reduce the possibility

46 *Railway Age* 108:3 (January 20, 1940), 159; 109:11 (September 14, 1940), 378-9; 110:6 (February 8, 1941), 287-8; 110:11 (March 15, 1941), 452-8; *Railway Locomotives and Cars* 127 (September, 1953), 84-9; *Wall Street Journal*, March 5, 1941; GM-EMD, "Conference Leader's Outline," Subject III, Unit 2A, GMI, folder 76-1.60, 28.
that railroad unions would demand a complete engine crew on each cab-equipped unit on the train. Richard Dilworth, the locomotive's designer, actually considered the FT to be one of the worst mistakes of his entire career. The early success of the FT should have served as a final wake-up call to the traditional steam locomotive builders, but it did not. After November, 1939, ALCo and Baldwin still had sufficient time to develop competing models prior to the advent of wartime production restrictions in April, 1942, but they chose not to. In any case, the defects of the FT gave EMC's competitors ample opportunity to design a superior locomotive, both before and immediately after World War II.47

While the FT was the most notable achievement of EMC's prewar locomotive development program, the company produced a variety of other locomotive designs. By 1940, in addition to the FT, EMC offered 600-hp and 1,000-hp switchers, a 1,000-hp road switcher, a 2,000-hp transfer unit, and a 2,000-hp road passenger locomotive. Unlike the case in the early and mid-1930's, EMC was no longer willing to custom design locomotives to meet the

specifications of individual railroads; and, soon after La Grange opened, Hamilton refused a large order for custom-built locomotives. The company thought that standardization was "... necessarily a fundamental policy of this new enterprise if it was to attain the success designed for it." Such standardization, for example, allowed the production costs of diesel switchers to be reduced by approximately 25 percent.

EMC's standardization of diesel locomotive designs during the 1930's did not mean that production was standardized during the same period. Custom fabrication and fitting were common practices until the 1940's. In addition, the location and type of headlights, horns, fuel tanks, and other items could be altered to suit the customer. Dynamic brakes and boilers for passenger car heating could also be added. This flexibility somewhat resembled the availability of options on passenger automobiles, busses, and trucks, although the correlation between the auto industry and the locomotive

industry has been overdrawn by some observers. Also, like firms in the auto industry, EMC made gradual, incremental improvements to its locomotives, thus allowing as many existing parts and subassemblies to be retained as possible.

Finally, unlike many of its competitors in the locomotive industry, EMC made extensive use of fabricated (welded) components in its locomotives, rather than iron or steel castings. This practice, which was an EMC copy of a Swedish innovation, reduced weight, increased strength, and reduced EMC's dependence on outside suppliers. The use of welded crankcases, for example, reduced weight by about 20 percent. By the end of the 1930's, EMC had thus made far greater progress in the integrated manufacture of diesel locomotives than had any of its competitors.⁴⁹

During the 1930's the locomotives manufactured by EMC resembled their ALCo diesel locomotive counterparts in many respects. Both companies offered standardized designs, although EMC was more forceful in its insistence that customers purchase the models that EMC engineers had designed. EMC locomotives performed better than ALCo diesel switchers, but the locomotives offered by both companies were far from perfect. EMC had the more modern production facility but was unsuccessful in its attempts to apply jigs, fixtures, and other standardized manufacturing techniques to the production of locomotives. Not until the 1940's would locomotive production become truly efficient at Electro-Motive. Instead, EMC's marketing efforts, not its technology, gave that company a crucial edge over ALCo during the 1930's.

Reference: Leader's Outline, "Subject III, Unit 3C, GMI, folder 76-1.60a."
While advances in manufacturing at EMC were spectacular during the 1930's, developments in marketing were even more important. EMC's sales staff was never very large -- the total number of salesmen in 1948, at the height of the dieselization rush, was only fourteen -- but they had a wealth of marketing experience to support them. In its attempt to discover the motive power needs of its customers, EMC was able to take advantage of the resources of GM's Customer Research Department, established in 1933, which was the largest market research organization in the world. In order to demonstrate clearly to railroad executives the advantages of diesel locomotives, EMC was the first company in the locomotive industry to develop the "economic study," which provided an extremely accurate estimate of the potential savings of dieselization. This type of study had become standard industry practice by 1947.50

Unlike the other locomotive builders, EMC realized that the travelling public could play a significant role in a railroad's decision to purchase diesel locomotives. Trains like the Zephyr gave the public a taste of what fast, comfortable, smoke-free travel could be like. In addition to displaying diesels at railroad equipment trade shows, EMC also featured them at public venues, such as the 1939 New York World's Fair. The public demand for diesel-powered passenger trains that followed this type of publicity further encouraged railroads to purchase diesels for passenger service. These initial sales in turn increased the likelihood that further diesel purchases, such as those for freight service, would be made.⁵¹

For railroads that were still undecided, EMC supplied demonstration units free of charge, a practice that soon became standard throughout the industry. The use of demonstrators was of course impossible in the steam locomotive industry. Orders for steam locomotives were usually unique, and, prior to actual delivery, 

⁵¹*Railway Age* 105:5 (July 30, 1938), 203-4.
railroads thus had only a theoretical idea of how their new locomotives would perform.

Once it had sold diesels to a railroad, EMC was able to arrange financing through the General Motors Acceptance Corporation. This procedure allowed railroads to avoid the equipment trust financing, arranged through banks, that predominated in the sale of steam locomotives. Many banks were reluctant to issue new equipment trust certificates during the depression, especially to financially troubled railroads. EMC and GMAC continued the 1920's practice of renting locomotives to railroads, with the stipulation that rental payments be less than the savings produced by the new diesels. In 1939, a 600-hp switcher cost $62,250 cash, or $750 per month for eight years, while a 1,000-hp model carried a price tag of $84,300 ($1,000 per month for eight years). Since diesel switchers saved the railroads approximately $1,500 per unit per month, this was essentially a fail-safe proposition. In 1938, when EMC diesel switchers were outselling their competitors ten to one, and outselling steam switchers a hundred to one, a Wall Street Journal article suggested that EMC's
success lay in GMAC financing, combined with the ready availability of locomotives from stock.\textsuperscript{52}

Initially, railroads could order EMC switchers from stock and expect to receive them in a few weeks, just long enough to apply a coat of the appropriate paint and make a few other minor modifications to suit the needs of a particular railroad. This kind of prompt service was impossible in the steam locomotive industry. According to Ralph Budd, president of the Burlington, "It is something entirely new for a railroad to be able to order a half dozen switch engines and have them delivered within a week, just as one might purchase highway trucks, but that has been our experience and the experience of other roads since the Electro-Motive plant has been going at La Grange."\textsuperscript{53} World War II ended the luxury of building locomotives for stock, and after the war the increased number and variety of locomotive

\textsuperscript{52}\textit{Railway Age} 99:6 (August 10, 1935), 193; \textit{Wall Street Journal}, September 1, 1938, 1, 4; O. F. Brookmeyer to J. B. Hill, January 23, 1939; Fitzgerald Hall to J. B. Hill, July 22, 1939; both in L&N Records, box 1, folder A-15113.

\textsuperscript{53}Remarks of Ralph Budd at a luncheon given by Alfred P. Sloan, Jr., New York, October 28, 1937, AAR (quote).
models, combined with the enormous expense of maintaining a locomotive inventory, ended the practice of building for stock once and for all. Nevertheless, the almost instant availability of diesel switchers during the 1930's greatly facilitated the initial decision of many railroads to purchase their first diesel locomotives.

Once EMC had built and delivered a locomotive to a railroad, it did not simply collect its money and leave, as had been the case of companies in the steam locomotive industry. Continuing the practice established by Hamilton in the 1930's, EMC provided training for operating and maintenance personnel. Initially, as had been the case in the railcar era, this took the form of travelling instructors who rode with the new engine until the regular railroad crews were familiar with its operation.

EMC's instructional services became more formal in 1934, when H. B. Ellis, EMC's service manager, established a locomotive school at the General Motors Institute in Flint, Michigan. Since these early classes were designed primarily for the U. S. Navy, the initial response from the railroads was poor; but, as La Grange
shipped locomotives to more and more railroads, the popularity of these two-week classes increased. In April, 1936, a railroad executive wrote to EMC, suggesting that the locomotive school be moved to La Grange, and this was done in 1937. By 1944, the school had trained more than 35,000 railroad employees. In 1937, EMC also built a travelling instruction car, housed in a converted passenger car, to eliminate the need for railroad employees to travel to Chicago. This car included a 44-seat classroom and a display room that contained cross sections of a diesel engine and other equipment. It could train more than 400 engineers, firemen, machinists, electricians, and other maintenance employees in one week. Classes at La Grange were thereafter generally reserved for higher ranking operations and maintenance supervisory personnel only.54

EMC added to its training capabilities as diesel locomotive demand increased during the 1940's and 1950's. In 1940, EMC established a Service Training

54Railway Age 102:20 (May 15, 1937), 832-3; 117:16 (October 14, 1944), 600; 118:12 (March 24, 1945), 541-2; 130:14 (April 9, 1951), 41-4; Untitled history of the Cleveland Diesel Division, 11-12; Reck, On Time, 169-70.
Center, which eventually trained more than 2,000 students per year. Between 1941 and 1944, the locomotive school was closed, and the instructors loaned to the U. S. Navy. This contribution to the war effort enhanced EMD's postwar competitive position, since many ex-soldiers put their wartime diesel training to use in the railroad industry after V-J Day, and were thus already accustomed to EMD engines. In 1945, EMD began a "teach the teacher" program, which trained railroad employees to create their own instructional courses. EMD offered its first advanced class (a follow-up to the basic two-week course) in October, 1947, and established a 60-day instructor training class in early 1948. In February, 1949, EMD began a special class for railroad purchases and stores employees, and in 1950 added a second travelling instruction car. By 1951, EMD had trained more than 10,000 railroad employees at La Grange, plus an additional 65,000 in the two instruction cars. Other locomotive builders, particularly ALCo, offered training programs, but the services pioneered by EMC were far superior to any offered by its competitors.55

In addition to showing railroads how to operate their new diesels, EMC also gave them advice on proper maintenance. Steam locomotive maintenance required highly skilled workers who were trained in the crafts of machining and foundry work and who could custom-build replacement parts. Diesel locomotive maintenance generally required fewer skilled employees, who replaced parts rather than built them, but did require that a substantial number of employees be well trained in the subjects of internal combustion and, especially, electricity. EMC provided such training through its locomotive school and with travelling instructors. Service manager Ellis also designed an ideal diesel locomotive maintenance shop, the plans of which he gladly furnished to any railroad that requested them. In addition, EMC began a "cooperative educational effort [to cause] a complete change in railroad maintenance practices [and create a] running maintenance program to keep diesels in constant service."56 Again, other locomotive builders

offered similar services, but none were offered as early or as thoroughly as those provided by EMC. The Chairman of the Board of the Louisville and Nashville remarked that "Unlike some locomotive builders who are only interested in the cash sale, the Electro-Motive Corporation furnish a service which is very valuable and really necessary to secure best results from their power."\(^5\)

THE COST OF MARKET DOMINANCE

One further issue that must be addressed is, of course, that of costs. GM has never released exact cost figures, but it is possible to piece together a fairly accurate picture of the expenses involved in placing EMC in an effective competitive position in the diesel locomotive industry. In 1930, GM paid $6 million for Winton and an additional $1.2 million for EMC. Between 1928 and 1939, the GM Research Laboratories, with its

\(^5\)Lyman Delano to J. B. Hill, July 8, 1941, L&N Records, box 57, folder 1883-A (quote).
staff of more than 500, spent approximately $3.3 million on research on diesels and related products. Various divisions, such as Detroit Diesel and Cleveland Diesel, spent additional money on research and development once Research gave them control over a project. Research alone spent $408,000 on the development of the Model 201 engine, while Hamilton estimated that GM's entire Model 201 research and development program cost something on the order of $7 million. Fortune estimated that GM had spent $25 million on all aspects of two-cycle diesel engine development. The FT diesel freight locomotive cost $500,000 to develop, plus another $300,000 to test. The initial La Grange plant cost $6 million in 1935. EMC expanded La Grange almost continuously for the next twenty years, with the added facilities to produce diesel engines and electrical equipment costing about $5 million. Of course, much of GM's diesel engine research and development work was later applicable to the production of marine, stationary, and motor vehicle diesels -- a clear illustration of the advantages of economies of

scope. Nevertheless, between 1930 and 1940, GM's efforts to enter the diesel locomotive industry cost the company at least $15 million.\(^5^9\)

This was a relatively small amount of money for the world's largest industrial corporation, even in the midst of the Great Depression. In 1936, when switcher production was gearing up at La Grange, less than 1 percent of GM's total horsepower output was in the form of diesel engines of all types. GM's initial investment was also small compared to the rewards that it might reap. The initial market, to replace all of the steam locomotives in the United States and Canada, was worth more than $4 billion. Moreover, the replacement locomotives would themselves have to be replaced eventually, which promised further revenues. On top of this was a substantial business in spare parts, overhauls, and factory rebuilding. By the end of 1938, in spite of the

depression, EMC had already sold 225 locomotives, worth $25 million.

Still, EMC did not earn a profit on its operations until 1940, and as late as 1947 Charles E. Wilson, the president of EMC's parent corporation, lamented that La Grange "... has as yet not returned one dollar to General Motors that could be used to pay a dividend to a stockholder."© Charles E. Wilson, speech at EMD silver anniversary dinner, Chicago, October 24, 1947, GMI, folder 76-16.2 (quote).©

GM's willingness to reinvest EMC's profits in the company set it apart from ALCo and Baldwin, whose stockholders milked their companies for everything they could get.©

INGREDIENTS FOR SUCCESS AT EMC

By combining its innovations in manufacturing, marketing, and management with those of General Motors, EMC thus established a first-mover advantage during the

©Charles E. Wilson, speech at EMD silver anniversary dinner, Chicago, October 24, 1947, GMI, folder 76-16.2 (quote).

©Iron Age 140 (November 11, 1937), 85-9; Railway Age 105:19 (November 5, 1938), 680; Harlow H. Curtice, speech delivered at the American Institute of Consulting Engineers, New York, November 27, 1956, GMI, folder 83-1.9-60.
1930's that allowed it to dominate the diesel locomotive industry for the next fifty years. EMC switcher output increased from 80 units in 1937 to 137 in 1939 and 176 in 1941. By 1936, EMC had attained market dominance in the diesel locomotive industry. Thus, by 1940, even though steam locomotives far outnumbered diesels on American railroads, EMC had created a first-mover advantage that ALCo and Baldwin would never be able to overcome.62

Several conclusions are evident from GM's diesel engine research and development program during the 1930's. First, the federal government provided a strong incentive for diesel engine development, in the form of Navy contracts. GM itself admitted that "one big impetus for ... large multicylinder [diesel] engine development was the Navy contract of November 1932, the railroad application being something of a byproduct."63

Second, GM, which became the dominant power in the diesel locomotive industry for nearly half a century, very nearly did not participate in that industry at all.

If GM had purchased any diesel engine producer other than Winton, if Winton had not enjoyed a symbiotic relationship with Electro-Motive, if Hamilton had been a less persuasive advocate of diesel locomotives, if Budd had not been so insistent on having a diesel for his Zephyr, if Kettering had not been so intrigued by diesel technology, if Sloan had been more forceful in his attempts to "throw out" the diesel locomotive program -- if any one of these events had occurred, the world would likely never have heard of GM diesel locomotives.

Finally, these events show that the process of corporate diversification is neither straightforward nor predictable. GM has rightly been depicted as a leader in the formation of diversified, decentralized companies in the decades following 1920.64 Because of its leadership role and its status as the world's largest industrial corporation, it is tempting to assume that this diversification proceeded in a planned, orderly manner. For the locomotive industry at least, this was not the case. Decision-making power flowed through backchannels

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64See, for example, Alfred D. Chandler, Jr., Strategy and Structure: Chapters in the History of Industrial Enterprise (Cambridge: The MIT Press, 1962).
rather than through the official pathways of organizational charts. Wholly owned subsidiaries were often blissfully unconcerned with the needs of their parent company. Customers, like Ralph Budd, did more to push GM into the locomotive industry than did that company's top management. During the early 1930's, at least, historical accident and pure luck played roles as important as careful planning.
CHAPTER IV

MANAGERIAL FAILURE:
ALCo AND BALDWIN DURING THE 1930's

While the 1930's was a decade in which EMC did almost everything right, it was also a decade in which ALCo and Baldwin did almost everything wrong. Both companies acquired the capability to produce diesel engines, thus allowing them to manufacture two of the three basic components of a diesel locomotive. Yet, both failed to acquire the electrical equipment capabilities that would have allowed them to become completely integrated producers of diesel locomotives. In addition, executives at ALCo and Baldwin failed to recognize the importance of marketing services to success in the diesel locomotive industry in this critical decade. More seriously, these managers, imbued with a corporate culture based on steam locomotive production, refused to acknowledge the superiority of diesels or the extent to which they would have to modify their firms in order to compete successfully in the emerging diesel locomotive market. Nevertheless, as World War II
approached, ALCo at least had a real opportunity of establishing itself as a viable producer in the diesel locomotive industry.

CORPORATE CULTURE AT ALCo AND BALDWIN:
CONTINUED FAITH IN THE STEAM LOCOMOTIVE

The most important obstacles that prevented ALCo and Baldwin from establishing leadership roles in the diesel locomotive market were the beliefs and attitudes of the senior management of the two companies. These executives, even as late as the 1940's, were convinced that diesels would never replace steam locomotives in the mainline freight and passenger assignments that formed the bulk of railroad motive power needs. This belief, based on decades of experience in the design and production of steam locomotives, created a corporate culture that blinded executives at ALCo and Baldwin to the economic realities of dieselization.

ALCo executives believed that few significant improvements would ever be made in the realm of diesel locomotive technology, particularly in the all-important weight-to-horsepower ratio. In 1938, ALCo president William C. Dickerman thought that "... the technical
potentialities of the Diesel-electric locomotive are about the same as they were at the beginnings," and that "The possibilities of the Diesel-electric locomotive are already fixed and known ... not so with the steam locomotive." After dismissing diesels as a technological dead-end, Dickerman went on to list the improvements that would increase the "possibilities" of the steam locomotive. These improvements included roller bearings, integral steel castings, streamlining, superheaters, and coil springs. ALCo executives thus believed that they were committed to technological innovation, but this technological innovation was limited to marginal improvements in the familiar, traditional steam locomotive technology. Management's commitment to technological innovation did not extend to the development of radically new forms of motive power, such as diesels.1

In the opinion of ALCo managers, diesels would always be relegated to specialized applications, such as yard switching. In an April, 1938, address to the

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1Railway Age, 104:19 (May 7, 1938), 796-801 (quote).
Western Railway Club, Dickerman explained that "For a century ... steam has been the principal railroad motive power. It still is and, in my view, will continue to be." The next six years, when railroad demand for diesels far exceeded the industry's ability to produce them, modified management's views, but only slightly. When it became clear that railroads overwhelmingly preferred diesel switchers over steam, Dickerman told the president of the Louisville and Nashville that "No matter how hard it puffs, the steam switcher cannot compete with the diesel-electric switcher, and in its proper applications on the road the diesel-electric is a streamlined carrier of better service and lower cost." Still, he concluded that these "proper applications" were extremely few, compared to the widespread applications of the steam locomotive.

2William C. Dickerman, address to the Western Railway Club, April, 1938, quoted in: "General Motors Diesel Locomotives," Statement by C. R. Osborn, Vice-President, General Motors, before the Subcommittee on Antitrust and Monopoly of the U. S. Senate Committee on the Judiciary, Washington, D. C., December 9, 1955, 17.

3William C. Dickerman to J. B. Hill, July 9, 1941, L&N Records, box 1, folder A-15113 (quote).
In 1944, Duncan W. Fraser, Dickerman's replacement as president of ALCo, predicted that postwar foreign demand would be almost entirely for steam locomotives. Domestically, he believed that "Progress in steam locomotives has gone hand in hand with Diesel developments ... it is unlikely that there will be any one dominant type of locomotive, at least in the foreseeable future. Steam, Diesel, and electric, each have their advantages." ALCo produced its last steam locomotive four years later.4

ALCo executives thus consistently expressed an undying faith in the long-term survival of the steam locomotive on American railroads. In the early 1930's, when diesels were beset with genuine technological difficulties, such faith might have been caused by a lack of entrepreneurial vision, or a lack of confidence in the company's research and development staff. Ten years later, however, when diesels had proven themselves as equal to or better than steam locomotives, management retained similar views. Their faith in the steam

4*Railway Age, 116:7 (February 12, 1944), 369 (quote).
locomotive, then, was not caused by any inefficiencies in diesel locomotive technology, but by their lifelong education and training in the design and production of steam locomotives.

Between 1929 and 1945, when ALCo might have been laying the foundations for a massive investment in diesel locomotive production, it was guided by two chief executives who were well versed in the techniques of steam locomotive production, but who had little understanding of mass production, standardization, or internal-combustion technologies. Compounding this shortage of managerial talent was the absence of a chairman of the board of directors during the difficult years of the Great Depression. In 1933, William H. Woodin resigned that post to become treasury secretary in the new Roosevelt administration. The board of directors did not select a new chairman until 1940. This lack of concern for long-term strategic decision-making stemmed from the fact that ALCo, like Baldwin, virtually ran itself, with production and marketing techniques in the steam locomotive industry being little changed from those in use fifty years earlier. However,
this lack of leadership reduced ALCo's ability to compete in the emerging diesel locomotive market.\textsuperscript{5}

William C. Dickerman served as president of ALCo from 1929 to 1940, when he became chairman of the board of directors. He received a degree in mechanical engineering in 1896, and soon began his career at the Milton Car Works (later American Car and Foundry), where his father was the general manager. During World War I, he was put in charge of all ACF production, and became vice president in charge of operations in 1919. Through his career Dickerman "... demonstrated a life-long interest in the technical aspects of the [steam] locomotive, backed by his education as an engineer, in his work in behalf of technical societies, and in many appearances as a lecturer on the subject of railroad motive power."\textsuperscript{6}

Duncan W. Fraser, ALCo's president from 1940 to late 1945, and again from 1950 to 1952, joined the company in 1901. His first position was as an apprentice

\textsuperscript{5}Railway Age, 108:10 (March 9, 1940), 445, 452.

\textsuperscript{6}ALCo, 1940 Annual Report, 5; Railway Age, 108:10 (March 9, 1940), 445, 452 (quote); 120:2 (January 12, 1946), 146; 120:18 (May 4, 1946), 906.
at the Rhode Island Locomotive Works, and he transferred to the Montreal Locomotive Works three years later. He rose through the ranks at MLW, eventually becoming works manager, then MLW managing director. He gave up this post in 1920 to become ALCo's vice president in charge of manufacturing.\(^7\)

Baldwin executives shared the training, attitudes, and corporate culture of their rivals at ALCo. Until his death in February, 1940, the name most frequently associated with Baldwin was that of Samuel Vauclain. Vauclain, whose father had worked briefly for Matthias Baldwin, was born in 1856. He rose through the ranks of the Pennsylvania Railroad at Altoona, where he acquired a reputation as a resourceful and innovative manager. In 1882, when the railroad ordered 60 locomotives from Baldwin, Vauclain was sent along to supervise their construction. He joined the Baldwin organization in July of the following year as foreman of their 17th Street shops, where he soon reduced the work force by 35 percent, yet increased productivity through what he called

\(^7\)ALCo, 1954 Annual Report, 14; New York Times, February 26, 1954, 32; Railway Age, 120:2 (January 12, 1946), 146.
"mass production." This system bore little resemblance to the mass production that later characterized the automobile industry but instead involved more efficient scheduling of production and better employee utilization. He became a general superintendent in 1886, vice president in 1911, and senior vice president a year later. During World War I, he served as chairman of the Council of National Defense Locomotive and Car Committee and the Special Advisory Committee on Plants and Munitions of the War Industries Board. Vauclain was elected to the Baldwin presidency in 1919, a post he held until he was replaced by George H. Houston in 1929. Vauclain thereupon became chairman of the board of directors, and remained so until his death in 1940.8

Vauclain, who was ultimately responsible for the construction of some 60,000 steam locomotives, was thus firmly schooled in the nineteenth-century techniques of steam locomotive production. In his long tenure at

8Baldwin Locomotives 8:1 (July, 1929), 3; Railway Age 86:14 (April 6, 1929); 791-2; 108:6 (February 10, 1940), 282-3; Marvin W. Smith, Samuel Vauclain: Courageous Pioneer, Believer in America!, a Newcommen Address, The Newcommen Society, 1952; Samuel M. Vauclain, Mass Production Within One Lifetime, a Newcommen Address, The Newcommen Society, 1937, (quote).
Baldwin, Vauclain "... built up a fine body of engineers, superintendents, foremen, and workmen, to all of whom I sold my ideas..." Henry Ford could doubtless have made a similar assertion about his company during the 1920's. In 1920, Vauclain claimed that a good executive "... refuses to acknowledge the presence of trouble," and he certainly refused to acknowledge the trouble that diesels were about to bring to his company.10

In 1926, Vauclain conceded "... the established efficiency of modern internal combustion engines...," but concluded that "... it will be many years before the steam locomotive, owing to its simplicity, its serviceability, and its low production cost, will be relegated to the era of the past."11 In particular, he believed that a research and development program taking several years and costing millions of dollars would be

8Railway Age 108:6 (February 10, 1934), 282-3; Vauclain, Mass Production Within One Lifetime, 22 (quote).

10System 38 (November, 1920), 930 (quote).

11Baldwin Locomotives 5:1 (July, 1926), 43-9 (quote).
needed in order to produce a successful diesel locomotive. Baldwin of course had those millions of dollars, but it chose to spend them on dividends, rather than on research and development. A transcript of Vauclain’s June, 1930 address to the annual convention of the American Railway Association shows that he devoted three pages to steam locomotive development, and only one paragraph to diesels. He called the steam locomotive "... the greatest of all human devices" and concluded that "... we are just beginning to realize what actually can be done with the steam engine ... that will continue it in service, so that it can be more ably discussed in the year 1980 than at this convention in 1930."\(^{12}\)

As Vauclain made clear, other Baldwin executives were trained along similar lines, and most had similar opinions regarding the supremacy of the steam locomotive. In 1932, Baldwin vice-president Robert S. Binkerd, in a *Railway Age* article, concluded that steam

\(^{12}\) *Railway Age* 88:25D (June 25, 1930), 1548D140-4 (quote). After World War II, Baldwin and several other companies attempted to develop steam turbine locomotives. These were failures, however, since steam turbine technology proved better suited for larger applications such as ships and electrical generating facilities.
was the "modern" power and was suited to virtually all railroad applications. He did concede, however, that gasoline-electrics might be useful in light duty service and switching. Two years later, Baldwin described the Chicago-to-Milwaukee run of a Baldwin steam locomotive and concluded that "Steam Meets the Challenge" of the Burlington Zephyr and the Union Pacific M-10,000. In 1935, Baldwin published an article, "Muzzle Not the Ox that Treadeth Out the Corn," that convinced many in the railroad industry that Baldwin executives had completely lost touch with reality. In adapting a biblical passage (Deuteronomy 25-4), Baldwin stressed that steam was still far superior to diesels and cautioned railroad executives against heedlessly discharging the faithful iron horse that had served them well for the past 100 years.\(^1\)

Even after EMC's La Grange facility began manufacturing efficient standardized diesel locomotives, Baldwin executives continued to support steam propulsion.

\(^{13}\) *Railway Age* 92:25, (June 18, 1932), 1009-10; *Baldwin Locomotives* 13:2 (October, 1934), 12-17 (quote).

In 1936, Vauclain wrote that "... the last fifty years have enabled steam to gain supremacy over all other prime movers." A year later, Baldwin estimated that 94 percent of all railroad locomotives were "more or less obsolete" but believed that most of them would be replaced by steam, which will "... continue to be the mainstay of railroad operation for the indefinite future."

Westinghouse, Baldwin's supplier of electrical equipment, was not much more enthusiastic about the possibilities of the diesel. In 1926, A. H. Candee, general engineer for Westinghouse, predicted that diesels would not replace steam for a very long time, if ever. As late as 1942, Frank B. Powers, Manager of Engineering in the Transportation and Generator Division at Westinghouse, believed that "... it is most unlikely that [diesels] will exclude all other types of

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15 Baldwin Locomotives 15:1 (July, 1936), 12-17 (quote).

16 Railway Age 103:13 (September 25, 1937), 432-3 (quotes).
locomotives."

The directors of ALCo and Baldwin shared the steam-based corporate culture of top executives and were often either managers or directors of firms that were closely tied to the production and use of steam locomotives. Thus, even though these directors were often both highly respected and financially and politically powerful individuals, their long-standing business connections reinforced the tendency of their companies to continue to concentrate on steam locomotive production. Like the managers of the steam locomotive producers, these directors were content to "stay the course" by milking lavish dividends from their investments while making only marginal improvements in the production and marketing of proven steam locomotive designs.

ALCo's directors were linked to both the steam locomotive supply industry and the railroad industry. In addition to serving as president and as a director of ALCo, William Carter Dickerman was a director of the Montreal Locomotive Works, the Superheater Corporation

17 *Railway Age* 80:7 (February 13, 1926), 443-6; 112:14 (April 4, 1942), 704 (quote).
(manufacturers of steam locomotive feedwater heaters),
the Railway Steel Spring Company, the Canadian Steel
Tire & Wheel Company, the Shippers Car Line Corporation,
the American Car and Foundry Company, and the J. G.
Brill Company, and was a trustee of the Pacific Car and
Foundry Company. ALCo board member Lewis Latham Clarke
was on the board of directors of three railroads, and
was president of one of them. Vice-President and direc­
tor Duncan W. Fraser also held a seat on the boards of
the Railway Steel Spring Company, the Montreal Locomo­
tive Works, the General Steel Castings Corporation, the
Canadian Steel Tire & Wheel Corporation, and the
Dominion Steel & Coal Corporation. Banker Albert Henry
Wiggin served on the boards of three railroads. William
H. Woodin was president of the American Car and Foundry
Company and was also a director of the Cuba Railroad.
Charles Hayden devoted most of his efforts to oil, cop­
per, and steamships, but found time to serve on the
boards of ALCo and three New York subway companies.
John W. Griggs brought considerable legal experience to
the ALCo board of directors (he had been attorney gen­
eral during the McKinley administration), and was also
on the board of Bethlehem Steel.\textsuperscript{16}

The collective experience of board members at Baldwin was not substantially different. Like ALCo board member Charles Hayden, Baldwin director W. Hinckle Smith was a director of both the Kennecott Copper Corporation and the Utah Copper Company. Smith was also on the boards of directors of three railroads. Thomas Newhall, a partner in both J. P. Morgan & Company and Drexel & Company, had been president of the Philadelphia and Western Railway between 1910 and 1922 and held seats at Baldwin, the Midvale Company (suppliers of steam locomotive components), the General Steel Castings Corporation, and the Philadelphia & Reading Coal & Iron Company. Thomas S. Gates, who had also been a partner at both J. P. Morgan & Company and Drexel & Company, was

president of the University of Pennsylvania and a director of the Academy of Natural Sciences and the Pennsylvania Railroad. Conrad Newton Lauer was on the board of both Baldwin and the Federal Steel Foundry Company. William E. Corey, who had succeeded Charles Schwab as general superintendent of the Homestead Works in 1897, was on the boards of directors of several mining and metal processing companies, and was a member of the American Iron and Steel Institute.19

Many of the board members at ALCo and Baldwin were successful, respected business executives who were often leaders in the fields of manufacturing, transportation, and finance. Several, such as Thomas Gates at Baldwin, had a definite interest in engineering and the sciences. Yet the collective experience of these board members served to reinforce the traditional steam-based

corporate culture of ALCo and Baldwin and reduce the ability of those companies to enter the emerging diesel locomotive market. Many directors were familiar with the craft-based techniques of the foundry, techniques such as casting and machining. Others had ties to the railroad industry that helped to perpetuate the customer-driven marketing of custom products that characterized the steam locomotive industry. Few directors had any connection with the relatively new "high-tech" industries of internal combustion or electricity. As a result, the directors of ALCo and Baldwin, capable though they were, reinforced the steam-based corporate culture of company management during the 1920's and 1930's and provided little incentive for a radical redistribution of corporate assets into an aggressive diesel locomotive research, development, and marketing program.

ALCo BECOMES A SECONDARY PRODUCER OF DIESEL LOCOMOTIVES

Unfortunately for ALCo, a slow decline in locomotive orders during the 1920's was but a prelude to a drying up of demand in the 1930's. Between 1901 and
1910, ALCo sold an average of 2,000 locomotives per year. During the five years between 1931 and 1935, ALCo sold only 76 steam locomotives. In 1932, ALCo did not produce a single steam locomotive. The $29 million profit of the 1926-30 period turned into a loss of $13.3 million incurred between 1931 and 1935. The company also lost money in 1938 and 1939.20

The Great Depression forced ALCo to suspend dividend payments on the company's 7 percent preferred stock. When payments resumed in 1942, the arrearage had reached $15 million, or $42.75 per share. Nevertheless, ALCo executives could congratulate themselves on avoiding the fate of their principal competitor in the steam locomotive market. The Baldwin Locomotive Works found itself unable to service the huge debts that resulted from the construction of its massive steam locomotive production facility in Eddystone, Pennsylvania, in the late 1920's. Baldwin went through a lengthy

reorganization process between 1935 and 1937. Although ALCo avoided this financial embarrassment, Baldwin may have come out better in the long run, for the reorganization meant that ALCo's annual preferred dividend obligations were nearly ten times those of Baldwin.\textsuperscript{21}

As discussed in Chapter 2, General Electric's decision to manufacture its own carbodies and, ultimately, its own locomotives caused ALCo to purchase the McIntosh and Seymour Company in 1929. ALCo operated this company as a wholly owned subsidiary until 1938, when it was merged into the ALCo corporate structure. Prior to its acquisition by ALCo, McIntosh and Seymour had built only two diesel engines for railroad service, one of 750 hp and the other of 900 hp. Because its non-standard engines were designed primarily for marine and stationary service, ALCo had to rework extensively that company's engine designs.

In January, 1931, ALCo delivered its first locomotive powered with the new Model 330 engine. The company

\textsuperscript{21}Barron's, October 19, 1942, 20; The Magazine of Wall Street, 77:8 (January 19, 1946), 460.
built ten 300-hp switchers with this engine between January, 1931 and December, 1938. In addition, ALCo completed twenty-four 600-hp switchers, equipped with the larger Model 531 engine between June, 1931 and November, 1935. By 1935, diesel switchers were 20 percent of ALCo's locomotive output.22

By 1935, ALCo executives realized that its Model 330 and Model 531 engines, particularly the weak 300-hp version, were not well suited to railroad service. In that year, ALCo began a collaboration with A. J. Buchi to develop a new turbocharged engine. These tests, which lasted until 1939, eventually increased total horsepower by 40 percent. The first Buchi turbochargers were imported from Switzerland, but in 1940 ALCo acquired the production rights to this design; and shortly after the end of World War II ALCo began building turbochargers of its own design. By 1937, the first turbocharged Model 531 engine was ready to be installed in a locomotive.  

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This gave ALCo a distinct competitive advantage over Baldwin, whose first turbocharged engine (the Model 608) was not ready until 1946, and EMD, which did not offer a turbocharger until 1948 or 1949. Unfortunately, even though the Buchi design was basically sound, it failed to respond quickly to changes in engine speed and thus caused excessive smoking, a common characteristic of ALCo diesels. In addition, the very fast 10,300 rpm speed of the turbocharger resulted in numerous catastrophic failures and placed a premium on high-quality construction.23

ALCo, like Baldwin, was unfamiliar with the close manufacturing tolerances necessary to produce turbochargers, fuel injectors, and other critical parts. Steam locomotives did not require such close tolerances, and the fact they were largely custom-built removed the burden of precision from those who designed the locomotives to the skilled machinists who assembled them. In

any case, the need for precision in diesel locomotive production put ALCo at a distinct disadvantage, compared to Electro-Motive.

By the end of the 1930's ALCo developed improved diesel engine and locomotive designs. In 1940, ALCo built the first Model 244 engine, a distinct improvement over earlier designs. This engine made use of two-piece pistons and jacketed cylinder liners, innovations that later became standard industry practice, even though ALCo itself discontinued the latter system. In all, ALCo built some 4,000 Model 244 engines before replacing it with the Model 251 in 1953-54. ALCo put the Model 244 to immediate use by building 660-hp and 1,000-hp switchers for stock, a practice that was abandoned during World War II.24

Although standardized, these locomotives were not produced on an assembly-line basis. Photos of the Auburn engine plant show evidence of machining and custom fitting and indicate that the diesel engines were built at fixed work stations, rather than transported on

24 Diesel Railway Traction 15:348 (May, 1961), 191-7; Railway Age 108:24 (June 15, 1940), 1069; Garmany, Southern Pacific Dieselization, 182.
an assembly line. With this type of production system, it is not surprising that ALCo's diesel locomotive facilities were operating at full capacity, even though ALCo sold far fewer locomotives than EMD. In 1941, sales of diesels ($13 million) surpassed those of steam locomotives ($10.1 million), which should have given management an indication that diesel power should become ALCo's main priority. Nevertheless, that year's annual report contained four pictures of ALCo steam locomotives and only one photograph of a diesel.25

By 1940, although ALCo had a diesel locomotive line that was roughly similar to that offered by EMC, the two companies were by no means equal. ALCo's Model 244 engine was inferior to the EMC Model 547. ALCo introduced its line of high-powered yard switchers five years

25 Photographs and maps are especially useful in this context, since written descriptions of ALCo's diesel locomotive production facilities did not appear until after that company's postwar modernization program. The cover photo of the 1940 annual report illustrated what management considered the most important new development in the locomotive industry -- the use of alloy steel for steam locomotive siderods. ALCo, 1940 Annual Report, 4, 14-16; 1941 Annual Report, 6; Railway Age, 108:3 (January 20, 1940), 179; 108:12 (March 23, 1940), 570; 108:24 (June 15, 1940), 1069; 109:15 (October 12, 1940), 505-7; 110:6 (February 8, 1941), 276-9.
after EMC had done so. ALCo's 2,000-hp freight and passenger locomotives were introduced less than a year after EMC's FT, but they were poorly designed and were actually overpowered for the needs of the railroads in the early stages of freight dieselization. Whereas EMC was producing its own electrical equipment, albeit to a modified GE design, ALCo found it necessary to purchase these components from an outside supplier.26

In 1940, ALCo entered into a joint production agreement with GE, under which all diesel locomotives weighing more than 100 tons were to be produced jointly by the two companies. ALCo agreed to use GE electrical equipment exclusively. In 1950, the sales and service facilities of the two companies were consolidated, largely under GE's control. The agreement, which was terminated in 1953, allowed GE to continue the manufacture of small diesel locomotives and made no provision for a division of the export market. The first locomotives built under this agreement were 2,000-hp

passenger units, each powered by two ALCo Model 539 engines.\textsuperscript{27}

While the 1940 joint production agreement gave ALCo a reliable supply of electrical equipment and temporarily prevented GE from entering the large diesel locomotive market, it also retarded ALCo's ability to develop its own marketing capabilities. Given the limited importance of marketing in the steam locomotive industry, it was hardly surprising that ALCo allowed GE to assume a large portion of its marketing efforts in the diesel locomotive industry. Nevertheless, by assigning advertising, sales, training, repair, and servicing responsibilities to GE, ALCo divested itself of the very organizational strengths that contributed to success in the diesel locomotive industry. Furthermore, because GE's marketing staff had no innate loyalty to ALCo, they could, and soon did, use these marketing capabilities to enter the large diesel locomotive market as a direct competitor against ALCo.

\textsuperscript{27}Diesel Railway Traction 15:348 (May, 1961), 191-7; Railway Age 108:24 (June 15, 1940), 1069; Garmany, Southern Pacific Dieselization, 182.
ALCo's initial success in the diesel locomotive market was overwhelmed by EMC's expanded production at La Grange. In 1934, ALCo had a 73 percent share of the American diesel locomotive market, and a year later its share had risen to 83 percent. The year 1935 also marked EMD's official entry into the diesel locomotive market, with the construction of its fully integrated La Grange facility. The following year, ALCo's market share fell to 23 percent. ALCo never fully recovered from this rapid, catastrophic collapse of its market share. With the exception of only one year, 1946, ALCo never again attained more than 26 percent of the market, and remained a poor second to EMD throughout its remaining years as a locomotive producer.28

The depression did not cripple ALCo, but it was the beginning of the end for ALCo's involvement in the diesel locomotive industry. The financial extravagance of the 1920's, combined with the pro-steam attitude of ALCo's management, prevented the company from making the

needed investments in production, marketing, and management vital for success in this developing industry. The window of opportunity for successful penetration of the diesel locomotive market was very narrow, perhaps no more than five years. Before the mid-1930's, diesel locomotive technology was too primitive for widespread application. After the late 1930's, EMD had attained an enormous first-mover advantage. Financially moribund ALCo, by failing to make the necessary investments in manufacturing, marketing, and management during the crucial mid-1930's, greatly reduced any possibility of assuming leadership in the diesel locomotive field.

FINANCIAL AND MANAGERIAL CRISES AT BALDWIN

While ALCo was at least moving in the right direction as the 1930's came to an end, Baldwin was without direction, reeling from a difficult financial reorganization and burdened with a management that cared even less for diesels than their counterparts at ALCo. As a result, it was clear, even by the early 1940's, that Baldwin would never be a major player in the diesel locomotive industry. Nevertheless, the company
continued to waste its resources on diesel-locomotive production until 1957. In so doing, it gave up any opportunity that it might have had to become a successful producer of non-locomotive products.

In spite of the Great Depression, Baldwin continued its diversification into related product lines. In 1929, when the Whitcomb Company, in which it already held a majority interest, ran into financial problems, Baldwin found it necessary to purchase all of the remaining outstanding preferred stock. In 1931, Baldwin purchased all of the assets of Cramp-Morris Industrials, which included the Pelton Water Wheel Company, Cramp Brass and Iron Foundries, the Federal Steel Foundry Company, and I. P. Morris and De La Vergne. In the same year, Baldwin established the Baldwin-Southwark Corporation, and placed the Pelton Company and the Southwark Foundry and Machine Company in its new subsidiary. Baldwin also assigned De La Vergne to this subsidiary, thus organizationally isolating its diesel-engine production from its locomotive production.

As Baldwin had intended, this diversification reduced its dependence on locomotive orders, which were
only 30 percent of total sales in 1930, and a scant 13 percent in 1933. However, Baldwin's control of Cramp Foundries, Federal Steel Foundry, and 22 percent of General Steel Castings, ensured that the company still had a strong vested interest in the older technologies of steam locomotive production, rather than the modern technologies of electricity and internal combustion that were essential to success in the diesel locomotive industry.29

In any case, Baldwin's diversification did not save the company from bankruptcy during the 1930's. Sales of locomotive products dropped from just over $31 million in 1930 to barely $1 million in 1933. Railroad orders increased somewhat in 1934, thanks to existing Reconstruction Finance Corporation loans and a new infusion of Public Works Administration funds, but Baldwin's locomotive business was losing money at an unprecedented rate. Dividends from the still-profitable Midvale

29Of course, the fact that locomotive orders made up less than a third of total business was also partly a result of the fact that few railroads were willing to order steam locomotives during the depression. Baldwin Locomotive Works, 1931, 1932, 1933, 1934 Annual Reports; Baldwin Locomotives 10:3 (January, 1932), 21-34.
Company and the Standard Steel Works Company helped, but they were not enough. The company as a whole lost money every year from 1931 through 1935. Baldwin stock, which hit an all-time high of $285 per share in 1928, split 4-to-1 in 1929 at $71.25, but sold for $1.50 a share in 1935. Dividends on the 200,000 outstanding shares of 7 percent preferred stock were suspended on July 1, 1931. The evaporation of working capital caused by massive losses in locomotive sales forced Baldwin to borrow additional funds. By mid-decade, Baldwin had two bond issues outstanding: $2,676,000 worth of 5 percent, 30-year bonds, due May 1, 1940 and $10,435,000 of 6 percent, 5-year bonds due March 1, 1938.³⁰

On March 1, 1935, Baldwin was unable to pay the $313,000 interest due on the 6 percent bonds. Six days later, the annual meeting of the foundering company had to be disbanded because a quorum could not be obtained. The 6 percent bondholders established an eight-member

protective committee, which included Samuel Vauclain. However, dissident bondholders soon established a separate protective committee, which was sharply critical of the company's efforts to regain solvency. On June 19, 1935, the dissident protective committee, claiming that Baldwin had sufficient money available, petitioned the U. S. District Court in Philadelphia to order the company to pay the interest on its 6 percent bonds.31

Even worse, on April 11, 1935, the newly formed Securities and Exchange Commission issued a series of allegations against Baldwin. The SEC charged that the trustee of the 5 percent first mortgage bonds had made little effort to protect the bondholders. In addition, the SEC thought that Baldwin had used poor accounting practices, with the result that its consolidated financial statements painted a healthier financial picture than was in fact the case. These allegations at the

very least embarrassed Baldwin still further and made it even more difficult to obtain outside capital.\textsuperscript{32}

In spite of these difficulties, on August 8, 1935, Baldwin filed a reorganization plan that reduced fixed interest payments from $1.3 million to $133,800 per year. Baldwin emerged from bankruptcy court in 1937 and completed its reorganization in September, 1938. Even though it lost money in 1938, it earned a profit in 1939 and since its bankruptcy had staged what \textit{Business Week} called "... one of the most spectacular comebacks in financial history."\textsuperscript{33} However, Eddystone was still operating at only a fraction of capacity; and, more importantly, while Baldwin's insolvency had awakened the company to the need for sweeping changes, these changes occurred too late to prevent its ultimate failure in the diesel locomotive industry.\textsuperscript{34}

Not surprisingly, one of the first changes to occur after Baldwin's bankruptcy was a purge of that company's


\textsuperscript{33}\textit{Business Week}, June 8, 1946, 66-8 (quote).

\textsuperscript{34}Baldwin Locomotive Works, 1938 & 1939 annual reports.
top management. This offered Baldwin a wonderful opportunity to create new business strategies and a managerial structure that would wholeheartedly embrace the advent of the diesel, but this step was not taken. Instead, while the new executives were more receptive to diesels than their predecessors, they still viewed Baldwin primarily as a producer of steam locomotives. In March, 1938, the company elected a new twelve-member board of directors that included Samuel Vauclain. George H. Houston resigned the presidency in September, 1938, replaced by Charles E. Brinley. Houston had been respected in the capital goods industry to such an extent that in 1934 he was appointed chairman of a committee of the National Recovery Administration, representing the entire capital goods industry. His expertise was not confined to the locomotive industry, however, as he had worked at the Fisher Body Company until 1929. His tenure in the automobile industry apparently did not teach him any of the lessons learned by Hamilton at the White Motor Company.\(^{35}\)

\(^{35}\)The Fisher brothers purchased a block of 120,000 shares of Baldwin stock in 1927, largely to have some measure of control over the production of large hydraulic sheet metal stamping presses at the Southwark Company. \textit{Business Week}, June 8, 1946, 66-8; \textit{Railway Age
Houston's successor as president of Baldwin, Charles E. Brinley, was somewhat better suited to the demands of the emerging diesel locomotive industry, but not much. He graduated from Yale, with a degree in mechanical engineering, in 1900, and from the Sheffield Scientific School a year later. Brinley joined the American Pulley Company in 1901, and became its president in 1919. He remained as president of that company until 1938, when Baldwin decided to make a fresh start with new management. Brinley also served for a time as director of the National Association of Manufacturers. However, he lacked contacts in the railroad industry and experience in the technologies of electricity and internal combustion.36

In addition, many of Brinley's subordinates were still firm believers in steam locomotive technology. For example, William H. Winterrowd, who became vice

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96:11 (March 17, 1934), 388; 104:11 (March 12, 1938), 475-6; 105:10 (September 3, 1938), 354-5; Baldwin Locomotive Works, 1938 annual report.

36 *Baldwin Locomotives* 17:3&4 (February, 1939), 3; 20:3 (October, 1943), 8; *Railway Age* 105:27 (December 31, 1938), 951, 4.
president in charge of operations for all of Baldwin except the Midvale Company in January, 1939, began his career as a locomotive wiper, blacksmith's helper, and roundhouse foreman. He earned a B.S. in mechanical engineering from Princeton in 1907, and a Ph.D. in engineering from Purdue in 1936. From 1918 to 1923, he was chief mechanical officer on the Canadian Pacific Railway, a position that gave him a wealth of experience about steam locomotives, but taught him virtually nothing about internal combustion. He joined the Lima Locomotive Works in 1923, and served as vice president of that company from 1927 to 1934. Between 1935 and 1939, he was vice president of the Franklin Railway Supply Company, another firm committed to the survival of the steam locomotive. His influence on Baldwin was limited, since he was killed in an auto accident on December 7, 1941. Nevertheless, the presence of such executives at a critical period in the development of both the Baldwin Locomotive Works and the diesel locomotive industry did not bode well for that company's future success.37

37Baldwin Locomotives 17:3&4 (February, 1939), 4; Railway Age 106:5 (February 4, 1939), 247; 111:24 (December 13, 1941), 1006; Baldwin Locomotive Works,
In spite of the ongoing commitment of Baldwin executives to steam locomotive technology, the company decided to enter the diesel locomotive field on a regular production basis. Even under the company's old management, its De La Vergne subsidiary had been experimenting with new diesel engine designs. By 1935, it was ready to begin tests on the Model VO. This four-cycle engine was originally designed for stationary service and was far inferior to the ALCo Model 244 and the GM Model 567. In late 1936, Baldwin completed its first production prototype, a 660-hp locomotive that employed a 6-cylinder Model VO engine and Allis-Chalmers electrical equipment. Its frame was a steel casting that, unlike later EMC production units, was heavy, expensive, and prone to cracks. However, it is not surprising that Baldwin chose casting rather than welding, since that was the technique commonly used in steam locomotive construction. In addition, Baldwin owned 100,800 shares of General Steel Castings Corporation, the company that cast the frames, another example of how Baldwin's 1938 & 1941 annual reports.
diversification during the prosperous 1920's ultimately reduced its chances of being a successful competitor in the diesel locomotive industry. Because EMC held the patent rights to the unit fuel injector, the Baldwin engines, like those manufactured by ALCo, used the Bosch fuel injection system, thus making repair and replacement more difficult.38

Baldwin soon offered 660-hp and 900-hp models of a standard design. These typically used Westinghouse electrical equipment, although the products of other manufacturers could be substituted at the request of the customer. Initially, these switchers were built for stock; but, as was the case at EMC and ALCo, this practice ended with the advent of World War II. Baldwin spent some $2 million to put its switchers into production. This was a small fraction of the funds being poured into EMC, but it was about all Baldwin could

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38Baldwin had paid $5,002,950 for its stock in General Steel Castings. Baldwin Locomotives 15:2 (October, 1936), 3-8; Railway Age 101:21 (November 21, 1936), 746-8; Baldwin Locomotive Works, 1935 annual report; GM-EMD, "Conference Leader's Outline," Subject III, Unit 18, 39, 43-4; Kirkland, Dawn of the Diesel Age, 43-4, 151.
afford, given its recent bankruptcy and its injudicious dividend policies of the 1920's.38

Still, Baldwin was not particularly anxious to sell the diesel locomotives that it offered. One railroad executive recalled that "The representative of the Baldwin [Company], in conversation with me, stated that during the development of the Diesel locomotives they were marketed at a considerable loss, and that his management had expressed the thought that they were in the locomotive business for a profit, and therefore they have not been as aggressive as some of the other manufacturers."40

As discussed in Chapter 3, EMC of course did not become profitable until 1940, but Baldwin was reluctant, though not completely unwilling, to sell diesel locomotives at a loss. Naturally, if top management instructed its

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38Baldwin Locomotives 17:2 (October, 1938), 17-9; 18:3&4 (February, 1940), 31-3; Railway Age 107:24 (December 9, 1939), 906; 107:27 (December 30, 1939), 992-5, 998; Railway Mechanical Engineer, February, 1940, 56-60, 64; Kirkland, Dawn of the Diesel Age, 187.

40W. E. Smith to J. B. Hill, August 23, 1939, Louisville and Nashville Railroad Collection at the University of Louisville (record group 123, hereafter referred to as the L&N Records), box 1, folder A-15113 (quote).
salesmen to sell as few diesel locomotives as possible, business was unlikely to grow at a rapid rate.

By the end of the 1930's, Baldwin's new management was somewhat more interested in diesel locomotive sales than their predecessors had been. In 1940, they admitted that "Prior to 1939 The Baldwin Locomotive Works had never made any very active effort to put itself in the position of a builder of competitive Diesel switching locomotives." They also claimed to be "alert to the growing demand for diesel power," even though their company had been producing this power for the past sixteen years. The February, 1940 issue of Baldwin Locomotives was devoted to diesel locomotives and, fittingly, was also the issue that carried Samuel Vauclain's obituary. Still, articles in the Baldwin company magazine that asked railroads to "estimate the savings" from dieselization could not save Baldwin from its own management. In May, 1940, Baldwin transformed the De La Vergne Engine Company into the Baldwin De La Vergne Sales Corporation. Even worse, in September, 1939, Baldwin transferred the sales and engineering staff of the Whitcomb Locomotive Company from Eddystone to Rochelle, Illinois. These employees, who were
rapidly gaining experience in the production and marketing of larger and larger gasoline locomotives, would have been immensely valuable to Baldwin's diesel locomotive program.41

By 1940, Baldwin was a participant in the diesel locomotive industry, but just barely. Baldwin failed to design and manufacture an acceptable product. The company instructed its sales agents not to market that product. Baldwin's management squandered the company's assets in the 1920's, led it into bankruptcy in the 1930's, and showed virtually no interest in the potential of the diesel locomotive. By 1940, opportunities were narrowing for Baldwin, but its executives chose not to see this reality. They could have made a gradual, graceful exit from the locomotive industry by moving into related product lines. By failing to do so until 1959, they wasted company resources that could have been put to better use. Even though it was an early producer

41On May 31, 1940, Baldwin purchased the last 8.05% of the outstanding stock of the Whitcomb Locomotive Company, thus making it a wholly owned subsidiary. Baldwin Locomotives 18:1&2 (October, 1939), 10; 18:3&4 (February, 1940), 5-8 (quotes); Baldwin Locomotive Works, 1939 & 1940 annual reports.
of internal combustion locomotives, Baldwin's failure to invest in manufacturing, marketing, or management during the critical decade of the 1930's ended any possibility of success in the diesel locomotive industry.

THE WINDOW OF OPPORTUNITY CLOSES FOR ALCo AND BALDWIN

By failing to construct and equip facilities dedicated to diesel locomotive production, create their own marketing and post-sale support networks, and alter radically their steam-based corporate culture, executives at ALCo and Baldwin during the 1930's seriously eroded the ability of their firms to ever emerge as effective competitors in the diesel locomotive industry. The five-year window of opportunity created by advances in diesel engine technology extended only from 1933 to 1938, and was almost certainly closed by 1940. Because EMC established a viable corporate culture and made coordinated investments in manufacturing facilities and marketing networks during the 1930's, it quickly became the industry leader and established substantial first-mover advantages. ALCo and Baldwin did not make comparable investments and throughout their existence as
diesel locomotive producers continued to struggle against the barriers to entry established by EMC.

The corporate culture that had made ALCo and Baldwin successful steam locomotive producers prior to 1930 also helped make them unsuccessful diesel locomotive manufacturers afterwards. Executives at these two companies had little difficulty supplying the limited long-range strategic planning necessary for survival in the steam locomotive industry. The informal, customer-driven production and marketing requirements of that industry had worked well for many decades. It was true that steam locomotive orders declined precipitously during the depression, but this was to be expected in a feast-or-famine industry. Also, to be fair, one might say that ALCo and Baldwin had been burned before. Elaborate promises by the proponents of electrification in the early 1900's had not come to fruition, and perhaps dieselization would eventually suffer the same fate. Finally, throughout the 1930's, executives at ALCo and Baldwin could point to the fact that some railroad executives shared their belief that steam locomotives would retain their dominance for years to come, thus seemingly justifying their own faith in steam power.
Nevertheless, the inability of executives at both ALCo and Baldwin to accept the mounting evidence of the superiority of diesels over steam bespeaks a serious managerial failure. Because they did not modify their corporate culture, these executives could not respond adequately to the growing potential of diesels, or even acknowledge that diesels had potential. The comfortable assumption that a feast of steam locomotive orders was inevitably followed by a famine, followed by another feast, seemed to explain the catastrophic effect of the depression, but could not rationalize permanent declines in steam locomotive demand. Because managers at ALCo and Baldwin refused to acknowledge the superiority of diesels, they erroneously attributed declining steam locomotive orders in the 1930's to a lack of railroad income, rather than to a lack of railroad interest. As such, their training, personal beliefs, and values interfered with basic sound business strategy, and placed the future of these two firms very much in doubt. This was true not only because of the advancing juggernaut of EMC, but also because the crisis of the Great Depression was about to give way to the far different crisis of World War II.
CHAPTER V

WORLD WAR II: RESTRICTIONS AND OPPORTUNITIES

World War II temporarily stemmed the decline of the established steam locomotive producers but had little long-term impact on the structure of the diesel locomotive industry. As Europe and later the United States became embroiled in World War II, American railroads faced unprecedented traffic demands. Western railroads in particular struggled to accommodate the massive movements of troops and material that accompanied the Pacific campaigns. They were anxious to obtain diesel locomotives, which were the most efficient motive power available. The rigorous wartime service that followed removed any lingering doubts in the minds of railroad executives about the superiority of the diesel.¹

Railroads did not purchase as many diesels as they wanted during World War II, however, because the War Production Board held diesel locomotive production to an artificially low level. Diesels, with their electrical equipment and specialty alloy steel components, required far more strategic materials than did steam locomotives. Despite postwar claims to the contrary, WPB restrictions showed little favoritism to EMD or any other builder. In actuality, these restrictions gave a last breath of life to the dying steam locomotive industry and even persuaded some in that industry that the steam locomotive would be reborn in the postwar period. In addition, wartime constraints gave marginal builders like Baldwin an opportunity to sell far more diesel locomotives than would have been possible under normal conditions.

Because the federal government had little long-term impact on the structure of the American locomotive industry, the collective experience of the locomotive producers during World War II indicates that the presumed power of government to influence business during wartime may be overrated. Historians, such as John Morton Blum, have suggested that some firms, such as
Coca-Cola, Wrigley's and Henry Kaiser's Six Companies consortium, used the war to their advantage. This is undoubtedly true, but this "manna-from-heaven" experience did not occur in every industry. For the locomotive industry, neither the war nor the War Production Board had much impact, other than to delay the dieselization of American railroads by a few years.

Because it was a part of the traditional manufacturing sector, the locomotive industry lacked the rapid growth potential of consumer goods (like soft drinks and chewing gum) and could hardly be considered as important as the high-tech, high-priority synthetic rubber program. As a result, the locomotive industry, like many others, neither benefited nor suffered from its interaction with the federal government during World War II.²

World War II greatly stimulated the production of diesel engines for railroad locomotives and for a myriad

of other purposes. The diesel engine industry as a whole, which had produced 2 million horsepower in 1936, turned out fifteen times that amount in 1945. In 1940, 1,111 diesel locomotives were in service on American railroads, representing 1 million horsepower. By 1945, 2,864 diesels were in service, with an aggregate of 4 million horsepower. At this time, there were still some 40,000 steam locomotives in the United States. Diesel locomotive orders for domestic service increased from 160 in 1938 to 937 in 1941. Government restrictions then caused a decline in orders, to 894 in 1942 and 670 in 1944. Locomotive prices increased as well; a 1,000-hp switcher that cost $79,000 in 1941 cost $10,000 more in 1946.

Most of these new diesel locomotives were assigned to the overburdened western railroads, already struggling to cope with mountainous terrain, heavy traffic, and an arid climate. By 1944, diesels were responsible for 13.5 percent of the freight locomotive mileage on western railroads, a figure that far exceeded that of eastern and southern lines.³

³Railway Age 118:20 (May 19, 1945), 888; 122:1 (January 4, 1947), 78; Diesel Engine Manufacturers Association, Diesel Locomotives, Chicago, 1945, Associ-
MANUFACTURING AND MANAGERIAL INNOVATIONS AT EMD

For Electro-Motive, World War II was both a blessing and a curse. The war greatly increased its diesel-engine sales, especially for marine use. However, wartime restrictions reduced its share of the locomotive market and gave a temporary advantage to its competitors. The war also forced EMD to adopt standardized production procedures to accompany its standardized designs. This transformation was ultimately of great benefit to the company in the postwar period. Finally, World War II saw an influx of new managerial talent from General Motors, talent that was essential to EMD's expanding organizational capabilities. Before World War II, EMC's flexible corporate culture allowed considerable latitude for experimentation and local control. By the end of the war, however, this culture had...
been replaced by another, one that changed EMD into a more rational and predictable business enterprise, and recognized EMD's need to take its place in the larger GM corporate hierarchy.

On January 1, 1941, the Electro-Motive Corporation was reorganized as the Electromotive Division of General Motors (EMD), largely because GM officials realized the potential for diesel engine sales in a world bent on war. At this time, EMD was directing its efforts more toward marine diesels than to locomotives. In 1937, Navy officials had asked GM's Research Laboratories to design a compact, lightweight engine suitable for a wide variety of naval applications. GM's efforts resulted in the Model 184 "pancake" engine, so called because the horizontal cylinders were arranged in four tiers of four cylinders each, like a stack of pancakes. This 1,200-hp engine had a then-unheard of weight of just four pounds per horsepower. The Navy accepted the first Model 184 engine in October, 1940, and put it through its first sea trials the following June. EMD ultimately produced 554 pancake engines. The division also supplied 2,100 conventional Model 567 engines to the Navy, primarily for use in landing craft. In all, General Motors sold
the Army and Navy 198,000 diesel engines during the war years.4

The increased military demand for marine diesel engines led to huge expansion programs at La Grange. For example, between January, 1942 and January, 1943, EMD enlarged its Model 567 manufacturing facilities by 125 percent. During the war, EMD spent $14 million to add 400,000 square feet of manufacturing space, which would be used after the war. For the duration, however, EMD was still overburdened and often short of key materials and components. Locomotive production necessarily suffered as a result, and, according to management, "... the demands of the Army and Navy for engines

and other equipment resulted in the curtailment and eventual discontinuance of locomotives..." Locomotive production stopped entirely during the first four months of 1943. After that, the increased availability of machine tools, combined with the demands of railroad executives for EMD locomotives, convinced the War Production Board to allow locomotive manufacture to resume. In 1944, the WPB increased EMD locomotive production quotas. Still, EMD lost market share during the war, from 67 percent of the diesel locomotive market in 1940 to 51 percent in 1945.6

Intense wartime demand also placed a premium on production efficiency, and it was here that EMD used the war to its greatest advantage. Before America's entry into the war, EMC had standardized locomotive designs, but had not standardized locomotive production. "Piece
by piece" construction and the use of "hand methods" predominated. Welders and other locomotive assembly workers approached each locomotive as if it were a unique design. On-the-spot measurements were far more common than the use of jigs and fixtures. EMC diesel locomotives incorporated many of the craft methods embodied in their ALCo counterparts. In other words, as shown in Chapter 3, during the 1930's EMC acquired market dominance through the effective marketing far more than through efficient manufacturing. Still, EMC's production methods during the 1930's were considerably more advanced than those at ALCo or Baldwin.7

Not until it was faced with unprecedented demand did it fully adopt mass production techniques. EMD used its WPB-mandated exclusion from the locomotive industry in early 1943 to plan for mass production and to rearrange the facilities and tools at La Grange for the assembly-line production of locomotive subassemblies. EMD also reduced the skills needed to assemble a locomotive by creating a system of jigs and fixtures. These

7EMD, "Conference Leader's Outline," Subject III, Unit 3C, 11-12 (quotes).
were based on weld-shrinkage statistics that had been compiled at La Grange since the facility opened, as well as on a detailed examination of the durability of weld joints on wrecked locomotives. EMD developed a just-in-time production and inventory system to allocate the more than 70,000 separate parts that comprised a typical diesel locomotive. Later in the war, it constructed separate buildings for the repair and rebuilding of parts and locomotives in order to avoid interference with regular production lines.

Because of EMD's improvements to production facilities and techniques, output increased dramatically. Within six months, freight locomotive production had increased by half, using the same floor space and only a few more employees. By late 1944, EMD was completing two locomotives per day at La Grange, a figure that would more than triple by 1950.8

Because GM understood that its corporate structure must conform to its corporate strategy, the company

revamped EMD's managerial structure during the war.*

The creation of the new Electromotive Division in 1941 was the most obvious sign of this transformation. The new division established a line-and-staff organization, with decisions flowing downward through the ranks of factory manager, production superintendents, shift superintendents, general foremen, and shop foreman. The Accounting, Defense Coordination, Engineering, Industrial Relations, Inspection, Material Supply, Sales, and Service Departments performed general staff functions.

In addition, new management training programs encouraged employees to "Develop a simple definition of management," and to come up with a list of managerial objectives. By creating an extensive managerial structure, EMD enhanced its ability to respond to changing customer demands and to devise improved production and marketing

*GM, along with DuPont, did much to replace the older unitary style of corporate management with a more flexible diversified and decentralized multidivisional corporate structure. For a comprehensive overview of this process, see: Alfred D. Chandler, Jr., Strategy and Structure: Chapters in the History of the American Industrial Enterprise (Cambridge: The MIT Press, 1962).
As part of its corporate restructuring, EMD acquired new managerial talent from General Motors. Cyrus R. Osborn transferred from GM's Allison Division in 1943 to become a GM vice-president in charge of EMD. Osborn was the first EMD executive to have climbed the traditional corporate ladder. Born in 1897, he earned a degree in mechanical engineering from the University of Cincinnati in 1921, and joined DELCo in the same year. In 1925, he became General Manager of the GM Overseas Motors Service Corporation, and later served as general manufacturing manager for GM's Export Division. Between 1932 and 1934, Osborn was general manager of GM's Swedish subsidiary, GM Nordiska. In 1937, he became general manager of GM's German subsidiary Adam Opel, a position, as war approached, with limited future growth potential. In 1941, he became assistant to R. K. Evans, GM vice-president in charge of the General Engines

\footnote{EMD, "Conference Leader's Outline," Subject IV, Unit 1 (quote) & Unit 2, GMI, folder 76-1.61.}
Group, a group that included EMD.\textsuperscript{11}

Other GM managers assumed senior positions at EMD. In early 1944, William O. Nelson, who had once been GM's director of purchases in Washington, D.C., transferred from DELCo to EMD to assist in implementing the new production techniques. In June, 1945, Nelson C. Dezendorf became the new director of sales at EMD. After graduating from the University of Oregon and the University of California with degrees in engineering, he began his career at GMAC in 1922. By 1927, he was manager of the Seattle office, and he became a GMAC vice-president four years later. In 1933, he developed a successful new GMAC financing plan.

As the appointment of these executives indicate, EMD reached a managerial turning point during World War II. GM realized that its once-neglected subsidiary had enormous potential and sought to protect and enhance that potential by replacing the manager-technicians at

EMC with true corporate men who were schooled not only in the practicalities of internal combustion technology but who also understood that EMD was subservient to the larger goals of GM corporate policy. Hamilton was no longer in control at EMD, though he continued as a GM vice-president. Other holdovers from the early days, such as Richard Dilworth, stayed on, but they had little influence over long-term corporate strategy.\footnote{\textit{Railway Age} 132:11 (March 17, 1952), 90-1; Reck, \textit{On Time}, 159-61.}

ALCo and Baldwin continued to be managed by technicians and master craftsmen until the late 1950's, however, and this continuity seriously damaged the competitive efforts of these two companies. Managers at ALCo and Baldwin understood their technology well, but this was the outdated technology of steam locomotive production. In addition, the technician-managers at the steam locomotive producers, unlike their counterparts at EMD, failed to understand the importance of innovative marketing techniques.

The manufacturing and managerial reorganizations at EMD prepared it well for the postwar dieselization
change-over. In spite of their commitment to the diesel, even EMD executives underestimated the speed with which this transformation took place. For example, EMD predicted that 20 percent of the postwar locomotive demand would be for steam locomotives, with the remainder for diesels. In reality, once freed of wartime productions, EMD quickly regained the market share that it had lost during the war. Because of wartime demands, EMD had become by far the most efficient producer in the industry and easily bested the efforts of Baldwin, Lima, and Fairbanks-Morse, a new entrant into the field. ALCo was a more formidable competitor, however, partly the result of its wartime experience.\textsuperscript{13}

\textbf{ALCo TEMPORARILY BENEFITS FROM WARTIME RESTRICTIONS}

World War II restored ALCo to prosperity but had little long-term impact on the company's position in the diesel locomotive market. Wartime controls on

\textsuperscript{13}EMD, "Conference Leader's Outline," Subject II, Unit 1, GMI, folder 76-1.59.
locomotive production temporarily allowed ALCo to gain market share at the expense of EMD. Once these controls were lifted, however, EMD quickly regained its former dominance. In April, 1942, the War Production Board allocated production of specific diesel locomotive types -- 5,400-hp freight, 2,000-hp freight, 1,000-hp road switchers, 1,000-hp yard switchers, and 600 to 660-hp yard switchers -- to certain builders. The WPB allowed ALCo to produce locomotives in four of these categories. Furthermore, the 5,400-hp freight locomotives, which only EMD was authorized to produce, were similar to the 2,000-hp freight locomotives produced by ALCo. WPB production restrictions thus did not give a competitive advantage in any segment of the diesel locomotive market to either builder. 14

The WPB placed no restrictions on the development of new diesel locomotive technology during the war, and

14"Title 32 - National Defense, Chapter IX - War Production Board, Subchapter B - Division of Industry Operations, Part 1188 - Railroad Equipment, General Limitation Order L-97," April 4, 1942; Summary of Meeting, Producers of Large Diesel Locomotives Industry Advisory Committee, November 10, 1943, Box 2162, both in the records of the War Production Board, National Archives (Record Group 179, hereafter referred to as the WPB Records).
ALCo finally began to make a concerted effort to design engines of sufficient quality and dependability to compete with those produced by EMD. The fact that EMD's La Grange facility was operating at full capacity, combined with the potential for diesel-engine sales to the Navy, undoubtedly influenced management's decision to invest in the new research and development program. In 1943, ALCo completed development of its Model 244 engine, which became its mainstay during the postwar dieselization boom. Thus, "When World War II ended and the railroads flooded manufacturers with orders for diesel-electric locomotives, ALCo was ready with its high-output engine."¹⁵

ALCo claimed that the Model 244 had "... characteristics well in advance of those of any other railway four-stroke oil engine..." This may have been true, but the Model 244 was markedly inferior to EMD's Model 567, which was a two-stroke engine. In a 1945 report to its stockholders, ALCo claimed that its postwar locomotives were "... a direct outgrowth of war-time research and experience." Still, the same shareholders report

¹⁵Alco Review, Spring/Summer, 1959 (quote).
concluded that "There seems little doubt that great advances will be made in the development of coal-burning steam locomotives during the next decade" — a juxtaposition that clearly indicates the true source of ALCo's difficulties in the diesel locomotive market. Thus, during and immediately after the war, ALCo still hoped to attain market dominance in the diesel locomotive industry.

ALCo diesel locomotives were technologically inferior to EMD units. ALCo's 1,000-hp switcher was over-rated, and often actually developed as little as 850 hp. In addition, it suffered from higher fuel and lubricating oil consumption than EMD units. Even before WPB restrictions went into effect, the Louisville and


Nashville favored EMD diesels. They could be used interchangeably with EMD locomotives that had already been purchased; and, in any case, the larger ALCo units were too heavy for the railroad's bridges. In May, 1941, the L&N saw "little difference" between ALCo, Baldwin, and EMD switchers. By July, 1943, the L&N's president preferred the EMD 2-cycle engine to the ALCo 4-cycle engine but wrote that "... I have an open mind on this and our people are giving it a most thorough investigation which will include the operations by some companies who have both types in service." By July, 1945, however, "The preference of our operating officers as well as the Mechanical Department is decidedly for the Diesel switcher of the Electro-Motive Corporation." In addition, errors in ALCo production, such

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18 EMD, "Conference Leader's Outline," Subject III, Unit 1B, GMI, folder 76-1.60, 32-3; W. E. Smith to J. B. Hill, May 25, 1941 (quote); Smith to Hill, June 21, 1941, both in the Louisville and Nashville Railroad Collection, University of Louisville (Record Group 123, hereafter referred to as the L&N Records), box 1, folder A-15113.

19 J. B. Hill to Lyman Delano, July 9, 1943, L&N Records, box 58, folder 1887 (quote).

as the delivery of two switchers to the Southern Pacific bearing identical road numbers, while minor, were unlikely to inspire much confidence in ALCo's abilities.21

The war also introduced ALCo executives to the realms of advertising and public relations for the first time. Prior to the war, the company "... never had to give particular attention to what the 'General Public' thinks of ALCo."22 Because ALCo was involved in large amounts of war work, much of it classified, Board Chairman Dickerman felt it necessary "... to reach out through advertising and other means for the attention and respect of a larger part of the general public than the company has needed to cultivate before."23 However, this advertising still failed to emphasize the transition from steam to diesel locomotives. An April, 1944 ALCo ad in a Railway Age special issue on streamlined


22 Earl Newsom & Co., Policy Memorandum, ALCo, January 2, 1942, ALCo Collection, Box 1 (quote).

23 The Commercial and Financial Chronicle, February 7, 1942, 593 (quote).
passenger trains showed five such trains, all pulled by ALCo steam locomotives. The ad emphasized that steam locomotives were perfectly suited to these trains, even though railroads had begun to dieselize their streamliners ten years earlier.24

ALCo's sales rose dramatically as a result of wartime demand. ALCo production during World War II included more than 2,000 locomotives, 6,000 tanks, 150 boilers for Liberty ships, and many other items. ALCo built 1,354 steam locomotives during 1944, the peak year of steam locomotive production. Employment at Schenectady, which had been 5,500 during World War I, soared to 10,958 in 1943.25

In the final analysis, the war was a boon to ALCo's diesel locomotive program. In spite of the company's

24 ALCo won the 1942 Harvard Award "For that advertisement or series of advertisements which contributes to the advancement of advertising as a social force." ALCo, 1942 Annual Report, 8-9; Railway Age 116:17 (April 22, 1944), 793b.

extensive participation in the production of tanks, gun carriages, shells, and bombs, it was able to keep 60 percent of its locomotive facilities open for railroad use. WPB restrictions ensured that ALCo's steam locomotive production outpaced that of diesels. Nevertheless, in 1942 the company produced more diesels than in any prior year. This was followed by another record year in 1943; and 1944 diesel locomotive tonnage was 60 percent above the previous year. More importantly, ALCo's market share increased from 21 percent in 1941 to 27.5 percent in 1944. During the same period, EMD's market share fell from 62 percent to 51.5 percent.²⁶

Although ALCo speedily reconverted to peacetime production, the company's managers failed to anticipate changes in locomotive demand. The reconversion process began in 1943, and was largely complete by late 1944. The company anticipated both a strong domestic and foreign demand for locomotives and, even during the war,

built additional diesel locomotive production facilities. However, since ALCo's executives continued to predict a strong postwar demand for steam locomotives, they failed to modernize the Schenectady facility to make it better suited for the assembly-line production of diesels. This failure, not WPB restrictions, prevented ALCo from exploiting effectively the first key years of the postwar dieselization boom.27

GENERAL ELECTRIC HONES ITS SKILLS IN THE SMALL DIESEL MARKET

While General Electric was not yet a participant in the large diesel locomotive industry, that company, like EMD, used the war to enhance its organizational capabilities. After GE began to manufacture its own car bodies in 1927, the company produced a variety of small and medium-sized locomotives, mostly intended for industrial and shortline railroad customers. Among the most popular of these was a 44-ton switcher, powered by

27ALCo, 1943 Annual Report, 3; 1944 Annual Report, 1, 3; Commercial and Financial Chronicle, April 2, 1945, 1418; Railway Age, 116:22 (May 27, 1944), 1046.
two 190-hp engines. This switcher filled an important niche market on railroads burdened with light bridges or poorly maintained track. In addition, this unit was just light enough to avoid the use of a fireman, mandatory on all locomotives weighing more than 90,000 pounds. This locomotive, introduced in 1940, was followed five years later by a larger, 70-ton, model. These locomotives were powered by either Cooper-Bessemer or Caterpillar engines and, of course, used GE electrical equipment.

At the same time, GE continued to supply electrical equipment for ALCo's diesel locomotives, and GE was careful not to produce locomotives that could compete directly with those manufactured by ALCo. GE experimented with a variety of other locomotives, including a 1,800-hp transfer locomotive and a 5,000-hp steam electric. Still, GE concentrated on diesel switchers, assuming, as did ALCo, that "... most of the heaviest hauling [on typical railroad lines] will in all probability be handled by steam locomotives for many years to come."28

28General Electric Review 40:9 (September, 1937), 421-8 (quote); Railway Age 100:16 (April 18, 1936), 647-51; 101:18 (October 31, 1936), 615-21; 104:7
In 1941, GE completed a reorganization that made it a truly diversified, decentralized corporation. The company was divided into four main operating departments: Appliance and Merchandise, Radio and Television, Lamp, and Apparatus. Locomotive production was assigned to the last division, which, because of its size and diversity, had five vice-presidents. At the same time, GE undertook a planning study, completed in 1945, that recommended the "invasion of new business fields with products of G.E. research, [as well as] expansion to maintain ... relative competitive position" and called for the expenditure of at least $280 million. Most of this money would of course not be spent on locomotive production, but the report should have given clear warning to the other producers, especially ALCo, that GE was considering an expansion of its locomotive program.29

(February 12, 1938), 311; 109:21 (November 23, 1940), 784-6; 110:12 (March 22, 1941), 520-2; 119:3 (July 21, 1945), 115; 133:5 (August 4, 1952).

29Business Week, November 10, 1945, 44-6 (quote).

30Railway Age 111:18 (November 1, 1941), 724-5.
Like EMD, GE used the intense wartime demand to its advantage by increasing production efficiency. It did so primarily by forcing railroads to accept standard models, thus cutting delivery time in half. GE noted that railroads learned of the advantages of standardization through this process, and soon dropped their insistence on custom-built models. By late 1943, G. W. Wilson, the manager of GE's Transportation Department, could proclaim that "Standardization of locomotives is here to stay." Because of the war, GE began to develop the manufacturing capabilities needed to become a viable producer in the locomotive industry. GE gradually expanded these capabilities after the war, thus enabling it to drive ALCo from the industry with astonishing rapidity during the 1960's.

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31 GE press release, October 13, 1943, AAR (quote).
32 Railway Age 114:26 (June 26, 1943), 1278-9.
World War II gave Baldwin a golden opportunity to enhance its position in the diesel locomotive industry. Wartime ordinance contracts filled Eddystone to capacity and banished the specter of financial austerity that had accompanied Baldwin's bankruptcy.\textsuperscript{33} By ordering EMD to end switcher production, the WPB cut Baldwin's competition in this market in half. In addition, since railroads were no longer able to obtain switchers from their preferred producer, EMD, they were forced to place Baldwin switchers in service. However, once railroads received their new Baldwin switchers, they quickly realized that these locomotives were poorly designed and constructed. Far from showing railroads the advantages of Baldwin diesels, wartime deliveries convinced many railroads to avoid further Baldwin orders at all costs.

Baldwin produced a variety of items for the war effort, including stress-testing machines, ship propellers, gun mounts and barrels, tanks and tank destroyers, 33

\textsuperscript{33}In 1942, Baldwin paid dividends on common stock for the first time since 1930. Baldwin Locomotive Works, 1942 annual report.
and both steam and diesel locomotives. Steam locomotive production, especially for military export use, increased dramatically. In fact, the pressing demand for locomotives caused Baldwin to suspend all ordinance production in early 1944. In 1944, for example, Baldwin produced 1,200 steam locomotives and only 352 diesels. While these orders temporarily guaranteed Baldwin's financial success, they also ensured that Baldwin's organizational capabilities stayed firmly centered on the production of steam locomotives.

Baldwin expanded its diesel locomotive production capabilities during World War II. In 1944, the company constructed a new diesel engine production facility, and, as a result, diesel engine output during the first four months of 1944 was 27 percent greater than the same period a year earlier. Nor did WPB restrictions have any significant impact on the development of new diesel locomotive designs. The company built an experimental passenger locomotive in 1943, and during the war it collaborated with Westinghouse on the development of a new steam turbine locomotive. In January, 1945, with Japan's surrender still potentially several years away, Baldwin introduced a new road freight locomotive,
complete with two 1,000-hp 8-cylinder diesel engines and Westinghouse electrical equipment, "... in the design of which knowledge gained from war-time operations has been incorporated..."34

Unfortunately, Baldwin was its own worst enemy during the war. Railroads, already dubious about accepting diesels not built by ALCo or EMD, found their fears justified. Many production defects occurred because of Baldwin's ill-advised attempt to transfer steam locomotive steel-casting technology to the production of diesels. Charles E. Brinley, Baldwin's chairman, admitted to defects in the cast cylinder heads of Baldwin switchers. After repeated attempts to repair a cracked crankcase casting, one Louisville and Nashville maintenance officer wrote in disgust that "The foregoing indicates a very unsatisfactory condition is existing, due to poor material or design, or both, and the builder

34 Railway Age 116:25 (June 17, 1944), 1186; 118:3 (January 20, 1945), 204 (quote); 118:16 (April 21, 1945), 708-10; Steel Horizons 5:3 (1943), 6-7; Baldwin Locomotive Works, 1944 & 1945 annual reports; Baldwin, press release, June 29, 1944, AAR; Garmany, Southern Pacific Dieselization, 107.
plainly is responsible."\textsuperscript{35} These switchers also suf­fered from excessive vibrations, and frantic efforts by Baldwin troubleshooters could discover neither cause nor cure. For the Louisville and Nashville, its "kindly feeling" toward Baldwin, its usual steam locomotive sup­plier, was not enough to offset the obvious dis­advantages of Baldwin diesels. The railroad's president concluded that "The Baldwin diesel has been less satis­factory in many respects than the other two [ALCo and EMD] locomotives ... Its operating costs are so much higher and along with other unsatisfactory performance that our people are distinctly prejudiced against the purchase of any more Baldwin locomotives at the present time."\textsuperscript{36} The war thus revealed Baldwin's incompetence in diesel-locomotive production.

Baldwin's manufacturing difficulties were partly responsible for an influx of new managerial talent from Westinghouse, which owned a block of Baldwin stock. In


\textsuperscript{36}J. B. Hill to F. B. Adams, July 25, 1945, L&N Records, box 56, folder 1870-B (quote).
March, 1942, Ralph Kelly left his position as vice-president in charge of sales at Westinghouse to assume the newly created position of executive vice-president at Baldwin. A member of the Harvard class of 1909, Kelly had worked in the Westinghouse Power Engineering Department and the Marine Engineering Division. Between 1934 and 1938, he was a vice-president in charge of the operating divisions centered around East Pittsburgh, the plant at which Westinghouse locomotive electrical equipment was produced. After serving for a year as executive vice-president, Kelly became president of Baldwin in April, 1943. He thus replaced Charles E. Brinley, who resigned the office he had held since 1938 in order to fill the newly created role of chairman of the board. Baldwin, like ALCo, apparently considered this position to be of little importance, since both companies lacked chairmen for many years. These Westinghouse executives did increase Baldwin's competitive abilities, particularly in manufacturing, but were too few and too late to alter significantly Baldwin's steam-based corporate culture.37

37Baldwin Locomotives 20:1 (June, 1942), 10; 20:3 (October, 1943), 8; Railway Age 114:15 (April 10, 1943), 715; Baldwin Locomotive Works, 1942 & 1943
World War II was a lost opportunity for Baldwin. While its share of the diesel locomotive market increased, Baldwin was not able to manufacture efficiently a high-quality product to meet this challenge. Unlike EMD and GE, which streamlined their production and managerial systems to cope with this sudden increase in demand, Baldwin continued to rely on the same archaic methods that it had used during the heyday of steam locomotive manufacture. The poor quality of its diesel switchers convinced many railroads to avoid Baldwin locomotives in the future, despite cordial relationships that they had developed with Baldwin during the days of steam. By bringing his experience at Westinghouse to Baldwin, Kelly was able to improve the situation somewhat; and, after the war, Baldwin's diesel locomotives were much improved over their wartime predecessors. But by then the damage had been done. It was too late to reverse the reputation of Baldwin diesels as junk, too late to erase the pro-steam mentality of most Baldwin executives, and too late to make the combined investment annual reports.
in manufacturing, marketing, and management that were crucial to success in the diesel locomotive industry.

FAIRBANKS-MORSE ENTERS THE LOCOMOTIVE INDUSTRY

World War II facilitated the entrance of Fairbanks-Morse into the diesel locomotive field. Unlike ALCo, Baldwin, and Lima, Fairbanks-Morse was not burdened with a legacy of steam locomotive production; but, like those three companies, it failed to survive in the diesel locomotive market. Aside from Lima, it had the shortest tenure in the industry -- just fifteen years -- and lost money on locomotive sales in fourteen of them.

Fairbanks-Morse entered the large diesel locomotive industry as a direct result of the end of World War II, in an attempt to fill excess capacity created by declining war orders. This was a common corporate response at the time; but, in hindsight, it would appear that its choice to produce locomotives was a poor one. The reasons for the downfall of Fairbanks-Morse are less obvious than those for ALCo, Baldwin, and Lima, but Fairbanks-Morse's bid to remain in the locomotive market seems to have been defeated by a combination of poor
management, insufficient resources, and an inadequate finished product. In addition, Fairbanks-Morse entered the market too late to be effective. By the time it had begun to climb its learning curve, EMD was already in a position of market dominance.

The origins of Fairbanks-Morse were far removed from the railroad industry. In 1830, Thaddeus Fairbanks invented the platform scale and, together with his brothers Erastus and Joseph, established a factory in St. Johnsbury, Vermont. Charles Hosmer Morse joined the company in 1850 and became a partner in 1866. In 1870, Morse began marketing Eclipse Windmills to a variety of customers, including railroads. Fairbanks-Morse bought the Eclipse Wind Engine Company in 1885, thereby acquiring its plant in Beloit, Wisconsin -- a facility that would later be used for the manufacture of diesel locomotives. In 1893, Fairbanks-Morse began marketing gasoline engines and offered small gasoline-powered railroad work cars three years later. In 1900, Fairbanks-Morse introduced a 2-cycle gasoline marine engine, followed by a 4-cycle version a year later. By 1908, Fairbanks-Morse was building a variety of products, including railroad coaling stations,
drawbridge mechanisms, small gasoline-powered railcars and inspection cars, light locomotives, logging cars, lighting systems, track tools, and water pumps and tanks. In the process, the company established a reputation as a supplier of top-quality products for a variety of railroad applications.38

Like GE, Fairbanks-Morse explored the possibilities of diesel power early in the twentieth century. In 1912, Fairbanks-Morse established a research laboratory at Beloit to develop a 2-cycle semi-diesel engine. Actual production began a year later. In 1922, Fairbanks-Morse began building large, heavy marine diesels in both 2-cycle and 4-cycle variants. In 1931, Col. Robert H. Morse, son of Charles Hosmer Morse, began a research program at Beloit to develop a 2-cycle diesel engine.

opposed-piston engine. As its name suggests, the OP engine had two pistons per cylinder, each at a 180 degree angle from the other. The opposed piston design was intended to have many advantages, including simpler design, reduced piston speed, easier maintenance access, better heat dissipation, and fewer moving parts. After World War II, Fairbanks-Morse claimed that the OP was designed specifically for locomotive use, but this engine was actually better suited for marine applications, and ships were probably the original target market. In 1934, the U. S. Navy gave its preliminary approval to the OP engine, with the first actual installation occurring a year later.

Largely on the strength of OP engine sales, Fairbanks-Morse was the second-largest producer of diesel engines in the United States in 1940. Diesel engines were also the largest single component of Fairbanks-Morse sales, about a quarter of the total. Although the Navy used OP engines in destroyers, minesweepers, and battleships, their primary application was in submarines. During World War II, half of the engines that Fairbanks-Morse produced were used in submarines, and half of all submarines built during the war had
Fairbanks-Morse engines. The Navy, by far Fairbanks-Morse's best customer, purchased more than 3.5 million horsepower from the company during the war.\(^{39}\)

In 1939, Fairbanks-Morse used its OP engines in railroad service for the first time. These 750-hp engines, along with Westinghouse electrical equipment, were installed in six 2-unit railcar sets built by the St. Louis Car Company for the Southern Railway. This limited application hardly constituted a serious effort to enter the large diesel locomotive industry. In fact, Fairbanks-Morse might never have done so, had it not been for World War II. In 1939, shortly after the Southern railcars were completed, Navy demand increased to such an extent that it precluded the production of OP engines for any other applications. This of course

would have put an end to any effective Fairbanks-Morse locomotive development program, if it had had one.⁴⁰

The wartime demand that greatly increased Fairbanks-Morse's production capacity ultimately formed the rationale for the company's involvement in the locomotive industry. In late 1941, the company spent $5.5 million to expand the Beloit plant for increased production of OP engines, a process not completed until 1943. In addition, the rigors of wartime service gave Fairbanks-Morse engineers valuable experience regarding the OP engine. When Fairbanks-Morse announced its decision to enter the locomotive industry, it asserted that "Submarine service has been a most severe test for proving the quality of the new [OP] engine. This and the experience gained in mass production for war needs will have surmounted the two major obstacles facing the new enterprise."⁴¹


⁴¹Railway Age 111:18 (November 1, 1941), 724; 116:15 (April 8, 1944), 702; Fairbanks, Morse & Co., Pioneers in Industry, 107; Fairbanks-Morse, press release, May 8, 1944, AAR (quote).
In mid-1943, as American industry reached its full wartime strength, Fairbanks-Morse contemplated the postwar function of the expanded plant that it had built to fill military demands for the OP engine. Accordingly, Fairbanks-Morse requested and received permission from the War Production Board to begin research and development work on a new line of diesel locomotives. In May, 1944, Fairbanks-Morse publicly announced its plans to build locomotives using OP engines. In spite of the fact that Fairbanks-Morse already built AC and DC electric motors and generators, ranging from 1/2 to 10,000 horsepower, the company chose to use Westinghouse electrical equipment for its new locomotives.

In an astute move, Fairbanks-Morse asked railroad industry executive John W. Barriger III to become the manager of the new Diesel Locomotive Division. Barriger was an ardent advocate of both diesels and "super-railroads," routes that were well maintained and capable of handling large volumes of freight at high speeds. A 1921 graduate of the Massachusetts Institute of Technology, he had considerable influence in Washington, having served as director of the Railroad Division of the Reconstruction Finance Corporation between 1933 and 1941.
and associate director of the Office of Defense Transportation from then until 1943. He was also on the board of directors of the Chicago and Eastern Illinois and the Alton. In spite of these accomplishments, however, Barriger could do little to counter the technical and organizational deficiencies that hindered the ability of Fairbanks-Morse to participate in the diesel locomotive market.\footnote{Railway Age 116:20 (May 13, 1944), 910; 120:16 (April 20, 1946), 840; 123:12 (September 20, 1947), 476-7; Fairbanks, Morse & Co., Pioneers in Industry, 134-5; Garmany, Southern Pacific Dieselization, 289.}

Fairbanks-Morse's facilities, though large, were not well-suited to diesel locomotive production. Production was divided between the new buildings at Beloit and a plant in Freeport, Illinois (the former Stoner Manufacturing Company), that had been leased from the national government in March, 1942. Other components were manufactured at a plant in Three Rivers, Michigan. The 118-acre Beloit plant was not dedicated solely to the production of locomotives, or even to diesel engines, since it also manufactured pumps, motors, magnetos, lighting systems, water systems, and other items.
Beloit's huge foundry, the largest in the world when it was built in 1921, was, like similar facilities at Schenectady and Eddystone, not designed for the requirements of diesel locomotive production. Photographs of the diesel-engine assembly area, taken during the war, fail to show anything resembling an assembly line. Finally, although Fairbanks-Morse ultimately planned to offer a full complement of diesel locomotive models, limitations at Beloit restricted actual production to small switchers until well after the war.*3

In spite of the inadequate facilities at the Beloit plant, Fairbanks-Morse delivered its first switcher in August, 1944. For Fairbanks-Morse, however, the event represented not so much the beginning, but rather the beginning of the end. In a market already crowded with three other producers -- EMD, ALCo, and Baldwin -- even a well managed company with a sound product would have found it difficult to secure an adequate market share. And, as events during the next fifteen years clearly

*3Diesel Power and Diesel Transportation, March, 1947, 76-80; Railway Age 116:20 (May 13, 1944), 910; Fairbanks, Morse & Co., Pioneers in Industry, 76, 80, 84, 96-7.
indicated, Fairbanks-Morse had neither sound management nor a sound product. Even in 1945, management evinced little interest in the diesel locomotive market. A company-sponsored pictorial summary of Fairbanks-Morse product lines, published in 1945, devoted more space to sewage disposal pumping systems than to locomotives. This disinterest, combined with maintenance difficulties in the OP engine, contributed to failure in the locomotive market. Even by 1945, it was too late for Fairbanks-Morse to do anything more than waste its resources on diesel locomotive production. 44

THE WAR PRODUCTION BOARD AND THE LOCOMOTIVE INDUSTRY

In discussing the locomotive industry during World War II, historians must address the relationship between the locomotive producers and the federal government. Scholars and business people have occasionally alleged that the actions of the United States government in general and the War Production Board in particular altered

44Railway Age 116:20 (May 13, 1944), 910; 117:12 (September 16, 1944), 440-3; Fairbanks, Morse & Co., Pioneers in Industry, 72, 145, 155.
the competitive patterns within this industry. Specifically, some of the locomotive builders claimed that the WPB, through misallocation of resources or favoritism toward big business, prevented established producers of steam locomotives from fully exploiting the diesel locomotive market, thus ensuring the wartime and postwar dominance of giant firms such as General Motors.

Government regulation of the locomotive industry began even before Pearl Harbor. As early as March, 1941, Edward R. Stettinius, director of priorities for the Office of Production Management, gave locomotive builders an A-3 preference rating and placed diesel, gasoline, and electric locomotives on a "priorities critical" list. Stettinius also gave the armed forces priority on all locomotive orders.

In January, 1942, President Franklin D. Roosevelt established the War Production Board, under the direction of Sears executive Donald Nelson, to control wartime production and the allocation of raw materials.

In April of that year the WPB enacted General Limitation Order L-97 to "control the production and delivery of railroad locomotives." This order allocated production of specific locomotive types to certain builders, based on proven designs. The WPB established a number of advisory committees, the two most important of which were for the producers of large steam locomotives and large diesel locomotives. ALCo, Baldwin and Lima each sent representatives to the steam locomotive committee, while ALCo, Baldwin, GE, EMD, and Westinghouse participated in the meetings of the diesel locomotive committee. The WPB supplied one representative to each committee from its Transportation Equipment Division. In addition, numerous government representatives from several divisions of the WPB, as well as the War Department, the Office of Defense Transportation, the Office of Price Administration, and other government agencies

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46 "Title 32 - National Defense, Chapter IX - War Production Board, Subchapter B - Division of Industry Operations, Part 1188 - Railroad Equipment, General Limitation Order L-97, April 4, 1942; Andrew Stevenson to C. H. Matthiessen, April 2, 1942, (quote); both in WPB records, box 2162."
attended these meetings.\textsuperscript{47}

WPB committees established and maintained production schedules for both steam and diesel locomotives. Of the two, the WPB placed more restrictions on diesel locomotive production, since diesels required larger quantities of scarce strategic materials, such as copper and high-strength specialty steels. In addition, a large portion of diesel engine output was requisitioned by the Navy for use in submarines and patrol boats. The WPB then issued monthly directives for the production of 600-hp and 1,000-hp switchers, as well as quarterly directives for large freight diesels. Orders given to one builder could be filled from the available stock of any other builder.\textsuperscript{48}

\textsuperscript{47}Blum, \textit{V was for Victory}, 121-4.

\textsuperscript{48}"Title 32 - National Defense, Chapter IX - War Production Board, Subchapter B - Division of Industry Operations, Part 1188 - Railroad Equipment, General Limitation Order L-97, April 4, 1942, WPB Records; Summary of Meeting, Producers of Large Diesel Locomotives Industry Advisory Committee, Nov. 10, 1943, WPB Records, Box 2162; \textit{Railway Age} 112:15 (April 11, 1942), 753-4; 110:12 (March 22, 1941), 536; 110:19 (May 10, 1941), 813; 111:4 (July 26, 1941), 170-1; 118:1 (January 6, 1945), 60-4."
All of the major locomotive producers had some degree of influence on government policy during the war. Both ALCo and Lima had representatives on the WPB Transportation Equipment Division, while a Baldwin executive served on the Defense Transportation Authority.

EMD had no representation on either board but did have more subtle ways of exerting pressure on the federal government. Ralph Budd, long a staunch supporter of EMD, was an early member of the WPB. He frequently acted as a liaison between the locomotive builders, the railroads, the Office of Production Management and, later, WPB director Donald Nelson. Budd often gave advance advice to railroads concerning the probabilities of successful locomotive orders from various builders. In addition, he was quick to warn EMD, early in the war, that the government might classify diesel locomotives as "non-essential." Budd warned Hamilton that he needed to convince "the people in Washington" of the value of diesels -- something that neither Hamilton nor anyone else at EMD had thought to do.49 Hamilton then

49 Osborn, Statement before the Subcommittee on Antitrust and Monopoly of the U. S. Senate Committee on the Judiciary, Washington, December 9, 1955, 27; J. B.
encouraged railroad executives to put pressure on Washington. For example, J. B. Hill, president of the Louisville and Nashville, wrote to Joseph B. Eastman, director of the Office of Defense Transportation, stressing the need for diesels, because "... they represent a greater addition to our freight locomotive capacity than we could otherwise obtain."\(^5\) Hamilton, who received a copy of Hill's letter, wrote back that "This is exactly the kind of pressure ... that I had in mind would be effective in Washington."\(^1\)

Budd's ability to help his friends at EMD was limited, however. He could not undo WPB regulations, nor could he, or any other member of the WPB, ensure that EMD would receive the majority of new diesel

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\(^1\)Harold L. Hamilton to J. B. Hill, February 17, 1942, L&N Records, box 57, folder 1883-A (quote).
locomotive orders. In fact, wartime restrictions often worked against EMD. The Louisville and Nashville, which preferred that builder's diesels, was told that these were unavailable, but "It was hinted in Washington, however, last week that if we would be willing to take a 4,000 hp engine of the four cycle type from the American Locomotive Company, it would be possible to get such an order attended to." 52

It would thus appear that no builder had an undue influence on the activities of the War Production Board. All of the major locomotive producers exerted either direct or indirect influence on government policy. EMD's indirect approach did not prevent the division from losing market share to ALCo. Furthermore, like their counterparts at Baldwin and Lima, ALCo executives expressed no concerns about EMD's influence.

In the minutes of the meetings of the Large Diesel Locomotive Builders Industry Advisory Committee, there is no evidence of favoritism by the WPB toward EMD or any other locomotive producer. In fact, EMD was forced

52 J. B. Hill to Lyman Delano, July 9, 1943, L&N Records, box 58, folder 1887 (quote).
out of the locomotive industry during January and February of 1943, since its entire output of diesel engines was requisitioned by the Navy. Moreover, and perhaps more revealing, none of the locomotive producers complained about their treatment under the WPB guidelines. None of the builders thought that General Limitation Order L-97 restricted their development of improved diesel locomotive technology. This acceptance was clearly illustrated by an advisory committee meeting in December, 1944, in which the WPB considered ending L-97. Without exception, the representatives of all of the locomotive builders agreed that it should be continued. If any of the locomotive producers had viewed the WPB as unfair, or had believed that L-97 was restricting them from improving their diesel locomotive technology, they would have undoubtedly called for the revocation of L-97.  

53 "Summary of Meeting - Builders of Large Steam Locomotives Industry Advisory Committee," December 6, 1944, 7; General Limitation Order L-97, Revocation, July 16, 1945, both in WPB Records; Railway Age 119:3 (July 21, 1945), 111; "General Motors Diesel Locomotives," Statement by Cyrus R. Osborn before the Subcommittee on Antitrust and Monopoly of the U. S. Senate Committee on the Judiciary, Washington, December 9, 1955.
ALCo executives did express concerns about their treatment by the WPB, but only after World War II was long over. Before, during, and immediately after World War II, ALCo was the only serious threat to EMD's dominance of the diesel locomotive industry. By the late 1940's, when it became clear that ALCo would never rival EMD in market share, its management searched for scapegoats to explain this failure to its disgruntled shareholders. ALCo found one in the WPB. This agency, complained ALCo's management, had shown undue favoritism to EMD and had prevented ALCo from designing or producing a full line of diesel locomotives. In 1949, ALCo executives whined that "... throughout the long period of war, ALCo was prevented ... from making substantial progress in the research and development work which are required for the creation and introduction of an entirely new [diesel engine]." 54 William F. Lewis, an ALCo vice-president, reiterated these claims in testimony before a 1955 Senate Subcommittee on Antitrust and Monopoly. Senator Joseph C. O'Mahoney (Democrat,  

54 ALCo, Report of the annual meeting of shareholders, April 19, 1949, ALCo Collection, Box 6 (quote).
Wyoming), the subcommittee chairman, failed to question these assertions, saying that the war "... changed the whole direction of the industry -- it placed a handicap on the pioneers [like ALCo] and gave an advantage to the newcomers [like EMD]."\textsuperscript{55} It is of course questionable to what extent ALCo was a pioneer, rather than simply being the first company to build a diesel locomotive. Finally, it should be emphasized that ALCo raised none of these objections during the war itself. In fact, its claims have little validity.

Far from excluding ALCo from the diesel locomotive market, the WPB allowed that company to produce a wide range of steam and diesel locomotives during the war. The WPB defined five categories of diesel locomotive production: 5,400-hp freight locomotives, 2,000-hp freight locomotives, 1,000-hp road switchers, 1,000-hp yard switchers, and 600 to 660-hp yard switchers. The WPB allowed ALCo to produce locomotives in four of these five categories, and its production allocations in those categories were in fact higher than those awarded to

EMD. Furthermore, the 5,400-hp freight locomotives, which only EMD was authorized to produce, were similar to the 2,000-hp freight locomotives produced by ALCo. It is true that EMD received production allocations in all five categories, but it produced only diesel locomotives, while ALCo produced several thousand wartime steam locomotives, in addition to its diesel locomotive output. Finally, these restrictions enabled ALCo to increase its diesel locomotive production to record levels during each year of the war. ALCo unquestionably prospered under WPB jurisdiction. It was only in the late 1940's and early 1950's, when ALCo was losing market share, that ALCo's management decided that this decline was not their responsibility, but rather the fault of the WPB.®®

When the WPB revoked L-97 in July, 1945, the competitive structure of the locomotive industry was identical to that in 1941. EMD still dominated the industry, though its market share had fallen from

®®Summary of Meeting, Producers of Large Diesel Locomotives Industry Advisory Committee, Nov. 10, 1943, WPB Records, Box 2162; ALCo 1943, 1944, 1945 annual reports.
62 percent in 1941 to 47 percent in 1946. ALCo, still the only company capable of challenging EMD, had increased its market share from 21 percent to 40 percent during the same period. ALCo's introduction of new diesel engine and diesel locomotive designs soon after the war ended indicates that much preliminary design work must have occurred under WPB control. ALCo President Robert McColl, who had been ALCo's representative to the WPB, stressed that "the [newly introduced] diesel engine itself has been developed on the principle of constant-pressure turbocharging, the advance of which was greatly accelerated by war developments."\(^5\) He made this statement in 1946, before ALCo's failure to compete against EMD became apparent and before ALCo's managers invented the myth of a hostile WPB. ALCo's subsequent failure to compete with EMD resulted from poor corporate organization, inefficient production facilities, and a

continuing misguided faith in the steam locomotive, not from the policies of the WPB or any other government agency.

Furthermore, and ALCo executives apparently failed to realize this, market dominance after 1945 was ensured, not by how many diesel locomotives a particular company had produced before that date, but rather by the extent to which a company had established a combined investment in production facilities, marketing services, and managerial talent. In fact, no diesels, not even those produced by EMD, dominated the railroad industry by the end of World War II. By September 15, 1945, the Santa Fe, EMD's best customer, had only 80 freight and 15 diesel passenger locomotives -- hardly extensive saturation in a potential market of some 40,000 locomotives. Between February, 1934 and April, 1944, railroads placed only 224 diesel passenger locomotives in service -- again, just a small fraction of the market potential. By January 1, 1946, only 12.5 percent of the potential road freight diesel market had been filled, and nearly two-thirds of all railroads had not yet taken
delivery of a single diesel freight locomotive.\textsuperscript{58}

By holding EMD in check, the WPB unintentionally gave ALCo and the other locomotive builders the opportunity to develop new locomotive designs that could be put into production after the war. Had it not been for government restrictions, railroads would have purchased even more diesel locomotives than they were actually able to obtain, and most of these orders would have undoubtedly gone to EMD, the dominant prewar producer. ALCo and Baldwin failed to develop high-quality diesel locomotives, however. In addition, they failed to establish effective manufacturing, marketing, and management practices after the war, thus allowing EMD to regain its market share with astonishing speed.

In spite of ALCo's postwar criticism of the WPB, that company's own survival is ironically the best testimony that its claims were without merit. ALCo

complained that, because it was not allowed to produce large freight locomotives during the war, railroads were forced to buy EMD units. In order to maintain a standard roster, railroads continued to buy EMD units after the war. If the war had indeed caused railroads to standardize with EMD units, to the exclusion of ALCo, the obvious question that requires explanation is why some railroads kept buying ALCo diesels for the next 24 years. Surely, by 1950 at the latest, even the most incompetent of railroad executives would have understood that standardization on the product of one company means that you stop buying from its competitor. In all probability, ALCo would have remained in the diesel locomotive market indefinitely had not a new competitor -- General Electric -- offered a superior product in 1960.

In conclusion, then, WPB policies toward the locomotive industry showed no favoritism toward any producer, nor did they alter the competitive structure in that industry. It is not my intention to dispute the findings of John Blum, and others, that the WPB and military procurement agencies did favor large firms in many key industries. Instead, I conclude that, in the
locomotive industry, the ability of firms to respond to technological change was neither aided nor constrained by government policy. The inability of ALCo, Baldwin, Fairbanks-Morse, and Lima to compete against EMD and, later, GE during the postwar period was the outcome of defective methods of management, production, and distribution, and not misguided government policy.
CORPORATE RESPONSE TO TECHNOLOGICAL CHANGE:
DIESELIZATION AND THE AMERICAN RAILWAY LOCOMOTIVE
INDUSTRY DURING THE TWENTIETH CENTURY
Volume II

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American railroads poured millions of dollars into improvements after World War II, and these investments included the purchase of thousands of new diesel locomotives. Substantial wartime profits allowed railroad executives to replace track, bridges, structures, cars, and locomotives that had been worn out by a decade of deferred maintenance during the depression and years of overuse during World War II. Capital improvements to American railroads, which had equalled $563 million in 1945, soared to $1.3 billion in 1949. Investments in new locomotives increased from $128 million to $406 million during the same period. The years immediately after World War II thus witnessed a surge of investor confidence in the American railroad industry that belied the later reputation of railroads as inept and conservative.¹

The fifteen years following the end of World War II witnessed a rapid turnover of firms in the locomotive industry. Railroads, freed from the twin burdens of depression and war, were quick to replace their steam locomotives with diesels. This dieselization boom temporarily sustained five manufacturers: EMD, ALCo, Baldwin, Fairbanks-Morse, and Lima. Of these, however, only the first two were truly viable producers. Once locomotive orders began to subside, the remaining competitors were driven from the market, a process described in Chapter 7.

The postwar competition between ALCo and EMD was by no means equal, however. EMD possessed modern plant and equipment at La Grange, while ALCo was burdened with outdated manufacturing facilities at Schenectady. More importantly, EMD had revitalized its corporate culture during World War II, replacing the rather haphazard experimentation of the 1930's with a smooth-running

managerial hierarchy. Many ALCo executives, however, continued to delude themselves and their stockholders with visions of continued steam locomotive production, an image that they should have abandoned years earlier. EMD executives further outclassed their rivals at ALCo with their willingness and ability to expand their already extensive marketing and post-sales support services.

The proven advantages of diesels, combined with the low availability of high-quality coal for steam locomotives, led to a rapid dieselization of American railroads in the postwar period. In 1945, diesels handled 8 percent of all passenger train miles, a figure that increased to 22 percent by 1947 and 34 percent a year later. In September, 1950, only 17 percent of all freight locomotives were diesels, but these diesels were responsible for 44 percent of freight ton-miles. In 1953, railroads in the United States owned 14,657 diesels and 15,903 steam locomotives which, although they were in the majority, performed less than a fourth of the work done by diesels. Dieselization was virtually complete by early 1959, with 96.8 percent of all freight ton-miles hauled by diesels. The number of
diesel locomotives in service on American railroads increased from 3,882 at the end of 1945 to 20,604 at the end of 1952 to more than 28,000 by the end of 1961. At the same time, steam locomotive orders dropped from 83 in 1945 to zero in 1946.²

Observers of the locomotive industry understood that not all companies would benefit equally from the postwar dieselization boom. In 1949, an industry analyst predicted that EMD would sell between $900 million and $1.8 billion worth of locomotives over the next decade, with ALCo receiving nearly as much business, $800 million to $1.6 billion. This prediction clearly placed more faith in ALCo than it deserved, for ALCo's subsequent sales were far less than those enjoyed by EMD. The analyst also predicted that Baldwin,

²American railroads did order a few additional steam locomotives in the years that followed, but, for all practical purposes, the steam locomotive industry had expired by V-J Day. Barron's 28 (October 18, 1948), 29-30; 33 (May 11, 1953), 15-16; Coal Age 52:12 (December, 1947), 74-8; Railway Age 123:20 (November 15, 1947), 829-31; 146:14 (April 6, 1959), 10; 152:2 (January 15, 1962), 16, 103; GM-EMD, "Why America Needs More Diesels Now," 1950, Association of American Railroads Library, Washington, D.C. (hereafter referred to as AAR).
Fairbanks-Morse, and Lima would split the remaining $300 to $600 million worth of business.  

In reality, however, EMD captured an overwhelming majority of both locomotive sales and the accompanying profits. EMD's market share dipped to a low of 47 percent in 1946 but reached 64 percent in 1950 and 75 percent in 1954. The division's market share reached an all-time high of 89 percent in 1957. Between 1946 and 1959, GM earned an estimated average annual return of 55 percent on its investment in EMD. During the same period, EMD always enjoyed at least an 11 percent return on sales, with an average of 20 percent. ALCo, however, lost money in four of these years, and averaged only a 2 percent annual return on sales. EMD earned a 144 percent return on investment during the 1950's, with ALCo earning 9 percent and Fairbanks-Morse losing 14 percent during this decade. In 1951, one of the best years in the entire history of the locomotive industry, EMD earned a 269 percent return on its investment in plant and equipment. In the same year, ALCo managed only a

3Barron's 29 (January 17, 1949), 4, 46.
28 percent rate of return, while Baldwin and Fairbanks-Morse lost money.⁴

CONTINUED SUCCESS AT EMD

The years between 1945 and 1957 were golden ones for EMD. At last, the investments in manufacturing facilities and the creation of an effective marketing and managerial system during the Great Depression and World War II paid substantial dividends. Employment at EMD, which had been only 400 in 1936, increased to 12,000 by 1947, while the annual payroll rose from $117,000 to $43.5 million in the same period. By 1947, La Grange represented an $80 million capital investment, including inventory, with additional millions invested in EMD's service and parts distribution network.

⁴Once again, EMD's earnings were but a fraction of those of its parent company. While EMD locomotive sales were $85 million in 1960, total GM sales were $12.7 billion. United States of America vs. General Motors Corporation, case # 61CR356, United States District Court, Southern District of New York, filed April 12, 1961, National Archives, Northeast Region, New York, 2, 7-10; Thomas G. Marx, "Technological Change and the Theory of the Firm: The American Locomotive Industry, 1920-1955," Business History Review 50 (Spring, 1976), 9.
La Grange had produced more than $400 million worth of locomotives by 1947, and orders continued to flood the factory.

EMD's production and sales figures increased dramatically. For the next five years, EMD earned approximately $400 million per year. Even though the actual construction of a locomotive took only six weeks, La Grange was booked to capacity and railroads had to queue up for space at the factory. In November, 1947, EMD boasted that it had reduced its order backlog to "only" 18 months. By mid-1948, EMD was producing five locomotives per working day, a figure that doubled by 1956. This output, combined with production at ancillary plants in Chicago and Cleveland, allowed EMD to produce 200 locomotives per month by 1950. In March, 1954, less than 18 years after La Grange began production, EMD completed its 15,000th diesel locomotive. Between 1946 and 1959, EMD built 17,343 locomotives, valued at $2.7 billion.\(^5\)

\(^5\)These production figures, while impressive, represent only a small fraction of GM's total output. In 1948 alone, for example, GM's total diesel engine sales were $250 million. American Machinist, April 22, 1948, 74-5; Business Week, September 1, 1956, 52-8; Fortune 38 (July, 1948), 76-81, 144-9; Railway Age 123:18 (November 1, 1947), 726-8, 739; 128:24 (June 17, 1950),
By the early 1950's, EMD had moved beyond the experimental pioneering that had characterized the 1930's in favor of gradually and incrementally improving its locomotive models. EMD engineers enhanced the performance of the locomotives they designed while attempting to retain the highest possible degree of interchangeability with parts and subassemblies from older EMD units. Marketing experts at EMD ensured that these gradual changes would be made to accommodate customer needs, yet EMD retained full control over the design process -- a situation far different from the customer-driven design methods of the now-vanquished steam locomotive industry.

The popularity of EMD's new locomotive models was responsible for much of its success in the postwar period. In 1945, EMD began production of the 1,500-hp F-3, an improved version of the FT. This locomotive was followed in 1949 by the even more popular F-7, and both models gained widespread use in freight and passenger service. The F-3 and F-7 were rugged, versatile, and reliable. EMD also introduced the 1,500-hp BL-2, which was a largely unsuccessful foray into the road switcher market.

EMD's introduction of the GP-7 in November, 1949, allowed the division to capture the largest share of this emerging road switcher market. The 1,500-hp GP-7 was powerful enough for mainline service, light enough for low-density branchlines, and provided engine crews with excellent visibility. The GP-9, introduced in 1953, was similar, but offered increased horsepower. Railroads ordered nearly 7,000 GP-7's and GP-9's before these locomotives were replaced by more powerful models. These two models did more to ensure EMD's success than any other locomotives that it produced.6

6Railway Age 121:17 (October 26, 1946), 674-7, 683; 123:20 (November 15, 1947), 877-8; 126:15 (April 9, 1949), 726-30; 127:19 (November 5, 1949), 790-3; 135:19
Other models followed as EMD continued to improve the construction and performance of its locomotives while maintaining substantial parts interchangeability. The SD-7, introduced in 1952, incorporated improved trucks and devices to reduce wheel slippage. It also provided railroads with a highly popular heavy-duty road freight locomotive. By January, 1954, following a five-year research and development project, EMD introduced ten new models in the 9-series. In addition to the GP-9 road switcher, these included the F-9 and E-9 passenger units, as well as the SD-9 road freight locomotive. Five more models followed in 1959 -- a line that Nelson Dezendorf, the GM vice-president in charge of EMD, called "the most important contribution to railroad progress since we brought out our wide-range freight locomotives - the F-3 - immediately following World War II." These new locomotive models featured increased

(November 9, 1953), 28-30.

7Railway Age 146:19 (May 11, 1959), 62-3 (quote).
horsepower and improved electrical equipment.*

EMD's locomotives, while successful, were far from perfect, and their imperfections created a final opportunity for ALCo to increase its market share. For example, some railroads reported that GP-7's had a tendency to jackknife when coupled in multiple units. The F-3 also experienced a variety of problems. Despite substantial production and marketing efforts by EMD, the BL-2 was clearly unpopular with the railroad industry. EMD wasted additional resources on its ill-conceived Aerotrain. This trainset, designed to reduce railroad passenger losses, incorporated a 1,200-hp locomotive that was semi-permanently attached to ten coaches built by GM's Truck and Coach Division from modified 40-passenger intercity bus bodies. The combination of lightweight construction and jointed railroad rails gave the Aerotrain a riding quality similar to that of a

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*In 1959, GM's Detroit Diesel Division introduced a complementary line of diesel engines, ranging from 20 hp to 1,650 hp -- a clear example of the advantages of economies of scope in a large firm. Business Week, November 12, 1949, 68-74; January 10, 1959, 54-8; Railway Age 132:22 (June 2, 1952), 85-7; 135:19 (November 9, 1953), 28-30; 146:4 (January 26, 1959), 14; 146:19 (May 11, 1959), 62-3; EMD press release, October 31, 1949, AAR.
schoolbus travelling over a perpetual series of speed-bumps. This misguided attempt to exploit economies of scope among different divisions was a failure. ALCo did not exploit these deficiencies, however, and was unable to develop locomotives that were superior to those offered by EMD.⁹

Although EMD increased the size of La Grange without interruption between 1935 and 1958, the division wisely refrained from expanding its facilities to such an extent that it could accommodate all of the locomotive orders from the entire railroad industry. Had it done so, it could have driven all of its competitors from the industry, creating two problems. First, the federal government was likely to take a dim view of any company possessing a 100 percent market share and did in fact prosecute EMD for alleged antitrust violations during the 1960's. Second, when the dieselization boom

began its inevitable downturn, EMD could retrench easily and allow its smaller, high-cost competitors to suffer the brunt of declining demand. EMD's voluntary restraint in the diesel locomotive industry was similar to GM's earlier decision to refrain from monopolizing the automobile market.\(^{10}\)

In addition, the dieselization rush led to the creation of new research and development and production capabilities. In 1947, EMD concentrated all diesel locomotive research and development functions in a new $1 million research center. This new Diesel Locomotive Development Center housed the Power Plant Group, the Transmission Group, the Equipment Group (responsible for fans, blowers, and steam heating boilers), the Air Brake Group, the Electrical Control Group, the Sales Engineering, Service Engineering, and Styling Groups, as well as the Fuel Section of the Engine Group. At the same time, EMD established a process engineering department for the purpose of increasing its production efficiency. The Advance Engineering Department was assigned the task of

\(^{10}\)Address by John F. Gordon at EMD banquet, Detroit, October 18, 1961, AAR.
preparing new locomotive designs and custom designs for foreign orders. The Development Center also converted a surplus locomotive body into a self-contained mobile laboratory that could test new EMD locomotive designs in actual railroad service.\footnote{\textit{Railway Age} 122:23 (June 7, 1947), 1180; 123:18 (November 1, 1947), 726-8, 739; 127:5 (July 30, 1949), 221-3; GM press release, July 27, 1949, AAR; Franklin M. Reck, \textit{On Time: The History of Electro-Motive Division of General Motors} (GM-EMD, 1948), 99, 163.}

In order to relieve the production overload at La Grange and avoid overexpansion of that facility, EMD opened two additional locomotive plants. EMD acquired Plant #2, located in South Chicago, in May, 1946 in order to increase its production of locomotive sub-assemblies. In 1951 EMD installed its first conveyor belt assembly line in Plant #2 in order to apply rust-proofing materials to locomotive cabs. This was the exception, however, and EMD generally used overhead cranes to transport large locomotive components. In January, 1949, a plant in Cleveland began production of 600-hp and 1,000-hp switchers. The U. S. Navy had built this 460,000-square-foot facility for the production of diesel engines by GM's Cleveland Diesel Engine Division.
in 1942. After purchasing the plant, GM allocated 60 percent of the space to EMD. By 1950, 3,000 people worked at Plant #2, with 1,500 more at Cleveland, in addition to 10,000 employees at La Grange.\textsuperscript{12}

Along with these improvements in manufacturing, EMD expanded its marketing capabilities during the postwar period and continued to recognize the importance of public opinion in the locomotive industry. The division's 1946 "Better Trains Follow Better Locomotives" and "Bright New Era" ad campaigns were targeted at railroad passengers. In May, 1947, EMD dedicated the GM Train of Tomorrow by launching it on a six-month tour of more than thirty cities in the United States. This combination of a single diesel locomotive and four luxury passenger cars was never intended to be a regular production item for EMD. Instead, GM President Charles E.

\textsuperscript{12}Because of declining locomotive demand, GM transferred the Cleveland plant to the Euclid Division in 1954, although the facility continued to produce diesel locomotive parts. \textit{Railway Age} 124:26 (June 26, 1948), 1306; 129:8 (August 19, 1950), 43-4; 130:25 (June 25, 1951), 96; 137:15 (October 11, 1954), 11-12; EMD Streamliner 12:2 (June 18, 1948), GMI, folder 83-12.101; GM-EMD, 1951 Progress Report, John W. Barriger III Collection at the St. Louis Mercantile Association Library (hereafter referred to as the Barriger Collection), box H-34, 15-16.
Wilson was interested in "... creating a greater interest in rail transportation by the public and a greater acceptance of the products we furnish to railroads."¹³ A few years later, EMD issued a thirty-two-page booklet, targeted at the general public, that stressed the virtues of diesel locomotives in general and EMD locomotives in particular. EMD thus knew, as it had since the 1930's, that public pressure could be a significant factor in encouraging railroads to replace their dirty and noisy steam locomotives with modern diesels.¹⁴

Other EMD marketing efforts were targeted directly at railroad executives. EMD ads initially stressed "super-production and super-transportation." By the late 1940's, the emphasis of the ads had shifted from "selling the concept of the diesel-electric to selling complete and total dieselization." EMD ads in the early 1950's continued to focus on the elimination of steam,

¹³Railway Age 122:22 (May 31, 1947), 1110-1 (quote).

but with the addition of statistical information. The booklet "Safeguarding Railroad Earnings" provided a well-written, easy-to-understand description of how EMD could save money for its customers, particularly in the areas of parts service and locomotive rebuilding. Shortly after the war, EMD developed the Operating Comparison Report to serve as a clearinghouse for information from more than thirty railroads regarding the most efficient utilization of EMD diesel locomotives. Some railroad executives thought that these reports were of little value, since most railroads had vastly different operating characteristics. Nevertheless, services such as these often impressed the senior railroad executives who made the final locomotive purchasing decisions.¹⁵

EMD also played on the vanity of senior railroad executives. It supplied them with handsomely framed pictures of EMD diesels for the office walls. More

¹⁵Railway Age 173:4 (August 28, 1972), 40-1 (quotes); GM-EMD, "Safeguarding Railroad Earnings," 1952, AAR; Nelson C. Dezendorf, speech before the New York Society of Security Analysts, New York, June 1, 1951, AAR; R. C. Parsons to Ivan E. Rice, October 13, 1953, Louisville and Nashville Railroad Collection, University of Louisville (Record Group 123, hereafter referred to as the L&N Records), box 2, folder B-77203.
importantly, its highly successful 1957-1959 ad campaign, "Men Who Build the Future of American Railroads," placed color portraits of important railroad executives on the front cover of *Railway Age*, the leading industry trade journal. EMD locomotives also appeared on these covers, but they were in the background and were, appropriately, smaller than the heads of the railroad executives. In comparison, ALCo's efforts to cultivate the goodwill of important railroad officials in the postwar period were much less well developed. At the 1946 New York premiere of ALCo's new locomotive line, for example, the senior railroad executives in attendance watched an Arizona Indian tribal dance and were each given a free carnation. Clearly, EMD's marketing efforts were both more professional and more effective than those employed by its competitors.16

After the war, EMD's Service Department was given responsibility over an expanded set of training programs. The importance of these instructional courses

is indicated by the fact that EMD had approximately twenty salesmen in the United States, yet employed 120 locomotive instructors. In addition to its two instruction cars and its classes at La Grange, EMD sent a complete diesel locomotive on an instructional tour of American railroads. In 1953, recognizing the increasing importance of foreign orders, EMD instituted a 90-day export training class. Gradually, as larger numbers of railroad operating and maintenance employees became familiar with diesel locomotives, the importance of these instructional services declined. For many years, however, EMD's locomotive school increased goodwill and accustomed a generation of railroad employees to EMD locomotives.\textsuperscript{17}

EMD expanded its parts and service network to accommodate the growing number of diesel locomotives on American railroads. In February, 1949, EMD opened a new parts distribution center at La Grange, containing some $3 million in inventory. EMD also operated parts

\textsuperscript{17}Railway Age 125:26 (December 25, 1948), 1188; 134:9 (March 2, 1953), 12; United States of America vs. General Motors Corporation, case # 61CR356, filed April 12, 1961, U. S. District Court, Southern District of New York, National Archives, Northeast Region, 4.
distribution centers in other cities, including Jacksonville, Halethorpe (Baltimore), Maryland, Minneapolis, Los Angeles, Emeryville, California, and St. Louis. By the end of 1949, EMD had invested $39 million in its parts distribution network, an amount that was nearly double what ALCo had expended on its entire postwar plant modernization program. EMD also conducted extensive research into methods of spare-parts packaging. In 1959, EMD installed an IBM punchcard Daily Multiple Order Invoice System to coordinate parts distribution at La Grange and eight branch locations.

EMD's investments in parts distribution were well rewarded. Parts sales of more than $20 million in 1948 were expected to more than triple by 1953. One railroad superintendent declared that "... we find that our storeroom is about the most deserted place on the railroad. The necessity of storing a number of parts has been eliminated due to the fact that the manufacturers have established supply depots that will furnish parts..."¹⁸ Since EMD had a larger parts distribution

network than any of its competitors, it captured both the largest portion of the spare parts business and the goodwill that accompanied this service.\footnote{\textit{Fortune} 38 (July, 1948), 76-81; \textit{Railway Age} 126:10 (March 5, 1949), 478-9; 127:6 (August 6, 1949), 246-9; 146:9 (March 2, 1959), 23, 26; EMD press release, February 24, 1949, AAR.}

EMD also established locomotive rebuilding locations throughout the United States. Division managers believed that locomotive rebuilding would increase goodwill, provide a captive market for EMD parts, allow greater amortization of research and development and tool and die costs, and serve as a testbed for experimental techniques that, if successful, could be implemented at La Grange. A former dog-biscuit factory in Oakland, California, was the location of the first rebuild facility, established in 1944. Facilities at Jacksonville, Baltimore, and Emeryville, California, soon followed. The rebuild facility in St. Louis, opened in 1950, was the first to use the same assembly-line techniques employed at La Grange, albeit on a much smaller scale. Assembly-line capabilities were soon
installed at Baltimore and Los Angeles as well. In 1955, EMD opened a Salt Lake City branch plant.20

EMD's competitors were never able to match this investment in rebuilding facilities. Baldwin had only its main plant at Eddystone, along with the facilities operated by Westinghouse. Similarly, ALCo expanded its rebuild capabilities only by using GE service centers, though ALCo did begin to establish its own parts distribution centers in 1952. Fairbanks-Morse was forced to rely on its main plant in Beloit. The failure of Baldwin, ALCo and Fairbanks-Morse to match EMD's investment in rebuilding centers was thus yet another factor that reduced their chances for survival in the locomotive industry.

EMD added to its managerial capabilities in the postwar period, as lifelong GM employees continued to replace older technician managers, a process that had begun during World War II. In early 1950, Richard Dilworth retired from EMD, though he continued to serve as

a consultant until 1952. Dilworth was among the last of the informally trained technician-managers left at EMD. The year 1953 saw the departure of O. F. Brookmeyer, another manager of this type. An early advocate of gasoline rail cars, Brookmeyer had served as superintendent of transportation for the Big Four Railroad, a subsidiary of the New York Central. He joined EMC as a sales manager in 1925 and later became general sales manager at EMD. 21

As these technician-managers retired from EMD, the division became increasingly dominated by managers, often supplied by General Motors, who were trained in sales, rather than production techniques. When Cyrus Osborn, the GM vice-president in charge of EMD, left the division in 1950 to become head of GM's General Engine Division, he was replaced by B. A. Dollens, the former assistant general manager at EMD. Dollens, a 1925 graduate of Purdue University, had spent many years at DELCo before being transferred to EMD in 1946. When Dollens died in February, 1952, he was replaced by Nelson C.

Dezendorf, the former director of sales. Dezendorf was himself replaced by Richard L. Terrell in 1959. Terrell had begun his career as an apprentice in GM's Detroit Research Laboratory. He joined EMC as a service engineer in 1939, and after a three-year stint in the U. S. Navy, became a district sales manager, then general parts manager, then assistant regional manager. The promotion of these managers thus indicates that EMD, and GM, recognized the importance of marketing and salesmanship.\textsuperscript{22}

A temporary lull in the dieselization boom in the early 1950's forced EMD to reduce its production and seek ways to increase the scope of its business. Railroads cut their capital expenditures for diesel locomotives in 1952, even though there were still some 16,000 inefficient steam locomotives in service. In addition to their concerns about the high debt incurred with diesel locomotive purchases, railroad executives were disappointed by the unexpectedly small increase in

\textsuperscript{22} \textit{Railway Age} 129:7 (August 12, 1950), 76; 129:8 (August 19, 1950), 43-4; 132:7 (February 18, 1952), 13; 132:11 (March 17, 1952); 132:15 (April 14, 1952), 57-8; 147:11 (September 14, 1959), 67.
traffic produced by the Korean War. La Grange was no longer booked to capacity, as it had been between 1936 and 1951. In 1953, EMD reduced output at La Grange from 7.5 locomotives per day to 4 locomotives per day. La Grange stopped production for the entire month of July, 1954, because of a lack of orders. By this time, employment at La Grange had decreased from 10,000 to 6,500. The first plant closing occurred in October, 1954, when the Cleveland switcher plant was transferred to GM's Euclid Division for the production of earthmoving equipment.

In an attempt to secure additional business for La Grange, EMD introduced specialized railroad cars, mobile diesel-powered electric generating stations, and integrated power packages for the oil-drilling industry. In addition, it placed increased emphasis on foreign orders and locomotive rebuilding. The success of its power packages, along with an unexpected increase in locomotive orders, led to an immediate increase in employment, as well as a 42 percent expansion of La Grange between 1956 and 1957. By August, 1956, La Grange had a fourteen-month order backlog. This boom did not last, however, and as railroads replaced the
last of their steam locomotives, orders once again declined. The years between 1957 and 1961 were difficult ones for the entire locomotive industry. By the latter year, employment at La Grange had fallen to just 6,000 people.  

During the postwar dieselization boom, EMD enjoyed the benefits of the investments that it had made in manufacturing, marketing, and management during the 1930's and the early 1940's. EMD engaged in a carefully planned expansion of these organizational capabilities during the postwar period. When locomotive orders unexpectedly declined in the early 1950's, EMD was able to exploit economies of scope in order to secure additional business. By 1960, the completion of railroad

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dieselization programs had not created any serious hardships for EMD. Because it had refrained from over-expansion at La Grange, and because it had used expendable outlier plants, EMD's continued survival in locomotive industry was never in doubt. Instead, the decline in locomotive orders fell hardest on the smaller, high-cost producers, Fairbanks-Morse and Baldwin-Lima-Hamilton. After these firms had been driven from the market, ALCo alone remained as a competitor to EMD.

ALCo FAILS TO KEEP PACE WITH EMD

As the only other viable producer in the locomotive industry, ALCo also enjoyed considerable success in the postwar period. Even though it was a higher-cost producer than EMD, ALCo's locomotive prices were often slightly lower. This price differential, combined with the long order backlog at La Grange, persuaded many railroad executives to place their orders with Schenectady. ALCo gradually lost market share in the postwar period, however, as EMD improved its products and services at a rate that ALCo could not match. The collapse of the dieselization boom threatened not only ALCo's
profitability but its continued survival in the locomotive industry.

By the late 1940's, ALCo executives finally began to understand that the steam locomotive industry, long their company's principal source of business, was about to vanish forever. During the 1930's they could use the periodic famine of economic depression to rationalize low locomotive orders while failing to understand that even railroads that could afford steam locomotives no longer wanted them. When steam locomotive sales soared during World War II, ALCo executives misinterpreted this increase in demand, incorrectly attributing it to genuine customer desire for steam locomotives rather than to temporary government restrictions on the production of diesel locomotives. Not until after the war was it clear to everyone, including those whose corporate culture centered around steam locomotive production, that railroads demanded only diesels.

The speed with which American railroads replaced their steam locomotives, many only a few years old, came as a surprise to ALCo executives. Although they were ready to produce new locomotive designs shortly after World War II ended, ALCo executives delayed for several
crucial years before attempting the extensive plant modifications that were necessary for diesel locomotive production. In addition, the inexperience of ALCo engineers with internal-combustion technology resulted in the continued production of a diesel engine that was considerably inferior to that offered by EMD. Finally, ALCo began to rely even more heavily on its production partner, General Electric, for critical locomotive components and marketing expertise, thus weakening ALCo's organizational capabilities.

As the war neared its end, ALCo's ordinance production virtually ceased and seemed unlikely to reappear. The prospect of 1920's (and earlier) vintage facilities, formerly used for tank production, standing empty and unused was a daunting one. Accordingly, ALCo executives adopted a dual strategy of expansion.

First, the company diversified into related product lines. In 1945 it purchased the Beaumont Iron Works, based in Beaumont, Texas. This firm, which produced oilfield equipment, gave ALCo additional outlets for pipe, pressure vessels, and diesel engines. In the same year ALCo established the American Locomotive Export Company, a wholly owned subsidiary, to market its
locomotives abroad, primarily to Latin America. As part of this diversification process, president Robert McColl appointed a new administrative committee to manage and coordinate the company's varied activities. At this time, ALCo's corporate structure consisted of four divisions -- Locomotive, Railway Steel Spring, Diesel Engine, and Alco Products -- and two wholly owned subsidiaries, the Montreal Locomotive Works and the American Locomotive Export Company. The segregation of locomotives and diesel engines into two separate divisions may well have caused difficulties in management and production.24

Second, although it did not immediately abandon steam locomotive production, the company placed new emphasis on diesel locomotive development. In spite of their faith in steam locomotives, ALCo executives could not escape the fact that railroads no longer wanted outdated steam technology. According to Board Chairman Fraser, "The company has been quick to reflect the

demands of railroads for Diesel-electric locomotives ... without disturbing our steam locomotive productive capacity ..."  

ALCo attempted to satisfy these demands with a 2,000-hp passenger locomotive, a 1,500-hp freight unit, a 1,500-hp road switcher, and 1,000-hp and 600-hp yard switchers -- all of which were in production by late 1946. EMD produced similar models, and that firm's Model 567 diesel engines were far superior to the 12-cylinder and 16-cylinder Series 244 engines offered by ALCo.

As with earlier units, ALCo's locomotives used GE electrical equipment, and were thus marketed under an "ALCo-GE" nameplate. ALCo became even more reliant on GE in 1950, when it transferred authority for diesel locomotive sales and service to that company. This arrangement added more than 300 GE sales outlets to ALCo's seven such facilities. Although ALCo certainly did not need this many sales offices, the agreement did give that company access to GE's superior marketing network. The fact that ALCo turned over all marketing

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25 Railway Age, 120:16 (April 20, 1946), 839 (quote).
responsibility to another company offers further evidence of the inability of ALCo managers to understand the importance of marketing in the diesel locomotive industry. In addition, the prominent role of GE in marketing and post-sales support services allowed that company to acquire valuable expertise that it later used when it became a direct competitor to ALCo.\textsuperscript{26}

Between 1945 and 1947, ALCo invested approximately $20 million in facilities and equipment for diesel locomotive production. The funds necessary for this investment were acquired through the sale of 46 percent of ALCo's holdings in the General Steel Castings Corporation, slightly less than half of its holdings in the Montreal Locomotive Works, a $13.5 million bank loan, and the issuance of 400,000 shares of common stock.\textsuperscript{27}


ALCo also bore the cost of converting its subsidiary, the Montreal Locomotive Works, to diesel locomotive production. Working in cooperation with the Canadian General Electric Company (electrical equipment) and the Dominion Engineering Works (diesel engines) MLW built its first diesel locomotive in 1948. The Montreal Locomotive Works completed its last steam locomotive two years later.\(^2\)

In spite of management's claims to the contrary, this expenditure was not sufficient to establish "... assembly-line production methods never before used in the locomotive-building field."\(^2\) The physical arrangement of the Schenectady plant remained much as it had been during the halcyon days of steam locomotive production, a layout that was never suited to assembly-line production. As late as 1946, the plant was still cluttered with buildings (the Boiler, Tank, Rod, Jacket, and Cylinder Shops) that were suitable only for steam

\(^2\)ALCo, 1948 Annual Report, 8; 1950 Annual Report, 8; *Railway Age*, 124:2 (January 10, 1948), 142-3.

\(^2\)ALCo, 1946 Annual Report (quote). This statement ignores the opening of EMD's La Grange facility some ten years earlier.
locomotive production. The newly constructed diesel engine machine shop sat next to the flood-prone Mohawk River, on the opposite side of the 112-acre facility from the other diesel locomotive facilities.30

ALCo's $20 million investment in new postwar production facilities, while impressive, was not nearly enough to keep pace with EMD. The tooling for EMD's diesel engine production alone represented a comparable investment. In addition, EMD had nearly twice that amount invested in its parts distribution network. La Grange itself was worth some $80 million, or four times the cost of ALCo's modernization program. Of course, ALCo could not hope to match the financial might of EMD's parent corporation; in 1960, ALCo's assets were 1 percent of GM's assets, its sales 0.7 percent of GM's sales, and its profits 0.005 percent of GM's profits. However, the fact that much of EMD's expansion was financed through reinvested earnings reduces the

30 "General Layout of the Schenectady Works: November 1, 1946," map file, ALCo Collection, Box 13.
validity of any claims that GM's financial might gave
EMD an unfair advantage over ALCo.  

A more serious handicap was the continued unwillingness of ALCo managers to admit that the steam locomotive was no longer a viable power source for American railroads. In August, 1945, a memorandum issued to shareholders predicted "... that great advances will be made in the development of coal-burning steam locomotives during the next decade." Four months later, ALCo senior vice-president Joseph B. Ennis remained convinced "... that the future holds an expanding role for both the steam locomotive and the Diesel." These attitudes were reflected in ALCo's supposedly enlightened ad policy. In October, 1945, ALCo was

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31 Summary of remarks by Ralph Budd at the EMD Silver Anniversary Dinner, Chicago, October 24, 1947, AAR; United States of America vs. General Motors Corporation, case # 61CR356, filed April 12, 1961, U. S. District Court, Southern District of New York, National Archives, Northeast Region, 6; Our GM Scrapbook, 124-30.

32 Railway Age, 119:9 (September 1, 1945), 388.

33 Railway Age, 119:24 (December 15, 1945), 970-2. This "expanded role" for steam locomotives did not materialize, as ALCo produced its last such locomotive less than three years later.
promoting its steam locomotives with ads bearing the heading "Alco: The Mark of Modern Locomotion."\textsuperscript{34}

The faith of ALCo executives in steam locomotives continued into the late 1940's. As late as December, 1947, ALCo's Junior Engineer Training Program was instructing trainees in the techniques of steam locomotive construction. In the same year, ALCo exhibited an all-welded steam locomotive boiler -- the latest in steam locomotive technology -- at the Railway Supply Manufacturers Association convention in Atlantic City. W. A. Callison, an ALCo vice-president, stated, in 1947, that "We do not, by any means, believe that the steam locomotive is dead."

In 1948, as ALCo turned out its last steam locomotive, Perry T. Egbert, then vice president in charge of the locomotive division and later president of the company, lamely announced that "American Locomotive is not intentionally going out of the steam locomotive business. It is simply a matter of

\textsuperscript{34} Railway Age, 119:14 (October 6, 1945), 48a-b (quote).

\textsuperscript{35} Railway Mechanical Engineer 121 (October, 1947), 541-2 (quote).
Rather than abandoning its steam locomotive production facilities or converting them to more productive uses, ALCo mothballed them in anticipation of future orders, orders that never materialized.37

Even after it became abundantly clear that American railroads were no longer interested in steam locomotives, ALCo worked in cooperation with the Locomotive Development Committee of Bituminous Coal Research, Inc. to design a steam turbine locomotive. In cooperation with GE, ALCo built several similar models, which burned crude oil rather than coal. Because small turbines were considerably less efficient than those that powered ocean-going ships and power-generating facilities, these

36Railway Age, 124:25 (June 19, 1948), 1225 (quote).

37Railway Age, 122:25A (June 23, 1947), 1294D21; Diesel Power and Diesel Transportation, December, 1947, 66-69. In April, 1949, ALCo transferred its business in steam locomotive repair parts to the Lima-Hamilton Corporation -- an apparent admission that ALCo's role in the steam locomotive field had ended. (Railway Age 126:16 (April 16, 1949), 802).
steam-turbine locomotives were never more than moderately successful.\textsuperscript{38}

Postwar ALCo executives were scarcely better equipped than their predecessors to manage the company's transformation from a steam locomotive builder to a producer of diesels. Robert B. McColl, elected president in December, 1945, was trained in the now-outdated skills of steam locomotive production. He began his career as an apprentice draftsman at the famous English locomotive builder, Robert Stephenson & Sons. He later worked at the Montreal Locomotive Works, then as the manager of ALCo's Schenectady facility. McColl's successor, Duncan W. Fraser, was also his predecessor, thus continuing the succession of executives who lacked experience in diesel locomotives and internal-combustion technology. Compounding this problem was the confusion and discontinuity created when nineteen officers and

\textsuperscript{38} ALCo, "Report of the Annual Meeting," April 20, 1948, ALCo Collection, Box 6; Dunkirk Observer, September 16, 1948; Railway Age, 125:22 (November 27, 1948), 1039-40. The bituminous coal industry was naturally interested in preserving its principal market. In 1945, for example, railroads used 125 million tons of coal -- more than any other single industry. (New York Times, January 27, 1947, 1, 13).
directors of the company retired, resigned, or died between 1947 and 1954, the years of peak diesel locomotive demand. 39

Not until 1952 did an ALCo chief executive have significant experience with diesel locomotives. In December of that year Perry T. Egbert became president of the company. He received a mechanical engineering degree from Cornell University in 1915 and later served in the U. S. Air Corps. He taught experimental engineering at Cornell in 1919 and 1920 and in 1921 became ALCo's technical representative in East Asia. In 1929, following the acquisition of McIntosh and Seymour, he took control of ALCo's diesel-engine development program. Egbert became manager of railroad diesel sales in 1934, and vice president in charge of diesel locomotive sales ten years later. In addition, he directed ALCo's postwar conversion from steam to diesel locomotive production. ALCo now had a president who understood how to exploit the dieselization boom; yet,

even as Egbert began his new duties, that boom was ending.\textsuperscript{40}

By the mid-1950's, most railroads had replaced the last of their steam locomotives, leaving a much smaller market for upgraded or replacement units. This situation forced ALCo to change its competitive strategy yet again. This market shrinkage forced Fairbanks-Morse and Baldwin-Lima-Hamilton out of the locomotive market entirely and substantially reduced ALCo's locomotive sales. After 1957, ALCo was EMD's only competition in the domestic market for large diesel locomotives. ALCo's market share seemed likely to decline still further, as railroads chose to standardize on the technologically superior products offered by EMD. As a result, ALCo made some improvements to its diesel locomotive line and, more importantly, began to diversify into fields unrelated to railroading. This diversification program was unsuccessful, largely because ALCo executives made the same mistake that had kept them

\textsuperscript{40}ALCo, report of the annual meeting, May 19, 1953, ALCo Collection, Box 6; ALCo, press release, December 27, 1962, ALCo Collection, Box 13; \textit{New York Times}, March 13, 1942, 27; July 14, 1944, 21; \textit{Railway Age}, 133:23 (December 8, 1952), 85.
so enamored of steam locomotive production: they concentrated on custom-designed, custom-built products rather than standardized, mass-produced ones.

While custom batch production has undoubtedly been the salvation for some companies, such was not the case for ALCo. Success in batch production, as in mass production, depends on the organizational and managerial skills of a given company, as well as on often-uncontrollable market forces. ALCo failed in both areas, since it lacked adequate management and diversified into product lines where it was buffeted by stronger competitors. The company was thus unable to transfer its skills as a successful batch producer of steam locomotives to diesel locomotives or non-locomotive products.41

Other problems plagued ALCo's locomotive production and distribution. The ALCo Model 244 engine, in production until 1953, was considered more difficult to

41 In a recent article, business historian Philip Scranton shows that batch production can be catastrophic for many firms, such as those in the American jewelry industry during the 1920's. Scranton, "Diversity in Diversity: Flexible Production and American Industrialization, 1880-1930," The Business History Review 65 (Spring, 1991), 27-90.
service than its EMD Model 567 counterpart. In addition, since La Grange was located in Chicago, at the center of the North American railroad network, delivery times tended to be shorter and delivery costs lower than from ALCo's Schenectady plant. Taxes were higher in New York than in Illinois, putting ALCo at a further disadvantage. In addition, ALCo suffered from declining labor productivity, probably caused by outdated manufacturing facilities, and relatively higher wages and fringe benefits.\(^2\)

As ALCo's difficulties became more apparent, railroads became increasingly reluctant to purchase the diesels that emerged from Schenectady. As late as the mid-1950's, the Louisville and Nashville had no clear preference between ALCo or EMD locomotives and resolved to purchase both models on a relatively equal basis, a fact that negates any assertions that World War II had ended ALCo's hopes for success in the locomotive industry. In fact, L&N executives found it "difficult

\(^2\)"Telecast Script of James J. Reynolds, Vice-President of Manufacturing, Presenting the Facts Behind the Strike Affecting Alco's Schenectady, Auburn, and Dunkirk Plants," April 1, 1957, ALCo Collection, box 6; Garmany, *Southern Pacific Dieselization*, 221.
indeed to justify..." the extra $10,000 per unit cost of EMD locomotives.43 Gradually, however, as ALCo began to demonstrate its failings, the L&N began to favor EMD models. Railroad executives complained about the difficulty of obtaining spare parts from ALCo, a situation exacerbated by chronic strikes at Schenectady. For example, one ALCo locomotive was kept out of service for ten days at Louisville, Kentucky, because of a broken headlight. ALCo shipped a replacement to Chicago by mistake, and, once there, the headlight vanished without a trace. By 1955, the chairman of the board of the Louisville and Nashville was impressed by the fact "...that other railroads that have given the subject careful study consider the Electro-Motive units a better value than Alco..."44 It is clear, therefore, that continued difficulties, not World War II restrictions, hindered ALCo's efforts to compete against EMD.45


45 R. C. Parsons to L. L. Morton, February 12, 1948, box 2, folder 81930; Parsons to John E. Tilford, January 26, 1955; Parsons to Tilford, June 22, 1955, both in box 2, folder A-15113; J. F. Ryan to Parsons, June 23, 1953, box 2, folder B-77203; A. L. M. Wiggins
In addition, labor disputes and high wage rates put ALCo at a serious competitive disadvantage. In 1947, ALCo President Robert McColl declared that "The Taft-Hartley Act is certainly no obstacle to excellent relations between a friendly management and a friendly employment group. We think, on the contrary, it can provide a new impetus toward good relations."\footnote{Railway Age 122:25E (June 27, 1947), 1294D213 (quote).} In spite of this confident assertion, ALCo was racked by labor disputes in the postwar period. Between 1943 and 1960, ALCo's locomotive production was interrupted by at least eighteen separate strikes or work slowdowns. These ranged from a two-day strike by 200 workers in 1943 to a two-month strike in 1946 to a three-month strike in 1951 to a six-month strike in 1952-1953. Concessions made by ALCo executives to the United Steelworkers of America contributed to the company's high wage rates, as did overuse of piecework incentives. In December, 1951, average wage rates at GM were $1.91 per

\footnote{to Tilford, August 11, 1955; Parsons to Tilford, March 7, 1955, both in box 2, folder A-15113; all correspondence in L&N Records.}
hour, while workers at Schenectady earned $2.41 per hour. To produce a diesel locomotive, ALCo spent 58 cents more per hour than the industry average.47

ALCo made several attempts to reduce its wage imbalance with EMD. In 1947, the company reduced its piece rates, a decision that affected 60 percent of the workforce. ALCo executives claimed that the only alternative to this reduction, which it called Plan V, was a forced exit from the locomotive business. ALCo was also quick to lay off unneeded workers in the event of a decline in business. Layoffs occurred in 1949, 1952 (twice), 1954, and 1956. In addition, ALCo closed its

47 Barron's, April 9, 1956, 29-30; New York Times, June 5, 1943, 11; August 2, 1945, 36; October 5, 1945, 14; October 8, 1945, 30; April 16, 1947, 2; February 14, 1949, 7; April 16, 1949, 8; May 26, 1949, 18; August 19, 1950, 28; March 7, 1951, 33; March 10, 1951, 18; October 23, 1952, 15; November 4, 1952, 20; February 21, 1953, 6; March 9, 1953, 18; March 1, 1955, 18; March 18, 1955, 23; January 17, 1957, 36; March 2, 1957, 42; May 18, 1957, 23; June 10, 1958, 25; January 8, 1959, 11; April 11, 1960, 15; April 25, 1960; 130:7 (February 12, 1951), 125; ALCo, 1946 & 1952 annual reports, ALCo, "Report of the Annual Meeting," April 17, 1951, ALCo Collection, box 6; United States Wage Stabilization Board, "In the Matter of the Panel Hearing Conducted Under the Dispute Resolution Procedures of the Wage Stabilization Board Relating to Terms of a Renewed Contract Between American Locomotive Company ... and the United Steelworkers of America, CIO, May 21-June 27, 1952," (Washington: WSB, 1952), 399-400, 647.
Schenectady plant in 1956 and 1960. These strikes, layoffs, plant closings, and pay reductions lowered worker morale and productivity. The strikes, in particular, slowed locomotive deliveries and prevented the company from attaining a reputation as a trustworthy supplier.

EMD, on the other hand, suffered only one serious strike during the postwar period, the 1945-1946 United Autoworkers strike against all GM facilities. GM executives, unlike those at ALCo, were able to reach an accommodation with organized labor that traded steadily rising wages and fringe benefits for workplace stability. As a result, EMD's relative labor harmony, along with its lower wage rates, gave it a strong competitive advantage against ALCo.48

ALCo's marketing efforts were also inferior to those of EMD. ALCo had a national advertising campaign, but it allowed GE to prepare these ads, since that

company had better graphic facilities, another example of ALCo's willingness to give away its organizational capabilities. In addition, as late as 1946, these weekly ads alternated between portrayals of steam and diesel locomotives. Two years later, ALCo declared that it had now realized the importance of post-sales support services such as locomotive schools and parts distribution centers. ALCo's locomotive school was never as extensive as that offered by EMD and was burdened with the additional responsibility of retraining the thousands of ALCo workers whose careers were based on steam locomotive technology. Finally, ALCo was able to extend its service and spare parts distribution network only by making use of GE facilities. ALCo's inability to develop its own marketing capabilities initially reduced its ability to compete with EMD and later put it at the mercy of GE.49

Although most American railroads did not complete their dieselization programs until the mid-1950's,

ALCo's peak years of diesel locomotive production lasted only from 1946 to 1952. By 1953, ALCo had reduced its diesel locomotive output from four units per day to three. While 1951 locomotive sales were $131.2 million, those in 1954 were but $26.4 million. As the company's market share collapsed, ALCo executives sought both a scapegoat and a solution for their declining market share.50

In an attempt to rationalize their failure in the postwar locomotive industry, ALCo managers found a scapegoat in World War II in general and the War Production Board in particular. In 1949, these executives explained to their company's stockholders that "...throughout the long period of war, Alco was prevented by its war job from making substantial progress in the research and development work which are required for the creation and introduction of an entirely new [diesel locomotive] product."51 This statement contradicted ALCo's earlier position that the


51 ALCo, Report of the Annual Meeting, April 19, 1949, ALCo Collection, Box 6 (quote).
war had facilitated diesel locomotive development and ignored the fact, shown in the previous chapter, that the WPB placed no restrictions whatsoever on locomotive research and development. Statements such as these, made by a management anxious to absolve itself of all responsibility for the company's declining market share, have given rise to the mistaken belief that WPB restrictions aided EMD at the expense of ALCo and the other locomotive builders.

ALCo's solution to declining market share and the cessation of military orders associated with the Korean War was three-fold.

First, as locomotives purchased during the initial dieselization rush began to show their age, ALCo placed additional emphasis on spare parts and locomotive renewals. In 1952, the company established a locomotive rebuilding and repair service at its Schenectady plant. Two years later, ALCo opened its first parts warehouse, in St. Louis. ALCo eventually had seven such warehouses. As had been the case with assembly-line production, ALCo merely followed the lead of EMD, albeit nearly a decade behind its larger rival. Compared to locomotives, spare parts tended to be a low-profit item,
however. For the most part, only those railroads that had initially purchased ALCo locomotives were likely to have any interest in either the parts warehouses or the rebuilding services. Thus, as ALCo's locomotive sales declined, these ancillary businesses eventually did the same. In addition, the concentration of locomotive rebuilding at Schenectady gave a comparative advantage to EMD's more centrally located La Grange facility. For all of these reasons, ALCo's share of rebuild orders was by the early 1960's much smaller than management had anticipated.

Second, in 1956, ALCo introduced a new line of locomotives, including the 900-hp DL-430 and the 1,800-hp DL-701. The primary advantage of these locomotives was ALCo's new Model 251 diesel engine, an engine roughly comparable to that offered by EMD nearly twenty years earlier. In most railroad applications, these new ALCo diesels performed no better than their EMD

52 ALCo, 1952 Annual Report, 8; 1957 Annual Report, 25; ALCo, 1957 advertisement, reprinted from Diesel Progress, ALCo Collection, Box 1; Jack Lillis to Art Batts, February 19, 1963, ALCo Collection, Box 12; Railway Age, 136:5 (February 1, 1954), 13; 136:21 (May 24, 1954), 40, 44; 137:24 (December 13, 1954), 70.
counterparts and, in any case, had been introduced too late to take advantage of the postwar dieselization boom.\textsuperscript{53}

In order to produce this new line of diesels more efficiently, ALCo embarked on a major plant modification program in 1957. ALCo reduced the size of its Schenectady plant by a third, mostly by selling or demolishing the vacant buildings formerly used for combat tank and steam locomotive production. ALCo's latest physical plant modernization program, enacted some twenty-two years after comparable developments at EMD, created a "progressive station" assembly line in which production bays on either side of the main erecting shop funneled components onto one of three assembly tracks. This system speeded production and reduced the costly transfer of locomotive components between various parts of the plant.\textsuperscript{54}

\textsuperscript{53}Alco Products Review, 5:2-2 (Spring/Summer, 1956), 15; Railway Age, 140:4 (January 23, 1956), 43-44; 140:9 (February 27, 1956), 24-26.

\textsuperscript{54}ALCo, 1957 Annual Report, 3-4; ALCo press release, August 6, 1957, ALCo Collection, Box 12; Railway Age, 142:15 (April 15, 1957), 12 (quote); 143:8 (August 19, 1957), 10. In 1957, as ALCo was divesting itself of a third of its Schenectady plant, EMD was planning a 42 percent expansion of its La Grange facility. (Railway Age, 142:2 (January 14, 1957), 134.)
Third, ALCo began to diversify out of railroad-related product lines. Symbolic of this transformation was the 1955 renaming of the American Locomotive Company as Alco Products, Incorporated. The new company sold its holdings in the railroad-dependent General Steel Castings Company and purchased the Central Pipe Fabricating and Supply Company and the Carter Craft Company. Alco Products also merged with its wholly owned subsidiary, the Beaumont Iron Works, and established a new atomic energy products department. This last group, managed by Kenneth Kasschau, former head of the Atomic Energy Commission's Oak Ridge facility, soon began work on a prototype nuclear reactor at Fort Belvoir, Virginia. AlCo's atomic energy products department also built several portable nuclear reactors, which could be transported anywhere in the world (most were sent to Alaska) by cargo plane.\(^5\)\(^5\)

ALCo thus offered a wide range of products in the railroad, atomic power, chemical, and petroleum industries. In addition to diesel locomotives, these included diesel engines, diesel-powered drilling rigs, heat exchangers, pressure vessels, water heaters, steel pipe, cement kilns, evaporators, guided-missile components, steam generators, and some forty-four other products. Aside from its standardized, mass-produced diesel engines and locomotives, virtually all of these ancillary products, ranging from lock gates for the New York State Barge Canal to shields for the Lincoln Tunnel, were custom-engineered and custom-built. Because of intense competition, profit margins on these products remained low, and the cyclical nature of the markets for which these products were designed (oil, defense, public works) actually exacerbated the "feast or famine" tendencies associated with the locomotive industry. ALCo's attempts to carve out niche markets that were isolated from competition by larger firms was thus a failure, primarily because ALCo chose the wrong products in the wrong industries. In addition, chronic

managerial incompetence and poor labor relations seriously hampered ALCo's competitiveness in any product line.\textsuperscript{57}

**EMD RETAINS ITS ADVANTAGE OVER ALCo**

During the postwar dieselization boom, EMD enhanced its position as the leading producer in the diesel locomotive industry through continued investments in manufacturing, marketing, and management. Even though ALCo made some investments in additional production and distribution capabilities, these investments failed to keep pace with those enacted by EMD. In 1960, ALCo was still a viable locomotive producer, but one that had already sown the seeds of its own destruction. ALCo allowed GE to assume a large portion of its manufacturing and marketing responsibilities and ignored mounting evidence that its former production partner was preparing to enter the large

diesel locomotive industry. As shown in Chapter 8, the decade of the 1960's saw ALCo crushed between the continued organizational strength of EMD and the growing organizational strength of GE. In the meantime, however, the more marginal producers in the diesel locomotive industry were experiencing serious difficulties of their own.
CHAPTER VII

WEEDING OUT THE UNFIT:
BALDWIN, LIMA, AND FAIRBANKS-MORSE

As ALCo and EMD struggled for market dominance in the decade after World War II, Baldwin, Lima, and Fairbanks-Morse battled for survival. The three smaller producers were financially weak, poorly managed, and technologically backward. During the postwar rush to dieselize, they eked out an existence largely by taking orders that could not be accommodated at La Grange or Schenectady. In addition, railroads were often willing to try at least a few examples from each builder in order to determine for themselves which models were best. Finally, Baldwin in particular offered several models that were especially suited to a few specialized applications. By 1955, however, as railroads replaced the last of their steam locomotives, these marginal producers had either left the industry or were about to do so. As their product lines improved and as their orders declined, ALCo and EMD drove the smaller, high-cost, producers from the diesel locomotive market. A 1950
merger of Baldwin and Lima could not save either company, and Baldwin-Lima-Hamilton built its last locomotive in 1956. Similarly, Fairbanks-Morse left the industry in 1959.

THE COLLAPSE OF BALDWIN

Baldwin's woes intensified in the postwar period. Because of a reduction in steam locomotive and ordinance production, Baldwin's sales declined from a high of $221.5 million in 1943 to $85.3 million in 1946. Postwar labor troubles were also a poor omen for the future. A strike by the Steelworkers closed Eddystone from January 21 to March 26, 1946, forcing a wage increase of 18.5 cents per hour. Strikes at outside suppliers caused additional difficulties in obtaining key components, a problem that EMD largely avoided through its more extensive integration. An additional strike occurred in December, 1950, further reducing Baldwin's output.

Partly because 1947 steam locomotive production at Baldwin still exceeded that of diesels, 227 to 163, the company was not completely convinced that steam
locomotives were a lost cause. In 1946, Charles Kerr, Consulting Transportation Engineer at Baldwin's production partner, Westinghouse, predicted that "Better steam locomotives than we have ever known before are on their way," and concluded that "... the old 'iron horse' is far from dead."¹ A year later, a Baldwin spokesman still believed that "The Diesel locomotive is in its infancy..."² Not until 1948 did Baldwin finally conclude that "it seems evident that future railroad motive power purchases for use in this country will be chiefly of the Diesel type and that further large [steam] export orders must be considered as highly uncertain."³

Baldwin still held some hope for the long-term survival of the steam locomotive industry. In 1948, The Locomotive Institute, composed of Baldwin, ALCo and Lima, submitted a report to James Forrestal, the Secretary for National Defense, asking the federal

¹*Railway Age* 120:15 (April 13, 1946), 765-9 (quotes); Baldwin Locomotive Works, 1945 & 1946 annual reports.

²*Railway Age* 122:26 (June 28, 1947), 1309-10 (quote).

³*Railway Age* 124:14 (April 3, 1948), 687-8 (quote); Baldwin Locomotive Works, 1950 annual report.
government's advice on what they should do with their steam locomotive production facilities. They noted that during wartime, fuel oil might be unavailable, while coal for steam locomotives would always be readily accessible. The report stated that ALCo, Baldwin, and Lima had a capital investment of $35 million in plant and equipment designed for steam locomotive manufacture, and noted that, if this were disposed of, it would take three years and cost twice as much to replace, should it be needed in a wartime emergency. They asked for a clear statement of government policy on this issue, because "The [steam] locomotive builders are not of themselves able to determine what policy they should follow, and it seems clear that they should have some indication to guide them." This report, which elicited only a cursory response from the federal government, thus shows that Baldwin, like ALCo and Lima, still hoped that the steam locomotive market would revive. In

"Report of the Locomotive Institute to the Honorable James V. Forrestal, Secretary for National Defense," January 27, 1948, Louisville and Nashville Railroad collection at the University of Louisville (Record Group 123, hereafter referred to as the L&N Records), box 56, folder 1870-C (quote).
addition, it indicates that executives from the three companies were seeking advice, protection, and support from the federal government, a common response from companies in declining industries. In the decades since the end of World War II, the steel, automobile, and petroleum industries, among others, have asked for special privileges from the federal government, often justifying their requests on the grounds of national security.

Like ALCo, Baldwin did not firmly commit to diesel locomotive production until well after the end of World War II. According to Baldwin, "The year 1947 was one of transition in the locomotive department during which [the] Company undertook its first substantial program in the construction of large diesel road locomotives and, naturally, experienced many of the difficulties which occur in the establishment of a new project."5 Baldwin waited eight years after the introduction of the FT and twelve years after the construction of La Grange to launch its new diesel line, a delay that proved fatal to

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5Baldwin Locomotive Works, 1947 annual report (quote).
the company's prospects in the industry. As late as 1948, Baldwin was still struggling to standardize production techniques.⁶

After their wartime experience with inferior Baldwin units, many railroads refused to place additional orders. The Louisville and Nashville, for example, complained that Baldwin units cost as much as those from EMD, yet were too heavy for the railroad's bridges. Still, railroads did order some Baldwin locomotives, either because they were unable to obtain the products of other builders or because they wanted to test the capabilities of these new models. The Santa Fe purchased a number of units, including a 3,000-hp experimental gas turbine. The Southern Pacific found one model, the AS-616, particularly well suited to the mountainous terrain of its lines in the Pacific Northwest. By early 1949, Baldwin was turning out approximately 50 diesel locomotives per month at Eddystone, as well as 25-30 steam locomotives per month for export. As this rate, Baldwin's monthly diesel locomotive production roughly equalled EMD's weekly output.

In mid-1950, Baldwin introduced a completely new diesel locomotive line, consisting of eight different models, ranging from 800 hp to 6,400 hp. These new designs featured increased horsepower, easier maintenance, and, finally, a high degree of interchangeability between parts and subassemblies. Had Baldwin introduced and aggressively marketed these locomotives a decade earlier, it might have captured a large portion of the diesel locomotive market. As it was, this new line was too little, too late; and, in any case, the company could not keep pace with the engineering improvements being introduced by ALCo and EMD.\footnote{Railway Age 122:6 (February 8, 1947), 341; 126:21 (May 21, 1949), 1058; 129:9 (August 26, 1950), 56; 129:10 (September 2, 1950), 63-6; Barron's 29 (January 17, 1949), 4, 46; C. J. Bodemer to J. R. Watt, February 3, 1948, L&N Records, box 2, folder 81930.}

Baldwin's marketing efforts were also ineffectual. In terms of financing, Baldwin's terms were not markedly different from those offered by ALCo and EMD. For example, on roughly similar diesel locomotives, with no money down, Baldwin offered 2 percent interest for eight years, with EMD giving the same terms and ALCo charging 1.78 percent for 6-8 years. In terms of post-sales
support, Baldwin was far inferior to its two larger competitors. Baldwin did not establish a nationwide parts distribution network and frequently relied on Westinghouse for parts distribution. In addition, its locomotive school was of dubious quality. Classes were offered as early as 1942, but these were held at both Eddystone and East Pittsburgh, and they were organized by Westinghouse. Baldwin's first true locomotive school did not hold its first classes until 1948. This 20-hour course used "life-size operating panel boards" to simulate actual locomotives at a time when EMD was sending real locomotives on training duties around the United States. In addition, by the late 1940's, railroads themselves were beginning to establish their own training programs, thus rendering the training services provided by builders in the 1930's and early 1940's less valuable.®

In addition to its manufacturing and marketing difficulties, a series of managerial crises plagued Baldwin. The new managers introduced in 1938, shortly after Baldwin’s financial reorganization, had been an improvement, but they had not done enough to direct the company into the growing diesel locomotive market. As discussed in Chapter 5, several former Westinghouse executives also had difficulty in steering Baldwin in the right direction during World War II. Finally, in 1948, Westinghouse decided to settle the issue once and for all. In July of that year, Westinghouse purchased 500,000 shares of authorized but unissued Baldwin common stock for $15.11 per share. This purchase, combined with earlier Westinghouse holdings, gave that company ownership of 22 percent of the 2,375,553 shares of outstanding Baldwin stock. In addition to giving Baldwin $7.5 million in desperately needed working capital, the purchase also gave Westinghouse a continued incentive to supply electrical equipment. However, this purchase was not followed by the consolidation of manufacturing facilities or the creation of true vertical integration,
which, in any case, would have been too late to save Baldwin's share of the locomotive market.\(^9\)

Not surprisingly, this purchase was followed by an immediate influx of managerial talent from Westinghouse. In 1955, Baldwin admitted that "This holding constituted virtual control and rightfully entitled them to dominant policy determination."\(^{10}\) Marvin W. Smith, a former vice-president in charge of engineering at Westinghouse, became Baldwin's new executive vice-president and chief executive officer. James R. Weaver left his position as the head of manufacturing at the Westinghouse plant in Springfield, Massachusetts, to become vice-president of manufacturing at Eddystone. John S. Newton, an expert in steam and gas turbines at Westinghouse, was appointed vice-president of engineering at Eddystone. Ralph Kelly, who, at the time of the stock sale had been both president of Baldwin and executive vice-president at Westinghouse, resigned in order "... to be afforded

\(^9\)Railway Age 125:6 (August 7, 1948), 303; Baldwin Locomotive Works, 1948 annual report; Baldwin press release, July 29, 1948, AAR.

greater freedom for personal and civic activities," though he continued as chairman of the board at Baldwin.\textsuperscript{11}

Other Westinghouse executives were transferred to Baldwin in later years. For example, in 1952 L. A. Hester, the Westinghouse middle Atlantic district transportation manager, became the locomotive sales manager of the company, now known as Baldwin-Lima-Hamilton. This continued influx of managerial talent from Westinghouse clearly illustrates the massive managerial failure at Baldwin.\textsuperscript{12}

Unfortunately for both companies, this managerial infusion was not enough to save Baldwin. The company experienced a substantial decline in business during 1949, with the result that employment was reduced to 9,587 by the end of the year -- half the wartime high of 20,095. A 1951 article in The Magazine of Wall Street criticized the company's poor management and its

\textsuperscript{11}\textit{Railway Age} 125:6 (August 7, 1948), 303 (quote).

\textsuperscript{12}\textit{Railway Age} 125:8 (August 21, 1948), 396; 133:11 (September 15, 1952), 15; Baldwin Locomotive Works, 1948 annual report.
inability to adopt modern manufacturing methods, concluding that "No matter how favorable business conditions may be, there always seem to be some companies which fail to gain their rightful share of prosperity." In the years that followed, this "rightful share of prosperity" became even more elusive. Sales of locomotives and parts, which had been 45 percent of all business in 1951, declined to 30 percent in the following year. Although Baldwin had more than 3,600 diesel locomotives in service by the end of 1953, orders continued to decline, and the foreign market was not large enough to fill the gap. In addition, as railroads began to complete their dieselization programs, industry sales in 1954 were about half the level of 1953, and less than a fourth of those in 1950.

Given this dismal performance, it is hardly surprising that Westinghouse decided to cut its losses and get out. In early 1954, Westinghouse announced that it

13 The Magazine of Wall Street, June 30, 1951, 362-3 (quote).

was withdrawing from the locomotive electrical equipment market, leaving GE as the only independent supplier of this equipment. Westinghouse continued to manufacture equipment for urban mass transit systems and similar applications. In May, Baldwin repurchased 515,000 shares of its own stock from Westinghouse, at a loss to the latter company of $6.11 per share. Once this purchase was made, the inadequate "Present management then was called on to assume immediate responsibility for many long-standing problems facing the Corporation."  

Baldwin attempted to address these problems by continuing its established policy of diversification and by starting a new policy of merger and decentralization. The highlight of this program was a November, 1950, merger with the Lima-Hamilton Corporation, an event described in greater detail later in this chapter. Briefly, Baldwin exchanged 1.9 million shares of its stock for the stock of its smaller competitor on a share-for-share basis. In order to make the arrangement as lucrative for Baldwin stockholders as possible, the

asset-rich Midvale Company and the General Steel Castings Corporation, along with the proceeds from the earlier sale of the Flannery Bolt Company, were transferred to the newly created Baldwin Securities Corporation. The stock of the Baldwin Securities Corporation was then distributed as a dividend to Baldwin shareholders. While this payment was a nice bonus for these shareholders, the removal of these assets reduced the ability of the new Baldwin-Lima-Hamilton Corporation to consolidate its production and distribution facilities.\textsuperscript{16}

Although George A. Rentschler, chairman of the executive committee at Lima-Hamilton, replaced Charles E. Brinley as chairman of the board at Baldwin-Lima-Hamilton, the diversification program continued after the merger. Shortly after the merger, Baldwin-Lima-Hamilton traded 304,000 shares of its stock for 486,000 shares of the Austin-Western Corporation, based in Aurora, Illinois. This new subsidiary, primarily a producer of road-building equipment, was merged with the Lima Division in 1952, forming the Construction

\textsuperscript{16}Business Week, August 12, 1950, 80; Baldwin-Lima-Hamilton, 1950 annual report.
Machinery Division. At the same time, Baldwin-Lima-Hamilton dissolved its ailing Whitcomb Locomotive Company subsidiary. What production remained was transferred to Eddystone; and Whitcomb's old Rochelle, Illinois plant was transferred to Austin-Western for use in the production of road rollers and street sweepers. Thus expired the subsidiary that had given Baldwin the distinction of being the oldest producer of internal combustion locomotives, a subsidiary that Baldwin failed to use to enhance its own capabilities in the diesel locomotive industry.  

Baldwin-Lima-Hamilton attempted to improve its fortunes by concentrating on the defense, construction, and electronics industries, although its output still consisted largely of custom-built products. In 1954, Baldwin-Lima-Hamilton acquired the Hydropress Company and its subsidiary, the Loewy Construction Company, manufacturers of hydraulic presses, the O. S. Peters Company, and the Ruge-deForest Company, producers of

precision electronic devices. Baldwin-Lima-Hamilton also bought the Madsen Iron Works which, like Austin-Western, was a manufacturer of road-building equipment. On January 1, 1956, Baldwin-Lima-Hamilton changed its four wholly owned subsidiaries into divisions, which included the Construction Equipment Division and the Electronics and Instrumentation Division. Baldwin-Lima-Hamilton also created a multidivisional structure, with a "... centralized executive policy and decentralized administration." To a certain extent, this new strategy worked. In 1957, Baldwin-Lima-Hamilton was featured in "The Security I Like Best" column of The Commercial and Financial Chronicle, which said that the company had "... definitely turned the corner..." However, this corporate rebirth involved a final realization that Baldwin could not continue to participate in the diesel locomotive industry, a decision that might have been made at least ten years earlier.

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19 Ibid., 1955 annual report (quote).
20 The Commercial and Financial Chronicle 185 (May 16, 1957), 2274 (quote); Railway Age 140:2 (January 9, 1956), 204.
Baldwin built its first diesel locomotive in 1926, and its last in 1956. The company rarely, if ever, earned a profit on its diesel locomotives and between 1946 and 1952 lost money every year on combined (steam and diesel) locomotive sales. By 1954, Baldwin-Lima-Hamilton executives had finally reached the inescapable conclusion that they should leave the industry within the next two years.

In the meantime, the company continued to waste money on ultimately futile experimental locomotives. In 1955, Baldwin-Lima-Hamilton began a short collaboration with the Walter Kidde Nuclear Laboratories and the Denver and Rio Grande Western Railroad to develop an atomic-powered locomotive, a task that was "... difficult and perhaps dangerous." Later that year, the company built an experimental diesel-hydraulic locomotive based on a German Federal Railways design. Because of its hydraulic transmission, this diesel required fewer electrical components -- doubly important now that Westinghouse had ceased to supply them. In 1956 and

1957, Baldwin-Lima-Hamilton built three production-model diesel-hydraulic locomotives. Although Baldwin-Lima-Hamilton promised substantial savings in weight, fuel, and maintenance, these locomotives failed to meet expectations, and the company's 126-year legacy of locomotive production concluded on a decidedly sour note.\textsuperscript{22}

Baldwin-Lima-Hamilton soon began to dispose of the vast buildings originally designed for steam locomotive production, but poorly adapted to the manufacture of diesels. By 1956, 75 percent of Eddystone -- 300 of the original 381 acres, including eight buildings -- had been sold. Two years later, virtually all of the former locomotive facilities at Eddystone had been demolished.\textsuperscript{23}


\textsuperscript{23}The Commercial and Financial Chronicle 185 (May 16, 1957), 2274; Railway Age 145:2 (July 14, 1958), 17; Baldwin-Lima-Hamilton, 1956 annual report.
Baldwin frittered away chances for success in the diesel locomotive market. In the 1920's and 1930's, Baldwin entered and remained in that market to explore the possibilities of what Baldwin executives believed was a niche market and to provide a favor for long-time Baldwin steam locomotive customers. By artificially reducing the output of EMD, the War Production Board gave Baldwin a small captive market during World War II. After the war, the insatiable demand for diesels kept this inefficient, marginal producer in business. Once the postwar dieselization rush had subsided, railroads had little reason to purchase Baldwin's technically backward products. The company that had been one of the most respected producers of steam locomotives in the world for more than a century was largely a failure in the diesel locomotive industry. Several factors help to explain Baldwin's lack of success in diesel locomotive production.

First, Baldwin was simply unable to manufacture a high-quality product. The well-honed craft of steam locomotive construction was ill-suited to the demands of standardized diesel locomotive production. The use of techniques such as casting, while appropriate for steam
locomotives, did not work when used on Baldwin diesels. Its facilities at Eddystone were designed for steam locomotive production and could never be fully converted to the integrated manufacture of diesels. Once railroad mechanical officials learned how inefficient and unreliable these locomotives were, the company had little chance for survival. In addition, like ALCo and Fairbanks-Morse, Baldwin failed to establish a truly integrated facility for the efficient production of diesels. It continued to rely on and ultimately was controlled by Westinghouse, a company with far different priorities than Baldwin. Baldwin waited too long to introduce a standard switcher in the 1930's and a complete locomotive line in the postwar period. Finally, the company wasted its resources on the manufacture of steam locomotives, continuing to build these for export until 1955.²⁴

Second, Baldwin failed to market its diesels effectively. During the 1930's the company instructed its salesmen to avoid selling diesels if at all possible. Its post-sales support facilities were minuscule.

compared to those offered by EMD and ALCo. Baldwin had no effective repair or rebuild program and no chain of parts warehouses scattered across the country. Baldwin's locomotive school was started too late and was of poor quality. In addition, much of Baldwin's meager marketing program in fact utilized Westinghouse facilities and personnel. Like their counterparts at ALCo, the willingness of Baldwin executives to assign marketing responsibilities to a separate company indicates their disregard for the importance of this skill. While a company with weak marketing capabilities could survive and even thrive in the steam locomotive industry, this was simply not possible with diesel locomotive production. The complexity of diesels required manufacturers to field a dedicated, knowledgeable, and loyal sales staff, something that Baldwin did not do.

Finally, and most seriously, was the chronic managerial paralysis at Baldwin. During the "feast" of the 1920's, Baldwin's managers squandered $34.4 million of the company's wealth in the form of dividends. When the "famine" hit in the 1930's, these managers were unable to save the company from financial ruin. Baldwin's bankruptcy effectively prevented that company from
undertaking a comprehensive diesel-locomotive research and development program. That, however, was not an issue until 1938, since Vauclain and his colleagues assumed that diesels would never truly challenge the supremacy of the steam locomotive.

Subsequent infusions of managerial talent, most notably from Westinghouse, failed to stem Baldwin's decline. In the process, Baldwin increased its reliance on the organizational capabilities of outside firms even further. Truly effective managers did not arrive until the late 1950's, and by then Baldwin's participation in the locomotive industry was over. Perhaps the ultimate example of managerial incompetence at Baldwin concerns the fact that the company built diesel locomotives for thirty years, yet never made any money at it. Baldwin would have been far better of if, during the 1930's, it had either made the necessary investment in manufacturing, marketing, and management or else had begun to phase out its locomotive line entirely. By failing to do so, Baldwin's managers ruined their prospects in the locomotive industry and nearly destroyed their company
The decade following World War II also witnessed the entrance and rapid exit from the diesel locomotive field of the Lima Locomotive Works, the least successful of the six producers that are the subject of this study. From the 1930's until its merger with Baldwin in 1950, Lima struggled to cope with the decline of its established heritage of custom-craft production and with an evolving industry that was becoming increasingly dominated by larger firms. With its meager financial resources, Lima was an even less likely candidate for diesel locomotive production than was Baldwin, and the merger of these two companies produced an extremely weak competitor in the industry. As was the case with Baldwin, the decision of Lima executives to enter the diesel-locomotive market at all showed extremely poor judgment.

As shown in earlier chapters, the Great Depression was a difficult period for Lima and the other steam

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25 Baldwin Locomotive Works, 1936 annual report.
locomotive producers. Railroads, many of which were themselves in danger of bankruptcy, slashed capital spending and canceled locomotive orders. Lima was inconvenienced by this financial downturn, but not devastated to the same extent as ALCo and Baldwin. Although Lima registered losses during most depression years, particularly in the locomotive division, its small size and conservative capitalization allowed Lima to survive the depression relatively unscathed. Financial analysts praised Lima's financial stability and technical prowess, predicting that it would receive a large share of post-depression orders. In particular, they stressed that most steam locomotives were obsolete, thus guaranteeing a substantial replacement market. As late as 1940, however, these analysts failed to realize that much of this replacement market would be in the form of diesel locomotives.26

26Barron's, January 27, 1936, 14; June 7, 1937, 9; August 8, 1938, 20; September 30, 1940, 13). While Barron's, in 1940, stated that the "...introduction of diesel power ...may leave its permanent mark in the trend for future motive power purchases ..." from Lima, it admitted that "the future of the Diesel in long-haul rail service is yet to be determined ...[and] no substantial inroads are anticipated for the immediate future."
Lima easily survived the depression because of its cautious management, conservative financial structure, and small physical plant. However, these very factors prevented Lima from entering the diesel locomotive market. Lima's performance during the depression reinforced the faith of its management in conservative operation. In addition, Lima misinterpreted the hoped-for rise in locomotive demand that followed the depression. When the orders finally came in, they were not for steam locomotives, but for diesels.

World War II provided only a brief respite for Lima's steam locomotive production. Since Lima had essentially no prewar experience with diesels, the WPB allowed it to produce only steam locomotives. In addition, Lima expanded its facilities to allow for the production of tanks and tank recovery vehicles.27

27"Title 32 - National Defense, Chapter IX - War Production Board, Subchapter B - Division of Industry Operations, Part 1188 - Railroad Equipment, General Limitation Order L-97, April 4, 1942, Records of the War Production Board, National Archives, (Record Group 179, hereafter referred to as the WPB Records); Railway Age 112:15 (April 11, 1942), 753-4. Lima produced 1655 tanks between 1941 and 1943. (Commercial and Financial Chronicle 161 (April 9, 1945), 1544; Railway Age 110:19 (May 10, 1941), 813; 113:12 (September 19, 1942), 464-5; Lima Locomotive Works 1943 annual report, 4-5.
The enormous increase in steam locomotive orders during the war (Lima built more than a thousand of these) represented the last gasp of a once mighty industry. However, Lima officials may have misinterpreted this temporary increase as an indication of a large post-war market for steam locomotives. They continued to improve steam locomotive technology for several years after the war, and President John Dixon maintained that "the modern steam locomotive [was] far from dead or defeated."²⁸

It was soon obvious, however, that railroads, freed of wartime restrictions, were rushing to replace their outdated steam locomotives with diesels. By early 1947, Lima officials realized that domestic demand for steam locomotives had virtually ceased. Some potential remained for export sales, but this demand was sporadic, at best, since most foreign railways were purchasing American-built diesel locomotives. In its 1949 annual report, Lima acknowledged that "there is almost no

demand currently for steam locomotives at home. Foreign inquiry continues and we are hopeful that because of better design and delivery some of this inquiry can be turned into actual orders."29 These foreign orders for steam locomotives never materialized.

Although Lima could have abandoned locomotive production entirely, in order to concentrate on the increasingly profitable Shovel and Crane Division, Allen and the other members of the executive committee began a search for a suitable producer of diesel engines. Lima selected the General Machinery Corporation of Hamilton, Ohio. The company was a 1928 consolidation of the Hooven-Owens-Rentschler Company (which was established in 1845), the Niles Tool Works Company, and the Hamilton Press and Machinery Company. General Machinery had produced its first diesel engine in 1924 for maritime use, and several of its engines were installed in self-propelled railroad cars. General Machinery produced one experimental diesel-hydraulic locomotive in 1939. During World War II, its 35-acre plant produced more than

800 steam engines for "Liberty"-class cargo ships. By 1947, the General Machinery Corporation was producing steam, diesel, and gasoline engines, machine tools, machinery for can-making and sugar-cane milling, welding equipment and supplies, and various types of hydraulic presses.³⁰

At a meeting on October 1, 1947, the stockholders of both companies agreed to exchange their stock for shares in the new Lima-Hamilton Corporation. Each Lima share was equivalent to 5 3/8 shares in the new company, while General Machinery shares were exchanged on a one-to-one basis.³¹ John Dixon and Samuel Allen of Lima were selected to head the new company, the first as president and the second as chairman of the board.

George A. Rentschler, the former president of General


³¹Lima-Hamilton was authorized to issue 3,000,000 shares of common stock, ten times the total authorization of Lima. Of these shares, Lima stockholders received 1,134,431 shares, while 805,952 shares went to General Machinery stockholders.
Machinery Corporation, was appointed chairman of the executive committee.\textsuperscript{32}

Although Lima executives filled many of the important positions in the new corporation, George Rentschler and his associates from General Machinery quickly assumed a large degree of control. Second-hand accounts indicate that they were appalled by the inefficiency, mismanagement, and waste at the Lima facility. Rentschler soon undertook a number of cost-saving measures, ranging from banishing photographs from the annual reports to firing hundreds of Lima employees.\textsuperscript{33}

\textsuperscript{32}Lima, "Notice of Special Meeting of Stockholders."

\textsuperscript{33}"Interview with Henry A. Rentschler," The Business History Bulletin 4 (Summer/Fall 1990), 5-8. Henry Rentschler, the grand-nephew of George Rentschler, was in his early twenties at the time of the Lima-Hamilton merger. He recalls that "it was obvious that we [executives from General Machinery] were running that show very quickly." In August, 1949, Lima-Hamilton president John E. Dixon resigned his position prior to becoming chairman of the board. Samuel G. Allen resigned from that position. Daniel Ellis, the former vice president in charge of manufacturing at Lima and at Lima-Hamilton, became the new president of the corporation. Lima-Hamilton 1949 annual report, 3,6-7; Railway Age 127:7 (August 13, 1949), 307; 127:7 (August 20, 1949), 353. Ironically, financial analysts initially claimed that Lima stockholders had been the principal gainers in the merger. (Barron's, September 1, 1947, 35).
In spite of these changes, Lima-Hamilton failed to integrate production facilities. Lima-Hamilton continued to build diesel engines in Hamilton and ship them north by rail to Lima, where they were installed in the locomotive shell. In addition, the generators and traction motors, which were at least as critical to locomotive production and performance as the diesel engine, were purchased from the Westinghouse Electrical Corporation. These deficiencies clearly placed Lima-Hamilton at a competitive disadvantage with the only integrated locomotive builders, EMD.

Lima-Hamilton executives decided to concentrate initially on the production of 1,000-hp. to 1,500-hp. switch engines, thus entering an already oversaturated market. ALCo-GE, Baldwin, Fairbanks-Morse, and EMD all produced similar products. Electro-Motive, in particular, had spent more than a decade refining its switcher line. Furthermore, by the late 1940's, most railroads had already replaced their highly inefficient steam switchers with diesels and were instead beginning to purchase more powerful and versatile road locomotives for long-distance freight and passenger service.

Within a year, the Hamilton facility developed a locomotive diesel engine that was actually more suitable
for marine and stationary applications. This engine, which could develop up to 1,200 horsepower, supposedly embodied several technological improvements, but was in fact inferior to those produced by the other locomotive builders.34

Although the first diesel engines were tested in July, 1948, and the first locomotive was completed ten months later, Lima-Hamilton remained temporarily committed to the production of steam locomotives. During 1948, the company produced and delivered 36 steam locomotives, and had 31 more under construction at the end of the year. These were delivered in 1949 and had the dubious distinction of being the last steam locomotives produced in the United States for domestic use. Lima continued to maintain a substantial parts inventory for its more recently produced steam locomotives. This inventory was supplemented in April, 1949, when it acquired ALCo's inventory of spare parts.35

34Railway Age, 125:14 (October 2, 1948), 643-4.

assured its stockholders in 1948 that "There is a substantial inquiry for steam locomotives and we believe that there is definitely a place for steam equipment. We will continue to build these [steam] locomotives and therefore our facilities in this regard are being well maintained." In reality, however, no American railroad placed orders for steam locomotives with any builder after 1948.

Lima-Hamilton also devoted its limited financial and technical resources to the development of a gas turbine locomotive. A number of locomotive builders and individual railroads experimented with various types of steam and gas turbines, which were a hybrid of steam locomotive, diesel locomotive, marine, and aviation technologies. This development was supported by the bituminous coal industry, which was desperately attempting to preserve its enormous railroad fuel market. Lima-Hamilton's version, developed in cooperation with Westinghouse, used a free-piston gas turbine to develop 3,200 hp -- an impressive amount, even by steam

36Lima-Hamilton, 1948 annual report, 5 (quote); Railway Age, 126:15 (April 9, 1949), 754.
locomotive standards. This locomotive was to embody "several outstanding technical characteristics," but a prototype was never built. Better-managed companies, such as EMD, continued to produce proven diesel locomotive designs, while Lima-Hamilton, Baldwin, and others squandered valuable resources on an unproven and ultimately unworkable technology.\textsuperscript{37}

Lima-Hamilton made a further, and more successful, attempt at diversification when, in 1949, it introduced the first commercially successful rotary snow plow to burn diesel fuel. One reason for its success was its reliance on proven technology: its power source had many

\textsuperscript{37}According to a committee report from the Mechanical Division of the Association of American Railroads, "the term 'free piston gas generator' is descriptive of the fact that the pistons are free to move in their stroke without the restriction of any mechanical connection, tied to any mechanical part that delivers power to drive the locomotive. This means that the stroke of the machine is variable and under control." The Union Pacific was the only railroad to use turbines extensively, beginning in 1948. They were retired by the early 1960's because of excessive noise (they could shatter windows on trackside buildings) and limited operating flexibility. \textit{Railway Age} 124:12 (March 20, 1948), 581-3; 127:2 (July 9, 1949), 61 (quotes); \textit{Railway Mechanical Engineer}, 123 (August, 1949), 453; John R. Signor, \textit{The Los Angeles and Salt Lake Railroad Company: Union Pacific's Historic Salt Lake Route}, (San Marino, California: Golden West Books, 1988), 194-5.
elements in common with Lima's Shay locomotive. In spite of this technical success, its sales potential was a fraction of that of diesel locomotives (only four were built) and it was thus a further dilution of Lima-Hamilton's scarce resources.38

Lima-Hamilton completed its first 750-hp switchers in November, 1949, six months after it delivered its first 1,000-hp units. A 2,500-hp transfer locomotive and a 1,200-hp switcher debuted in May, 1950, followed by an 800-hp switcher in January, 1951. A 1,600-hp transfer locomotive was planned, but never built. All of these locomotives were built to a standardized, almost modular, design that stressed "maximum interchangeability of parts between the ... models."

However, Lima's customers soon realized that the Hamilton diesel engine was more suited to marine and stationary applications than to locomotive use. The two versions that powered these locomotives were

inefficient, prone to cause pollution, and difficult to maintain.

The best feature of these locomotives was the simple, rugged, and dependable Westinghouse electrical equipment, parts that Lima-Hamilton did not produce. In addition to this high-value electrical equipment, Lima-Hamilton used parts and equipment from nearly forty independent suppliers for each locomotive that it built. Since Lima-Hamilton had little effective control over these outside suppliers, this policy increased costs, lowered profit margins, and greatly increased the possibility of delays in production. Lima-Hamilton's

reliance on subcontractors was clearly not in the company's best interest. Because Lima-Hamilton lacked a just-in-time inventory system and sufficient production volume, it was never able to ensure the reliability of independent suppliers. Overall, Lima-Hamilton locomotives were no better than those being produced by ALCo, Baldwin, and Fairbanks-Morse, and were probably inferior to those produced by EMD.

In spite of these deficiencies, a number of firms placed orders for Lima-Hamilton diesels. Lima-Hamilton sold some diesels to traditional purchasers of Lima steam locomotives, such as the New York Central. These sales to traditional customers suggest that Lima-Hamilton was, at least to some extent, able to exploit the connections that it had established as an innovative and respected producer of steam locomotives. However, some of the railroads that purchased Lima-Hamilton diesels had a policy of spreading an order for similar units among various builders. This policy of dispersing orders allowed railroads to assess the relative merits of each builder's products before placing a larger order with the builder judged to be the best. This practice initially aided Lima-Hamilton, but as the technical
deficiencies of its products became increasingly apparent, railroads chose other builders for the much larger final order.

Lima-Hamilton sold a number of locomotives to shortline railroads and industrial concerns, such as Armco Steel and the Terminal Railroad Association of Saint Louis. These customers did not need large numbers of locomotives, and they usually did not place repeat orders. Lima-Hamilton made no attempt to cultivate a foreign market for diesel locomotives. Had it done so, it might have been able to create a market niche by applying its long tradition as a custom builder to the diversity of gauges, operating conditions, and clearance restrictions of foreign railroad networks. Similarly, despite the fact that both Lima and General Machinery had produced rudimentary low-horsepower industrial switchers, Lima-Hamilton did not engage in industrial switcher production, a field that had been ignored by EMD.40

40Lima-Hamilton officials boasted that orders during the first third of 1950 were as large as those during all of 1949. This growth did not continue, however. Railway Age 128:18 (May 6, 1950), 899; "L-H Receives Orders For 12 Diesels," Lima News, October 6, 1949, "Erie Orders 6 Diesels Here," Lima News, March 3, 1950; "4 Railroads Buying L-H Switch Units," Lima News,
By 1950, Lima-Hamilton's position in the increasingly competitive diesel locomotive market was tenuous at best. Fairbanks-Morse announced a new line of standardized locomotives that embodied numerous technical improvements. Baldwin unveiled its own improved and standardized line during the second half of 1950. Baldwin offered 800-hp, 1,200-hp, 1,600-hp, and 2,400-hp units that were virtually identical to Lima-Hamilton models, but with improved performance. And, in October, 1949, EMD introduced its GP-7 road switcher. This locomotive, along with the similar GP-9, proved immensely popular with railroads (nearly 7,000 were built between 1949 and 1959), and, more than any other single model, ensured EMD's dominance in the post-war locomotive market.41

Accordingly, in August, 1950, the boards of directors of Lima-Hamilton and Baldwin announced plans for a merger of their two companies, claiming that "in the

May 3, 1950; Kirkland, The Diesel Builders, Volume 1, 114-5.

41Railway Age 125:15 (October 9, 1948), 669-70; 127:19 (November 5, 1949), 790-3; 129:10 (September 2, 1950), 63-6.
Diesel-electric field there should be substantial advantages in integrating the activities of the two organizations." On October 25, 1950, stockholders approved the creation of the new Baldwin-Lima-Hamilton Corporation. The new corporation issued an additional 2 million shares of common stock, most of which was exchanged for Lima-Hamilton stock on a one-for-one basis. Marvin W. Smith, the former president of Baldwin, became the president of Baldwin-Lima-Hamilton, and George Rentschler was elected chairman of the board. His nephew, Walter Rentschler, was appointed vice president in charge of the Lima-Hamilton division.2 After absorbing its smaller rival, Baldwin terminated locomotive production at Lima. Unfilled orders were transferred to the Baldwin facility at Eddystone, Pennsylvania, although locomotives already under construction at Lima were completed at that location. In August, 1951, the last of 7,823 locomotives

(only 174 of which were diesels) were completed at the Lima facility. Baldwin-Lima-Hamilton then used the buildings and equipment for the construction of road-building and earth-moving equipment.\textsuperscript{43}

Since Lima-Hamilton locomotives were virtually identical to their Baldwin counterparts, the manufacturing rationalizations that followed the merger included the discontinuance of the original Lima-Hamilton locomotive line. The plans and designs for these Lima-Hamilton locomotives were sold to Westinghouse, which chose not to produce them. Baldwin locomotives had more reliable diesel engines than those produced by Lima-Hamilton (both companies used the same electrical equipment), and Baldwin offered a superior service and repair policy, operated in conjunction with Westinghouse. In addition, Baldwin had already established a locomotive school, although it was not as extensive as those

Baldwin-Lima-Hamilton's diesel locomotive program soon experienced a number of serious problems. The company suffered from what it believed to be improper raw materials allocation procedures during the Korean War. Production was suspended during a 1954 strike by the United Auto Workers. Finally, railroads had largely completed their dieselization programs by the mid-1950's, leaving a much smaller market for replacement units. Baldwin-Lima-Hamilton produced its last locomotives in 1956. The next year, EMD controlled 89 percent of the diesel locomotive market.\footnote{45}


A number of factors were responsible for Lima's failure to transfer its skills as an innovative and successful producer of steam locomotives to the production of diesel locomotives.

First, Lima lacked the technical know-how and financial resources to develop its own diesel engines and electrical equipment. Lima was able to build only the frame and superstructure of the locomotive, portions which were the least technically sophisticated. This failure forced Lima into an unfavorable merger with a company (General Machinery Corporation) that produced a diesel engine that was unsuited to railroad applications. In addition, Lima relied on a number of outside suppliers, such as Westinghouse, for vital and expensive equipment. In short, Lima was unable to integrate its production facilities, and was thus unable to achieve economies of scale or scope.

Second, Lima's managers were unable to set aside their abiding faith in steam locomotives. As late as 1947, they remained convinced that diesel locomotives

were ill-suited for the long-haul freight service that formed the backbone of railroad operations. This belief was reinforced by the slow pace of dieselization during the Great Depression (caused by shortages of investment capital) and during World War II (caused by government restrictions). In fact, steam locomotives in service on American railroads outnumbered diesels until 1952. Lima's fatal mistake, however, was that the company failed to realize that orders for new diesel locomotives had exceeded those for steam engines since the late 1930's.

Third, when Lima began diesel locomotive production, it chose to manufacture 800-hp to 2,400-hp switchers. This virtually guaranteed failure, since that market niche was already filled. If Lima had instead produced small industrial units or custom-built locomotives for export, it might have been more successful. The scholars Philip Scranton, Michael Piore, and Charles Sabel have suggested that flexible, specialized small-batch production allowed some companies to carve out niche markets, thus participating in an industry, such as textiles, without competing directly against larger vertically integrated and capital-intensive
Lima had certainly benefited from batch production during its tenure as a steam locomotive producer, but the company was unable to transfer these skills to niche markets in the diesel locomotive industry. In all probability, even niche markets required greater financial resources and technical capabilities than Lima possessed.

Fourth, Lima, like Baldwin, was accustomed to the straightforward sales policies of the steam locomotive industry. Most steam locomotives were custom built to the specifications of individual railroads, the one notable exception being a line of standardized locomotives built for the United States Railroad Administration during World War I. Custom production allowed steam locomotive designs to be tailored to the specific operating requirements of individual railroads and did

not represent a major added expense, since locomotives were produced one at a time by highly skilled craftsmen.

Diesel locomotives, however, were most efficiently produced on an assembly-line basis by semi-skilled or unskilled workers, a concept unheard of in the steam locomotive industry. Large expenditures for technical development and tooling made standardization a necessity. Critical components were covered by warranty, and could be quickly and easily replaced by relatively unskilled mechanics. Obsolete diesels could be traded in on newer models. EMC pioneered these policies in the 1920's and 1930's; and, by the 1940's, EMD was the industry leader in manufacturing techniques and marketing services. Other locomotive builders adopted some portions of EMD's program, though never to the same extent or with the same effectiveness. Lima-Hamilton standardized much of its diesel locomotive production; however, its slow pace of production (it built as many diesels in two years as EMD could produce in six weeks) prevented it from recovering its research and development expenditures. 47

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47 Marre, "Too Little, Too Late," 51.
Furthermore, although Lima-Hamilton had the financial and technical ability to produce diesel locomotives, it was unable to offer the after-sale support services that were vital to successful diesel operation and hence, customer satisfaction and repeat orders. Unlike EMD, it failed to establish parts depots, repair and rebuilding facilities, or diesel locomotive training schools.

Finally, Lima simply waited too long before beginning diesel locomotive production. Along with the other steam locomotive builders, it faced a very narrow window of opportunity during the late 1930's. Before this period, deficiencies in diesel locomotive technology and the financial stringencies of the depression prevented conversion. By the time of Pearl Harbor, the first-mover advantages of EMD had rendered that company virtually unstoppable. By the time Lima awoke to the realities of dieselization, it was too late.

THE FAILURE OF FAIRBANKS-MORSE

Fairbanks-Morse also struggled to survive in the postwar diesel locomotive industry. Unlike ALCo, Lima,
and Baldwin, Fairbanks-Morse lacked traditional connections to railroad motive power officials. Still, the company's wartime production had given it considerable experience in the production and marketing of diesel engines. However, Fairbanks-Morse had considerable difficulty in transferring these skills to the manufacture of diesel locomotives. Fairbanks-Morse failed to establish a truly integrated production facility. In addition, like Baldwin, it was plagued by chronic managerial difficulties.

Like Baldwin, Fairbanks-Morse experienced a serious decline in sales following the end of World War II. Net sales fell from a 1943 high of $183.8 million to $56.6 million in 1946. Profits increased during that time, however, from $2.8 million to $3.1 million. Based on the unprecedented postwar demand for diesel locomotives, Fairbanks-Morse announced expansion plans in November, 1946. The company planned to spend $5.2 million to acquire and modify the government-owned buildings at Beloit, thus allowing it to manufacture a full range of diesel locomotives, ranging from 1,000 hp to 8,000 hp. This expansion, along with the retirement of $7 million
worth of bank loans, was made possible by the issuance of $20 million in bonds in May, 1947.**

Because Fairbanks-Morse wanted to introduce its new diesel line as soon as possible, it was forced to subcontract the assembly of its diesel locomotives until its new facilities at Beloit were completed, and this policy led to one of the most bizarre competitive patterns in American industry. Fairbanks-Morse awarded the assembly contract to GE, which was simultaneously building electrical equipment for one of Fairbanks-Morse's competitors, ALCo. The regular production locomotives were originally designed to accommodate electrical equipment manufactured by its competitor, Westinghouse. Westinghouse in turn supplied electrical equipment to Baldwin, another competitor of Fairbanks-Morse. Nevertheless, GE built 111 locomotives in this manner before the new Beloit plant was ready in 1948.*

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*The Commercial and Financial Chronicle 165 (May 5, 1947), 2412-3; Railway Age 121:22 (November 3, 1946), 932.

**Like the other locomotive producers, F-M suffered during the postwar strike wave -- Beloit was shut down for 144 days in 1946. Business Week, May 17, 1947, 59-64; Railway Age 121:4 (July 27, 1946), 126-9; Kirkland, The Diesel Builders, Vol. 1, 38.
In terms of its own locomotive production, Fairbanks-Morse had some notable successes but some even more notable failures. Fairbanks-Morse was the first builder to introduce a road switcher -- the Model H-15-44, which debuted in August 1947. Even though EMD did not introduce its first road switcher (the GP-7) until April, 1948, its superior locomotive soon captured the bulk of the road switcher market. Fairbanks-Morse's "Consolidation Line" was even less successful. This collection of 1,600-hp, 2,000-hp, and 2,400-hp freight and passenger units, introduced in 1948, was intended to satisfy virtually every road diesel market. These locomotives were similar to the E- and F-series locomotives manufactured by EMD during the late 1930's and early 1940's, but railroads now demanded diesels that were less stylish, but cheaper and more flexible. The Fairbanks-Morse "Trainmaster," perhaps the company's most successful model, made its appearance late in 1952. This 2,400-hp locomotive was rugged, powerful, and flexible, and was therefore exactly what the railroads had needed five years earlier. Trainmaster sales were disappointing, with only 107 built at Beloit, plus an
additional 20 manufactured in Canada. The Trainmaster was the last new model that Fairbanks-Morse offered.\textsuperscript{50}

Fairbanks-Morse lacked both suitable production facilities and successful locomotive component designs. The facilities at Beloit were not designed specifically for diesel locomotive production, and they were never really adequate for that purpose. In addition, the opposed-piston engine, though well-suited for submarines, performed poorly in locomotive applications. This discrepancy was often caused by the dirt and vibrations that were an inescapable part of railroad freight and passenger service. Excessive consumption of lubricating oil increased operating costs. Service access to key parts and subassemblies was often difficult, and Fairbanks-Morse locomotives spent an inordinate amount of time in the shops. The replacement of cylinder liners was a particularly onerous task.

Fairbanks-Morse received ".. several reports of engines stopping on the road and the crew being unable to start them again." Problems such as this eroded confidence in Fairbanks-Morse locomotives. Finally, like ALCo, Baldwin, and Lima, Fairbanks-Morse relied on outside suppliers (Westinghouse and GE) for its electrical equipment. This inability to achieve complete integration put it at a distinct competitive disadvantage against EMD.

Fairbanks-Morse was also unable to establish a successful marketing structure. The company did have regional sales and service offices, but these were neither as widespread nor as well-supplied as EMD facilities. In January, 1942, Fairbanks-Morse opened a diesel-engine school to train Navy submarine crews, another example of the war's tendency to enhance Fairbanks-Morse's organizational capabilities. These training programs continued after the company's entrance into the diesel locomotive market but, again, were never

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51* Railway Mechanical and Electrical Engineer, May, 1950, 281 (quote).

as extensive or as popular as those offered by EMD. Like several of its competitors, Fairbanks-Morse's managers assumed that diesel locomotives, once manufactured, would virtually sell themselves.\(^{53}\)

Managerial difficulties further reduced Fairbanks-Morse's effectiveness in the diesel locomotive industry. Far more than any of its competitors, Fairbanks-Morse was burdened with family management. Other companies did exhibit familial ties -- Charles Francis Kettering placed his son, Eugene, in charge of diesel engine development efforts at Winton, and Samuel Vauclain's son served as a vice-president of Baldwin, until advancing age and ill-health forced him to resign (his father continued working). Nowhere else, however, did nepotism reach the heights that it did at Fairbanks-Morse.

Charles Hosmer Morse joined the company in 1850. His son, Charles H. Morse, Jr., served as president from 1914 until 1927, when he became chairman of the board. In that year his brother, Col. Robert H. Morse, was

elected vice-chairman of the board. Born in 1878, he began as an apprentice at Beloit in 1895 and, not surprisingly, was soon promoted to salesman, department manager, sales manager, and finally president of the manufacturing division. He became a Fairbanks-Morse vice-president in 1918. By 1945, he was president and general manager and a director (at the same time).

Charles H. Morse, Jr., was still on the board of directors at this time, as was his nephew Charles H. Morse, III (son of Col. Robert Morse). C. H. Morse, III was also president of Inland utilities, a Fairbanks-Morse subsidiary, and later became vice-president in charge of manufacturing. At the same time, Robert H. Morse, Jr., son of Charles H. Morse, Jr., was vice-president, general sales manager, and a member of the board of directors. A fifth Morse, John, was coming up through the ranks as assistant manager of Fairbanks-Morse's San Francisco Branch when his career was cut short by a fatal auto accident.\(^5^4\)

As late as 1957, the Morses owned more than a third of Fairbanks-Morse's stock, and these managers were more than willing to pay substantial dividends to the principal stockholders (themselves). The company made little investment in research and development or in plant and equipment. Instead, "... the Morse family reputedly ran the company like a private preserve." This type of family mismanagement, perhaps more typical of British industry, put Fairbanks-Morse at a serious competitive disadvantage with companies, such as GM, that had been able to separate ownership from management.

Beginning in the mid-1950's, Fairbanks-Morse suffered through a series of takeover attempts and battles for control of the company. In 1954, Leopold Silberstein organized the Penn-Texas Corporation and soon

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55 Barron's 43 (May 6, 1963), 5, 17-19 (quote); Business Week, February 16, 1957, 42.

thereafter began to purchase Fairbanks-Morse stock. His primary interest was not Fairbanks-Morse's meager locomotive output, but rather that company's scale and precision electronics products. After Silberstein had acquired about 12 percent of Fairbanks-Morse's stock, he asked for the chairmanship of either the executive committee or the finance committee. Fairbanks-Morse's president, Robert H. Morse, Jr., refused and issued 141,890 shares of new Fairbanks-Morse stock in order to purchase the Canadian Locomotive Company, a move that diluted Silberstein's holdings. Robert Morse also added four additional seats to the board of directors, thus swamping Silberstein's influence. Penn-Texas continued to purchase Fairbanks-Morse stock, and was eventually able to secure four of the eleven seats on the Fairbanks-Morse board of directors. Morse countered by shifting all decision-making power to a three-person executive committee. He then sued Penn-Texas and hired Alfons Landa to raid the raider. Complicating the issue

\[57\] F-M established a new electronics division in 1954, primarily to enhance its competitive position in the scale industry. Barron's 35 (October 10, 1955), 27-8; Railway Age 136:17 (April 26, 1954), 38-9.
was the fact that Charles H. Morse, Jr., originally a supporter of the two Robert Morses, changed allegiances and sided with Silberstein.58

The struggle for control of Fairbanks-Morse was finally settled in May, 1957, by which time Penn-Texas owned 46.2 percent of all Fairbanks-Morse stock. Under the terms of a new agreement, each side would be entitled to five seats on the board of directors, with one additional member being independent. Robert Morse was allowed to remain as Fairbanks-Morse's president for up to five years. Fairbanks-Morse also bought back 300,000 shares of its own stock from Penn-Texas, at $50 per share. Unfortunately for Silberstein, his huge investment in Fairbanks-Morse thus did not give him actual control. In addition, he forced Penn-Texas more than $15 million in debt as a result of his takeover bid. Even worse, Penn-Texas was forced to continue buying Fairbanks-Morse stock in order to support the

58Barron's 43 (May 6, 1963), 5, 17-19; Business Week, April 14, 1956, 116-8; February 16, 1957, 42.
price of its principal asset.\textsuperscript{59}

Corporate upheavals at Fairbanks-Morse were by no means over, however. Not surprisingly, dissident Penn-Texas stockholders had largely stripped Silberstein of his power by February, 1958. Into the void stepped Landa, originally controlled by Robert Morse, but who was by now something of a loose cannon. Landa took control of Penn-Texas in mid-1958 and in November of that year purchased an additional 297,000 shares of Fairbanks-Morse stock from Col. Morse, giving Penn-Texas a 77 percent share of that company. At that time, the two companies were merged to form the Fairbanks-Whitney Corporation. This company was soon in serious financial trouble. Executive salaries remained excessive, production was inefficient, and incompetent managers failed to secure important contracts. In the first quarter of 1958, net earnings declined 97 percent from the same period a year earlier. Between 1955 and 1963, stock prices decreased from almost $23 a share to $4 a share. In 1962, the company lost $4.8 million. Landa left

\textsuperscript{59}Barron's 43 (May 6, 1963), 5, 17-19; Business Week, February 16, 1957, 42; May 18, 1957, 48; December 7, 1957, 82; Forbes 81 (May 1, 1958), 19.
Fairbanks-Whitney in May of that year. He was replaced by George A. Strichman, who, on assuming his new duties as president, unhelpfully declared that "This is the worst company I've ever seen." In 1963, Fairbanks-Whitney became the Fairbanks-Morse subsidiary of Colt Industries, still producing scales at St. Johnsbury, as it had done for the previous 129 years.

This corporate infighting was the final blow to Fairbanks-Morse's diesel-locomotive production. Production had declined to virtually nil by 1957, and a Fairbanks-Morse spokesman found it necessary to assert that the company was not leaving the locomotive industry. Regular locomotive production ended two years later, although Fairbanks-Whitney built a few units for railroads in Mexico until 1963. Thereafter, the company continued to manufacture opposed-piston engines for marine and stationary use at its Beloit facilities. In all, Fairbanks Morse built or supervised the construction of 1,256 locomotives, 1,100 of which were built

60 Barron's 43 (May 6, 1963), 5, 17-19 (quote).

during the period of peak production between 1944 and 1954.62

Like Lima, Fairbanks-Morse never really had a chance in the diesel locomotive industry. Fairbanks-Morse entered the market too late to compete against established firms like EMD. In addition, Fairbanks-Morse lacked the financial resources to develop an adequate marketing program, particularly in the realm of post-sale support services. The familial management at Fairbanks-Morse was not truly committed to the diesel locomotive program or even to the long-term survival of their own company. As with Baldwin, it is difficult to understand why Fairbanks-Morse remained in the locomotive industry as long as it did. The company's market share was never large -- 3.6 percent in 1949 and 6 percent in 1950, for example. Fairbanks-Morse made a profit on locomotive sales only in 1948, when it earned 4 percent. Two years later, it incurred a 14 percent loss on sales. During the 1950's, the rate of return on

62 Railway Age 137:10 (September 6, 1954), 16; 143:12 (September 16, 1957), 7; 147:11 (September 14, 1959), 68; Kirkland, The Diesel Builders, Vol. 1, 53, 65, 67.
Fairbanks-Morse's investment in the locomotive industry was negative 14 percent. By suffering these repeated financial losses, Fairbanks-Morse weakened its overall financial position and seriously endangered the profitability of its remaining product lines.\(^6^3\)

Fairbanks-Morse would have done well to follow the example of the Ingalls Shipbuilding Company. Although Ingalls announced plans for a complete diesel locomotive line in 1946, it built only one unit before its management realistically assessed the situation and left the industry. Ingalls, its financial resources still intact, later became a successful defense contractor. Executives at Ingalls realized that their company's skills in custom-built ship production were not applicable to the standardized production of diesel locomotives. Had Fairbanks-Morse acted with similar

\(^6^3\)It is doubtful that Fairbanks-Morse accepted these chronic losses in locomotive sales simply for the sake of a tax shelter, since the company continued to invest in research and development until the end of diesel locomotive production. Barron's 31 (April 16, 1951), 27; United States of America vs. General Motors Corporation, United States District Court, Southern District of New York, Case #61CR356, April 12, 1961, National Archives, Northeast Region, 7, 10.
foresight, the company would have been spared a great deal of financial hardship.\textsuperscript{64}

THE FAILURE OF THE MARGINAL PRODUCERS

In retrospect, Baldwin, Lima, and Fairbanks-Morse never really had an opportunity for success in the diesel locomotive industry. Baldwin, despite its size and reputation as a producer of high-quality steam locomotives, waited too long before introducing a comprehensive line of locomotive models and adapting its facilities at Eddystone to accommodate diesel-locomotive production. Much of this delay was the result of a corporate culture that caused managers at Baldwin to focus on continued steam locomotive development and production and ignore advances in diesel locomotive technology. In addition, Baldwin’s early diesels were of such poor quality that the company quickly lost its reputation as a supplier of quality locomotives -- and lost many of its traditional customers as well.

\textsuperscript{64}\textit{Railway Age} 120:21 (May 25, 1946), 1062-4.
Like Baldwin, Lima suffered from a steam-based corporate culture, and so failed to enter the diesel locomotive market in a timely fashion. Lima was further handicapped by its limited financial resources. The 1950 merger of the two firms, even though it was followed by the rationalization of production facilities, thus had little effect on the declining fortunes of Baldwin and Lima.

Since Fairbanks-Morse had never participated in the steam locomotive industry, that company was not handicapped by an outdated corporate culture. That did not mean that Fairbanks-Morse had a sound management structure, however, and the company was plagued with a family management that could not control the company or resist hostile takeover attempts. Like Lima, Fairbanks-Morse lacked the financial resources necessary to compete successfully in the diesel locomotive market and entered that market too late to establish an adequate market share. For all three companies, the decision of senior executives to begin and continue diesel locomotive production represented an extremely unwise allocation of corporate resources.

By 1960, the companies that were financially weak, exceptionally poorly managed, or had waited too long to
offer high-quality diesels had been driven from the locomotive industry. The American locomotive industry then consisted of two major producers, EMD and ALCo. Today, the American diesel locomotive industry still contains two major manufacturers. However, they are not these same two producers. The 1960's saw the awakening of the sleeping giant in the locomotive industry, General Electric. Because GE had been honing its competitive skills in the small diesel and export diesel markets since the early 1930's, that company was able to quickly displace ALCo as the secondary producer of large domestic diesel road freight locomotives during the 1960's.
CHAPTER VIII

THE MODERN INDUSTRY STRUCTURE CREATED:
GE REPLACES ALCo

As the decade of the 1960's began, ALCo's executives could congratulate themselves for having avoided the fate of their smaller rivals in the locomotive industry. ALCo's market share was by no means secure, however. EMD continued to improve its locomotives and retained its dominant position in the industry, despite efforts of the federal government to limit its power. Moreover, ALCo's former production partner, General Electric, entered the large diesel locomotive market in 1960. The superior financial, technical, and managerial resources of GE, honed by decades of participation in the small-diesel and export-diesel markets, enabled that company to displace ALCo with rapidity. ALCo ended locomotive production in 1969, thus creating an industry dominated, as it remains today, by two massive firms -- General Motors and General Electric.
EMD CONTINUES TO INVEST IN ORGANIZATIONAL CAPABILITIES

During the 1960's, EMD made substantial improvements to its locomotive line, easily enabling it to retain most of a shrinking diesel-locomotive market. ALCo posed even less of a threat than it had during the 1950's; and GE, despite its early success, posed no immediate danger to EMD's market share. The real threat came from the federal government, which equated EMD's 80+ percent market share with monopoly power rather than the successful integration of manufacturing, marketing and management skills. Legal actions by the Justice Department threatened EMD's market dominance, as well as its long-standing ties to General Motors.

While the American economy as a whole was somewhat sluggish during the late 1950's and early 1960's, the railroad industry was especially depressed. Improved highways and inland waterways, combined with the speed and flexibility of long-haul trucking services, reduced the railroad's share of freight traffic. The increasing popularity of air and auto travel resulted in massive losses in railroad passenger traffic. By 1961, railroad earnings had fallen to one of their lowest levels ever.
Capital expenditures for railroad equipment halved from just over $1 billion in 1957 to $427 million in 1961. While 1,015 new locomotives had been installed on American railroads in 1957, only 288 were purchased in 1961. This decline forced EMD, ALCo, and later GE to be particularly innovative in the development of new locomotive designs.¹

Responding to this decline in locomotive orders, EMD improved both its diesel engines and its locomotives. In 1961, EMD introduced the much-improved 2,250-hp GP-30, and secured orders for more than a hundred of these units within the first month of its availability. The GP-30 was followed by the even more popular 2,500-hp GP-35 two years later. These units, which featured a more powerful variant of the Model 567 engine, along with improved turbochargers, were well suited to both branchline and mainline service.

By the early 1960's, however, EMD engineers had concluded that the Model 567 engine, in production since

1938, was no longer adequate for the increasing horsepower requirements of the railroads. Accordingly, EMD increased the cylinder size from 567 to 645 cubic inches, and made other design improvements. The new Model 645 engines, along with improved traction motors, were introduced in June, 1965. In spite of these improvements, however, many components of the new Model 645 engine were interchangeable with those of the older Model 567. Along with the larger engine, EMD introduced a completely new locomotive line, consisting of nine models ranging from 1,000 hp to 6,000 hp. EMD predicted that these new locomotives would pay for themselves in one year, based on savings in repair costs alone, and boasted that three of these new locomotives could replace seven older units.²

Taken together, the development of the Model 645 engine and the creation of the new locomotive line constituted the longest research and development program

and the largest capital investment expenditure in EMD's history. This research guaranteed EMD's continued market dominance for nearly twenty more years. The changeover from the Model 567 to the Model 645 was well-timed. By 1965, railroad earnings were beginning to improve, but railroads were still anxious to take advantage of the cost savings offered by EMD's new diesel line. In addition, diesels purchased from EMD and other builders in the postwar dieselization boom were rapidly approaching retirement age, and the limited interchangeability between the two engine models was thus not a serious issue. In contrast, ALCo's switch from the Model 244 to the Model 251 engine in 1953, at the end of the dieselization rush, showed unfortunate timing. Railroads that had just spent millions of dollars on ALCo locomotives discovered that these new units were almost immediately obsolete.3

Improvements in EMD's marketing capabilities matched those in its product line. The division expanded its locomotive school, offering nine courses by 1965. These included a three-day purchases and stores ______

3Railway Age 158:23 (June 7, 1965), 18-22.
class, a six-week export class, and a six-week comprehensive class. In September, 1963, EMD replaced the industry-standard 2-year, 100,000-mile warranty with a new 2-year, 250,000-mile version.

Since railroads were buying fewer locomotives, and since their oldest locomotives were reaching the end of their useful life, EMD developed and aggressively marketed programs to overhaul or rebuild diesel locomotives, including those built by its competitors. Railroads typically had locomotives overhauled once every seven years, and this was a relatively minor procedure. Rebuilding, however, generally involved the complete disassembly of a locomotive, along with rewiring and, frequently, the replacement of the diesel engine and other key components. Often, a completely rebuilt locomotive bore little outward resemblance to the unit from which it had originated. Fourteen-year-old locomotives that were approaching their second overhaul were prime candidates for rebuilding. Since this category included virtually all locomotives produced during the postwar dieselization boom, rebuilding guaranteed substantial business for EMD during the 1960’s. By mid-1960, EMD had already rebuilt more than 390 locomotives, including 120 Model FT’s.
For railroads that desired new, rather than rebuilt, locomotives, EMD offered a generous trade-in policy. EMD allowed a 10 percent discount on the cost of the new unit, plus extra discounts based on the condition of the old locomotive. Railroads wishing to purchase a new GP-30, for example, could deduct as much as $54,000 from that locomotive’s $195,000 cost by trading in an older unit. Taken together, these marketing programs offered a valuable service to the financially strapped railroads and helped to ensure EMD’s continued market dominance during the 1960’s.⁴

THE FEDERAL GOVERNMENT INTERVENES

The federal government threatened EMD’s market dominance during the early 1960’s, however. Had the efforts of the Justice Department to prosecute General

Motors for alleged antitrust violations been successful, they could have seriously weakened EMD's competitive position in the diesel locomotive industry. While there is some evidence to support the government's accusations, it is clear that the Justice Department was incorrect in its assumption that EMD's large market share constituted a monopoly, or that EMD had obtained that market share through illegal means. The government exhibited a fundamental ignorance about the economic realities of the locomotive industry and confused first-mover advantages with monopoly. Given the impressive advances that had been made in the field of economics since the passage of the Sherman and Clayton antitrust acts, it is difficult to understand why the government decided to prosecute EMD.  

The rationale behind the government's attack on GM and EMD perhaps arose from a new interest in antitrust

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5To be fair towards the federal government, it must be noted that, during the 1960's, economists were only beginning to understand the relationship between economies of scale and bigness. The impact of path-breaking books, such as Alfred D. Chandler, Jr., Strategy and Structure (1962), The Visible Hand: The Managerial Revolution in American Business (1977), and John Kenneth Galbraith, The New Industrial State (1967), postdated the EMD antitrust suits.
activity after World War II. In 1950, Congress passed the Cellar-Kefauver Act, which allowed the Justice Department to use market share as evidence of monopolistic tendencies. This provision, along with restrictions on the acquisition of firms in the same or related industries, was one factor in the growth of conglomerates in the postwar period.¹

Because of its size and enormous economic power, General Motors and its various subsidiaries had long been the target of trustbusters and opponents of bigness. As early as 1955, the Subcommittee on Antitrust and Monopoly of the Senate Judiciary Committee issued a report entitled A Study of Antitrust Laws: Bigness and Concentration of Economic Power - A Case Study of General Motors Corporation. The report concluded that GM's financial resources were "... essential elements contributing to [EMD's] success in this field." Joseph C. O'Mahoney, who chaired a 1955 Senate Subcommittee on

Antitrust and Monopoly, echoed ALCo's inaccurate claims that War Production Board restrictions had also given EMD an unfair advantage. The report also criticized GM's involvement in the earthmoving equipment and bus industries.

A series of legal actions bore out the government's aversion to GM's size. In 1956, the Justice Department filed an antitrust suit against GM, charging that its 89 percent share of the intercity bus industry constituted a violation of the Sherman Act. In June, 1957, the Supreme Court ruled that DuPont's ownership of 23 percent of GM was illegal. Two years later, in October, 1959, the government claimed that GM's involvement in the construction equipment industry, through its Euclid Division, was a violation of the Clayton Act. Industry experts concluded that these developments were part of a larger effort to attack the periphery of General Motors, rather than confront the company directly. For

example, The Journal of Commerce, on October 23, 1961, stated that "The apparent attempt of the Justice Depart­ment to divest General Motors of its Electro-Motive Division bears all the ear-marks of an attack on 'big­ness as such,' rather than a bona fide move to check discrimination or other harmful or illegal prac­tices..."

On April 12, 1961, EMD became a part of this attack when a federal grand jury indicted GM for alleged viola­tions of Section 2 of the Sherman Act regarding its activities in the locomotive industry. This indictment was the direct outcome of a February, 1959 decision made by Attorney General William P. Rogers, an Eisenhower appointee, to launch an investigation against EMD. A grand jury, empaneled on November 17 of that year, met for the next 17 months. The Kennedy administration con­tinued and expanded this antitrust action.

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Specifically, the indictment charged that EMD had sold locomotives at a loss and that it had adjusted its locomotive prices to undermine its competition; that EMD had produced locomotives at a rate that no other company could match; that EMD's competitors could not match GM's financial resources, level of investment, advertising expenditures, or ability to establish service and repair facilities; and that GM could obtain better terms for parts and supplies than could any of its competitors. According to the Justice Department, EMD was also able to offer unfair financing and was making attempts to monopolize the diesel locomotive rebuilding market. Finally, GM was charged with reciprocity, using its position as the largest rail shipper in the United States to threaten railroads that refused to purchase EMD locomotives and reward those that did.¹⁰

While this criminal suit was winding its way through the legal system, the federal government, on November 14, 1963, filed a civil antitrust suit against

General Motors, charging that company with violating the Sherman and Clayton Acts. In addition to the now-familiar reciprocity charge, the government claimed that GM's 1930 acquisition of the Winton Engine Company and the Electro-Motive Company violated the Clayton Act's "... prohibition on acquisitions that tend to create monopolies." The Justice Department also reiterated its belief that EMD offered unfair financing terms, and that it sold locomotives at a loss.\(^\text{11}\)

Although GM officially denied all of these charges, there is evidence that EMD did indeed engage in questionable business practices, particularly regarding the issue of reciprocity. As early as 1944, ALCo president William Dickerman gave some thinly veiled hints regarding the issue of reciprocity, but he was unable to furnish any proof. The records of the Louisville and Nashville Railroad offer a more telling indictment. In 1939, when the president of the L&N considered the purchase of EMC locomotives, he "told the sales

representative of the Electro-Motive Corporation that I hoped they would consider this purchase in such a way as to influence a larger amount of competitive traffic via this railroad. He said the Electro-Motive Corporation itself had very little traffic that they could influence via this railroad. He further said, however, that all of their sales were brought to the attention of the General Motors Corporation. I am hoping, therefore, that you can use this purchase advantageously in the matter of securing traffic."\textsuperscript{12}

The reassurances of this EMC salesman probably did not represent official GM policy. In addition, this incident occurred during EMC's formative years, before GM incorporated it as a division in 1941. GM's increasing control over its subsidiary, a process described in Chapter 5, was in part designed to prevent potentially embarrassing situations of this nature. Furthermore, the Justice Department, despite its lengthy investigation, never found this letter, which, in any case, would

\textsuperscript{12}J. B. Hill to E. A. deFuniak, September 6, 1939, L&N records, box 1, folder A-15113 (quote).
not have been enough to convict GM of much of anything. ¹³

In fact, even after years of effort, the Justice Department amassed little concrete evidence against GM. In addition, Justice Department prosecutors made a number of mistakes during the course of their investigation. They filed the initial 1961 charges in New York, because that city was close to Washington, rather than in Chicago, where La Grange was located. An exasperated New York District Court Judge almost immediately ordered the case transferred to Chicago, adding that "Monopoly may have been thrust upon [EMD]."¹⁴ In his opening arguments before the court, Department of Justice Chief Prosecutor Sanford M. Litvack frequently referred to ALCo as "Alcoa." Based on a lack of evidence and a growing realization that EMD's success was a result of


investments in integrated production, distribution, and management rather than monopoly, the Justice Department dropped all charges against GM and EMD in December, 1964.15

Two factors had considerable impact on the decision of the Justice Department to drop the antitrust suits against EMD. First, scores of railroad industry executives, who understood that EMD offered both a better product and better service than any of its competitors, testified that EMD's success had been based on these factors alone, rather than economic pressure by GM. Second, GE's rapid success in the diesel-locomotive industry in the early 1960's offered clear evidence that EMD had not created insurmountable barriers to entry.

The dismissal of the two antitrust suits removed the last obstacle to EMD's continued market dominance. A sound management, along with continued investments in manufacturing and marketing, ensured that EMD would

prevent ALCo from attaining more than a minor share of the diesel locomotive market. GE, despite its initial success in the large diesel locomotive market, was unable to replace EMD as the industry leader during the 1960's.

GE ENTERS THE LARGE DIESEL LOCOMOTIVE INDUSTRY

The decade of the 1960's witnessed the entrance and subsequent rapid success of a new competitor in the large-diesel locomotive industry. General Electric used its decades of experience in the small-diesel and export-diesel markets to great advantage in its efforts to displace ALCo, its former production partner, from the industry. Managers at GE's Locomotive and Car Equipment Department, who were well aware of production and managerial difficulties at ALCo first terminated the long-standing joint-production agreement, largely to protect themselves from the embarrassment and expense associated with ALCo's mistakes. Realizing how easy it would be to produce large diesel locomotives that were superior to ALCo models, senior GE executives understood that their company could earn substantial profits in the
locomotive industry by making their own locomotives in competition with ALCo and EMD. GE's ability to do so, along with its superior managerial and marketing expertise, allowed that company to drive ALCo from the diesel-locomotive industry in less than a decade.

GE used World War II as an opportunity to implement standardized production techniques for its small diesel switchers, and the company soon reaped the rewards that resulted. In 1946, for example, GE secured orders for 178 diesel locomotives, all of 600 hp or less. Forty-eight of these were for service on American railroads, while an additional 104 were destined for domestic industrial use. This demand encouraged GE to make gradual improvements to its switchers in the postwar period. In 1952, GE expanded its production capabilities by constructing a new traction motor research and development facility. A year later, as part of a larger corporate effort to expand into the industrial automation sector, GE consolidated its DC motor and generator production at Erie. By 1955, GE was marketing its own electrical equipment and, even though it sold this equipment to
ALCo, its marketing campaigns made no mention of that company.\textsuperscript{16}

After World War II, GE gradually increased the number of locomotive models that it offered to potential customers. In 1954, GE offered forty different locomotive models, more than ever before in its history. Two years later, GE introduced a new line of "Universal" export locomotives, ranging from 400 hp to 1,980 hp. The largest of these would have qualified as road freight locomotives, had they been sold in the domestic market. This impressive, and increasing, production capability should have been a clear warning to ALCo that its production partner was preparing to turn against it.\textsuperscript{17}


\textsuperscript{17} Railway Age 138:12 (March 21, 1955), 7; 140:16 (April 16, 1956), 47-9.
GE also expanded its support services, largely at ALCo's expense. In 1949, GE established a facility in Richmond, Virginia, that had the capability to repair diesel locomotive traction motors and generators. Five years later, GE established a complete locomotive rebuilding facility at Erie. By 1957, the company had locomotive parts distribution centers in Chicago, Atlanta, St. Louis, and Los Angeles. GE had major locomotive overhaul facilities in Atlanta, Boston, Chicago, Cleveland, Dallas, Minneapolis, New York City, Pittsburgh, Portland, Oregon, Salt Lake City, and San Francisco. In addition, railroad customers could obtain many parts and services, 24 hours a day, at 37 other GE facilities in the United States -- a support network that far exceeded what ALCo was able to offer. Initially, these facilities were designed for GE's small diesel switchers, but they could be, and later were, converted to service facilities for large diesel locomotives. By 1971, this service network had grown to include five regional parts centers (at Erie, Atlanta, Los Angeles, Minneapolis, and St. Louis), along with
These investments in GE's physical plant were matched by investments in marketing services. Like the other builders, GE offered a locomotive school. In addition, GE, rather than ALCo, conducted marketing services to determine what type of GE or ALCo-GE locomotives were best suited for a particular railroad. GE employees also advised railroads on the most efficient design for new diesel locomotive service and repair facilities. As was the case with GE's service and repair capabilities, these efforts overwhelmed ALCo's feeble marketing efforts and ensured that GE had ample practice in the development of its own organizational capabilities prior to its introduction of large freight

diesels in 1960.18

GE's decision to enter the large diesel locomotive market was not based solely on its expanded manufacturing and marketing capabilities, however. The final impetus came from ALCo, whose incompetence was a continual source of embarrassment for GE -- and also offered an opportunity too good to pass up. During the postwar period, railroads made many complaints about ALCo-GE locomotives. A conference of railroad locomotive maintenance officers, for example, concluded that "The development of the Alco 244 engine has been a fertile field for research with respect to bearings and bearing failures."20 Since all ALCo-GE locomotives displayed a prominent GE emblem on their sides, these problems, though not caused by GE, were naturally of great concern to officials of that company. A 1954 GE marketing report concluded that "Present trends indicate that


it is imperative to get control of the complaint situation if we are to stay in business. The continued downward trend in business volume is traceable in most cases to poor product performance."21 A year later, another GE report noted how the "stigma of lack of reliability earned by the Alco passenger units on the Santa Fe is still following Alco and damaging their reputation, and ours."22

Since it was virtually powerless to remedy the chronic managerial manufacturing, and marketing failures at ALCo, GE did its best to distance itself from that company. In 1953, GE terminated the joint-production agreement, although it continued to supply electrical equipment for ALCo diesels. In addition to removing the GE nameplate from inferior ALCo diesels, this decision allowed GE to enter the large diesel market in its own right.


Unlike the rather haphazard entry of ALCo, Baldwin, Lima-Hamilton, and Fairbanks-Morse into the diesel locomotive industry, GE carefully planned its entrance into the field and committed itself only when it was certain that it could capture a substantial market share. In the mid-1950's, GE surveyed thirty-three railroads to determine their future motive power needs. From these studies, it became clear that railroads wanted reduced maintenance costs above all other qualities. Other considerations, in decreasing order of importance, included reduced operating costs, increased reliability, greater pulling power, lower cost per horsepower and increased horsepower per pound of locomotive weight.

Based on these marketing studies, GE concluded that it could participate successfully in the locomotive industry if it could reduce operating costs by at least 35 percent and lower locomotive costs from $100 per horsepower to $80 per horsepower or less. Significantly, potential problems in the design and construction of these new locomotives were not a cause for concern among GE engineers; they assumed, correctly, that they would have no difficulty designing a
locomotive that could meet these requirements. Based on these marketing forecasts, GE concluded that "The market for road diesel-electric locomotives, therefore, becomes a very inspiring picture ..." and predicted annual sales ranging from $160 to $200 million.\(^2\)\(^3\) This would ensure GE at least a 16 percent rate-of-return on capital. The company estimated that significant diesel locomotive replacement sales would begin in 1960, reach a peak in 1965, and remain at a high level for the following ten years.\(^2\)\(^4\)

As a result of these substantial potential profits, GE executives committed their company to the large diesel freight locomotive market. In September, 1954, GE placed a four-unit, 6,000-hp locomotive, using


Cooper-Bessemer diesel engines and GE electrical equipment, in railroad service. Officially, this Model XP 24-1 was to be used to test components for GE's export locomotive line, but in reality it was the prototype for the company's first large domestic locomotive. The introduction of GE's first production model, the U-25B in April, 1960, "... caught the railroad industry by surprise. Most railroad men thought the test locomotive was only a research lab for service testing of components." The 2,500-hp U-25B, which was basically a stripped-down version of the XP 24-1, contained a 16-cylinder, 4-cycle engine built by Cooper-Bessemer at its Grove City, Pennsylvania, facility. In spite of this, GE assumed all responsibility for the locomotive, including that of marketing the finished product. The U-25B was an immediate success, and GE received orders for more than 200 of these locomotives, worth some $31 million, before the end of 1960.

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25 *Railway Age* 148:19 (May 9, 1960), 32-3 (quote).

The success of the U-25B prompted GE to integrate production and offer additional locomotive models. As GE promised, the U-25B offered lower operating costs and better reliability than comparable ALCo and EMD locomotives. Following the success of its first model, GE introduced the U-25C in August, 1963, followed by three additional models in 1966. The company delivered its first 3,300-hp U-33B locomotive in December, 1967; and, by the end of the decade, was able to offer a complete locomotive line. GE's market share increased from 2.8 percent in 1960 to 18.7 percent in 1967, while ALCo's market share declined from 13.1 percent to 6.5 percent in the same period. The success of the U-Series locomotives caused GE to begin manufacturing its own diesel engines in 1964, thus giving it the distinction of being the second fully integrated manufacturer of diesel locomotives in the United States. A year later, GE elevated its Locomotive and Car Equipment Department to divisional status.²⁷

The decision of General Electric to enter the large diesel locomotive market was a direct response to ALCo's incompetence. Indeed, much of GE's early success occurred at ALCo's expense, but it was GE's organizational strength, not ALCo's weakness, that ensured success. GE utilized decades of experience in the industrial diesel and export diesel markets. In addition, GE carefully explored the needs of the railroads as well as its own capabilities in order to determine whether or not it should enter the large diesel locomotive market. Once that decision had been made, GE developed a locomotive that was superior to those offered by its competitors. The company thoroughly and secretly tested a prototype unit.

By using Cooper-Bessemer engines, GE reduced its initial investment, yet retained control over the final product. Finally, when it became clear that GE locomotives were viable products, GE integrated engine production with its existing locomotive manufacturing capabilities, thus ensuring control over production and

(Spring, 1976), 9.
profits. GE's organizational capabilities enabled it to replace ALCo as the secondary producer in the industry within three years and drive it from the industry in nine.

THE DOWNFALL OF ALCo

The organizational skills of General Electric stand in sharp contrast to the organizational failings of ALCo. ALCo's attempt to diversify in the late 1950's indicated a realization that the postwar locomotive boom was gone forever. It did not, however, include a realistic assessment regarding the wisdom of ALCo's continued participation in the industry in any form whatsoever. The clear progression of GE toward participation in the large diesel locomotive market should have given ALCo clear notice that its days in the locomotive industry were numbered. As had been the case with Fairbanks-Morse and Baldwin-Lima-Hamilton, the inability of ALCo to make a timely exit from the industry caused needless hardship for both the company, its stockholders, and workers.

By the early 1960's, the newly created ALCo Products Company was in serious financial trouble.
Total sales, which had been a respectable $440 million in 1953, had plummeted to $89 million in 1961. Total earnings fell 92 percent between 1955 and 1961. The wide variety of custom-engineered, custom-built products, which were intended to at least equal locomotive sales, instead comprised only 20 percent of revenues and an even smaller percentage of profit. This discrepancy occurred largely because of poor overall management by ALCo. In addition, ALCo executives unwisely diversified into custom-product lines, such as nuclear power, that required extensive capital investments and immense technical expertise — assets that were in short supply at ALCo.

ALCo’s locomotive division, battered at home by EMD and abroad by GE and EMD, was performing little better. Employment at the Schenectady plant declined from 10,000 in 1951, the peak year of ALCo’s diesel production, to 2,000 in 1960. Although not in imminent danger of bankruptcy, ALCo nevertheless required a substantial change in corporate strategy.  

Given the facts that 1961 was a particularly poor year for all railroad suppliers, that EMD was expanding both domestically and abroad, and that one financial analyst viewed the locomotive industry as "... one of the least profitable ends of the capital goods business," it would seem unlikely that ALCo executives would choose to concentrate still further on the diesel locomotive industry. Nevertheless, that is exactly what they did.29

On September 1, 1962, ALCo announced its second reorganization in seven years. The company instituted a line-and-staff managerial structure, and a multi-divisional corporate structure replaced the earlier centralized, functionally departmentalized one. The new structure allowed "... central control of policy along with operating autonomy for plant groups." Although the business historian Alfred D. Chandler asserts, in *Strategy and Structure*, that most well-managed companies allow the structure of the company to follow its

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strategy, ALCo adopted the opposite approach.\textsuperscript{30} The reorganization created a multidivisional structure in anticipation of an expansion into new product lines. Although that phase of ALCo's reorganization was never completed, the company was able to divest itself of many of its unprofitable subsidiaries.\textsuperscript{31}

Between early 1962 and mid-1963, ALCo sold all of its custom-engineered product lines, including heat exchangers, nuclear power components, and oil field products. ALCo continued to manufacture standardized machinery, including locomotives and diesel engines, forgings and springs.\textsuperscript{32} ALCo sold the Beaumont Iron Works division to the Shaffer Tool Works of Brea, California. Allis Chalmers acquired the nuclear


\textsuperscript{31}"Manufacturing Capabilities, Alco Products, Inc., Latrobe, Pennsylvania," 1963(?), Records of the American Locomotive Company at the George Arents Research Library, Syracuse University (hereafter referred to as the ALCo Collection), Box 11; Address by William G. Miller, President, Alco Products, Inc., presented before the New York Society of Security Analysts, August 29, 1963, ALCo Collection, Box 28.

\textsuperscript{32}William G. Miller, "Remarks at the Annual Meeting," April 17, 1962, ALCo Collection, Box 6.
products line. The Dunkirk plant and the heat exchangers that it produced went to the Worthington Corporation, the firm that later bought ALCo itself. The product lines that remained were concentrated into two divisions: the Locomotive and Engine Products Division and the Forge and Spring Division.33

Given the fact that locomotive demand was stagnant at the time of ALCo's reorganization, this concentration on locomotive production and disposal of unrelated profit lines seemed to defy logic. Two factors supported this decision by ALCo executives, however.

First, since EMD was generally too busy filling domestic orders to give much consideration to foreign demand, ALCo attempted to exploit this market. By 1960, since the domestic market was not very promising, ALCo managers began to place much greater emphasis on foreign demand. At this time, ALCo's entire international staff was based in New York City. The managers of the

Central, Eastern, and Latin American regions made five or six trips per year to the various nations within their region in an attempt to solicit business. ALCo lacked the resources to build diesel locomotive plants abroad and, in any case, such plants could never have operated at minimum efficient scale in small, local markets.

ALCo adopted a dual strategy for the penetration of foreign markets. Nations with low rail mileage and small locomotive demand had their diesels built in ALCo's Schenectady facility. In countries with larger rail networks, ALCo licensed firms to manufacture locomotives locally. Typically, these firms were already involved in the production of similar items, such as diesel engines or railway equipment. ALCo executives clearly favored domestic production over the issuance of production licenses to foreign firms. According to Board Chairman William G. Miller, "Direct sales of equipment, whereby locomotives are built in the United States and shipped overseas, are uppermost in our minds when dealing abroad. However, we have fully faced up to the facts of life, and have adapted our operations to meet the changing requirements of those nations that
increasingly are seeking ways and means of self-manufacture."

ALCo was willing to grant licenses to foreign producers. In 1959, ALCo executives signed an agreement with the London-based Associated Electrical Industries, Ltd. "... for joint collaboration in the design, manufacture and sale of diesel-electric locomotives [of more than 900 hp] for world markets." ALCo opened a London sales office in 1960 and, in the same year, signed an agreement with Davey, Paxman and Company, Ltd., for the joint production of diesel engines in Great Britain. It appears that no ALCo diesel locomotives were produced in that country, however. In 1964, ALCo issued a license to the Societe des Forges et Chantiers de la Mediterranee for the production of its diesel engines in France. ALCo maintained a similar agreement with Compania Euskalduna de Construccion y

34Remarks by William G. Miller at the annual meeting of stockholders, April 21, 1964, ALCo Collection, Box 6 (quote); Dick Mann to Roger Witherell, April 16, 1964, ALCo Collection, Box 29; Alco Products, Inc., Press Release, March 26, 1963, ALCo Collection, Box 28.

35Alco Products, Inc., press release, November 2, 1959, ALCo Collection, box 13 (quote).
Reparacion de Buques in Spain. A. E. Goodwin, Ltd., built diesel locomotives to ALCo designs for the Australian market. Finally, in February, 1962, ALCo executives signed a $200-million agreement with the Government of India for the manufacture of ALCo-designed locomotives at a plant in Varanasi, Upper Pradesh. By the mid-1960's, half of all ALCo locomotives destined for foreign markets were built abroad.36

As had been the case with locomotive rebuilding and spare parts warehouses, ALCo's penetration of the international market was only modestly successful. The granting of production licenses to foreign manufacturers, while profitable, did little to increase output at Schenectady. Foreign orders tended to be smaller than those placed by American railroads. In addition, foreign railroads often exhibited wide variations in

gauges and clearance restrictions, factors that made standardized production difficult. Moreover, by the late 1950's, as the domestic market for locomotives dwindled, EMD concentrated its resources on the foreign market, to the obvious detriment of ALCo. Thus, in 1959, EMD surpassed ALCo in sales of diesel locomotives for export. In all years prior to 1959 EMD averaged 27 percent of the foreign market, while in 1960 it had a 68 percent of all foreign orders. Finally, ALCo ran headlong into the locomotive development policy practiced by its domestic production partner, General Electric. In a policy opposite to that practiced by EMD, GE used the foreign market as a test market for the development of large, high-horsepower locomotives, thus gaining experience which it later used to wrest the number-two market share from ALCo in the domestic locomotive market.37

37 O. G. Dellacanonica, "Memorandum No. 3: A Brief Survey of Export Locomotive Sales for the First Eleven Months of 1959," December 7, 1959; Dellacanonica, "Survey of Export Locomotive Sales," September 1, 1960; both in ALCo Collection, Box 11. According to Dellacanonica, ALCo's manager of export sales, ALCo's 5 models were unable to compete with EMD's 13, and he called for less reliance on standardized designs, coupled with an increase in the number of licensees and fewer restrictions on existing licensees.
The second justification for ALCo's decision to focus on locomotive production arose from the fact that its executives hoped that the federal government might provide an artificial mechanism for reducing EMD's market share. They clearly hoped that the 1961 and 1963 antitrust suits would force EMD to split apart or, better yet, would force General Motors out of the locomotive business altogether. This was not to be, however, since the Justice Department was unable to provide any evidence to support its claims. In December, 1964, the government dropped both antitrust suits against GM, thus ensuring that EMD was not legally obligated to alter its competitive behavior. However, the threat of future prosecution may have encouraged EMD to allow its competitors to increase their market shares slightly, much as it did after World War II when it refrained from creating the facilities necessary to capture the entire American diesel locomotive market. ALCo was unable to take advantage of this opportunity, however, because the market share given up by EMD was soon appropriated by General Electric.\(^3^8\)

Finally, and most importantly, ALCo predicted that domestic locomotive demand would begin to increase over the next few years. Their predictions were correct. Locomotives purchased in the decade of 1945-55 were nearing the end of their careers, since diesels typically had a service life of approximately twenty years, and were fully depreciated after fourteen. Technological improvements, which boosted horsepower and lowered maintenance costs, persuaded many railroads to replace their aging diesel fleets en masse. Thanks in part to new locomotive depreciation schedules issued by the Treasury Department in July, 1962, locomotive demand surged forward. The years 1965 and 1966 constituted two of the best years in the history of the industry, with more than 1,200 new and rebuilt units added to railroad motive power fleets each year.39

ALCo was prepared to exploit this increased demand with its Century Series locomotives. ALCo executives

assigned the development of these models to its newly created Advanced Locomotive Design Group, which they kept separated from the regular Production Engineering Department. The company first offered these models in January, 1963, claiming that they lowered operating costs up to 40 percent, and maintenance costs up to 50 percent compared to locomotives that had been in service ten years or more. Fifteen 2,400-hp Century 424 locomotives were the first of the series to be built at Schenectady, and were completed in June, 1963. The company soon put other Century Series designs into production, ranging from the 2,000-hp Century 420 to the massive 3,600-hp Century 636. Since all of these locomotives used an improved version of the standard 12-cylinder and 16-cylinder Model 251 Engine, they delivered substantially more power than the 1,500 horsepower that was common on early postwar ALCo models.40

ALCo's Century Series was a success, though not a spectacular one. Between 1963 and 1966, the line grew from three models to nine. In the first three-and-a-half years of production, the company completed more than 500 Century Series locomotives, less than a fourth of EMD's production for the same period. The 1963 profit of $3.4 million was a substantial improvement over the $900,000 deficit incurred in 1960, encouraging the company to budget $1.7 million for an expansion of the Auburn plant that increased diesel engine output by 50 percent.  

As was the case with the abortive federal antitrust suit against GM, however, ALCo was not the only firm to seize the market opportunities created by this sudden increase in locomotive demand. The predilection of railroad motive power officials to standardize on the products of one builder gave EMD an obvious advantage, for by the early 1960's nearly 85 percent of the 23,000 diesel locomotives in service on American railroads had

been built by that company. In June, 1965, EMD introduced nine entirely new locomotive models, a number that increased to fourteen by the end of the year. These locomotives incorporated the larger and more powerful model 645 engine as a replacement for the standard model 567. EMD offered a massive 20-cylinder version of this engine, a product that ALCo could not match. Sales in 1966 were the highest in EMD's history, surpassing (in dollar value) those of the previous record year, 1951. Given EMD's consistent ability to outperform ALCo, it is thus not surprising that it was better able to exploit the locomotive boom of the 1960's.\(^2\)

However, it was General Electric, not EMD, that turned the 1960's into a bitter decade for ALCo. Given the sudden surge in locomotive orders, and given the sword of Damocles suspended over EMD by the Justice Department, ALCo might well have captured a large share of the locomotive orders that EMD would not or could not

accommodate. By carefully timing its entrance into the large domestic diesel locomotive market, GE diverted much of EMD's overflow away from ALCo. When it entered a market that could be served adequately by two large producers, GE's superior technology and greater production efficiency forced ALCo out of diesel locomotive production by the end of the decade. This situation, in which ALCo was a direct competitor with its only supplier of electric equipment, was most unusual in American business.

From ALCo's perspective, GE's entrance into the domestic large diesel locomotive market was little short of disaster. With excess production capacity in the industry, the least efficient of the three producers might well be driven from the industry if and when locomotive orders decreased. Unfortunately for ALCo, most railroads had completed their new motive power purchases by late 1966. This situation, combined with the temporary suspension of a 7 percent investment tax credit in early 1967, brought a quick end to the locomotive boom. While railroads had placed orders for 1,204 locomotives in 1966, they planned to order only 166 the following year. Faced with increased competition from
GE, ALCo's market share began to decline: from 11 percent in 1966 to 6 percent the following year to 3 percent in 1968. GE captured 33 percent of the market in 1968.43

The rapid success of GE in the locomotive industry was in large measure the result of the fact that their locomotives were superior to those produced by ALCo. Tests on the Louisville and Nashville Railroad, conducted in May, 1960, indicated that GE locomotives had more power and better acceleration than their ALCo counterparts. Robert N. Cotton, who was the first black locomotive engineer on the L&N, and one of the first in the United States, complained that "In the early 60's the Alco, oh, it was huge, and cumbersome and it seems it was made [to] aggravate the locomotive engineer." He also observed that "... it was just a contrary locomotive in my opinion. [but that] The General Electric locomotive, of all the locomotive [sic] used, is the

GE's superior product, and hence its ability to capture such a large portion of the locomotive market, intensified ALCo's financial difficulties. Following the 1962 reorganization, ALCo executives intended to diversify their operations by creating a conglomerate, a form of corporate organization then very much in vogue. Although they had both the cash and the necessary multidivisional corporate structure, ALCo executives were unable to purchase any additional companies or product lines. This failure to create a conglomerate continued ALCo's dependence on the vagaries of the "feast or famine" locomotive industry at a time when its foreign locomotive orders were declining.


Faced with dwindling locomotive orders and unable to diversify its own operations, ALCo itself chose to become part of a diversified enterprise. In July, 1964, the Worthington Corporation, which had purchased ALCo's feedwater heater business less than two years earlier, offered to buy the rest of the company as well. Worthington had been founded in 1840 by Henry Rossiter Worthington for the purpose of marketing several of his inventions, including a direct-acting steam pump and the world's first practical water meter. In the early 1900's, as ALCo was consolidating many of the smaller producers in the locomotive industry, Worthington was diversifying into compressors, generators, condensers, feedwater heaters and steam turbines. By 1964, Worthington was also producing diesel and gasoline engines, pneumatic equipment, electric motors, construction equipment, and air conditioning equipment.

Like ALCo, Worthington was a recent casualty of poor management and declining sales. Worthington's

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46 Typescript of a speech to commemorate the 125th anniversary of Worthington Corporation, February 26, 1965, ALCo Collection, Box 11; New York Times, July 23, 1964, 33; Forbes, August 1, 1964, 23.
earnings per share had fallen steadily from $6.35 in 1957 to $2.39 in 1963. The managers of both companies hoped that a merger would smooth out the "boom and bust" cycles associated with their respective product lines. As an analyst from Forbes explained, "... there's a real possibility that the two convalescing cripples can help each other."47

Accordingly, Worthington paid ALCo stockholders $22.8 million cash and agreed to assume $12.2 million worth of ALCo liabilities. Effective December 31, 1964, the former Alco Products, Inc. became the Alco Products Division of the Worthington Corporation. This division was in turn divided into the Locomotive and Engine Products Division, with plants at Auburn and Schenectady, and the Forge and Spring Products Division, with plants in Latrobe, Pennsylvania, and Chicago Heights, Illinois -- employing, in all, some 4,000 people. ALCo president William F. Lewis and board chairman William G. Miller both acquired seats on Worthington's board of directors.

47Forbes, August 1, 1964, 23 (quote).
ALCo's corporate structure transformed itself into Citadel Industries, a company with no output and no assets other than the cash that it had just received from Worthington. Citadel was intended to be an investment company, but its (ALCo's) managers had little idea what the company should do with its newly acquired financial resources. At the November, 1964, meeting to approve the merger, many of the smaller shareholders were vehemently opposed to the transaction and were especially disturbed at management's laxity regarding this issue. One stockholder, for example, inquired "... whether [ALCo's managers had] any ideas or offers on what the business that [they] will engage in in Citadel Industries?" Board Chairman Miller replied: "To the best of my knowledge, no."48 Clearly, ALCo executives retained the informal managerial style that had characterized their early involvement in the diesel locomotive industry. The transfer of locomotive production to

48 Transcript, Special Meeting of Stockholders, William G. Miller, Chairman, November 5, 1964, ALCo Collection, Box 6 (quote).
Worthington did little to improve the situation. What finally settled ALCo's fate as a locomotive producer, however, was the November, 1967, merger of the Worthington Corporation with the Studebaker Corporation. The newly formed Studebaker-Worthington Corporation, with assets of some $550 million, failed to perform as well as was expected. After a purge of top management, Derald H. Ruttenberg, a Chicago lawyer, was named president and chief executive officer in January 1969. He pledged to eliminate all of the financially unsound components of the corporation. First to go was the Alco Products Division. Locomotive orders were virtually nonexistent, and GE was once again in the process of expanding its line of diesel locomotives. Accordingly, ALCo ended 121 years of continuous locomotive production at Schenectady in 1969. In February, 1970, Studebaker-Worthington sold its diesel engine business to the White Motor Corporation. The design rights to the diesel locomotives themselves were transferred to the Montreal

Roger C. Witherell to Vincent J. Quatrini, November 6, 1964; Worthington Corporation, Press Release, November 5(?), 1964; all in ALCo Collection, Box 6; Wall Street Journal, November 6, 1964, 4; New York Times, November 6, 1964, 51; February 5, 1965, 41.
Locomotive Works, which remained a component of Studebaker-Worthington. Since then, EMD and GE alone have vied for control of the American diesel locomotive market.50

ALCo's transformation from a steam locomotive builder to a producer of diesel locomotives failed because that company did not make adequate investments in manufacturing facilities, marketing capabilities, or managerial talent. Although it was a pioneer in the locomotive industry, this failure prevented ALCo from developing the first-mover advantages necessary to attain market dominance. Given the company's inability to make the necessary investment in any of these three areas, the mystery is not why ALCo went out of the locomotive business, but how it lasted as long as it did. ALCo remained in the locomotive industry as a secondary producer for so long because it was more efficient than Fairbanks-Morse or Baldwin-Lima-Hamilton.

Even so, EMD could have driven ALCo from the industry after 1945, had EMD wished to incur the wrath of the Justice Department that was sure to accompany 100 percent market dominance. In addition, ALCo survived because, until 1960, no other company challenged this secondary position in the domestic large-diesel locomotive market.

In manufacturing, the company failed to establish a fully integrated facility for the standardized assembly-line production of diesel locomotives. Having squandered its financial resources through an excessive dividend policy in the 1920's, the company was financially unable to transform its antiquated Schenectady plant into a modern diesel locomotive production facility. Instead, these locomotives were produced in a variety of unsuitable, surplus buildings scattered throughout the plant site. Even a much-heralded postwar conversion program did not produce an efficient plant comparable to EMD's La Grange facility. Furthermore, ALCo, throughout its career as a locomotive builder, relied on General Electric for vital and expensive electric equipment. This inability to construct a third of the locomotive reduced ALCo's profitability and left the
company vulnerable to the vagaries of GE and other independent suppliers.

ALCo also failed to make the necessary investment in marketing. The 1940-53 ALCo-GE joint production agreement allowed GE, not ALCo, to develop a network for the marketing of diesel locomotives. When the agreement was terminated, ALCo failed to develop a comparable marketing network on its own. This was not a fatal omission, however, so long as GE was busy honing its skills on the foreign and small diesel markets. Once GE became a direct competitor of ALCo in 1960, GE's superior marketing skills and greater mastery of electrical equipment technology enabled it to drive ALCo from the diesel locomotive market with astonishing speed.

ALCo's most serious failure, however, was that of its management. During the 1920's, its executives gave away ALCo's nest egg to undoubtedly grateful stockholders. During the 1930's, they lacked the courage and the entrepreneurial vision to issue the bonds or request the bank loans that would have provided sufficient funds to rationalize the production of diesel locomotives. During the 1940's, they approved the use of diesel engines that were clearly inferior to those built by
EMD. During the 1950's, they diversified unwisely, purchasing companies that quickly became money-losers. During the 1960's, they adopted a multidivisional corporate structure in anticipation of a diversification that never materialized and then made the mistake of concentrating on the locomotive industry once again. By the late 1960's, ALCo could do little more than slide into oblivion.

Overarching all of these specific failures was the general inability of ALCo's managers to adapt to the ending of the way of life and thought that the steam locomotive represented. During the development and maturation of the diesel locomotive industry, key ALCo executives were simply unwilling to admit that the steam locomotive could ever be replaced. When diesels were in their infancy, management viewed them as curiosities, suitable only for a very few specialized applications. Once diesels had proven themselves in yard switching service, management was convinced that they could never be applied to freight and passenger service with the same degree of success. When railroads ordered diesels by the hundreds to re-equip their freight and passenger trains, management was convinced that somehow,
somewhere, there would still be a place for the steam locomotive. This bias toward steam, firmly grounded in ALCo's corporate culture, blinded ALCo executives to the possibilities of the diesel locomotive market and prevented them from making the investments in production and distribution that were necessary to capture that market.

In conclusion, ALCo failed to make a successful transition between the production of steam locomotives and the production of diesels largely because it failed to make the necessary three-pronged investment in manufacturing, marketing, and management. This failure was compounded by the inability of senior management to realize that their company was in the locomotive business, not the steam locomotive business. The failure of these executives and their company to adapt to technological change provides a powerful warning of the dangers of complacency in a rapidly changing business world.
CHAPTER IX

AMERICAN LOCOMOTIVE PRODUCERS IN FOREIGN MARKETS:
A CASE STUDY

Foreign markets, particularly those in Canada and Latin America, offer a case study of the global dominance of the American diesel locomotive industry in general, as well as the international success of EMD and GE in particular. Typically, changing competitive patterns in foreign locomotive markets mirrored those in the domestic locomotive industry. While foreign markets by themselves did not determine the structure or the participants in the locomotive industry, they nevertheless contributed to the decline of established locomotive producers and the ascension of new entrants in the industry. General Electric and General Motors in particular were able to use their enormous financial resources and their well-developed production, distribution, and management skills to drive the older steam locomotive producers from foreign markets, just as they had done in the United States. ALCo, Baldwin, and Lima had an opportunity to exploit small, customized niche
markets outside the United States even as they saw their
domestic orders dwindle. They did not do so, however,
and this failure contributed to their eventual exclusion
from the locomotive industry.

The participation of American locomotive producers
in foreign markets exemplifies the growth of American
multinationals during the twentieth century. After
World War I, when the United States shifted from debtor
to creditor status, American firms increasingly expanded
abroad, particularly in the western hemisphere. By
1929, American business investments in Latin America
were greater than those of British firms. Although the
depression and World War II temporarily slowed the
growth of multinationals, American investments abroad
increased dramatically after 1945. The marked increase
in nationalist sentiment after World War II forced many
American multinationals to alter their corporate
strategies, often by allowing local firms a measure of
control over production and managerial decisions. The
collective experience of the locomotive industry in
Latin America is largely compatible with the general
development of American multinationals, involving as it
does the displacement of British locomotive producers and the granting of concessions to local producers.¹

American diesel locomotive producers enjoyed success in many non-European foreign markets. In addition to Canada and Latin America, Australia and Africa have provided important markets. India purchased large quantities of American locomotives after gaining its independence from Great Britain in 1947, but has since begun production of its own locomotives. Three large markets were all but closed to American locomotive producers. European railroads engaged in massive electrification projects after World War II, thus sharply reducing the need for diesel locomotives. Those that were used were often diesel-hydraulics, not diesel-electrics, and were usually produced by European builders. China's heavy reliance on steam power, which continued into the 1990's, combined with its desire for industrial self-sufficiency, long excluded American locomotives. Nor did the Soviet Union purchase American locomotives.

locomotives. However, after World War II, the Soviets did build a sizable fleet of locomotives that were virtually identical to the ALCo diesels that they received under the auspices of wartime lend-lease programs.

Canada offered the most lucrative foreign market for American locomotive producers. Although Canadian railroads embraced dieselization at a later date than their American counterparts, diesels sold in that country were virtually identical to those produced for sale in the United States. The organizational strengths that gave EMD control over America's locomotive industry allowed it to dominate the Canadian market as well. EMD's dominance was not complete, however, and ALCo ultimately enjoyed more success in Canada than in the United States.

Latin American nations, particularly Argentina, Brazil, and Mexico, have offered a fertile ground for diesel locomotive sales by American firms. Although other Latin American nations, such as Chile, Colombia, and Cuba, bought substantial numbers of railroad locomotives, the first three countries have the most extensive rail networks and hence the largest market for
locomotives. In addition, they are the most heavily industrialized nations in Latin America, giving them the opportunity to begin local production of locomotives. Argentina and Brazil have done so in recent decades, reducing their dependence on imports and stimulating further domestic industrialization.

AMERICAN PRODUCERS INVADE CANADIAN MARKETS

Canadian railroads, like their American counterparts, showed an early interest in diesel locomotives. In 1922, the Canadian Car and Locomotive Foundry Company of Montreal built a 6-cylinder, 150-hp gasoline-hydraulic locomotive. Six years later, the Canadian National Railway built the first diesel-electric road locomotive used in Canada. The Canadian National used this locomotive, which was equipped with Beardmore engines, to reduce Montreal to Vancouver passenger train trips from 90 hours to 67 hours. As was the case in the United States in the late 1920's, diesel locomotive technology in Canada was not sufficiently advanced to permit widespread railroad dieselization. By the end of 1937, only four diesels were in service in Canada. In
1942, largely as the result of increased wartime traffic, several Canadian railroads began to purchase diesel switchers in significant quantities.²

In spite of these early purchases, however, the dieselization of Canadian railways did not become profitable until railroad traffic increased substantially in the late 1940's and early 1950's. Prior to that time, diesels were considered too unreliable for what one engineering report euphemistically described as the "varied climatic conditions" of Canada; and, in any case, Canada lacked adequate petroleum reserves. Unlike American railroads, Canadian lines assigned diesels to freight service before employing them on passenger runs, partly out of fears that diesels lacked sufficient steam-heating capacity for wintertime passenger trains. In 1947, oilfields in northern Alberta began production,

thus reducing the cost differential between diesel fuel and steam locomotive coal. By 1952, more than 610 diesels were in use on Canadian railroads, approximately 10 percent of the locomotives in service in Canada. Significantly, these were purchased to accommodate increased traffic, not to replace existing steam locomotives. ³

ALCo was the first to take advantage of this emerging market by building diesel locomotives in Canada through its subsidiary, the Montreal Locomotive Works (MLW). In 1948, MLW completed the first production-model diesel locomotive built in Canada. At first, MLW merely assembled diesel locomotives, using ALCo engines imported from the United States and electrical equipment supplied by the Peterborough, Ontario plant of the Canadian General Electric Company. The following year ALCo agreed to license the Dominion Engineering Works to produce ALCo engines in Canada for use in MLW locomotives. As a result, MLW/ALCo diesel locomotive production in Canada was even less integrated than was ALCo

production in the United States. In addition, MLW continued to manufacture steam locomotives, a decision that prevented the company from fully reorganizing its facilities for diesel locomotive production. Even worse, in April, 1946, just as the Canadian diesel market was finally emerging, ALCo sold three-fourths of its stock in MLW, in order to pay for its own modernization program at Schenectady.4

MLW was prosperous, however, and continued to make diesel locomotives and related railroad equipment for the Canadian and non-U.S. export markets. When ALCo ended locomotive production in 1969, the company transferred its diesel engine and locomotive designs to MLW. MLW, since renamed Bombardier, continues today as a successful railway equipment supplier, one that has secured many large orders from American railroads and mass-transit systems.

4By 1952, 25 percent of MLW's production was in the form of diesel locomotives, with the remainder being heavy equipment for the petroleum, chemical, and related industries. Commercial and Financial Chronicle 169 (January 20, 1949), 312; Railway Age 133:1 (July 7, 1952), 148-50; MLW-CGE press release, May 10, 1948, AAR; MLW press release, December 21, 1949, AAR; ALCo 1946 & 1952 annual reports.
For ALCo, however, its foray into the Canadian market was a disappointment, and was certainly not enough to save its position in the American locomotive industry. ALCo made the same mistakes in Canada that it did in the United States, failing to integrate production facilities, relying on other companies to produce vital locomotive components, and showing lethargy in terminating steam locomotive production. Not surprisingly, ALCo's inability to make the necessary investments in manufacturing, marketing, and management in the United States was mirrored by a similar inability in Canada -- a failure that produced comparable results in both countries.

Fairbanks-Morse had considerably less success in the Canadian market than ALCo. In 1910, Fairbanks-Morse organized the Canadian Fairbanks-Morse Company, primarily as a producer of tractors. The desire of Fairbanks-Morse executives to penetrate the Canadian locomotive market led to a May, 1950, joint diesel locomotive production agreement between Fairbanks-Morse, Canadian Fairbanks-Morse, and the Canadian Locomotive Company. CanLoCo, a century-old Kingston, Ontario firm, was primarily a producer of steam locomotives, which
lacked the capital necessary to convert to diesel locomotive production and thus needed an ally, such as Fairbanks-Morse, if it were to survive. As part of this ten-year agreement, Fairbanks-Morse purchased 30,000 shares of CanLoCo stock, with options for an additional 90,404 shares. Robert H. Morse, Jr., who was already president of Fairbanks-Morse and executive committee chairman at Canadian Fairbanks-Morse, assumed the additional duties of president and chief executive officer at CanLoCo.⁵

Production of Fairbanks-Morse-designed locomotives at CanLoCo was never extensive. Following a $2 million plant modernization program, CanLoCo produced its first Fairbanks-Morse diesel locomotive in 1951. The Canadian Westinghouse Company supplied electrical equipment for these locomotives, replicating the arrangement established by Fairbanks-Morse in the United States.

officials claimed that the Kingston plant could produce as many as sixteen locomotives per day -- a statement that is difficult to accept, given the fact that even LaGrange never produced more than seven locomotives per day. In addition, although CanLoCo officials promised to end the manufacture of steam locomotives immediately, their company continued to build these behemoths until 1955. Initially, CanLoCo imported Fairbanks-Morse engines that had been built at Beloit, but the company began to produce its own diesel engines in Canada in 1952. Four years later, CanLoCo added to its locomotive production capabilities by purchasing the locomotive division of the Davenport-Besler Corporation, a producer of small industrial locomotives at its plant in Davenport, Iowa. CanLoCo transferred much of this production to Kingston. CanLoCo produced fewer than a hundred of the 1,304 locomotives that were built to Fairbanks-Morse designs between 1944 and 1958. Although Fairbanks-Morse left the locomotive industry in 1958, CanLoCo continued sporadic locomotive production until 1963.  

Like Fairbanks-Morse, CanLoCo never really had a chance in the diesel locomotive industry. Because it employed Fairbanks-Morse designs, the Canadian firm suffered from the same manufacturing difficulties and product defects that cursed its American parent. In addition, CanLoCo was too small to exploit economies of scale in the locomotive industry. These problems alone were enough to exclude CanLoCo from continued participation in the diesel locomotive industry, regardless of its capabilities in marketing and management. Like their counterparts at Fairbanks-Morse, CanLoCo stockholders suffered unnecessary financial hardship because their executives failed to realize that neither company could ever become a viable producer of diesel locomotives.

Not surprisingly, EMD enjoyed more success in the Canadian market. In 1949, EMD announced plans to build a 226,000 square foot plant in London, Ontario, that would employ 1,000 people and have a capacity of one locomotive per day. This was part of a larger GM

Mail Press, 1985), 303.
expansion program in Canada that also included an increase in Canadian automobile production and the construction of a 500,000 square foot plant for Frigidaire Products of Canada. Initially, the EMD facility in Canada, known as GM Diesel, Limited, fabricated locomotive bodies, underframes, trucks, and ancillary electrical equipment. Diesel engines, generators, and traction motors were built at La Grange. When EMD finished its London plant in June, 1950, the facility already had a one-year backlog. By January, 1952, GM Diesel had built more than 200 locomotives in Canada. In 1952, GM Diesel expanded the London facility a second time, thus giving it the capability to rebuild diesel locomotives.  

Because of its investments in manufacturing in Canada, EMD and GM Diesel captured a large portion of the $500 million steam locomotive replacement market in Canada. By the end of 1973, diesels in service on North American railroads included 1,933 built by GM Diesel in Canada, along with 23,307 built by EMD in the United

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States, 1,288 built by MLW, and a mere 48 built by Can­LoCo. During 1973 GM Diesel sold 135 locomotives, com­pared to 1,011 for EMD and 49 for MLW.®

The other locomotive firms declined to produce locomotives in Canada. Lima was not large enough to risk a venture into the Canadian market, which, given their failures in the United States, was probably just as well. Baldwin did form the Baldwin Locomotive Works of Canada, but this wholly owned subsidiary only marketed diesel engines (not locomotives) and other products. The company subcontracted actual production to the United Steel Company of Toronto. General Electric sold a substantial number of locomotives in Canada, but it produced these units at its Erie plant rather than in Canada.

Given EMD's success in the American locomotive industry, it is hardly surprising that it captured a large portion of the Canadian locomotive market as well. GM Diesel succeeded because it employed the manufactur­ing, marketing, and managerial experience of EMD and GM.

®Business Week, August 19, 1950, 98; Railway Locomotives and Cars, April/May, 1974, 16.
MLW and CanLoCo had no similar reservoir of experience and talent to draw upon. Interestingly, however, MLW has been a far more effective competitor of EMD in Canada than ALCo has been in the United States. ALCo might well have benefited from an influx of managerial talent from MLW, an event that did not occur. Canada, it appears, was too much like the United States to offer ALCo, Baldwin, Lima, or Fairbanks-Morse much of a refuge against the overwhelming might of EMD.  

LATIN AMERICAN MARKETS BECKON

The diverse railroad networks of Latin America offered a wide variety of potential markets for American locomotive producers. ALCo and Baldwin participated in the growing involvement of American business in Latin America markets after World War I by largely displacing their British rivals, who were the traditional suppliers of steam locomotives to Latin America. While profitable, these steam locomotive export sales were never as important as domestic sales. ALCo and Baldwin failed

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9 *Railway Age* 118:19 (May 12, 1945), 848.
to develop the organizational capabilities necessary to ensure continued dominance in Latin America.

Because of EMD's dominance in the emerging diesel locomotive market, ALCo in particular showed increased interest in the largely untouched Latin American market for diesel locomotives. ALCo's earlier organizational failings cost it dearly, however. As a result of superior investments in manufacturing facilities and marketing networks, both EMD and GE supplanted ALCo in Latin America. Although all three companies exported diesels to Latin America, EMD also sold production rights to independent local companies, while GE produced diesels at its own facilities in Brazil.

METHODS OF SELLING LOCOMOTIVES IN LATIN AMERICA

Although they welcomed orders from foreign countries, ALCo, Baldwin, and Lima were primarily concerned with the domestic American market for steam locomotives prior to World War II. Lima, in particular, produced few locomotives for export after the 1920's. None of the three builders had effective techniques for soliciting foreign orders. The companies relied
extensively on the Departments of Commerce and State for information on foreign markets, particularly those in Latin America. Once aware of opportunities, they depended on commercial agents in the foreign countries to bid on the actual locomotive contract. This system was time-consuming and inefficient, but it was well-suited to the small export market that existed prior to World War II. As the market later expanded, however, and as the number of producers increased, the reliance of ALCo, Baldwin, and Lima on these outdated techniques allowed GM and GE to replace them in the international locomotive market.

One federal government agency, the Bureau of Foreign and Domestic Commerce (BFDC), was particularly useful to the American steam locomotive builders. The Bureau was created in 1912 as a consolidation of the Bureau of Statistics and the Bureau of Manufactures, both of which were divisions of what was then known as the Department of Commerce and Labor. One of the functions of the BFDC was to assist domestic manufacturers in penetrating foreign markets, particularly those in Latin America. By 1915, the Bureau had established offices in Washington, Boston, Atlanta, New Orleans,
Chicago, St. Louis, San Francisco, and Seattle to collect and disseminate statistical information and lists of trade opportunities. After 1914 the BFDC employed commercial attaches to seek out sales opportunities in Latin America for American manufacturing firms. 

Recognizing the enormous significance of Latin American markets for industrial firms in the United States, the Bureau created a Latin American Division in 1915 to promote American commerce in Central and South America. Three other divisions were later created to serve Western Europe, Eastern Europe, and East Asia. These divisions, based in Washington, processed reports from BFDC commercial attaches and trade commissioners, Commerce Department commercial and special agents, and State Department consular officials, economic consuls, and foreign trade advisers. 

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11 E. S. Gregg to Charles M. Muchnic, Apr. 4, 1924, The Bureau of Foreign and Domestic Commerce records in the National Archives, Washington (Record Group 151, hereafter referred to as the BFDC records), box 2361; Schmeckebier, The Bureau of Foreign and Domestic Commerce, 32, 41, 51, 86; Ernst B. Filsinger, Exporting to Latin America: A Handbook for Merchants, Manufacturers, and Exporters (New York: D. Appleton and
Many of these functionaries were housed in 29 BFDC foreign offices and 325 State Department consulates throughout the world. In Latin America, the BFDC employed commercial attaches in Buenos Aires, Rio de Janeiro, Mexico City, Lima, and Havana, along with trade commissioners in Bogotá and Santiago. State Department consulates were present in two cities in Argentina, ten cities in Brazil, twenty-three cities in Mexico, and in most other Latin American countries as well. Not surprisingly, this bureaucratic tangle of overlapping jurisdictions created a great deal of friction between the State Department and the Commerce Department. These interdepartmental conflicts limited the effectiveness of the Bureau and prevented many American firms from competing effectively against their British rivals in Latin American markets.¹²

During its most active period, in the 1920's and 1930's, the Bureau advised American locomotive builders whenever foreign railroads called for bids on new locomotives. This information was widely disseminated -- in newspapers, for example, to which any European locomotive builder had access. One representative of ALCo in Brazil even sarcastically questioned whether the BFDC represented American companies or their potential foreign competitors. The American firms also requested data on the output of their European competitors, information that the Bureau was unable to provide. The Bureau was, in fact, unable to come up with any data on the number of locomotives built outside the United States.

In the 1930's, as diesel locomotives gained increasing acceptance on American railroads, the Bureau began to collect data on producers of diesel locomotives for export and on the operating efficiency and operating 

American Division in Washington employed eleven people, and its two largest offices, those in Rio de Janeiro and Havana, employed seven people apiece. (Schmeckebeir, 101-104).
costs of diesels in use on Brazilian railroads. The BFDC then notified diesel locomotive producers of export opportunities. In addition, the Bureau arranged for Latin American railroad executives to tour American locomotive plants, hoping to persuade them to purchase the locomotives that they saw being produced.\textsuperscript{13}

Finally, the BFDC assisted American locomotive producers in the selection of commercial agents abroad. Since the established steam locomotive builders produced few additional products, they could not afford to maintain a large network of sales agents abroad. They were forced to rely on independent commercial agents, who represented a number of clients and did not owe their loyalty to any of them. The training and credentials for being such an agent were rather vague. One promising agent was "...an engineer who has a large number of friends in government circles. While not possessed with

\textsuperscript{13}Charles K. Rockwell to Eugene S. Gregg, November 6, 1923; Gregg to Rockwell, November 9, 1923; W. E. Embry to Gregg, February 26, 1924; A. Lane Cricher to BFDC New York Office, June 14, 1927; Thomas L. Foster to Long, May 25, 1939; Long, Enquiry on Diesel Locomotive Efficiency and Operating Costs, sent to various manufacturers, November 4, 1939; Thomas E. Lyons to the American Commercial Attache, Rio de Janeiro, January 11, 1940; all in BFDC records, boxes 2361-2363.
a large amount of capital, he nevertheless is known to be a man of character and integrity."\textsuperscript{14}

For many reasons, not the least of which was its inherent inefficiency, the Bureau of Foreign and Domestic Commerce failed to promote effectively the interests of American locomotive builders abroad, either during the boom period of the 1920's or the economic crisis of the 1930's. The larger, more diversified diesel locomotive producers, such as GM, ignored the "help" offered by the Bureau.\textsuperscript{15} Instead, they established their own networks of loyal company agents, a process that assisted them in capturing market share from both the older American steam locomotive producers and from their European counterparts. The reliance of the steam locomotive producers on the BFDC and independent commercial agents crippled their marketing efforts abroad at a time when the dieselization of Latin America was gaining momentum.

\textsuperscript{14}A. Lane Cricher, "Special Circular #92 - Transportation Division - Agencies for Locomotives and Railroad Materials," Bureau of Foreign and Domestic Commerce, N. D.; W. E. Embry to Eugene S. Gregg, May 1, 1924 (quote); both in BFDC records, box 2361.

\textsuperscript{15}A. Lane Cricher to The Trade Secretary of the Chamber of Commerce, Cleveland, Ohio, April 14, 1932; BFDC records, box 2361.
American railroads was offering unprecedented opportunities for locomotive sales.\(^6\)

The Great Depression slowed locomotive sales in the United States and Latin America. Demand for both steam and diesel locomotives soared during World War II, but the U. S. War Production Board demanded that the locomotive builders produce only for domestic or strategic purposes. Exports to Latin America were approved only if they assisted in the extraction of oil or mineral ores or in the rebuilding of railroads for military use. The war, as had the depression that preceded it, helped to remove British and German producers from the Latin

\(^6\)William H. Becker, in *The Dynamics of Business-Government Relations: Industry and Exports, 1893-1921* (Chicago: The University of Chicago Press, 1982), shows that large, integrated American manufacturing firms had little need for federal government assistance in their penetration of foreign markets. Typically, only small and mid-sized firms in declining industries sought help from the State Department and the Department of Commerce and Labor during the early twentieth century. The locomotive industry after the 1920’s essentially conforms to this pattern, since only the declining producers (ALCo, Baldwin, and Lima) actively sought government assistance in the solicitation of foreign orders.
American locomotive market and created an immediate demand for new locomotives at war's end.\textsuperscript{17}

American locomotive producers quickly moved to exploit the vacuum in the Latin American locomotive market after World War II. Since the demand for steam locomotives in the United States had virtually evaporated, ALCo, Baldwin, and Lima devoted much of their steam locomotive production to export. ALCo and Baldwin, in particular, anticipated a strong market for steam locomotives, spurred on by modernization programs in many Latin American countries.

Insufficient capital investment and a shortage of domestically produced fuel oil in countries such as Brazil delayed the dieselization of Latin American railroads and thus provided a temporary market for steam locomotives. Nevertheless, as the overwhelming superiority of diesels became evident, countries with large

\textsuperscript{17}Staff Report - Freight Cars for Latin American Republics, Requirements Committee, War Production Board, August 19, 1942; Memorandum - Building Diesel Locomotives for Stock, March 3, 1943; "Need for Twelve Diesel Electric Switching Locomotives by American Railroad Company of Puerto Rico," April 23, 1943, all in the records of the War Production Board in the National Archives, Washington (Record Group 179), box 2160.
rail networks (such as Argentina, Brazil, Mexico, Chile, and Cuba), began to purchase diesel locomotives in increasing numbers. By 1951, approximately two-thirds of all locomotive exports were diesels.\textsuperscript{18}

ALCo recognized the importance of the export market, especially in Latin America. The company designed a diesel locomotive specifically for the export market, the first models of which were delivered to the Matadi-Leopoldville railroad in the Belgian Congo in 1951. Many of the components of this 1,400-hp locomotive were identical to those used on American locomotives, thus allowing ALCo to take advantage of economies of scale in production. The company also sent one of

\textsuperscript{18}In 1945, for example, Baldwin produced 16 steam locomotives for Mexico (the first new locomotives in that country since 1935), and had orders for 47 steam locomotives for five railroads in Brazil, 14 for three railroads in Colombia, 3 for Ecuador, 6 for Guatemala, and 2 for Bolivia. In addition, it sent two diesels to Mexico for use on a trial basis. In the same year, ALCo had a production backlog of 558 steam locomotives for export, which included 85 for Brazil, 22 for Mexico, 10 for Cuba, 3 for Jamaica, and 1 for Honduras. Nevertheless, this increase in foreign demand was insufficient to offset the collapse of the domestic steam locomotive market. Frank L. Hirt to M. Joseph Meehan, February 15, 1952, BFDC records, box 2363; Railway Age, 119:9 (September 1, 1945), 388; 119:11 (September 15, 1945), 459; 119:24 (December 15, 1945), 1004.
its employees on a seven-month, 22,000-mile tour of Mexico, Cuba and four countries in South America to instruct more than 500 railroad employees in the operation and maintenance of their newly acquired diesel locomotives. Five years later, ALCo introduced its "Universal Locomotive," which it offered in a range of six models from 400 hp to 1,800 hp. Its design was based on an analysis of worldwide railroad operating conditions, track gauges, and clearance restrictions. As was the case with the earlier models, the design of the Universal Locomotive was largely standardized, although it could be adapted to accommodate more extreme operating conditions. These successes could not compensate for ALCo's poor management and outdated production facilities back in the United States, however.

General Electric introduced a new line of locomotives in 1960, seven years after it had terminated its joint production agreement with ALCo. The company offered four models of "universal diesel-electrics" in a range of sizes between 700 hp and 1,980 hp. In addition to securing a profitable business in export orders, these GE locomotives served as a testbed for that
company's entrance into America's large diesel market in 1960.  

EMD had such an immense backlog of domestic orders that it was largely absent from the export market until the mid-1950s. EMD was slower to introduce a line of locomotives designed specifically for export, preferring instead to make slight modifications to the existing designs that it produced for its American and Canadian customers. For example, EMD did not introduce its Model B export locomotive until mid-1953, and did not offer a complete export locomotive line until 1958. 

EMD compensated for its delay in exploiting foreign markets by offering a superior marketing, training, and post-sale support system. For example, in October, 1944, the Mexican National Railways, Nacionales de Mexico (NdeM), asked EMD to study methods of reducing congestion and water shortages on one of its more

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20 EMD press releases, June 21, 1953, December 15, 1958, both in General Motors Institute Alumni Foundation's Collection of Industrial History (hereafter referred to as GMI), folder 83-12.99.
mountainous routes. Not surprisingly, EMD concluded that the best solution would be for NdeM to purchase fourteen diesel locomotives. In return for this relatively small order, EMD agreed to send ten "operation instructors" to Mexico to train engineers and firemen and to establish maintenance facilities. EMD also translated its operating and service manuals into Spanish and taught its standard two-week training course in Spanish to ten NdeM employees. In addition, it selected and trained a Mexican national as its new district service engineer in Mexico. The training process took fifteen months, "...or until [he was] qualified to give the National Railways every assistance customarily furnished to any railroad in the states, without encountering any difficulties that arise in language, habits, and general way of life between the two countries."  

By 1953, EMD was offering a 90-day export training class and was also cooperating with the "Point Four" training program conducted by the Office of

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21 *Railway Age* 121:6 (August 10, 1946), 226-7 (quote).
International Labor Affairs of the U. S. Department of Labor. This dedication to customer service was one of the principal factors that allowed EMD to gain a large share of the locomotive market, both at home and abroad.22

During the 1950's, as foreign railroads replaced many of their remaining steam locomotives, EMD's sales increased dramatically. Between 1955 and 1966, for example, foreign locomotives sales through its GM Overseas Operations Division increased 60 percent. The general manager of EMD acknowledged that EMD produced two export diesels per day, and claimed that export markets offered a greater potential for sales than did domestic markets. Between 1954 and 1960, EMD built more than 700 Model G locomotives for export and, by 1960, offered seven diesel-electric and two diesel-hydraulic models specifically designed for the export market, ranging from 270 hp to 1800 hp. Many of these locomotives were destined for export to Latin American countries.

22 Business Week, May 31, 1947, 81-81; Railway Age, 134:9 (March 2, 1953), 12.
EMD also began locomotive production outside North America when it signed production licensing agreements with companies in Australia, Belgium, Germany, South Africa, Spain, and Sweden. Companies in Argentina and Brazil later signed similar agreements with EMD. While ALCo produced more locomotives for export than any of its American competitors, EMD's use of licensees ensured that its overall production for foreign markets was much greater than that of ALCo.23

The development of production facilities by EMD and General Electric might best be discussed within the

23 In 1954, GM transferred all control over the manufacture, sale, and service of diesel locomotives in areas outside North America from EMD to GM's Overseas Operations Division. EMD regained control over foreign marketing activities on January 1, 1975. Thus, all GM-EMD diesels produced and marketed in Latin America between 1954 and 1974 should technically be considered GM locomotives, not EMD locomotives. EMD's associate builders included the Clyde Engineering Company (Australia), La Brugioise et Nivelles (Belgium), Henschel-Werke (Germany), the Union Carriage and Wagon Company (South Africa), Material y Construcciones (Spain), and Nydqvist and Holm (Sweden). By the end of 1963, EMD's La Grange plant and its foreign associates had produced 2,813 diesels for service outside the United States and Canada. Railway Age, 142:2 (January 14, 1957), 134; 156:2 (January 20, 1964), 56-8; 176:19 (October 13, 1975), 36-7; World Railways 1960, A57, 264; GM Executive Bulletin #2, 1954, GMI, folder 83-12.101; GM-EMD, "General Motors Locomotives," ca. 1960, GMI, folder B3/17.
context of the evolution of locomotive markets and the locomotive industry in three Latin American countries -- Argentina, Brazil, and Mexico. These countries possessed the largest rail networks in Latin America, offered substantial markets for locomotives, and had the greatest potential for the sustained industrial development that would support domestic production of these locomotives.

While these countries had the largest rail networks, at least a few miles of railroad track have been constructed in every nation on the Latin American mainland, as well as on many Caribbean islands. Aside from the three countries listed above, Chile, Cuba, and Colombia have large railroad systems and have traditionally been important markets for American locomotive producers. This was especially true in Cuba because of the close connection between American sugar producers and railroad development. Of course, this market disappeared after Fidel Castro came to power in 1959.

Although Argentina possessed the best-developed railroad network in Latin America, that country's traditional reliance on British suppliers, combined with its ability to produce its own locomotives, ensured that
Brazil received the majority of the locomotives produced in the United States for export to Latin America. During the 1940’s, of the 1,225 locomotives destined for Latin America, 35 percent went to Brazil, 29 percent to Argentina, 14 percent to Mexico, and the remaining 23 percent to other countries in the region. Between 1950 and 1959, 37 percent of American locomotive exports were sent to Brazil, 21 percent to Mexico, and 13 percent to Argentina. Brazil accepted 42 percent of all American locomotive exports to Latin America between 1960 and 1965, with Mexico receiving 24 percent and Argentina, 15 percent.24

While ALCo and Baldwin produced the vast majority of American locomotives exported to Latin America during the 1930’s, GE challenged the dominance of these two companies during the 1940’s. Between 1930 and 1939, Baldwin exported 71 locomotives to Latin American

24The figures in this paragraph and the two that follow were compiled from lists of locomotive orders published annually in Railway Age. This market share information refers only to locomotives manufactured in the United States for export to Latin America. Since some units were produced jointly (such as in collaboration between ALCo and GE) the total number of units shown may exceed actual production, and market shares for some years exceed 100 percent.
countries (all but four of these were steam locomotives), giving that company a 45 percent market share. ALCo's export of 54 locomotives (only one of which was a diesel) gave it a 34 percent market share. GE and Electro-Motive together had less than 9 percent of the Latin American export market. During the 1940's, GE's share of the Latin American export market increased to 33 percent, based on sales of 301 diesel and 64 electric locomotives. Baldwin's share declined to 25 percent (270 steam and 10 diesel locomotives), while ALCo's share fell to 21 percent (195 steam, 40 diesel, and 4 electric locomotives). EMD, still overwhelmed with domestic orders, produced only 38 diesel locomotives between 1940 and 1949 for export to Latin America, giving the division little more than a 3 percent market share.

The participation of GE and EMD in Latin American export sales increased steadily during the next two decades, while that of ALCo and Baldwin declined dramatically. Between 1950 and 1959 GE had a 43 percent market share (748 diesel locomotives), followed by EMD with 32 percent (563 diesels), then ALCo with 15 percent (272 diesels), and finally Baldwin, with less than
9 percent of the Latin American export market (9 steam and 145 diesel locomotives). Between 1960 and 1965, EMD’s market share increased to 51 percent (661 diesels), while that of GE decreased to 33 percent (421 diesels), and ALCo’s share remained steady at 15 percent (187 diesels).

AMERICAN LOCOMOTIVE PRODUCERS DISPLACE THE BRITISH IN ARGENTINA

Argentina has long enjoyed the most extensive coordinated railroad network in Latin America, thus offering a tempting market for locomotive producers. Prior to World War II, extensive British ownership of Argentine railways ensured that American locomotive manufacturers were largely prevented from selling locomotives in Argentina. After World War II, however, political changes in Argentina allowed American firms to displace their British rivals from the Argentine locomotive market.

Argentina’s reliance on export agriculture led to an early interest in railway development, thus producing a substantial market for locomotives. Although Argentina was an early entrant into railway
construction, opening its first railroad in 1857, by 1880 the country had only 1,388 miles of track. Construction proceeded rapidly after this date, however. Landowners, anxious to transport their agricultural products to the port of Buenos Aires, granted generous concessions to foreign investors, most of whom were British, to build and equip new railroads. By 1900, 10,292 miles of railroad were in operation.

In an effort to stimulate further construction, the Argentine government passed the Mitre Law on September 30, 1907. This law established a system of railway regulations and provided new types of incentives for future construction. As the government had hoped, this law caused a boom in railroad construction. Between 1907 and 1914, more than 1,100 miles were added to the Argentine railroad network each year. The pace of construction slowed after 1914, however, as a result of World War I, labor disputes, lower traffic levels, and higher operating costs.  

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In 1908, the Argentine government began the construction and operation of its own lines. By 1923, the Ferrocarriles del Estado (Argentine Government Railways) owned 4,053 miles of railroad. During the Great Depression, as service on the foreign-owned lines deteriorated, the government attempted to purchase some of these railroads. President Augustín Justo announced a plan for the gradual nationalization of the foreign railways to Congress on December 23, 1936. Little came of this plan, however, aside from the purchase of the Central Córdoba Railway in 1938, at which time the government controlled a fifth of the nation's railroad mileage.

During World War II, service on the foreign-owned lines deteriorated still further, Argentina acquired immense blocked sterling credits as a result of agricultural exports to Great Britain, and the staunch nationalist Juan D. Perón came to power. Perón, who controlled Argentina from 1945 to 1955, used the blocked sterling credits to purchase the British-owned railroads in Argentina, "Political Science Quarterly 52 (December, 1937): 565-6."
in February, 1947. To this day, the government owns and operates nearly all of the railroad mileage in Argentina.²⁶

Argentina was the first Latin American nation to use diesel locomotives. As early as 1924, when diesel locomotive technology was still primitive, the Port of Buenos Aires Railway expressed an interest in diesel locomotives, although there is no indication that these units were ever built. In 1934, the British-owned Buenos Ayres Railway ordered two diesel railcars from the British firm of Armstrong, Whitworth, and Company. These were probably the first diesels used anywhere in Latin America. In the same year, the Argentine State Railways ordered several diesel railcars from Ganz and

Company of Budapest for luxury tourist service to resort hotels in the vicinity of Bariloche National Park. The railroad ordered additional diesel railcars for several Buenos Aires commuter lines in 1938. By 1940, the Argentine State Railways had 74 Ganz railcars in service.27

In spite of this early adoption of diesel technology, Argentina continued to purchase steam locomotives until well after World War II. This market, much to the chagrin of the American steam locomotive producers, was dominated by the British. England produced 85 percent of the locomotives that were imported into Argentina in 1912, and this dominance continued for many decades.

27 The British journal Engineering described the Ganz railcars as "the first important step towards the introduction of Diesel traction on a large scale." During the late 1930's, the Buenos Aires Pacific Railway, in collaboration with Ganz, built three oil-hydraulic and three oil-mechanical railcars. These were probably the first diesel locomotives of any type to be constructed in Latin America. John E. Dixon to J. F. Keeley, October 17, 1924; H. Bentley MacKenzie to BFDC Director, Washington, December 2, 1926; Norman F. Titus to the BFDC Philadelphia District Office, December 30, 1926, all in BFDC records, box 2361; Engineering 142 (October 9, 1936), 400-1; 146 (December 16, 1938), 702-3 (quote); 147 (May 19, 1939), 601-2; 149 (February 2, 1940), 111-2; The Engineer 165 (February 18, 1938), 198-201.
thereafter. The British also sold approximately 62 percent of the railroad equipment and supplies that were imported into Argentina. Belgium and Germany each controlled about 11 percent of this market, with much of the remainder going to French and American firms. The American market share declined slightly during the 1930's, while that of Germany increased. This was largely the result of Nazi Germany's refusal to remit foreign exchange in cash, a policy which greatly annoyed the American producers.28

British domination of the steam locomotive market was assured by the enormous capital investment of British firms in Argentine railways, not by lower prices, better financing or higher product quality. In 1935, the British owned approximately 65 percent of the

28Statistics on railway equipment and supplies include freight and passenger cars, rail, signaling systems, bridge members, and miscellaneous supplies, in addition to locomotives. Accurate statistics on Argentine locomotive imports are difficult to obtain, since customs records indicate imports by weight, rather than number of units. D. C. M. Platt, Latin America and British Trade, 1806-1914 (London: Adam and Charles Black, 1972), 240-2; Foreign Commerce Weekly, December 7, 1940, 433; March 8, 1941, 413-4; Thomas E. Lyons to BFDC Santiago Office, December 19, 1934, BFDC records, box 2361.
railroad mileage in Argentina and were responsible for building or operating much of the rest. The same individuals often controlled Argentine railroads and British equipment producers. Also, the familiarity of Argentine railway employees with British equipment, combined with the location of railway purchasing offices in London, rather than Buenos Aires, guaranteed a large market for British firms. In addition, Great Britain enjoyed "favored nation" trade status, since their imports from Argentina exceeded their exports to Argentina. This gave Britain a 20 percent premium, based on the difference between the official and free market exchange rates. American firms lacked this advantage.29

The Argentine State Railways, which was the largest rail system in the country that was not owned by the British, purchased its locomotives through public bids, usually without favoring a particular country. They were generally more interested in liberal credit terms than in price or product quality. This enabled American producers to capture a small share of the Argentine

29Foreign Commerce Weekly, December 7, 1940, 433-4; Business Week, October 15, 1938, 44-5.
The reliance of British producers on the sheltered Argentine market ultimately caused their downfall, however. British domination of the country’s rail network, among other industries, fueled the fires of nationalism in Argentina. When Perón, partly in response to this sentiment, nationalized the British railways in 1947, he adequately compensated their British owners. However, this action shattered Britain’s virtual monopoly on the locomotive trade. In 1948, Perón initiated a much-needed modernization program on the newly nationalized railways. Argentina purchased some of the required rail and rolling stock from British firms, but all of its new locomotives came from the United States. Because of their inability to provide adequate credit terms, British producers were shut out of the emerging market for diesel locomotives.  

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30 Foreign Commerce Weekly, December 7, 1940, 434.
31 Winthrop R. Wright, British-Owned Railways in Argentina, 255-69. Several Argentine railways extensively rebuilt steam locomotives between 1883 and 1940, but they were unable to construct any complete locomotives using locally produced parts. The Review of the River Plate, June 28, 1946, 27-8.
After World War II, the newly-nationalized Argentine railways began purchasing increasing numbers of diesels from American firms, particularly General Electric. One such order, in 1948, was for 65 locomotives, at a total cost of $18 million. The National Railways ordered 30 more locomotives two years later, for an additional $7.5 million. GE customized the design of these locomotives, based on a six-month study of Argentine railway operating conditions. During the next two decades, Argentina continued to import locomotives built by GE and EMD, but did not produce any large diesel locomotives domestically.32

The flow of American-built locomotives into Argentina slowed in 1971, when the Argentine State Railways signed a $100 million agreement with the General Motors Interamerica Corporation to allow a consortium of manufacturers to produce diesel locomotives in Argentina. EMD produced the first 80 locomotives of the 250-locomotive order at its La Grange facility. It

supplied the diesel engines for the remaining 170 locomotives, along with designs and technical expertise. The Argentine firm ASTARSA (Astilleros Argentinos Rio de la Plata) built the underframe and body and assembled and tested the locomotives at its factory in Buenos Aires. Aceria Bragado fabricated the trucks, Siam di Tella provided the traction motors, and Siemens Argentina supplied the electrical equipment. For the first time in its history, GM guaranteed the parts that were manufactured by these local suppliers.

By the early 1980's, an additional firm, AFNE (Astilleros y Fabricas Navales del Estado), began production of small diesel-hydraulic locomotives. Five additional Argentine firms produced rolling stock, but not locomotives, at this time. These included José Callegari y Hijos, FAVYS SAIC (Fábrica Argentina de Vagones y Silos), and Vázquez Iglesias in Buenos Aires, Bautista Buriasco y Hijos in Santa Fé, and Industrias Metalurgicas in Rosario.\(^{33}\)

Argentina provided a significant market for American locomotive producers after nationalization in 1948. Of the six large American locomotive producers, only GM and GE had the resources to adapt their locomotives to Argentine railway operating conditions and to provide effective marketing and post-sales support for their products. With its shortage of high-quality coal, Argentina had little postwar interest in steam locomotives and thus offered the American steam locomotive builders little assistance in their frantic efforts to replace domestic steam locomotive orders with foreign ones.

The large Argentine market encouraged GM to pursue its own low-cost expansion strategy of licensing foreign manufacturing affiliates. Local production of GM diesel locomotives under licensing agreements helped to increase GM's share in the Argentine market and contributed to employment, manufacturing development, and technical capabilities in Argentina.
GE ENABLES BRAZIL TO PRODUCE DIESEL LOCOMOTIVES

Brazil's railroad network has always been poorly developed and largely uncoordinated. Most rail lines served the heavily populated coastal strip, and they were often constructed to different track gauges. Brazil thus offered a more diversified market for railroad locomotives than Argentina. ALCo and Baldwin were unable to exploit this diversity to their advantage, however, and GM and GE supplanted these firms in the Brazilian locomotive market. GE, in particular, expanded its existing production facilities in Brazil to accommodate the manufacture of electric and diesel locomotives.

Unlike Argentina, Brazil did not develop an integrated railroad network until the 1950's and even today has the least adequate rail network of the three nations discussed here. In April, 1854, Irineu Evangelista de Sousa completed the first railroad in Brazil, an accomplishment that contributed to his later selection as the Baron of Mauá. Construction proceeded sporadically during the rest of the century, however, since after 1850 most of the available capital was
invested in the coffee industry. Primitive technology and a shortage of labor also created difficulties.

As in Argentina, the federal government attempted to overcome these problems by offering increasingly generous financial concessions, such as those expressed in the Railroad Law of 1855. Individual states also offered incentives, primarily in the form of interest guarantees. This resulted in the construction in a number of unnecessary, unprofitable, poorly located, and poorly constructed railroads. The political power of the wealthy coffee-growing elite ensured that wealthy states, such as São Paulo, were able to develop the most extensive railroad networks. Most of the rail lines were designed with the sole purpose of efficiently transporting agricultural and mineral products from the interior to the Atlantic seaboard. These lines were built by different companies to different standards, and were rarely interconnected. At least four different track gauges were used, a situation that caused enormous difficulties when connecting lines were finally built. A wide variety of railroad ownership added further complications. After 1889, some railroads were federally owned and operated, others were federally owned, but
leased to private companies, others were owned by a state or municipality and either operated by them or leased to a private company.34

International connections with Bolivia and Paraguay were not established until the 1930's, and it was 1950 before northern and southern Brazil were linked by rail. By 1950, Brazil had approximately 23,000 miles of railroads, but maintained an integrated rail network only in the region surrounding the cities of Rio de Janeiro and São Paulo. In recent years, Brazil's generally inefficient railroads have lost a large portion of their business to highway traffic.

British capital never dominated the Brazilian railway network to the same extent as in Argentina. In 1940, British firms controlled only 24 percent of Brazil's railway mileage. This absence of corporate ties to the Brazilian railroad industry prevented British locomotive producers from attaining the near-monopoly that they had enjoyed in Argentina prior to

1948. Between 1910 and 1937, Great Britain supplied only 15 percent of the locomotives and railway equipment imported into Brazil, while the United States captured 38 percent of that market. A slightly smaller share (25 percent) came from Belgium and Luxembourg, and 13 percent was produced by German firms. Between 1930 and 1941, 29 percent of United States railway equipment exports to Latin America went to Brazil. This situation improved further after World War II, when railroads purchased American equipment under the terms of the 1951 National Plan for the Economic Rehabilitation of Brazil.35

Several Brazilian railways embraced the concept of electrification in the early twentieth century, and this interest would later have important implications for GE. Like Argentina, Brazil lacked high-quality domestic coal reserves. An equally acute shortage of oil caused the

pace of dieselization to lag behind that of Argentina, however. Instead, Brazil, beginning in the 1920's, exploited its tremendous potential for generating hydroelectric power and electrified sections of its rail network. The first such line was the Cía. Paulista de Estrada de Ferro, which purchased thirty electric locomotives from General Electric, Westinghouse, and a British company, Metropolitan Vickers. GE was an early leader in this process, and was able to translate its dominance of the heavy electrical equipment and consumer electrical industry into extensive control of the Brazilian diesel locomotive market as well.36

General Electric had been interested in Brazilian markets since the late nineteenth century. A GE predecessor company sold lightbulbs in Brazil as early

36Brazil obtained most of its locomotive coal from Wales. Wood was becoming increasingly scarce, even in the 1940's. Gregory H. Eickhoff to BFDC Director, Washington, May 27, 1929; G. Blockidge to the Association of American Railroads, November 10, 1939, both in BFDC records, box 2361; Railway Age 123:21 (November 22, 1947), 909-11; General Electric Review 56 (September, 1953), 56-60.
as 1881, and another predecessor, the Thomson-Houston International Electric Company, equipped the first street railway in South America to be powered from overhead wires, in Rio de Janeiro in 1892. Rising foreign demand for electrical products encouraged GE to increase its participation in the Brazilian market, and it established the Companhia General Electric do Brasil in 1914. This wholly owned subsidiary was primarily a sales agency for imported GE products.

GE's timing was superb, since World War I caused a decline in the participation of British and German electrical firms. This reduction in competition encouraged the company to begin production of incandescent light bulbs at a factory in Rio de Janeiro in 1921. These bulbs used largely imported parts -- some GE executives joked that the only locally produced component was the vacuum -- but additional products and more advanced production techniques were soon introduced. In 1929, GE began local production of watt-hour meters, followed by transformers in 1930, radio receivers in 1936, fluorescent lamps in 1942, domestic refrigerators in 1951, and televisions in 1954. In 1960, GE began construction of a new factory in Campinas, São Paulo, for the
 manufacture of heavy electrical equipment, including electric and diesel locomotives. 37

Building on the managerial skills of its American parent, General Electric do Brasil implemented a sophisticated corporate organization. The company was largely autonomous, though certain major decisions, such as plant and product expansion, capital flows, and large investments, were controlled by the International General Electric Company, which was itself a wholly owned subsidiary of GE. After a 1958 reorganization, GE do Brasil became increasingly decentralized along product lines, thus allowing for greater local initiative and control. The company was divided into three segments: the Lamp and Illumination Department, the Consumer Goods Department, and the Producer Goods Department. Diesel and electric locomotives were manufactured by the latter department. The production of these locomotives was a natural adjunct to the other manufacturing activities of GE in Brazil. By exploiting substantial economies of scope in manufacturing and organization, GE was well

equipped to exploit the long-anticipated post-war boom in Brazilian locomotive orders.\textsuperscript{38}

Baldwin, Lima, and ALCo (after it canceled its joint-production agreement with GE in 1953) were unable to match the organizational commitment and financial strength of GE in Brazil, and General Motors was the only serious challenger to that company. Although GM established automobile assembly facilities in Brazil in the 1920's, it made no attempt to expand into related product lines. GM's integrated manufacturing facility at São José dos Campos, São Paulo, completed in 1959, produced only automobiles. GM continued to rely on economies of scale by exporting locomotives from its La Grange facility.\textsuperscript{39}

\textsuperscript{38}In addition to GE, large producers of heavy electrical equipment in Brazil include Allmanna Svenska Elektriska (ASEA), based in Sweden, Brown Boveri, based in Switzerland, COEMSA, based in Italy, and Siemens, based in Germany. \textit{Foreign Commerce Weekly}, August 26, 1944, 28-9; \textit{American Machinist} 101:14 (July 15, 1957), 176; U. S. Department of Commerce, Brazil: Survey of U. S. Export Opportunities, 112; Geiger, \textit{The General Electric Company in Brazil}, 54-5.

\textsuperscript{39}General Motors do Brasil maintained two plants in São Paulo. General Motors Argentina operated two facilities in Buenos Aires, while General Motors de Mexico has the same number of plants in Mexico City. None of these facilities are used to produce locomotives, however. General Motors Corporation, 1967 annual report, 45; John P. Dickenson, \textit{Studies in Industrial
EMD's pattern of exporting locomotives to Brazil changed when GM signed a production licensing agreement, similar to the one enacted in Argentina, with Equipamentos Villares. That company also obtained production rights to electric locomotives designed by GEC, a British firm. By the early 1980's, Engenharia e Máquinas in Rio de Janeiro was also producing electric locomotives under license from the French firm MTE, and diesels under license from the Montreal Locomotive Works, a descendant of ALCo.

Brazil also supports a flourishing railway equipment industry that produces sophisticated subway cars and light rail vehicles in addition to freight and passenger cars. The oldest of these, the Compania Sorocabana de Material Ferroviário (SOMA) was founded in São Paulo in 1929. Other firms in the industry include Companhia Brasileira de Material Ferroviario (COBRASMA), Fábrica Nacional de Vagões (FNV), Material Ferroviario (MAFERSA), Pidner, and Cia. Industrial Santa Matilde. As early as the 1950's, Brazil was exporting railway

Geography: Brazil (Folkestone: William Dawson and Sons, 1978), 172.
equipment to other Latin American countries, often in exchange for agricultural or mineral products. In more recent years, however, this industry has experienced increasing competition from Japanese and Eastern European firms.\textsuperscript{40}

\textbf{AMERICAN PRODUCERS CONSISTENTLY DOMINATE LOCOMOTIVE MARKETS IN MEXICO}

The Mexican market for both steam and diesel locomotives was largely the exclusive domain of American producers. According to the Bureau of Foreign and Domestic Commerce, high product quality, rapid delivery, a large American capital investment in Mexico, extensive railroad and steamship connections, and the presence of a common border all contributed to the dominance of American producers in Mexican markets.

Although Mexico has an extensive, integrated railroad network, the country's proximity to the United

\textsuperscript{40}World Railways 1960, 276; Jane's World Railways 1984–85, 50, 64, 75, 85–6, 122–3, 148, 155–6, 171, 192; Dickenson, Studies in Industrial Geography: Brazil, 131; American Machinist 101:14 (July 15, 1957), 176; U. S. Department of Commerce, Brazil: Survey of U. S. Export Opportunities, 28.
States has discouraged local production of diesel locomotives. In 1940, ALCo produced the first diesel locomotives used for regular operation in Mexico. During the Great Depression and World War II, Mexican railroads bought few locomotives, either steam or diesel, however. After the war, a pent-up demand, combined with a railroad modernization plan enacted during the presidency of Miguel Aleman, guaranteed a large market for diesel locomotives. By 1952, 156 diesels were in use, constituting nearly a quarter the available horsepower on the Nacionales de Mexico. Virtually all of the locomotives used in Mexico were imported from the United States, and none were manufactured locally. Perhaps because of its reliance on imported American equipment, Mexico has never had a large railway equipment industry. Little manufacturing of any type existed prior to 1930; and, by 1940, Mexico could produce only a few minor components of railroad cars. Even today, Mexico contains only one rolling stock producer, Constructora Nacional de Carros de Ferrocarril in Mexico City.\textsuperscript{41}

\textsuperscript{41}\textit{U. S. Bureau of Foreign and Domestic Commerce, Mexican Market for Industrial Machinery (Trade Information Bulletin #666), (Washington: US Government Printing Office, 1929), 4-5, 8; Railway Age 108:3 (January 20, 1940), 169-70; 133:9 (September 1, 1952), 77-82; General...}
THE IMPACT OF DIESELIZATION ON LATIN AMERICA

In 1930, by using commission agents to market their steam locomotives, and by working in tandem with the Bureau of Foreign and Domestic Commerce, ALCo and Baldwin penetrated Latin American markets. Their market share varied from virtually nil in British-dominated Argentina to nearly 100 percent in Mexico. Individual Latin American countries lacked the technical and industrial capacity to produce their own locomotives.

Fifty years later, steam locomotives had virtually disappeared from Latin America. After futile attempts to produce commercially successful export diesel locomotives, ALCo and Baldwin were driven from foreign markets by the financial resources and the managerial, technical

and marketing skills of General Motors and General Electric. By exploiting economies of scale, GM saturated the Latin American market with the locomotives produced at La Grange. By adopting economies of scope, GE expanded the product line of its Brazilian subsidiary to include electric and diesel locomotives, thus enabling it to take advantage of an established marketing network in Latin America. In both Brazil and Argentina, local manufacturers were able to go beyond the construction of unsophisticated rolling stock and produce diesel locomotives under license from GM. In addition to assuring GM of a large income from royalties, this process has increased the managerial, technical, and marketing skills of local firms.

In Latin American history, the events of these fifty years in the locomotive industry do not loom large when compared with years of depression, global war and political upheaval. Nevertheless, this topic is illustrative of larger issues, both in Latin American history and in American business history.

First, the technological changes produced by dieselization crippled the established steam locomotive producers in Latin America, just as they had in the
United States. The inability of ALCo, Baldwin, and Lima to establish a marketing network as sophisticated as that used by GM and GE partly caused their international decline. The three steam locomotive producers, with their long tradition of craftsmanship and customized batch production, had an opportunity to capture a niche market by building customized locomotives for the wide variety of gauges, clearances, and operating conditions that existed in Latin America. Their failure to do so indicates the relative failure of their production, marketing, and managerial systems, when compared with those of General Motors and General Electric.

Second, the inability of the Bureau of Foreign and Domestic Commerce and the State Department to promote effectively the interests of ALCo, Baldwin, and Lima in Latin America illustrates the ineffectiveness of the United States government in ensuring the economic penetration of American producers in foreign markets. In short, the United States government was an ineffective and unreliable ally of American business abroad.

Third, this topic illustrates the declining significance of European producers in Latin American markets. For Argentina, in particular, the involvement
of European nations in global war after 1939, combined with the nationalization of the railroads during the Perón era, allowed the United States to replace Britain as the leading supplier of locomotives.

Fourth, the development of the diesel locomotive industry in Latin America to a certain extent parallels that of the automobile industry. General Motors was, of course, involved in both industries, though there was little coordination between the two. As in the automobile industry, locomotive construction progressed from the assembly of imported components in the 1950's, to the construction of complete locomotives by American firms in the 1960's, to the local manufacture of locomotives based on imported designs and technology in the 1970's and 1980's. Unlike the automobile industry, however, no attempt has been made to re-export locomotives or locomotive parts back to the United States.²

Finally, the locomotive industry has stimulated the growth of technical knowledge and manufacturing skill in Argentina and Brazil. An accurate analysis of the magnitude of the benefits produced by the initiation of locomotive production in Argentina and Brazil goes beyond the scope of this study. Nevertheless, it is apparent that the ability of these two nations to produce such expensive and complicated pieces of equipment should increase their capabilities in the fields of internal combustion, electricity, and metal fabrication. Equally important, Argentine and Brazilian nationals should be able to add to their managerial skills by participating in the locomotive industry.

Railways have traditionally been a symbol of national achievement and pride, both in the United States and in Latin America. In spite of increasing competition from highways and airlines, railroads are still crucial to the economic development of Latin America and the United States. The increasing control of Latin American nations over their railroad systems, first through the nationalization of the railroads, then through the control of the production of locomotives and rolling stock, bodes well for the continuation of integrated economic development in Latin America. At the same time, collaboration between locomotive producers in the United States and those in Latin America seems likely to increase.
CONCLUSION

With ALCo's departure from the locomotive market in 1969, the American diesel locomotive industry emerged in its modern form as a duopoly. During the four decades preceding this development, three established, well-respected producers of steam locomotives had tried, and failed, to build and market diesel locomotives. In their place, General Motors and General Electric attained dominance in the diesel locomotive industry. This complete turnover of firms in an industry in so short a time is an unusual -- perhaps unique -- event in American business history. In the next few pages I will offer my own explanations for this transformation, assess the relevance of these answers to past and present developments in business and society, and offer suggestions for further research into related topics. First, however, it will be useful to summarize briefly the evolution of the locomotive industry.
Although Rudolph Diesel and others did much to develop the diesel engine in the 1890's, they did not immediately apply this new technology to railway locomotion. The diesel engine's enormous weight and coarse mechanical tolerances generally limited its application to marine propulsion. In the early 1900's, advocates of internal combustion-powered railway equipment had more success with gasoline engines. The McKeen Company and General Electric in particular made notable advances in the use of gasoline engines to power railcars. However, it was Harold Hamilton, as president of the Electro-Motive Company, who did the most to ensure the success of internal-combustion railcars in the 1920's. Hamilton used his experience at White Motor Company to create an advanced sales and service network at EMC. These marketing efforts, more than the actual railcars themselves, allowed EMC to dominate the railcar market in the interwar period. In addition, Hamilton's marketing expertise, when combined with GM's financial resources, gave EMC a tremendous first-mover advantage in the diesel locomotive industry during the 1930's.
The traditional steam locomotive builders initially had little interest in applying gasoline or diesel engines to railroad equipment and left that field to firms such as Electro-Motive. ALCo, Baldwin, and Lima chose not to enter the railcar market. Baldwin constructed two experimental diesel locomotives during the 1920's, but showed no inclination to proceed with a more extensive research and development program. Samuel Vauclain and other Baldwin executives thought that the development of a practical diesel locomotive would require an unacceptably large financial investment. ALCo demonstrated a greater willingness to become involved in diesel locomotive production, but only as a supplier of locomotive carbodies. Other companies, such as Ingersoll-Rand and GE, produced the complicated and expensive diesel engines and electrical equipment. ALCo had no involvement in the marketing of these consortium-built locomotives. At the same time, both ALCo and Baldwin rewarded their stockholders with lavish dividends. This fiscal extravagance during the 1920's caused both companies great hardships during the Great Depression, and prevented them from making the investments necessary for efficient diesel locomotive production.
While the onset of the Great Depression nearly destroyed EMC, the decade of the 1930's also witnessed that company's ascent to the pinnacle of the locomotive industry. As part of a larger strategy of corporate diversification into automotive diesel production, GM purchased the Winton Engine Company in 1930. Although GM had no intention of entering the diesel locomotive industry, GM also purchased Winton's principal customer -- EMC -- later the same year. Setbacks in automotive diesel research, combined with the possibility of lucrative contracts from the U. S. Navy, encouraged Charles Francis Kettering and other GM engineers to develop a large diesel engine for submarine use. Once Ralph Budd, president of the Burlington, saw this engine in use at the 1933 Chicago World's Fair, he demanded that it be used to power the new Zephyr streamlined passenger train -- a use for which it had never been intended. The engine performed well, however, causing other railroad executives to join Hamilton in his efforts to build more diesel locomotives. This surge in demand, which occurred in the middle of the depression, convinced GM officials to fund an expansion program at EMD. The highlight of this program was the construction of a
dedicated locomotive plant at La Grange, Illinois, in 1936. Two years later, this facility had become the world's first integrated plant for the manufacture of diesel locomotives. At the same time, EMC developed new standardized locomotive designs and enhanced the marketing capabilities it had developed during the 1920's. As a result of these investments in manufacturing, marketing, and management, EMC created a first-mover advantage during the 1930's. By 1940, it was probably too late for any of the established steam locomotive builders to catch up.

World War II slowed the pace of dieselization but had little long-term impact on the competitive structure of the diesel locomotive industry. War Production Board restrictions temporarily suppressed the ability of railroads to purchase diesels, and thus gave a final respite to the steam locomotive producers. These wartime restrictions also enabled ALCo and Baldwin to increase their share of the diesel locomotive market at EMD's expense. At the same time, however, EMD and GE accommodated the increased demands on their manufacturing facilities by making their production more efficient, an advance that the steam locomotive producers failed to
match. In addition, as GM recognized the increased importance of the large diesel engine market, it placed professional managers in charge of EMD. As the war neared its end, Fairbanks-Morse converted its increased wartime production capacity to the manufacture of diesel locomotives, thus becoming the fourth producer to enter the industry.

Of all the competitors in the locomotive industry, only EMD and ALCo were in a position to exploit effectively the postwar dieselization boom. EMD continued to expand its capabilities in manufacturing, marketing, and management, an expansion that ALCo was unable to match. New locomotive designs, such as the GP-7, proved very popular with American railroads. Economies of scope enabled EMD to weather temporary declines in locomotive orders with relative ease. ALCo, in contrast, was plagued with labor disputes and continued managerial incompetence. ALCo's postwar modernization program was both too small and too late to be effective. Finally, ALCo's diesel locomotives were technologically inferior to those produced by EMD. ALCo's decision to replace the Model 244 engine with the Model 251 engine during the dieselization boom demonstrated this inferiority to
the railroads. By the late 1950's ALCo remained in the locomotive industry, but, as the high-cost producer, that company was in a very precarious position.

The postwar dieselization boom also witnessed the entrance of Lima into the diesel locomotive field, as well as the failure of Lima, Baldwin, and Fairbanks-Morse. Lima lacked the financial resources to compete successfully in the large diesel locomotive industry, although it might have survived in the industrial diesel or export diesel locomotive market. Lima's 1950 merger with Baldwin could not save either company. Baldwin offered a poor-quality product line and, despite infusions of managerial talent from Westinghouse, was adrift in a sea of managerial incompetence. Fairbanks-Morse likewise never had any hope of success in the diesel locomotive industry. Like Lima, Fairbanks-Morse lacked the necessary financial resources and, in any case, entered the market too late to overcome the first-mover advantages established by EMD. Lima, Baldwin, and Fairbanks-Morse all remained in the diesel locomotive industry long after it became obvious that they could not compete against EMD and ALCo. Their production of diesel locomotives was a waste of corporate resources.
The elimination of Baldwin-Lima-Hamilton and Fairbanks-Morse from the locomotive industry allowed ALCo to survive in the diesel locomotive industry, but could not protect that company from the growing organizational strengths of General Electric. During the 1950's, GE recognized that chronic manufacturing difficulties at ALCo offered an opportunity for GE to oust its production partner from the locomotive market. GE refined the manufacturing, marketing, and managerial skills that it had developed in the small diesel locomotive and large export diesel locomotive markets. Because it offered a superior product, GE rapidly drove ALCo from the diesel locomotive market in the 1960's. EMD had erected formidable barriers to entry, and it was thus in no immediate danger from GE's locomotive sales.

Foreign markets offered the steam locomotive producers the best chance for survival in the locomotive industry; yet ALCo, Baldwin, and Lima failed to exploit this market niche effectively. Canada provided little respite for ALCo and Fairbanks-Morse, especially since both companies committed many of the same fundamental errors that eventually ended their locomotive production in the United States. Latin American railroads, with
their variety of track gauges and operating conditions, offered greater opportunities for producers attempting to exploit niche markets. ALCo and Baldwin, in particular, might well have turned their success in steam locomotive sales into a profitable Latin American diesel locomotive market. However, ALCo and Baldwin failed to develop an adequate marketing network in Latin America. As a result, GM and GE were once again able to attain dominance in this portion of the diesel locomotive industry. In the process, GM and GE contributed to the economic development of Latin America by implementing local manufacture of diesel locomotives.

THE SIGNIFICANCE OF THE LOCOMOTIVE INDUSTRY

It would be overly simplistic to assume that any complex historical development could be caused by a single factor, and the evolution of the American locomotive industry is no exception to this pattern. A variety of factors caused, and were influenced by, the complicated and often imprecise interactions between hundreds of executives, thousands of workers, dozens of companies (if customers in the railroad industry are
included), and the federal government. Nevertheless, it is possible to identify the broad factors that contributed to changing competitive patterns in the locomotive industry. This explanation also has a larger historical -- and current -- relevance to the issues of corporate response to technological change, the decline of established producers and industries, and national and international competitiveness.

While both exogenous and endogenous factors contributed to the decline of ALCo, Baldwin, and Lima and the ascension of EMD and GE, factors external to the locomotive industry were of lesser importance. The federal government played only a minor role in establishing the competitive patterns of the locomotive industry. All six locomotive producers participated in decisions made by the federal government, whether through official or unofficial channels. In the 1930's, the interest of the U. S. Navy in the Model 201 engine convinced GM to proceed with the development of large diesel engines, a decision that ultimately led to a new corporate interest in EMC and the locomotive industry. By 1940, however, EMD had established a substantial first-mover advantage in the locomotive industry, and the federal government
could do little to alter that fact. War Production Board restrictions during World War II temporarily eroded EMD's market share, but its competitors failed to exploit this opportunity. ALCo was never prevented from developing new diesel engine and locomotive designs during the war, but the designs that it developed were inadequate. The war revealed Baldwin's incompetence in the field of diesel locomotives, which many railroads did not soon forget. Fairbanks-Morse entered the industry as a direct result of wartime expansion, but its participation occurred too late for the company to be an effective competitor. In the postwar period, the federal government's relentless attack on GM's bigness culminated in two antitrust prosecutions of EMD during the 1960's. These legal actions, which could potentially have been of great benefit to ALCo, were instead little more than a temporary impediment to EMD.

Those seeking an explanation of the evolution of the diesel locomotive industry will find few answers in government policy or other external factors. Instead, the actions of individual companies determined whether their lot would be success or failure. In particular, corporate culture played a crucial role in determining
success or failure in the locomotive industry. Restrictive corporate cultures prevented executives at ALCo, Baldwin, and Lima from developing new organizational techniques to cope with technological change. Executives at EMD and GE worked in far different corporate cultures, and were thus able to realize the importance of investments in production and marketing.

ALCo and Baldwin both failed to establish adequate manufacturing facilities and to produce acceptable products. Both companies relied on outdated plants that had originally been designed for the radically different requirements of steam locomotive production. Money that had been spent on lavish dividends during the 1920's was unavailable for diesel locomotive research and development programs during the 1930's. ALCo's postwar modernization program was a classic case of too little, too late, for it produced a factory that was inferior to La Grange at a time when EMD was virtually invincible. Baldwin made even less of an effort to modernize its plant at Eddystone. In addition, the diesels that emerged from Schenectady and Eddystone were inferior to those produced by EMD. ALCo and Baldwin relied too much on outdated production techniques such as casting.
Improvements in their locomotives came after similar advances had already been made by EMD.

Even more seriously, executives at ALCo and Baldwin failed to appreciate adequately the crucial impact of marketing on diesel locomotive sales. Prior to the 1940's, railroads had assumed a large portion of the responsibility for steam locomotive orders and post-sale support services. As a result, ALCo and Baldwin had never developed extensive marketing capabilities. Their executives were slow to realize the importance of marketing in the diesel locomotive industry. ALCo and Baldwin failed to develop effective advertising campaigns. They waited too long to establish locomotive schools. Their parts distribution and service network was inadequate, and was based largely on the facilities and organizational capabilities of GE and Westinghouse. As was the case in manufacturing, the steam-based corporate cultures at ALCo and Baldwin blinded executives to the vastly different requirements of a new technological system.

Electro-Motive was blessed with a far different corporate culture; and, most importantly, that organization was able to alter its corporate culture to match
changing competitive patterns. During the 1920's and 1930's, EMC benefited from the managerial expertise of Harold Hamilton and his associates. Individuals such as Hamilton, Richard Dilworth, and Charles and Eugene Kettering created a culture based on experimentation and innovation. In particular, Hamilton astutely realized that the diesel locomotive industry had much more in common with automobile production than it did with the steam locomotive industry. Experience at the White Automobile Company taught Hamilton the importance of effective marketing strategies, financial incentives, and post-sales support services. He took advantage of GE's declining interest in railcar production to recruit the best technicians in the field. These individuals formed the nucleus of EMC during the 1920's and 1930's. Hamilton and Kettering persuaded GM's senior management to bankroll EMC and led the company to the top of the locomotive industry by 1940. This managerial structure and the corporate culture that pervaded it were not static. When GM realized the enormous profit potential of EMD, that company replaced Hamilton and other technician-managers with loyal and experienced GM career executives. As a result, GM ensured that EMD would
continue to grow in an orderly, predictable manner.

By 1940, Electro-Motive's success in the design and manufacture of diesel locomotives was readily apparent to industry observers and railroad executives. By constructing the first integrated diesel locomotive manufacturing facility, and by equipping that facility with modern machinery, EMD soon became the lowest-cost producer in the industry, acquiring a substantial first-mover advantage in the process. During the late 1930's EMC pioneered the development of standardized locomotive models by refusing to accept railroad demands for custom designs. In so doing, Electro-Motive shifted the locomotive industry from the small-scale, custom-batch production so familiar to ALCo and Baldwin toward mass production. True mass production was, of course, never achieved in the locomotive industry, since orders were generally small and since locomotives were too large to be produced on an assembly line basis. Nevertheless, the fact that diesel locomotive production was more akin to mass production than was steam locomotive manufacturing indicates that many gradations of production strategies exist in the spectrum that encompasses custom production at one extreme and mass production on the
other. Because many, perhaps most, industrial corporations are found in the broad gray area between these two extremes, scholars should at least hesitate before declaring that they have discovered a "typical" or bellwether company or industry. In any case, EMD, and its GM-appointed managers, benefited from the similarities between flexible mass production in the auto industry -- a form of production that GM had done much to advance -- and flexible small-scale semi-mass production in the locomotive industry.

Although Electro-Motive enjoyed a viable corporate culture, superb management, and excellent manufacturing facilities, it was its marketing capabilities that gave it the crucial edge in the diesel locomotive industry and allowed it to attain market dominance by 1940. As early as the 1920's, Harold Hamilton and other EMC officials realized that engineer training, creative financing plans, performance guarantees, and efficient service networks could give their company an overwhelming advantage over their competition. Many of these innovations were based on Hamilton's experience in the auto industry, experience that complemented the views of GM executives. As EMD expanded, it continued to offer
sophisticated advertising campaigns, trade-in allowances, and expanded parts and service networks. In addition, EMD's managers understood that these marketing services, besides boosting locomotive sales, could themselves be profitable. By the late 1950's, spare parts production and locomotive rebuilding, originally designed as support services, smoothed out production cycles at La Grange and added to EMD's profitability.

Significantly, the size and financial might of General Motors contributed only slightly to Electro-Motive's success. By the late 1920's, EMC's marketing and managerial expertise had enabled that company to become the dominant producer in the railcar industry, with market shares of greater than 80 percent. This was, of course, before GM purchased EMC in 1930. Even after 1930, GM expressed little interest in its tiny subsidiary or in the locomotive industry in general. Only after EMC had proved the worth of its Model 201 engine, which had been designed for submarine use, in railroad applications did GM begin to invest heavily in EMC. The $15-plus million that GM spent on diesel locomotive research and development during the 1930's could easily have been matched by ALCo and Baldwin, had
they not spent several times that amount on dividends during the 1920’s. Finally, GM’s decision to change EMC to divisional status and supply it with new GM managerial talent was based more on the potential of military diesel engine sales than those of diesel locomotives.

Just as Electro-Motive’s success was the result of an appropriate and adaptable corporate culture, the failure of the established and successful steam locomotive producers was largely the product of a corporate culture that had outlived its usefulness. Senior executives, such as Samuel Vauclain at Baldwin and William C. Dickerman at ALCo were experts in the manufacturing and marketing of steam locomotives. This success was a double-edged sword, however, for it blinded them to the reality that the era of the steam locomotive was rapidly ending — that the technological changes produced by railroad dieselization demanded sweeping changes in the managerial, production, and marketing capabilities of their companies. Executives at ALCo, Baldwin, and Lima waited too long to begin making these changes, and even then changed too little. Finally, long after it was apparent that they had done too little, too late to
compete against EMD, ALCo, Baldwin and Lima continued to manufacture diesel locomotives, often at a loss. As a result, senior executives at these companies, after destroying any opportunity to compete successfully in the diesel locomotive industry, nearly destroyed their companies as well.

This study should provide a point of reference for those seeking to explore important related topics in the development of American business and society. My discussion of the impact of corporate culture on managerial decisions has focused mainly on the training, beliefs, and values of senior executives. Other scholars have profitably examined the impact of corporate culture on the complex interrelationships between managers and workers.¹ This type of analysis would certainly offer an appropriate topic for an additional study of the locomotive industry, since dieselization often had devastating effects on skilled craft workers at the steam locomotive producers, as well as in railroad

¹For example, see David M. Vrooman, Daniel Willard and Progressive Management on the Baltimore & Ohio Railroad (Columbus: The Ohio State University Press, 1991).
shops. An international perspective would also be helpful, one that would perhaps compare the managerial, production, and marketing efforts of American locomotive producers with those of their counterparts in Europe.

More broadly, further research on the role of corporate culture in American and foreign business enterprises would offer a useful perspective, and perhaps a cautionary note, applicable to the current interest in corporate culture in American business. While comparisons between business practices in the United States and Japan -- long a favorite of corporate culture advocates -- are certainly useful, they can obscure more than they reveal. The United States and Japan are vastly different countries, and their differences stem from the centuries of social, economic, and political evolution that comprise their respective histories. Just as people have an effect on history, past events have an impact on the present. Studies of the impact of corporate culture on American business, undertaken from a historical perspective, may thus have as much relevance as similar studies based on a comparative or global perspective. If nothing else, the historical example of the locomotive industry indicates that a
well-developed, successful, and respected corporate culture can lead a company to great economic success -- but that same corporate culture can lead the same company to disaster.

The recent financial difficulties of many large and traditionally prosperous American firms, including General Motors, should at the very least call into question the notion of overall managerial adaptability and infallibility. The locomotive industry provides a disturbing picture of managers adrift in a sea of incompetence, self-importance, and organizational ossification. The corporate culture that made ALCo and Baldwin great steam locomotive producers proved disastrous in the diesel locomotive industry. The organizational skills that made managers like Samuel Vauclain titans of steam locomotive manufacture made them failures in diesel locomotive production. The lesson of the locomotive industry is that technology often changes more rapidly than the people whose careers depend on it, and that technological change, in order to be exploited effectively, must be accompanied by more than plant modernization, by more than research and development, by more than government action; it must be accompanied by
fundamental changes in the hearts and minds of those who claim to control it.
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