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Bottles for Beer: The Business of Technological Innovation in Mexico, 1890–1920

Successful technological change in countries outside the northern Atlantic during the nineteenth and early twentieth centuries depended on entrepreneurial skills, not inventive expertise. In this examination of the Owens automatic glass-bottle-blowing machine in Mexico between 1905 and 1912, innovation is seen to have occurred within a broad context of incipient social and economic modernization. Although the obstacles encountered by technology importers and innovators were both substantial and stubbornly persistent, in this case, they turned out to be malleable.

Despite exploding demand for glass bottles over the last decades of the nineteenth century, in 1900 all were still blown by hand. Highly skilled glassblowers produced hundreds of bottles daily, to hold milk, fruits, vegetables, patent medicines, and of course the emerging intoxicant-of-choice for the burgeoning working class: beer. Glassblowing techniques remained little changed from previous centuries, yet demand for bottles had risen rapidly over the preceding decades. Rising tension between demand and supply was felt acutely by brewers and other bottle users in the United States, Europe, and beyond. Since the 1870s, inventors on both sides of the northern Atlantic had worked to mechanize part or all of the delicate bottle-blowing process, but with only limited success. Not until 1903 was a fully automated glass-bottle-blowing machine developed that would prove commercially viable, and

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Michael Owens's system quickly became the foundation for the modern glass-bottle industry. From the perspective of U.S. business history, this story of technological innovation is typically seen as one centered on inventive activity (the creative genius and determination of one man), supported by adept entrepreneurship (the management of that invention by Edward Libbey and his partners at the Toledo Glass Company). But seen from abroad, from countries in Europe, Latin America, and elsewhere, the story of glass-bottle innovation becomes one centered on entrepreneurship. There, technological innovation meant overcoming multiple obstacles in order to acquire, import, and commercialize the new machines.

In countries like late nineteenth-century Mexico, potential investors anticipated that adopting the most modern machines and processes from abroad would be a relatively frictionless process. After all, new technologies of all sorts were being rapidly developed, manufactured, and marketed in the North Atlantic countries; entrepreneurs in places like Mexico had ready access to information about these developments; machine manufacturers abroad were interested in overseas marketing and sales; and local governments were typically favorable to supporting the introduction of new technologies through tariffs, tax exemptions, patent protection, and sometimes with direct support. Moreover, the rapid growth of international trade and investment between 1870 and 1914 encouraged expanding markets and facilitated the movement of capital, information, and know-how.[1]

In this article, I examine the relation between entrepreneurship and the innovation of imported technologies during Mexico's incipient industrialization, roughly from 1890 to 1910. Entrepreneurship constitutes the essential agency in capitalist development. Entrepreneurship, in Joseph Schumpeter's deceptively simply phrasing, consists of "getting things done," especially when "new things" involve new technologies,

[1] For continental Europe, see, among others, David S. Landes, *The Unbound Prometheus: Technological Change and Industrial Development in Western Europe from 1750 to the Present* (Cambridge, U.K., 1969); and Kristine Bruland, ed., *Technology Transfer and Scandinavian Industrialization* (New York, 1991), for example. Beyond Europe, see David J. Jeremy, *International Technology Transfer: Europe, Japan and the USA, 1700–1914* (Aldershot, 1991); Joel Mokyr, *Lever of Riches: Technological Creativity and Economic Progress* (New York, 1990); Jan Todd, *Colonial Technology: Science and the Transfer of Innovation to Australia* (Cambridge, U.K., 1995); and Ryoshin Minami et al., eds., *Acquiring, Adapting and Developing Technologies: Lessons from the Japanese Experience* (New York, 1995). On technology transfer, see Edwin Mansfield, "International Technology Transfer: Forms, Resource Requirements, and Policies," *American Economic Review* 65, no. 2 (1975); Vernon Ruttan and Yujiro Hayami, "Technology Transfer and Agricultural Development," *Technology and Culture* 14, no. 2 (1973); Sanjaya Lall, *The Economics of Technology Transfer* (London, 2002); Martin Fransman and Kenneth King, *Technological Capability in the Third World* (London, 1984); and Minami et al., "Concluding Reflections: Lessons from the Japanese Experience," in *Acquiring*, ed. Minami et al.

products, or markets, or new combinations thereof.[2] Entrepreneurial attributes are essential for activity "outside of routine tasks," activity that identifies and pursues new business opportunities in the face of risk, uncertainty, and resistance.[3] This, of course, was exactly the situation in Latin America through the late nineteenth century. Resistance was typically not overt. Instead, innovation was constrained by undeveloped markets for final products and for production factors, such as raw materials, intermediate inputs, labor, and information itself. Transportation could be slow and costly, and capital was scarce. As a result, innovation proved substantially more problematic than most contemporary observers anticipated. The challenge of innovation in societies without substantial factor and product markets demanded a particularly acute level of entrepreneurship.[4]

Yet much of the literature on the sociocultural environment for Latin America's historical development has long argued that the region's dominant attitudes and values were anti-entrepreneurial: Latin American cultures tended to value social status and consumption, denigrated work, discouraged the pursuit of mechanical or engineering professions, depended on political patronage, and resisted innovation in general. Scholars' frequent assertions that Latin American business elites simply lacked entrepreneurial virtues form one basis for their explanations of colonial dependence, nineteenth-century stagnation, and twentieth-century underdevelopment.[5] Economic and social histories of the past decade or so have gone far to dispel this notion. Nevertheless, few recent studies have examined entrepreneurship in the nineteenth-century Latin American context, and many continue to argue that foreigners (and later the state) provided a critical substitute for weak domestic entrepreneurship during the era of late nineteenth-century growth.[6]

[2] Joseph Schumpeter, *Capitalism, Socialism, and Democracy* (New York, 1962), 132; also Jonathan Brown and Mary B. Rose, eds., *Entrepreneurship, Networks, and Modern Business* (Manchester, 1993); and Frederic Scherer and Mark Perlman, eds., *Entrepreneurship, Technological Innovation, and Economic Growth* (Ann Arbor, 1992), 1.

[3] Schumpeter, *Capitalism*, 132. For discussions of entrepreneurship in the Latin American or in a late-developing context, see Nathaniel H. Leff, "Entrepreneurship and Economic Development: The Problem Revisited," *Journal of Economic Literature* 17 (Mar. 1979), 47; Carlos Dávila and Rory Miller, *Business History in Latin America: The Experience of Seven Countries* (Liverpool, 1999), 12.

[4] Leff, "Entrepreneurship," 46.

[5] This was the dominant view in early works within the "dependency" approach, such as André Gundar Frank's *Capitalism and Underdevelopment in Latin America* (New York, 1967). See also Dávila and Miller, *Business History*, Introduction.

[6] Twenty years ago, H. V. Nelles introduced a special issue of this journal on Latin American business history by writing that "the broader economic and social implications of . . . business enterprises are now among the most hotly debated subjects in the field." Nelles, "Latin American Business History since 1965," *Business History Review* 59 (Winter 1985): 543. This is certainly not the case today. Even the small but vital field of Latin American economic

The story of glass-bottle manufacturing in Mexico makes two contributions to the literature on entrepreneurship and innovation in Latin America during the closing years of the nineteenth century. First, it supports the conventional view that foreign immigrants frequently played key entrepreneurial roles in the pursuit of innovation and new economic opportunities.[7] But the story of Owens's commercial venture in Mexico refines this view in two ways: First, it demonstrates that the conventional dichotomy between foreign and domestic actors is largely a false one. Most innovative projects involved some type of transnational partnership, especially in the manufacturing sector. Furthermore, what foreigners contributed—and what domestic actors frequently lacked—was not the attitude and aptitude for seeking wealth and for bearing risk and uncertainty. Such attributes were readily present in local societies. Instead, foreign immigrants frequently had access to a more extensive network of contacts, whose sources of information about factor markets and technical expertise enabled them to troubleshoot the multiple obstacles to innovation in an undeveloped context. Obstacles were inevitable, and solutions were beyond the abilities of a single person. Success—if it came—would depend on the ability to negotiate the relation between innovation and undeveloped markets.

Second, this account demonstrates that ready access to off-the-shelf technologies in the North Atlantic did not necessarily provide countries like Mexico with a late-developing advantage. World trade in new technologies exploded after 1870 as machines and processes flowed from the North Atlantic economies to proximate and distant corners of the world. Investors in this process, attracted by the productive potential of new inventions, tended to see the universality of technology. They perceived its characteristics as fixed at the point of origin: invented, developed, patented, and manufactured in Philadelphia, Manchester, Hamburg, or Toledo, Ohio, and readily available through catalogs and

history has largely ignored entrepreneurship. Strikingly, the two now classic articles on the obstacles to investment and growth in nineteenth-century Mexico do not address this issue: John Coatsworth, "Obstacles to Economic Growth in Nineteenth Century Mexico," *American Historical Review* 83 (1978); and Stephen H. Haber, "Assessing the Obstacles to Industrialization," *Journal of Latin American Studies* 24 (1992). Nor do the recent major works on Latin American economic history: Stephen H. Haber, *How Latin America Fell Behind* (Stanford, 1997); John Coatsworth and Alan Taylor, *Latin America and the World Economy since 1800* (Cambridge, Mass., 1999); Victor Bulmer-Thomas, *The Economic History of Latin America since Independence* (Cambridge, U.K., 1994). Notable exceptions include Flavia Derossi, *The Mexican Entrepreneur* (Paris, 1971), and the contributions to Dávila and Miller, *Business History*.

[7] See the many works by Mario Cerutti on the business elites of Monterrey, including his contribution to Dávila and Miller, *Business History*, 125–26; and also Stephen H. Haber, *Industry and Underdevelopment: The Industrialization of Mexico 1890–1940* (Stanford, 1989), ch. 5.

contracts. Yet, as recent scholarship has argued, technologies cannot be separated from the particular social and cultural environment in which they exist.[8] New knowledge—embodied in hardware or not—bears the imprint of its environment of origin, and consequently innovation in new locales implies problems of fit and the challenges of adaptation. As a result, obstacles to the commercial innovation of imported technologies were common and, historically, failures were frequent. The primary challenges were entrepreneurial ones, to be faced by investors in the importing country.

The story of the Owens automatic bottle-blowing machine in Mexico between 1905 and 1912 vividly illustrates these issues.[9] While firms in the United States demonstrated that the commercial innovation of the Owens system was both possible and profitable within a few short years of its development, the Mexican story dragged out over nearly a decade of halting fits and starts. Innovation of the Owens machine in Mexico was not inevitable. Alternate paths presented themselves, and in this case were closed off as one group proved sufficiently entrepreneurial to negotiate successive challenges to commercial success.

Glass-Bottle Innovation in the North Atlantic

Glass bottles housed many things in the nineteenth century, but it was beer that created the most rapidly growing demand for bottles after the 1860s. In Europe and the United States, major mid-nineteenth-century innovations in brewing techniques transformed beer from a cottage, craft-based activity to a large-scale commercial enterprise. Changing consumer tastes, urban growth, the development of mass markets, and the rise of vertically integrated corporations yielded a radically

[8] See Edward Beatty, "Approaches to Technology Transfer in History and the Case of Nineteenth Century Mexico" in *Comparative Technology Transfer and Society* 1, no. 2 (2003): 167–200, for one discussion.

[9] The Owens in Mexico story has been partially told by several historians, including Juan Ignacio Barragán and Mario Cerutti, *Juan F. Brittingham y la industria en México, 1859–1940* (Monterrey, n.d.); Haber, *Industry*, 90; Miguel Ángel Fernández, *El Vidrio en México* (Mexico, 1990), 190–201; Juan Mora-Torres, *The Making of the Mexican Border: The State, Capitalism, and Society in Nuevo León, 1848–1910* (Austin, 2001), ch. 7; Michael Snodgrass, *Deference and Defiance in Monterrey* (Cambridge, U.K., 2003), 16. All state simply that Brittingham and the owners of the Cervecería Cuauhtémoc purchased the Owens rights and parlayed the patent into a national monopoly. My reconstruction of the story is based primarily on papers in the Juan Brittingham Archive at the Universidad Iberoamericana, Campus Laguna, in Torreón (hereafter AHJB), complemented by papers in the Toledo Glass Company in the Libbey Owens-Ford Glass Company Records at the Canaday Center Archives of the University of Toledo (hereafter TGC). All references to materials in the Archivo Histórico Juan Brittingham are from either his copybooks (numbered, for instance, 0017428) or from boxes of received letters (numbered, for instance, 06-0135).

altered industry between the 1860s and the 1890s.[10] Yet the growing divergence between brewers' demand for bottles (as well as rising demand for milk bottles, lamp chimneys, and electric lightbulbs) and the traditional, hand-blown nature of all glass-bottle production created a supply bottleneck and high bottle prices.[11] This constraint inspired competing efforts to mechanize the process in Britain, continental Europe, and the United States.[12]

Automating the blowing process proved extremely difficult, and the big breakthrough did not come until after 1900. Michael J. Owens worked for Edward Libbey in the New England Glass Company and, after 1892, in the reorganized Libbey Glass Company of Toledo, Ohio.[13] Owens's early inventions mechanized the process to raise and lower molds for the skilled glassblowers, and by 1894 he had patented a semiautomated process in which skilled workers began a blowing process that was completed with compressed air. In 1895, Libbey, Owens, and several other Ohio investors organized the Toledo Glass Company to market the patent rights to these new devices and to support further research and development by Owens and his mechanics. By 1898, Owens had taken the first step toward the mechanization of bottle blowing with the development of an experimental hand gun. The basic idea embodied a reversal of the traditional process: instead of blowing molten glass into a hollow mold by hand, a vacuum drew the molten glass from a tank into the mold. Over the next five years, Owens doggedly worked through a series of technical obstacles in several parts of the glass- and bottle-making processes. By 1903, he had developed and patented a fully automated machine that, with one tender, could make eighteen thousand pint bottles daily.[14] This machine represented a revolutionary jump over the prevailing hand methods in the bottle industry. As Edward Libbey reported,

[10] On the beer industry in the United States, see Stanley Wade Baron, *Brewed in America* (Boston, 1962). For Britain, see John Vaizey, *The Brewing Industry, 1886–1951* (London, 1960).

[11] United States Bureau of the Census, *Twelfth Census of Manufacturers*, III, vol. 9 (Washington, D.C., 1900), 975. See also Warren C. Scoville, *Revolution in Glassmaking: Entrepreneurship and Technological Change in the American Industry, 1880–1920* (Cambridge, Mass., 1948), 103.

[12] Scoville, *Revolution*, 178–89, 325–29; Pearce Davis, *The Development of the American Glass Industry* (Cambridge, Mass., 1949), ch. 9; T. K. Derry and Trevor I. Williams, *A Short History of Technology from the Earliest Times to A.D. 1900* (New York, 1993, 1st ed. 1960), 598.

[13] On Owens, see E. William Fairfield, *Fire and Sand: The History of the Libbey-Owens Sheet Glass Company* (Cleveland, 1960), ch. 5–9, and Scoville, *Revolution*, ch. 4. The following paragraphs are largely based on these works, as well as on the record books in the archive of the Toledo Glass Company.

[14] For a summary description of the machine's operation and capacity, see Scoville, *Revolution*, 154–62; Davis, *American Glass*, 208–9; Derry and Williams, *Short History*, 598; Fairfield, *Fire and Sand*, 48.

the glass men who gathered for its first public demonstration in October 1903 were "thunderstruck with the machine."[15]

Quickly on the heels of acquiring the U.S. patent rights to the Owens machine in early 1903 and issuing its first three U.S. licenses in 1904, the Toledo company's lawyers applied for numerous foreign patents, including one in Mexico.[16] Interest in the machine spread rapidly, and the Toledo Glass Company developed a strategy for marketing its patent rights and the machine itself. This strategy was conditioned by two related characteristics of the new machine: scale and cost. The output of the first Owens machine ran to roughly five and one-half million pint bottles per year, and this figure more than doubled through constant improvements by 1910. The price tag for the machine was steep, and only large, well-financed firms could afford one.[17] Consequently, Toledo Glass followed a restrictive marketing strategy, offering use licenses to a limited number of firms. In the United States, they licensed the Owens technology to glass companies for a specific kind of bottle (milk, medicines, beer, among others) in exchange for a payment in cash or stock and a continuing stream of royalty payments on annual production levels.[18] For the European market, Toledo Glass set up the independent Owens European Bottle-Machine Company to market the use rights to the technology. They established a demonstration plant in Manchester, England, and shortly thereafter licensed and installed the machines in Rheinahr, Germany. The right to sublicense the machine was subsequently sold to a syndicate of European manufacturers for twelve million German marks.[19]

By late 1904, then, there existed a fully automated machine that would shortly revolutionize the bottle industry in the United States.[20]

[15] Scoville, *Revolution*, 103–64; also TGC, record book #1, 263.

[16] Libbey and Owens formed the Owens Bottle Machine Company in September 1903, to market rights to U.S. bottle producers only. For the U.S. Owens patents, see TGC, box 2, record book #1, 33, 270–77, 285; record book #2, 1–19; and box 6, folder 10. For the European patent negotiations, see record book #2. The Owens patents in Mexico are #3904 on 10 Mar. 1903 for "Machine and method of shaping glass"; #3271 on 1 Oct. 1903 for "Glass tank or pot"; and #4832 on 31 Aug. 1905 for "Improvements relating to the production of articles of glass and apparatus therefore." See *Gaceta Oficial de la Oficina de Patentes y Marcas*, various months.

[17] The Owens machine cost somewhere just under $10,000 in 1904 and between $35,000 and $40,000 by 1914. Installing the machine also required the acquisition of new furnaces, lehrs, feeders, and other equipment—essentially the construction of an entirely new physical plant, running to several hundred thousand dollars. TGC, box 2, record book #2, 39ff; Scoville, *Revolution*, 103, 165–60.

[18] Davis, *American Glass*, 213; Scoville, *Revolution*, 104–7. Royalties fell between fifteen and fifty-four cents per gross from 1904 to 1909 and declined to around fifteen to twenty-five cents per gross over the next decade. See Scoville, *Revolution*, 107–85. See also Fairfield, *Fire and Sand*, 55.

[19] TGC, box 2, record book #2, 47–58, 124–26, 195–99, 259.

[20] The machine would become an "important competitive factor in bottle production" by 1907, placing increasingly intense pressure on the nonmechanized firms in the industry. Davis, *American Glass*, 214–16.

One firm held the U.S. and foreign patent rights to the key innovations and sought to market these rights to bottle producers or middlemen around the world. The productive capacity of even one Owens machine represented a truly revolutionary leap over previous hand methods. In less than a decade, the Owens machine accounted for over 50 percent of national bottle production and had forced a 40 percent contraction in the wages of skilled glassworkers. At the same time, bottle costs dropped dramatically relative to general price inflation: average bottle costs in 1919 were 44 percent lower than in 1899, and labor costs per unit fell 94 percent by the 1920s.[21] The machine's tremendous scale also meant that the Toledo company would only issue a limited number of licenses for the use of the Owens machine, conferring effective monopolies on a small number of firms, and that the bottle industry would become increasingly consolidated in a smaller number of large firms. Everyone else had to find other ways of surviving: by dramatically cutting the wages of traditional skilled blowers; by adopting cost-saving, partially automated machines; or by focusing on a distinctive niche in the larger bottle market. In the years following 1903, there was little reason to believe that a similar story would not play out in foreign markets where there existed sufficient demand to support Owens-based production.

Glass-Bottle Innovation in Mexico

Mexican entrepreneurs quickly became aware of the productive promise of the Owens machine and sought to introduce it south of the border. They were not simply fascinated with the idea of gaining access to a "modernity" embodied in new technology; they were principally interested in taking advantage of the rapidly growing market for glass bottles in Mexico, itself a product of the preference for a new form of alcohol that was emerging among tens of thousands of Mexicans. To investors' dismay, however, the combination of a rapidly growing market and available technology did not yield a simple process of commercial innovation. In fact, a lengthy series of challenges would obstruct the commercialization of the Owens machine in Mexico for almost a decade. Successful innovation of the Owens glass-bottle-blowing system would ultimately depend on protracted entrepreneurial negotiations between the new technology itself, on the one hand, and aspects of its contextual environment, such as access to raw materials, fuel, transport costs, government policy, business rivalries, consumer markets, and the availability of technical skills, on the other.

[21] Average unit values in the bottle industry lagged nearly 50 percent behind the U.S. wholesale price index between 1909 and 1919. Davis, *American Glass*, tables 19 and 223.

The Mexican Market for Glass Bottles. By the end of the nineteenth century, the fastest-growing source of demand for glass bottles in Mexico, as elsewhere, was the beer industry. As late as 1890, bottled beer was a scarce and expensive drink throughout the country. It was, in the words of one observer, an "aristocratic beverage" drunk by foreign expatriates and relatively few Mexicans, mostly in the northern states.[22] Existing Mexican breweries were small-scale, specialized affairs catering to the tastes and pocket books of a narrow social group, and the vast majority of the country's limited beer consumption was imported from the United States, Germany, and Britain. *Pulque*—the traditional fermented product of the maguey plant—remained the intoxicant of choice for the majority of Mexicans, as it had for centuries.

Yet a mere decade and a half later, Mexico's common alcohol culture had been transformed, especially in urban areas. By 1907, national consumption of bottled beer had exploded to over one hundred million pints annually, and the newly popular beverage was being marketed aggressively and competitively in all of Mexico's largest cities.[23] Changing tastes reflected changing attitudes, and as the editors of one Monterrey newspaper suggested, it was beer, not pulque, that brought men "comfort and happiness, and open[ed] the way to a higher civilization."[24]

Why beer consumption rose so rapidly between 1890 and 1910 remains a puzzle. Although the cost of a pint of beer declined through this period, its price still lay well above the price of a glass of pulque. Despite a steady increase in the (still small) urban middle class and in the number of men and women employed in modern industries (manufacturing, transportation, and public works especially), a bottle of beer represented the better part of a day's wage, and thus was likely unaffordable for most of the working population.[25] It would have been entirely

[22] Fernández, *El Vidrio*, 176; Werner P. Sutton, "Malt and Beer in Spanish America," in U.S. Department of State, Bureau of Statistics, Special Consular Report No. 1 (Washington, D.C., 1890), 331; Percy F. Martin, *Mexico of the Twentieth Century* (New York, 1908), 235; Jeffrey M. Pilcher, *Que Vivan los Tamales! Food and the Making of Mexican Identity* (Albuquerque, 1998), 120.

[23] National consumption calculated as beer imports plus domestic production; per capita consumption uses the male population of Mexico's seventeen largest cities. Using all adult males likely understates consumption per capita, while using the population of the largest cities likely overstates consumption per capita. Import data from Colegio de México, *Estadísticas económicas del Porfiriato: Comercio exterior de México, 1877–1911* (Mexico, 1960), 208, for total bottled beer imports, and U.S. Department of Commerce, *Foreign Commerce and Navigation of the United States*, (Washington, D.C., 1880–1911), for U.S. unbottled beer exports to Mexico; production calculated from Cervecería Cuauhtémoc production in Haber, *Industry*, table 4.3, as 28 percent to 30 percent of national production; population figures from Mexico, Instituto Nacional de Estadística (INEGI), *Estadísticas históricas de México*, 2 vols. (Mexico, 1994).

[24] *Monterrey News*, 29 Aug. 1905, quoted in Bunker, "Marketing," 233.

[25] Around 1890, a bottle of beer sold from between 0.25 to 0.75 centavos, while one estimate has the average daily wage in manufacturing at about 0.31 centavos per day (for beer

out of reach for the majority of Mexicans who worked in rural agriculture. Together, the urban middle class and new industrial workers accounted for at most 20 percent of the population. Resolving this puzzle will require further research into both the cultural patterns of alcohol consumption and the material lives of the Mexican working class. What we do know now is that Mexican consumption of beer was ten times higher in 1910 than it had been a generation earlier.

Beer consumption rose dramatically, but beer imports fell to less than a third of their previous level as new, large-scale breweries (*cervecerias*) opened through the 1890s in Monterrey, Chihuahua, Toluca, Guadalajara, Orizaba, Mazatlán, and Mérida to supply the domestic market behind protective tariffs.[26] National beer production lay somewhere in the neighborhood of just two- or three million pints in 1890; by 1910, national production reached nearly one hundred million pints per year and perhaps more—satisfying almost all of the national demand. But these breweries faced a common constraint, as did their counterparts in the United States and Europe. The bottles to put the stuff in were either imported or blown locally by hand, and most breweries hired their own small force of émigré glassblowers, who invariably could not keep up with exploding demand.[27] The late 1890s witnessed several efforts to establish new glass-bottle manufactories.[28] Moreover, the breweries' glassworks were frequently plagued by labor strife stemming from the high wage demands of the skilled glassblowers. The north's

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prices, see Sutton, "Malt and Beer" and attached reports; and for wages, see Fernando Rosenzweig, "La industria" in Daniel Cosío Villegas, ed., *Historia moderna de México: El Porfiriato: La vida económica* [Mexico City, 1965], 411). By 1900, domestic beer sold for about 0.12 to 0.25 centavos per bottle, while manufacturing wages had risen modestly. For a comparison with the price of a glass of pulque, see Sutton, "Malt and Beer," 331, 336; and Mario Barbosa Cruz, "Controlar y resistir: Consumo de pulque en la ciudad de México, 1900–1920" (unpublished ms., 2004), 24.

[26] Each of these new breweries was begun with the advice and expertise of foreign brewers, usually from the United States or Germany. Some were founded with foreign capital (like the breweries in Toluca and Orizaba), and some with Mexican capital (like the Cervecería Chihuahua and the Cervecería Cuauhtémoc in Monterrey—the largest and most successful of the group). There has not yet been a substantial history of Mexico's early brewing history. On beer tariffs, see Beatty, *Institutions*, ch. 3.

[27] Beer was distributed in bottles and barrels by both foreign and domestic brewers. Before the increase in domestic production, 85 percent to 90 percent of all imports came in bottles; see Sutton, "Malt and Beer," 330, and Colegio de México, *Estadísticas Económicas*, 206–8. Sutton notes that consumers' preference for bottles meant that it was "more difficult to sell a glass at 15 cents than a pint bottle for 31 cents." By 1905, the percent imported in barrels had increased substantially, because domestic sales in bottles had largely replaced bottled imports.

[28] See the applications of Thomas y Compañía and from Carlos Banoni to the Ministry of Development for tax exemptions; papers in Mexico's National Archive, Ramo Industrias Nuevas, box 53, folder 6, and box 35, folder 4. In addition, there were well over two hundred patents taken in Mexico for objects and processes related to glass bottles during this period; see patent database, 1850–1911, compiled by the author.

largest bottle producer, the Fabrica de Vidrios y Cristales, S.A. (associated with Monterrey's Cervecería Cuauhtémoc), shut its doors and sent its glassblowers home in 1904, due to the problems of high wages and labor unrest.[29] Reliance on imports and limited local production led to "a shortage of bottles for beer" and high bottle prices, as one Monterrey distributor lamented in early 1905.[30]

In their search for a solution to the bottle constraint, Mexico's brewers were confident of four basic preconditions. First, they believed that the rapidly expanding domestic market for beer, and thus for glass bottles, was sufficient to justify substantial investment in large-scale mechanized domestic production. National consumption by 1905 had reached nearly one hundred million liters annually, enough to keep ten Owens machines busy. Second, potential bottle producers enjoyed substantial protection, as the relative tariffs on beer and bottles presented a classic case of "infant industry" development policy. Before 1890, bottle tariffs were essentially prohibitive and served federal revenue needs as well as the interests of skilled glass artisans. The major *arancel* revision of 1891 considerably reduced bottle tariffs in relation to beer tariffs, creating highly effective protection for the latter consumer product—it is no accident that the 1890s witnessed an explosion of investment in Mexican breweries. The tariff revisions of 1905, in contrast, saw increased duties on glass bottles relative to beer, in order to foster investment in the domestic production of the manufactured input; after 1905, glass bottles enjoyed a roughly 100 percent ad valorem protection against imports.[31] Third, potential glass manufactures were confident that they could acquire the requisite glass inputs, at reasonable cost. Indeed, artisans and traditional manufactories had made glass in Mexico for centuries.[32] The most important of these inputs were silica, an alkali product, lime, and fuel. Finally, increasing national competition between regionally located Mexican breweries increased the incentives of each brewery to gain advantage by finding a solution to high bottle costs. Beginning around 1900, nearly all the large breweries began opening multiple distribution agencies well outside their own regional territory. In

[29] Isidro Vizcaya Canales, *Los orígenes de la industrialización de Monterrey* (Monterrey, 2001), 89.

[30] Quoted in Mora-Torres, *Mexican Border*, 242.

[31] For a full discussion of the tariff issue, see Beatty, *Institutions*, 63–66. New data on bottle prices and tariff rates for this paper are taken from Romero, *Report of Finance*, 132–33; United States, *Census Reports* (Washington, D.C., 1900, 1905, 1910); Scoville, *Revolution*, 230, 250; and Mexico, Ministerio de Hacienda, *Boletín del Ministerio de Hacienda* (Mexico, various years).

[32] Fernández, *El Vidrio*, and Gonzalo López Cervantes, "Notas para el estudio del vidrio en la nueva españa," in *Cuadernos de Trabajo No. 19*, Instituto Nacional de Antropologia e Historia, Departamento de Prehistoria (1979).

1901, for example, Monterrey's Cuauhtémoc entered the Mexico City market of the Cervecería Toluca y México, which in turn responded by selling aggressively in the Monterrey market, as did Orizaba's Moctezuma brewery.[33] Thus, by 1904, rapidly growing consumer demand, substantial tariff protection, confidence in input markets, increasing levels of competition among Mexican brewers, and the opportunity presented by expensive imported or hand-blown bottles combined to produce a fruitful ground for interest in the Owens machine. Whether these conditions would be sufficient to readily adopt and commercialize this new technology is the subject of this story.

Acquiring the Owens Rights. No one in Mexico had more motivation to acquire the new Owens machine than the principal owners of the Cuauhtémoc brewery in Monterrey, the largest of Mexico's half dozen or so large breweries. Founded in 1890, by 1901 it controlled roughly 28 percent of the national market.[34] Isaac Garza, founder and president of the brewery, had been interested in the Owens machine since early 1904.[35] In June of 1905, Garza and his partner Tomás Mendirichaga traveled by train north to Ohio to meet with the managers of the Toledo Glass Company. To their dismay, they discovered that they were not the first visitors from Mexico. Only days before their arrival, Juan Terrazas and Juan Brittingham—shareholders in the rival Cervecería Chihuahua—had been in Toledo and had signed an option to purchase the Mexican patent rights to the Owens machine.[36]

Juan Brittingham first came to Mexico in 1883, at age twenty-four, to visit his college friend Juan Terrazas, heir of the wealthy Terrazas family of Chihuahua. This initial visit turned into an extended stay and eventually into a lifetime committed to a wide range of business activities while raising a family in the twin central-north cities of Gómez Palacio and Torreón. Brittingham quickly became a key founder, investor, and entrepreneur in a wide range of business activities in northern

[33] The larger breweries (Cuauhtémoc, Toluca y México, Moctezuma, and Sonora) all opened multiple sales agencies in the country's largest markets; see Gustavo Adolfo Barrera Pagés, "Industrialización y revolución: El desempeño de la cervecería Toluca y México, S.A. (1875–1926)" (ITAM, 1999), 3, 12; Juan Manuel Romero Gil, "Las Bebidas espirituosas en Sonora: Notas sobre su producción y consumo, 1850–1920," (unpublished ms., 2004), 16; Juan Mora-Torres, *The Making of the Mexican Border* (Austin, 2001), 242; Haber, *Industry*, 52–53; and Nora Hamilton, *The Limits of State Autonomy: Post-Revolutionary Mexico* (Princeton, 1982), 310–11.

[34] Haber, *Industry*, 52–55; Vizcaya Canales, *Orígenes*, 76–77.

[35] Juan Terrazas reported to Brittingham, in March, 1905, that Garza and the directors of the Cervecera Cuauhtémoc had been "paying close attention" to the Owens machine for nearly a year; AHJB 20-0096.

[36] On Garza and Mendirichaga's trip, see Brittingham to Belden, 28 June 1905, AHJB 19A-401; for the contract, see TGC box 2, record book #3, 29; box 6, record book #13, 13 June 1905.

Mexico.[37] In early November of 1904, Brittingham wrote his friend and business partner Enrique Creel in Chihuahua to suggest that the Owens machine might be of interest to the Chihuahua brewery, in which both Creel and Brittingham were among the principal investors.[38]

That Brittingham had heard of the Owens machine in the first place is not surprising. Over the course of his career, he served as a one-man clearinghouse for information on diverse business opportunities in northern Mexico and on new technological developments abroad. Brittingham corresponded extensively with businessmen, investors, and plant managers in the United States. He traveled almost yearly in the United States, touring factories and meeting with businessmen and visiting relatives. He received trade journals and machine catalogs in the mail, and would frequently follow up news of foreign developments by writing directly to the managers of machine plants in the States, seeking technical details, prices, and sometimes exploring the possibility of serving as a sales agent in Mexico.[39] South of the border, he would pass new information on to friends, partners, and business acquaintances, and he proved adept at discussing and debating detailed technical issues regarding a wide range of new developments. His daily correspondence—sometimes reaching a dozen letters daily—reveals an entrepreneur closely attuned to developments and opportunities on both sides of the border and dedicated to pursuing them aggressively in Mexico.

Brittingham first saw the Owens glass-bottle machine exhibited at the International Exposition held in St. Louis in the fall of 1904. In August, he reserved a "special car" with the president of the Mexican Central Railroad, and in early October he packed his family on board for what would become a typical working vacation. Upon his return to Mexico several weeks later, Brittingham raved about what he had seen in letters to Terrazas and Creel. "So grand, superior, and extraordinary," he wrote, "one cannot describe this exposition but must see it in all its detail."[40] He urged Terrazas and Creel to visit on their own, "because

[37] After Brittingham established himself in Mexico, he went exclusively by "Juan" in all correspondence, whether writing in English or Spanish. Brittingham was no foreign investor, but an emigrant, never naturalized, who had no intention of returning to the United States. Although he sent his children to high school and college in New England, they too pursued professional opportunities in Mexico. Only the violence of the 1910 revolution drove Brittingham temporarily back to the United States, after which he returned to Gómez Palacio and eventually Mexico City, before dying in Los Angeles in 1940. For a biographical account, see Barragán and Cerutti, *Juan Brittingham*.

[38] Creel to Brittingham, AHJB 02-0518 and 0519. Also Creel to Brittingham, 15 Nov. 1904 and 6 Mar. 1905, AHJB 02-0221, 0222.

[39] For examples of this kind of activity, see AHJB 19-B140, 0020123, 0020190, 0020272, 0020562, and 0021206 and AHJB 0024505 and 0024-148.

[40] Quotations on the St. Louis Exposition from Brittingham to Terrazas, 7 Nov. 1904, and to Creel, 16 Nov. 1904, AHJB 0017428, 0017507.

undoubtedly it is one of those accomplishments, the fruit of the genius and talent of men, never seen until now." With a bit of chagrin and perhaps more than a touch of pride, Brittingham explained that in order to "dedicate [himself] exclusively to a detailed study of the exhibits," he had missed all the clubs and theaters of the city, instead retiring to his hotel between nine and ten o'clock each night so as to be "fresh and ready" to continue his "campaign" through the exhibit halls the next morning. Within days of returning to Gómez Palacio in late October, he sent a detailed description of the Owens machine and its capabilities to Creel, which he followed up with a series of letters touting the opportunity it presented.

Initially, Brittingham's reports generated hardly any enthusiasm. Creel was distracted by his gubernatorial duties, and Juan Terrazas initially had little interest in venturing alone into new commercial territory —at least without the support and assurance of his "oldest friends." To Brittingham he candidly admitted his natural "suspicion of any new invention."[41] Where Brittingham raved about the technological advances he saw in St. Louis and constantly encouraged investment in new machines, Terrazas not only reserved judgment but flatly expressed his suspicion, saying he would invest "*ni un centavo*" ["not even a penny"] without some kind of contractual guarantee of success.[42] Yet, by early March 1905, Brittingham's encouragement and badgering persuaded a reluctant Terrazas to arrange an exploratory trip to Toledo. The two benefited from a serendipitous connection. Arthur Fowle was the technical manager at a glycerin plant owned by Terrazas and Creel, affiliated with their giant soap factory, the Compañía Industrial Jabonera de La Laguna. Fowle was first cousin to Edward Libbey, founder and president of Toledo Glass.[43] Through Fowle, Terrazas and Brittingham obtained a special invitation from the managers at Toledo Glass to visit the company and view the Owens machine in operation.

But Isaac Garza and his Monterrey partners had also been communicating with Toledo, as had many others: the Toledo Company received at least ten inquiries concerning its Mexican patent rights.[44] Brittingham and Terrazas were well aware that if they did not act quickly, their competitors in Monterrey could shut them out of any participation in

[41] Terrazas to Brittingham, 9 and 17 Mar. 1905, AHJB 20-0096, 06-0083.

[42] Terrazas to Brittingham, 17 Mar. 1905, AHJB 06-0083.

[43] Fairfield, *Fire and Sand*, ch. 6; Scoville, *Revolution*, 288–54.

[44] These include only the inquiries mentioned in their correspondence with Brittingham: from a Mr. Pedrazo (Aug. 1905, AHJB 20-0138); from a J. A. Bolton of Montclair, New Jersey (Nov. 1905, AHJB 20-0107); from George W. Ditheridge (Nov. 1906, AHJB 20-0109); from a Dr. Corkrell of Mexico City, with a letter from Pittsburgh (Apr. 1907, AHJB 20-0049); and from Hermann Heye of Germany, a principal in the ownership of the Owens European rights (Apr. 1908, AHJB 63-A126).

the automated bottle business.[45] "The news we get from Toledo," reported Brittingham on the eve of their trip north, "is that we should be ready to make a [financial] commitment. [As] Isaac Garza will have preference after us . . . I fear we will have to take immediate action."[46]

Brittingham and Garza's race to Toledo in the early summer of 1905 was a reflection of their personal entrepreneurship and of the growing competitiveness within the Mexican beer industry. But this race was also shaped by the particular marketing strategy adopted by the Toledo Glass Company and the political institutions governing foreign patents in Mexico. Mexican patent law offered exclusive rights for twenty years to both domestic and foreign inventors.[47] Toledo Glass had solicited and received the Mexican patent rights in 1903, as it had in foreign markets around the world. The company then sought to sell the monopoly rights outright to business groups who would either commercialize the machine or license its use rights to bottle manufactures. For Mexico, this meant that one, and only one, bidder would receive the Toledo Company's monopoly right to exploit the Owens technology, and this is what both Brittingham and Garza sought that June. Each feared that failure would give a potential competitor significant advantage in the domestic beer market.

Brittingham and Terrazas signed an option in Toledo that gave them until September to make an initial payment of fifty thousand dollars, followed by two annual installments of twenty-five thousand dollars.[48] By September, they had formed the Owens Mexican Bottle Machine Company (La Owens de México) in order to purchase the Owens rights.[49] The sales contract obligated Toledo to supply the Mexican company with two Owens machines and the necessary technical support to install them at any time within a four-year period.[50] Thus, the contractual requisites for the physical transfer of the Owens technology to Mexico were complete by September, 1905.

Failure to License the Technology. Buying the Mexican patent rights to the Owens machine represented only the smaller of two necessary investments: raising sufficient capital actually to establish a glass

[45] Terrazas to Brittingham, 9 Mar. 1905, AHJB 20-0096.

[46] Brittingham to Creel, 27 May 1905, AHJB 19A-274.

[47] See Beatty, *Institutions*, ch. 4, for a more detailed discussion.

[48] All prices cited in this paper will specify either dollars or pesos; the ratio between the two during this period was roughly 1:2.

[49] Contract of incorporation (copy), 1905, AHJB 20-0153. The company's capital was set at 400,000 pesos, divided equally among the four investors. Brittingham and Terrazas were joined by Francisco Belden, a friend and Monterrey businessman, and by Arthur Fowle. Each man contributed one-fourth of each installment.

[50] Contract with option of 13 June 1905, AHJB 20-0020, 0021. See also TGC, box 6, record book #13, 13 June 1905.

factory would eventually double or triple the initial hundred-thousand-dollar investment.[51] For Brittingham and his partners, the decision to make that second investment required resolving two central questions: The first largely had to do with business strategy. Would they establish an Owens-based bottle factory on their own, or would they seek to license the machine rights to other groups interested in the beer-and-bottle business in Mexico? The second question raised the economics of bottle production in Mexico: could any domestic producer actually compete with foreign manufacturers, assuming both utilized the Owens system? For Brittingham, the host of specific issues involved in determining production costs and competitive price levels—markets, raw materials, fuel, labor and management concerns, transport costs, ancillary technology choices, and tariff protection—were only worth pursuing if his group became the primary investor in a bottle plant. They had thus far spent little time exploring these issues, despite committing one hundred thousand dollars to the future of the Owens system in Mexico. Although both Juan Terrazas and Francisco Belden favored direct exploitation, Brittingham's own instincts pointed in the opposite direction. As the dominant partner, over the next two years he would lead efforts to license the system to other parties.[52] Part of the explanation for this initial strategic choice is found in the particular structure of Mexico's beer industry.

The prodigious capacity of the Owens machine meant that any Owens-equipped factory required access to Mexico's largest beer markets in Monterrey and central Mexico. But these were the markets dominated by the country's largest breweries: the Cuauhtémoc and Toluca y México. The Cervecería Chihuahua was not big enough alone to absorb the productive capacity of even one Owens machine, and Brittingham feared that Chihuahua's larger competitors would act to shut out any bottle production that threatened their regional position.[53] "They know," he wrote Walbridge, "we would not risk to put up a large glass works because we could not count on their bottle consumption, except at their price."[54] Erecting an Owens-based factory without assured access to

[51] See, for instance, the cost estimates in Walbridge to Roever, 14 Feb. 1907, AHJB 20-0064. Ultimately, the company that established the first mechanized bottle plant in Mexico was capitalized at $1.2 million and spent over $230,000 on construction costs; Barragán and Cerutti, *Juan Brittingham*, 172.

[52] See, for instance, Brittingham to Walbridge, 7 July 1906, AHJB 022229.

[53] Whether Chihuahua's annual demand for bottles matched the output of one Owens machine (1905 model) is unclear from the data; it is clear that the Cuauhtémoc's production of nearly nine million liters per year was more than sufficient; compare Mexico, Secretaría de Fomento, Colonización e Industria, *Anuario estadística de la República Mexicana . . . 1899* (Mexico, 1900), 70–71, with Haber, *Industry*, 53. The central Mexican market could even more easily support the Owens output; see Barrera, "Industrialización," table 3.8.

[54] Brittingham to the Toledo Glass Company, 31 Aug. 1905, AHJB 19B-217.

Mexico's main consumer markets was simply too risky. The Cervecería Chihuahua could not do this alone, and Brittingham knew it. Licensing the Owens rights to the larger brewing interests, he believed, remained the most promising strategy.

Almost immediately upon returning from the Toledo trip, Brittingham and his partners began to aggressively pursue possibilities. Francisco Belden opened negotiations with Tomás Mendirichaga and Isaac Garza of the Cervecera Cuauhtémoc in Monterrey, while Brittingham asked Juan Terrazas to write letters of introduction to a Mr. Wiechers of the Cervecería Toluca y México and to Julio Limantour, a director of the Moctezuma brewery in Orizaba.[55] These brewing interests and others were simultaneously pursuing independent strategies to buy into the Owens system.[56]

Mexico's brewers were not the only ones interested in the Owens patent rights. Several U.S. investors sent inquiries either to the Toledo company or directly to Brittingham. Some, like J. A. Bolton of Montclair, New Jersey, had developed fairly detailed plans to establish a modern bottle factory on Mexican soil.[57] Others simply sought additional ways to capture a significant share of the Mexican bottle market through exports. As Walbridge warned Brittingham early on, "I believe today that [these American companies] will make an effort to obtain the Mexican [bottle] trade, and any glass factory in Mexico not equipped with the Owens machines might just as well close its doors."[58] Principal among these U.S. interests was Adolphus Busch, president of the Anheuser Busch company of St. Louis, in this case representing his subsidiary interest in the American Bottle Company. Busch had begun talks with Toledo Glass about the Mexican patent rights in early 1905, and he protested strongly against the option acquired by Brittingham that summer.[59] Although Brittingham's preference was to strike a deal with the larger Mexican breweries, he felt that the American company offered a "safety valve," in case the Mexican options broke down entirely.[60]

Yet licensing the rights to the Owens machine in Mexico proved

[55] Brittingham to Terrazas, 3 Aug. 1905, AHJB 19-B028. Both breweries in central Mexico showed interest in making a deal for use of the Owens machines; the Toluca Company was particularly aggressive in pursuing Brittingham over the next several years. See Walbridge to Brittingham, 31 Aug. 1905, AHJB 20-0138, and Brittingham to Walbridge, 6 Sept. 1905, AHJB 19-B278; and regarding Julio Limantour, see Brittingham to Terrazas, 6 Dec. 1905, AHJB 0020218.

[56] See, for instance, Walbridge to Brittingham, 31 Aug. 1905, AHJB 20-0138.

[57] Bolton to Brittingham, 9 Nov. 1905, AHJB 20-0107.

[58] Walbridge to Brittingham, 29 Sept. 1905, AHJB 20-0130.

[59] Brittingham to Belden, 13 Nov. 1905, AHJB 0020071; also Brittingham to Terrazas, 24 Aug. 1905, AHJB 19-B162; Walbridge to Brittingham, 18 Sept. 1905, AHJB 20-0131.

[60] Brittingham to Terrazas, 6 Dec. 1905, AHJB 0020071; also Brittingham to Belden, 22 Dec. 1905, AHJB 63-A004.

impossible. As Brittingham and his partners aggressively pursued licensing deals with three different firms through 1905 and 1906, royalty payments emerged as the intractable obstacle. Despite the technology's promised ability to overcome the container bottleneck, uncertainty about whether an Owens-equipped factory could compete successfully against imports, even with substantial tariff protection, was widespread. The specter of royalties turned this uncertainty to deep pessimism.

Brittingham's first effort was to strike a deal with Monterrey's brewing interests at the Cervecería Cuauhtémoc. Yet these negotiations rapidly degenerated into mutual frustration and stalemate. Following the Toledo company's practice in the United States, Brittingham offered to license the machinery at cost in exchange for royalty payments on annual bottle production. Brittingham's royalty offers through this period ranged from fifty to fifty-five cents (gold, or U.S. dollars) per gross of bottles, but Isaac Garza in Monterrey insisted on a royalty payment of no more than fifty cents (silver, or Mexican pesos) per gross, exactly half Brittingham's asking price.[61] Garza argued that Monterrey held the upper hand. An Owens-based factory, he asserted, could only survive with the business of Mexico's largest brewery—the Cuauhtémoc. If Brittingham's group undertook production without Monterrey's participation, Cuauhtémoc would refuse to buy their bottles. "The weapon they are holding over us," complained Brittingham, "is that we cannot establish a glass factory of our own because we will then lose the consumption of bottles used by the Cuauhtémoc Brewery, the biggest plum on the Mexican tree."[62] On the other hand, Brittingham was confident that the Monterrey brewing interests would ultimately be forced to use Owens-produced bottles, either as the products of their own factory, or as imports from American manufacturers like the American Bottle Company, or purchased from a Brittingham-controlled bottle plant. "I told [them] I was sure they would [buy from us]," he reported to Belden in late December, "because they would have prices so low that they wouldn't be able to match anywhere else."[63] The web of business relations between Brittingham's and Garza's respective business groups gave him hope that the Monterrey people were not as disinterested as they sought to appear: "I know from our friend Belden that Mendirichaga and Garza believe the machine will be the salvation of their bottle factory."[64]

[61] The negotiations were conducted primarily between Francisco Belden—a prominent Monterrey businessman and the Brittingham group's link to the financial and industrial interests in that city—and Isaac Garza and Tomás Mendirichaga. See Brittingham to Belden, 22 Dec. 1905, 16 Feb. 1906, and 8 Mar. 1906 in AHJB 63-A004, 63-A012, and 0021164, respectively.

[62] Brittingham to Walbridge, 22 Dec. 1905, AHJB 63-A002.

[63] Brittingham to Belden, 22 Dec. 1905, AHJB 63-A004.

[64] Brittingham to Terrazas, 17 July 1905, AHJB 19-A574.

Nevertheless, the royalty issue proved intractable. Privately, Brittingham expressed little tolerance for Monterrey's hard line. To his partners in Mexico and to Walbridge in Toledo he voiced his "great disappointment" in Garza and Mendirichaga's negotiating efforts. By December 1905, he was condemning their "threats," their "intrigues," their "constant menacing," and their efforts to "put the screws to us."[65] He viewed their counteroffer of fifty cents silver per gross as "a complete joke," and by March 1906 had all but abandoned negotiations in frustration.[66] "We are getting tired of these people," he admitted to Walbridge as he asked the Toledo Company to more actively encourage negotiations with Busch and the American Bottle Company.[67] By July, communications between Gómez Palacio and Monterrey had been abandoned altogether.

The other alternative in 1906 was a possible deal with the American Bottle Company in the United States. For Brittingham and his partners, this option was decidedly second best. A deal would at least recoup their investment in the Owens patents, and perhaps net them a profit. But the intentions of American Bottle remained obscure. As the largest manufacturer of glass bottles in the world, American Bottle could have acquired the Mexican rights simply to secure an additional export market by ensuring that no other firm could produce competitively south of the border. Indeed, they were accused of "dumping" large quantities of their bottles on the Mexican market in 1906.[68] Yet, by March 1906, Brittingham's growing frustration with Garza and the Monterrey group led him to offer the American Bottle Company the same patent transfer deal that Brittingham had received from Toledo.[69] By July, several directors of the American company were pressing hard to consummate a deal with Brittingham, but they apparently lacked unanimous support among their board. By September, it was clear that those opposed had won, despite Brittingham's last-minute appeals to his intermediaries in Toledo.[70]

[65] Brittingham to Belden, 22 Dec. 1905, AHJB 63-A004; Brittingham to Walbridge, 4 Jan. 1906, AHJB 63-A007; Brittingham to Belden, 11 June 1906, AHJB 0022077.

[66] Brittingham to Belden, 9 Mar. 1906, AHJB 63-A016.

[67] Brittingham to Walbridge, 22 Dec. 1905, AHJB 63-A002, 4 Jan. 1906, AHJB 63-A007 and 9 Mar. 1906, AHJB 63-A013. Brittingham offered a royalty of fifty cents gold per gross to both the American Bottle Company and the Cervecera Toluca y México, plus the machinery itself at cost (roughly 8,000 dollars). See Brittingham to Terrazas, 12 Sept. 1906, AHJB 022602.

[68] Walbridge to Brittingham, 22 Sept. 1906, AHJB 20-0115.

[69] Brittingham to Walbridge, 9 Mar. 1906, AHJB 63-A013. Brittingham believed that the American Company would be more successful in reaching a deal to license the patents to the Monterrey group, given the American Company's ability to credibly threaten import supplies.

[70] Brittingham to Belden, 9 June 1906 and Walbridge to Brittingham, 2 July 1906 in AHJB, 63-A027 and 20-0119, respectively. The negotiations with the American Bottle Company had yielded a contract option for the Owens license. The option was signed in Aug. 1906, but expired in September without any payments from the American company. It is unclear whether

The last of the three sustained attempts to license the Owens machine came closest to fruition. In February of 1907, W. D. E. Negovetich and Luis Roever approached the Toledo Glass Company to inquire about the Mexican rights.[71] They claimed a long interest in the Mexican bottle business, connections with European bottle makers, and sufficient financial backing to establish a Mexico City bottle plant with an annual capacity of ten million pint bottles. All they lacked was the Owens machine. Toledo Glass responded to their query with technical and production details on the Owens machines, but otherwise referred them to Brittingham. Although Brittingham initially viewed these men as "simply promoters . . . and [patent] speculators," he met with Roever in Gómez Palacio later that month to begin negotiations, but royalties again proved divisive.[72] Brittingham raised his earlier demands and asked for sixty-five cents (gold) per gross on annual production under a million gross, and fifty cents (gold) on annual production over a million gross. Given the size of the Mexican market, the effective offer was the former. Roever countered with a willingness to consider seventy-five cents (silver), barely over half of Brittingham's request. Roever also wanted an exclusive license, which Brittingham refused, unless Roever's firm agreed to pay royalty on all bottles *consumed* in Mexico, not just on their factory's eventual *production*. On the royalty issue, Roever and Negovetich found an ally in the Toledo Company. Anxious to see their machines installed in Mexico, Walbridge urged Brittingham to reconsider his initial position. Royalties charged in other markets by the Toledo Glass Company, Walbridge explained, were based on the relative cost of production and levels of tariff protection in different countries. While relative costs and protection levels allowed the Toledo Company to charge fifty cents gold or higher per gross in the United States, conditions in Germany

this was the result of disagreements over royalty levels or derived from the general disinterest in the American company. See Brittingham to Walbridge, 7 July 1906, AHJB 0022229; Brittingham to Terrazas, 19 Sept. 1906, AHJB 0022602; Brittingham to Walbridge, 14 Sept. 1906, AHJB 0022634.

[71] It is not clear whom Negovetich and Roever represented. Their stated goal was to establish a large-scale modern bottle factory in Mexico City, perhaps with secondary plants in Chihuahua. They referred generally to their financial backers "back east," and some of their letters were postmarked in Providence and New York City. Roever claimed close ties with European glass producers, and both men were socially connected to Mexico City's American community. See the *Mexican Herald*, 28 May 1905 and 19 Aug. 1910. Negovetich had first contacted the Toledo Glass Company in September 1905. Walbridge identified him to Brittingham as "of the British Club" and reported that he wanted to open a bottle factory in Toluca with a capacity of 100,000 gross per year. Brittingham, in turn, assumed that Negovetich represented the Cervecería Toluca y México. There was no further contact until February 1907.

[72] Negovetich to Mills, 6 Feb. 1907, AHJB 20-0063; Walbridge to Roever, 14 Feb. 1907, AHJB 20-0064; Brittingham to Walbridge, 19 Feb. 1907, AHJB 63-A055 and 23 Feb. 1907, AHJB 63-A057.

and Canada allowed royalty levels of only 70 percent those charged to American companies (at thirty-six and thirty-five cents gold, respectively).[73] In deciding on the amount they would charge in royalties, Walbridge argued, the Mexicans needed to consider tariff protection and the likelihood that there would be substantially higher costs for raw materials; thus, he claimed, they should set the amount closer to royalties charged in Canada and Germany.[74] Brittingham was convinced by this argument, accepted a new figure of seventy-five cents silver (or thirty-seven and a half cents gold) per gross, and lamented, "We could have induced both Monterrey and Toluca to go into the business from the start; both were willing but we held out for 50 cents gold, citing your contract with the American Bottle Company."[75] Through May and June of 1907, Brittingham worked closely with the lawyers of Toledo Glass to draw up a licensing contract with Roever and Negovetich. By August, however, negotiations had again bogged down. In part, Roever and his partners sought briefly to obtain the exclusive rights to the technology, only to be rebuffed by both Toledo Glass and Brittingham.[76] More important, the severe economic contraction of 1907 tightened possibilities for financing new ventures in both Mexico and the United States and fatally undermined the deal.

In each of these cases, high royalties coupled with uncertainties about the profitability of production drove successive licensing negotiations toward failure and slowed the pace of efforts to innovate the new technology directly. In the first two negotiations, Brittingham remained stubbornly wedded to the royalty model established in the licensing agreement between Toledo Glass and the American Bottle Company in the United States. Despite his business abilities and connections, in this case Brittingham had too little information concerning business practice in the United States and the comparative costs of bottle production. Not until the Toledo company presented evidence of the wide variance

[73] A large percentage of Mexico's bottle imports came from Germany, and that country's relatively cheaper labor costs (compared to the United States) meant that high royalties in Mexico would leave its industry uncompetitive with German products; Walbridge to Brittingham, 28 Mar. 1907. Royalties to licensees in the United States were initially set as a percentage (e.g., 50 percent) of the reduction in labor costs made possible by the Owens machine; Scoville, *Revolution*, 107.

[74] Brittingham to Walbridge, 23 Feb. 1907, AHJB 63-A057; Walbridge to Brittingham, 6 Mar. 1907, AHJB 20-0055 and 18 Mar. 1907, AHJB 20-0058.

[75] Brittingham to Walbridge, 28 Mar. 1907, AHJB 63-A062.

[76] Negovetich to Toledo Glass, 12 Aug. 1907, AHJB 20-0020; Geddes to Brittingham, 13 Aug. 1907, AHJB 20-0011 and 14 Aug. 1907, AHJB 20-0008; Negovetich to Geddes, 14 Aug. 1907, AHJB 20-0010; Negovetich to Geddes, 15 Aug. 1907, AHJB 20-0089 and 16 Aug. 1907, AHJB 20-0093. See also Roever to Brittingham, 5 Sept. 1907, AHJB 20-0078 and 17 Sept. 1907, AHJB 20-0079 and 15 Oct. 1907, AHJB 20-0083. See also Brittingham to Roever, 19 Sept. 1907, AHJB 63-A099 and 18 Oct. 1907, AHJB 63-A110.

in its licensing contracts with firms in the United States, Canada, and Germany did Brittingham retreat from his earlier position. By this point, however, it was too late. Furthermore, it was not at all clear to potential Mexican investors that the Owens machine would produce bottles at a cost sufficiently low to compete with foreign imports. Indeed, most observers believed that production costs for an infant industry in Mexico would be substantially higher, at least initially. The burden of royalty payments only made them more uncertain, and less willing to invest.[77]

The Challenge of Direct Innovation. Successive failures in the licensing negotiations pushed Brittingham's group to consider direct commercialization of the Owens machine more seriously. Terrazas and Belden had long felt that "in the end, [they would] probably have to establish a glass factory [themselves]."[78] Yet the obstacles that continued to delay innovation until 1912 came in two phases. In the early spring of 1906, and continuing through the next three years, Brittingham and his partners began to seek specific answers to a set of questions centered on the economics of glass-bottle production with the Owens machine in Mexico. By 1909, these questions had been partially resolved, a new corporation was formed to establish a glass factory, and the machines themselves were finally shipped to Mexico. Nevertheless, the three following years would be marked by new frustrations and setbacks growing out of a series of decisions and adjustments that were necessary to adapt the Owens system to its new environment. Commercial operation would not begin until 1912.

The overriding concern during the first phase was foreign competition. Investing several hundred thousand dollars in a domestic factory would make sense only if its products would undersell imported glass bottles. Without the ability to undersell imports, no one would invest—even with the *valiosa* (precious) opportunity offered by monopoly rights to the powerful Owens machine. "Bottles made by your machine," complained Brittingham to Toledo in 1906, "can be imported into this country about as cheap[ly] as they can be made here."[79] Potential Mexican producers enjoyed, of course, the de jure protection of Mexican tariffs and the de facto protection of transport and breakage costs on imports. Nevertheless, it became clearer that the costs and uncertainties of under-

[77] Ideally, Brittingham's group would have liked to license the Owens technology to multiple bottle-producing firms in Mexico, collecting royalties from each. None, however, proved willing to consider anything except an exclusive license agreement, yet another sign that only the assurance of a monopoly position was sufficient to overcome doubts about profitable production.

[78] See Terrazas to Brittingham, 1 Aug. 1905, AHJB 06-0100, 5 Mar. 1906, AHJB 06-0129; Brittingham to Terrazas, 16 Mar. 1906, AHJB 0021204; Brittingham to Walbridge, 7 July 1906, AHJB 0022229. Fowle eventually sold his interest in La Owens de México in order to return to the United States, where he took a management position with Toledo Glass.

[79] Brittingham to Walbridge, 14 Sept. 1906, AHJB 022634.

taking domestic bottle production would be substantial. Of primary concern to Brittingham and his partners was access to raw materials, fuel, and transportation.

Initially, Brittingham had "great confidence" in finding reliable and proximate sources of the most important production inputs: raw materials and fuel. "We have already studied [these]," he wrote to Belden and Terrazas in early 1906.[80] This early optimism, however, proved premature and turned quickly to a more plodding state of uncertainty and frustration. Locating low-priced, high-quality sources of each input proved substantially more difficult in Mexico's undeveloped economy than Brittingham and others had initially calculated.

"The most difficult problem to resolve," Brittingham reported in October 1906, was the question of raw materials, especially sand.[81] At first, Brittingham had believed that "it would seem impossible that [they] could not find in this country sand and pure silica that are so abundant in Europe and the United States," but time and again his searches ended in frustration.[82] Brittingham's correspondence through 1907 is replete with efforts to locate raw-material deposits of sufficient quality and that could be shipped to a factory site at reasonable cost.[83] While sand made up roughly three-fourths of the final product by weight, chemical ingredients accounted for the largest cost share among the raw materials.[84] Various alkali chemicals could work, but sodium sulphate or carbonate were the ones most commonly used. Although many observers believed such alkalis were "abundant" through northern Mexico, finding the right supply at the right cost bedeviled investors through late 1910.[85] Again, several regional sources were considered and rejected. In 1906, Brittingham explored the possibility of purchasing bisulphate of soda from a local explosives firm; several months later, he pursued several leads for exploiting the natural-soda deposits of the Pacific Coast.[86] Neither

[80] Brittingham to Belden, 28 Mar. 1906, AHJB 63A-021 and to Terrazas, 28 Mar. 1906, AHJB 63A-023. On glass production, see, Davis, *American Glass*, 41–42; Scoville, *Revolution*, 14–17, 39–40.

[81] Brittingham to Walbridge, 12 Oct. 1906, AHJB 63A-038.

[82] Brittingham to Belden, 31 July 1905, AHJB 19-B003. Indeed, he eventually heard reports that the earlier failure of the old Monterrey glass factory was due not to labor problems, as had been widely reported, but instead to its failure to secure an adequate supply of the raw material.

[83] Brittingham to Lawton, 8 Nov. 1906, AHJB 63-A040. Brittingham received more favorable, yet still overly optimistic, reports of Chihuahua River sand from George Dithridge, recommended by Toledo, see TGC, box 2, record book #1, p. 131. See also Dithridge to Brittingham, 25 Jan. 1907, AHJB 20-0061. On white sand in Michoacán, see Brittingham to Dithridge, 21 Jan. 1907, AHJB 63A-050.

[84] Brittingham to Walbridge, 24 Mar. 1909, AHJB 63A-196.

[85] Dithridge to Brittingham, 18 Jan. 1907, AHJB 20-0067.

[86] Dithridge to Brittingham, 21 Feb. 1907, AHJB 20-0060; also Agusto Genin to Brittingham, 1 Sept. 1906, AHJB 20-0103.

option proved viable, and the chemicals were eventually imported from England at relatively high cost.

Even more important to final production costs was the price of the fuel used to melt raw materials and to power the automated bottle machine and ancillary equipment. Indeed, the geography of the U.S. glass industry had been fundamentally shaped by fuel costs for a century.[87] In Mexico, fuel costs had long been a "grave obstacle" to all industry, according to Finance Minister José Yves Limantour and many other observers.[88] This was increasingly the case as forests near industrial and mining regions thinned in the late nineteenth century, and as new large-scale automated technologies exceeded the caloric capacity of wood-based fuels. "Fuel is critical [to glass production]," George Dithridge advised Brittingham in early 1907. "[T]he fuel question is really the most serious to be properly answered."[89] At one point, Brittingham estimated that between 80 percent and 90 percent of the final cost of glass bottles would be fuel costs—hence, the desperate need to shave every cent from its price.[90] The newly opened coal mines in Coahuila presented the cheapest fuel source available, but doubts about its quality were common. "Salinas coal is not of the first quality," admitted Dithridge (who had initially recommended its use), and he quickly proposed that Brittingham explore imported coal or fuel oil instead, noting that the electric-power plant in Parral, Chihuahua, ran on coal imported from New Mexico.[91] But imported coal right away ran up against high freight rates on the railroads, and Brittingham engaged in a strenuous and lengthy campaign between 1907 and 1909 with the major railroads to obtain lower rates, lobbying railroad presidents as well as Finance Minister Limantour and President Díaz in Mexico City.[92]

[87] Naomi R. Lamoreaux and Kenneth L. Sokoloff, "Inventive Activity and the Market for Technology in the United States, 1840–1920," in NBER Working Paper #7107 (Cambridge, Mass., 1999), 4–6; Scoville, *Revolution*, 88–89.

[88] Limantour to Brittingham, 18 Nov. 1908, AHJB 06-0013. Dithridge spoke of the "sparseness of timber in the Mexican forests of the north"; see his letter to Brittingham on 15 Dec. 1906, AHJB 20-0070. In 1902, the commercial weekly *El Economista Mexicano* had listed fuel costs as the fourth most important economic problem facing Mexico, after the monetary system, irrigation, and immigration (6 Dec. 1902, p. 200); see also Mora-Torres, *Mexican Border*, 236.

[89] On the fuel question, see Dithridge to Brittingham, 18 Jan. 1907, AHJB 20-0067.

[90] Brittingham to Garza, 17 Mar. 1909, AHJB 63A-193.

[91] Dithridge to Brittingham, 15 Dec. 1906, AHJB 20-0072; 18 Jan. 1907, AHJB 20-0067; and 21 Feb. 1907, AHJB 20-0060.

[92] For the appeals to Limantour and Díaz, see Limantour to Brittingham, 18 Nov. 1908, AHJB 06-0013; Brittingham to Garza, 4 May 1909, AHJB 63A-204. See also Travis to Brittingham, 4 Aug. 1907, AHJB 20-0023 and Dithridge to Brittingham, 21 Feb. 1907, AHJB 20-0060. Transport costs, and thus locational decisions, were more critical for fuel than for raw materials, because the latter had to be shipped both to the factory and away from it (embodied in the final product), whereas fuels—consumed in the production process—paid transport only to the factory; Scoville, *Revolution*, 41.

Nearly all who shipped goods in late Porfirian Mexico complained about high freight rates, and those interested in markets for glass inputs and products were no exception. Brittingham began by requesting rate information from the relevant U.S. and Mexican rail lines, but was repeatedly frustrated by what he saw as unreasonably high quotations.[93] The consolidation of the National Railroad lines in early 1909 only exacerbated these frustrations, as rates for most classes of freight increased, threatening the viability of the entire project. "Freight rates on coal are now $3.19 ton and will go to $3.90 ton and we cannot have more than $2.50 ton and compete with foreign imports," he reported.[94] Brittingham tried to play one rail company off against another in an effort to obtain lower rates, by suggesting that the decision about the final location (and thus which rail line would receive the company's business) would depend on the rates they could offer, but he received little satisfaction.[95] By early 1908, the fuel question remained unresolved.

As Brittingham continued to investigate the troubling question of production costs, he returned to the strategic question of accessing Mexico's main bottle markets. He remained convinced that a sales commitment with the brewers of Monterrey, or those of central Mexico, was a requirement for erecting a factory. By early 1908, Brittingham and his partners explored a combination of Mexican brewing interests to jointly undertake an Owens-based bottle enterprise.[96] In March, he renewed contact with Isaac Garza in Monterrey for the first time since 1905, seeking a "mutually convenient" arrangement for a joint enterprise.[97]

Negotiations between Gómez Palacio and Monterrey through the summer and fall of 1908 displayed considerably more "expressions of fine courtesy and friendship" than those they had conducted three years earlier.[98] What was different this time? Other options had repeatedly failed, despite Brittingham's initial optimism. More critically, royalties no longer posed an obstacle to investment. Now Brittingham and Garza sought a direct path toward commercial innovation through a partnership that would combine the patent rights of Brittingham's group with

[93] Correspondence with C. B. Cleveland of the Chicago, Rock Island & Pacific Railroad, 5 Nov. 1906, AHJB 20-0110; and with H. Lawton of the Ferrocarril Central Mexicano, 1 Dec. 1906, AHJB 20-0097. For reaction to "absurdly high" rates, see, for instance, Dithridge to Brittingham, 25 Jan. 1907, AHJB 20-0061.

[94] Brittingham to Garza, 4 May 1909, AHJB 63A-204.

[95] See Dithridge to Brittingham, 15 Dec. 1906, AHJB 20-0072 and 25 Jan. 1907, AHJB 20-0061.

[96] Brittingham to Walbridge, 17 Mar. 1908, AHJB 63A-118. William Walbridge at Toledo Glass had suggested this possibility (modeled on their deal with the American Bottle Company). This was not an unfamiliar tactic for Brittingham, one that he also pursued with the Laguna region's cotton planters; see Haber, *Industry*, 88–89.

[97] Brittingham to Garza, 25 Mar. 1908, AHJB 63A-122.

[98] Brittingham to Walbridge, 8 Nov. 1908, AHJB 63A-127.

the consumer market commanded by Garza's group, thereby avoiding the burden of royalties altogether. By October 1908, the deal was inked, leaving only several important, but tractable, issues to negotiate.[99] One year later, the Compañía Vidriera Monterrey, S.A., was officially constituted, capitalized at 1,200,000 pesos. The Monterrey group contributed the facilities of their old glassworks, and Brittingham's group contributed the Owens patent rights.[100] Construction on the new factory began in late 1909 under the direction of an American engineer, Mr. Wilcox from the Arbuckle Ryan engineering firm of Toledo, who came highly recommended as "one of [the] best erecting engineers" by the management at Toledo Glass.[101] The two Owens machines crossed the border on rail cars sometime in midwinter, marking one relatively insignificant moment in this particular story of technological innovation. By February 1910, the factory was nearing completion, and its investors hoped that it would begin producing bottles by August.[102]

That optimism proved misplaced. Recurring challenges and obstacles would prevent operation for nearly another three years. Despite the adoption of a technological package well tested and firmly established in U.S. factories—machinery delivered ready to install from Toledo—and despite the deployment of experienced American technicians and glass engineers to erect the new Mexican plant, its directors and managers continued to face a host of choices and challenges. The largest of these centered on fuels, labor, and adaption of the technology itself to a new input mix.

Glassmaking placed great pressure on fuel choices because it required exceptionally high temperatures in the melting furnaces. Not just any fuel would do, and gas-burning furnaces would burn hotter than coal-fired ones. Most U.S. glass plants used gas to fire their ovens; many produced their own gas from anthracitic or bituminous coal. By March 1909, however, Brittingham and Garza had concluded that Mexican coal was not of sufficient quality to burn directly, nor was it "ade-

[99] These included a valuation of the existing buildings and equipment of the old glass factory owned by the Cuauhtémoc investors. See, for instance, Brittingham to Walbridge, 8 Apr. 1909, AHJB 63A-199; Garza to Brittingham, 13 May 1909, AHJB 09-0321; Arbuckle Ryan Company to Brittingham, 4 Aug. 1909, AHJB 09-0336.

[100] Both were valued at 200,000 dollars. See the valuations made by Brittingham in a letter to Isaac Garza, 20 Apr. 1909, AHJB 63A-212, although there would be some conflict over this issue, leading to the delay in the constitution of the new company until early October, 1909. The board of directors for the new company included Juan Brittingham, Isaac Garza, Juan Terrazas, Mariano Hernández, Francisco Garza, Manuel Cantú Treviño, José Belden, and Roberto G. Sada, among others. Barragán and Cerutti, *Juan Brittingham*; see also TGC, box 6, record book #30, 20 Jan. and 23 Feb. 1909.

[101] Brittingham to Walbridge, 8 Nov. 1908, AHJB 63A-127.

[102] Brittingham to José Yves Limantour, 22 Dec. 1909, AHJB 0033127; Brittingham to Walbridge, 27 Dec. 1909, AHJB 0033155; Brittingham to Creel, 15 Feb. 1910, AHJB 0033592.

quate to produce gas."[103] Increasingly, then, the most attractive alternative appeared to be crude petroleum, obtained from newly opened oil fields on Mexico's gulf coast and processed into gas. Brittingham spent several weeks in July in the United States visiting the Toledo Company and several glass factories, noting that many were actively experimenting with different fuel arrangements. He reported to Garza that some had success using a mixture of petroleum and oxygen to fuel their ovens, obviating "the need to invest in a gas plant that is so costly."[104] By early August, Garza had gathered information on the use of fuels by other Monterrey industries, had located diesel-motor suppliers, and had obtained delivery prices from the Waters Pierce Oil Company via Tampico. He reported to Brittingham that, at current prices, such an arrangement would cost just under one and a quarter centavos per horsepower per hour: "This is high, but secure, and more economical than the use of coal, and will resolve our problem."[105] Nevertheless, the company would begin its operation with coal, then quickly switch to petroleum, before finally settling, a decade later, on natural gas imported from Texas.

If the Owens system raised new technical issues for glass producers, it reduced the importance of the labor question. Labor posed little concern to Brittingham and his new partners, despite having long made the glass industry "an unholy business for all who have entered it."[106] Most informed observers in Mexico viewed labor as a "serious hindrance" and a source of "great anxiety," and it had reportedly been the downfall of Monterrey's first bottle company.[107] But the Owens machine radically reduced the need for skilled labor in the production process. José Yves Limantour warned Brittingham in 1908 that the labor issue had been "the true cause of all failures" in the glass business, but claimed that the Owens system would "eliminate [this] great anxiety."[108] Skilled labor would be limited to a permanent manager, a technical director, and several machine operators. Such skilled workers proved easy to locate and hire.[109]

[103] Brittingham to Garza, 17 Mar. 1909, AHJB 63A-193. For more on the high price of imported coal to produce gas, see, for instance, Brittingham to Niggli, 24 Apr. 1909, AHJB SN07-414; also 4 May 1909 in AHJB, 63-A193 and 63-A204.

[104] Brittingham to Garza, 20 May 1909 and 21 July 1909 in AHJB 63-A212 and 63-A216.

[105] Garza to Brittingham, 7 Aug. 1909, AHJB 09-0232.

[106] Limantour to Brittingham, 18 Nov. 1908, AHJB 06-0013.

[107] Travis to Brittingham, 4 Aug. 1907, AHJB 20-0023 and Dithridge to Brittingham, 21 Feb. 1907, AHJB 20-0060.

[108] Limantour to Brittingham, 18 Nov. 1908, AHJB 06-0013.

[109] For example, see Brittingham to Walbridge, 9 Mar. 1909; Brittingham to Overa, 19 Mar. 1909; and Brittingham to Kemff, 20 Feb. 1909 in AHJB 63-A191, 63-A195, and 63-A172, respectively. One typical inquiry began, "The writer is a clean cut young business man of thirty with five years banking and eight years practical experience with the above concern [the Mannington Glass Works Company]." See Layton to Terrazas, 30 Nov. 1908, AHJB 20-0101.

The Owens system also reduced the need for unskilled labor. Instead of the old ratio of two or more assistants for each skilled blower, the automated system required only a handful of semiskilled machine tenders and a few common laborers, principally to assist the technicians and machine tenders and to facilitate the flow of raw materials and final products through the factory. Although we do not have direct evidence on the number and nature of the plant's workforce after 1911, the total payroll covered just over one hundred employees during the early years of operation. Labor costs fell to a fraction of their traditional level, as they had in the United States.[110] The majority of workers were local laborers performing unskilled jobs throughout the factory.

Technical problems in adjusting the American-designed Owens system to the Mexican context proved a more difficult challenge. For example, when engineers heated the furnaces to melt the first batch of ingredients in early September 1910, the resulting glass looked good, but the tube running from the melting furnace to the supply tanks clogged with solidified material. This "frozen throat" problem forced the American engineers to spend weeks cleaning the piping, and months to run a series of "extremely costly" experiments to find a solution to the problem.[111] November found them still working on a solution, when technicians at the Toledo Company suggested that the problem lay in the interaction between the raw materials and the design of the technology. Monterrey's furnace, they explained, was designed for the use of materials similar to those used in the United States. The silica used in the Monterrey plant cooled more quickly, and thus created the flow problem. "If we had known [this]," they wrote, "we should have designed a . . . style of furnace such as we built for the factory at Rheinahr [Germany]."[112] Although the "frozen throat" posed the biggest technological challenge in adjusting the Owens system to the new Mexican setting, a host of relatively minor issues plagued start-up efforts. The experimental production runs conducted through the fall of 1910 led to a lengthy list of minor adjustments to the system and its ancillary parts, and the entire operation remained "unsuccessful" through 1911.[113] If this was a turnkey operation, it did not imply seamless commercialization in Mexico. The "fit" between technological components of the system and constituent parts of the Mexican context—principally, but not limited to, raw materials—proved a persistent problem. The Toledo engineers thought that the Monterrey sand was the principal obstacle. "You may be able to use

[110] Mora-Torres, *Mexican Border*, 250; Snodgrass, *Deference*, 63.
[111] Walbridge to Brittingham, 8 Nov. 1910, AHJB 09-0240.
[112] Ibid.
[113] TGC, box 2, record book #3, p. 68; also the memo of 10 Nov. 1910 in AHJB 09-0276.

these materials some day," they advised the Monterrey plant, "but with your present tank we must continue to advise American materials."[114] For the Monterrey directors, however, using American sand (or fuel) was out of the question, given the additional burden of transport costs. The American engineers at the Monterrey plant had also learned this lesson, and used every effort to make the Mexican materials work.[115] They ultimately redesigned the connection between furnace and tank, although their ability to do so was delayed by the slow pace of ordering new parts and materials from U.S. suppliers.[116]

By 1912, the problems that had plagued innovation of the Owens technology for the better part of a decade had largely been solved. Although no dividends were issued to shareholders until 1918, the success of early production runs led the company to expand its capital by three hundred thousand dollars in late 1912, in order to acquire two additional Owens machines from Ohio.[117] The Vidriera's production level had begun at forty thousand bottles per day—over twice the hand-blown level—and within little more than a decade had risen to nearly one hundred and fifty thousand per day or roughly fifty million per year.[118] Although this was still below the plant's capacity, it represented a major share of national demand and largely displaced imported bottles in the Mexican market. By the mid-1920s, the Vidriera Monterrey was poised for several decades of what would be extraordinary growth. The company aggressively reinvested profits to expand and modernize the plant, developed an internal research-and-development program to improve machine- and glass-processing techniques, vertically integrated into several levels of bottle and glass production, and developed new businesses to produce crystal, flat glass, and packaging. By the 1930s, Vidriera Monterrey was itself producing all the plans and blueprints for expanded facilities and, most critically, had developed the internal capacity to

[114] Walbridge to Vidriera Monterrey, 11 Nov. 1910, AHJB 09-0239. On these and related issues, see Walbridge to Brittingham, 22 June 1907, AHJB 20-0040; Toledo Glass to Brittingham, 5 Dec. 1910, AHJB 09-0290; Livaudais to Brittingham, 28 Mar. 1911 and 19 Apr. 1911 in AHJB 09-0372 and 09-0370; Roberto Sada to Brittingham, 27 Oct. 1911, AHJB 09-0347.

[115] Mariano Hernández to Brittingham, 11 Nov. 1910, AHJB 09-0273.

[116] See Mariano Hernández to Brittingham, 5 Nov. 1910, AHJB 09-0272, also Barragán and Cerutti, *Brittingham*, 175.

[117] Hibino, "Cervecería Cuauhtémoc," 33–34. On effects of the revolution, see Barragán and Cerutti, *Juan Brittingham*, 175–76.

[118] For 1923 production figures, see the annual report of Roberto Garza Sada, manager of the factory, 31 Dec. 1923, AHJB 09-0149. For 1924 production figures, see the Dunn & Company report of 30 July 1924 in AHJB 09-0148. For comparative numbers, see Mora Torres, *Mexican Border*, 250, and Fairfield, *Fire and Sand*, 53. Despite rapid production increases, the plant continually ran below capacity through its first decade or so, largely due to wartime disruptions, not insufficient national demand.

design and manufacture its own production machinery. The firm went on to develop new machines that it marketed internationally, holding numerous foreign patents by the 1970s as an international leader in glass technology.[119]

Conclusions

Mexicans' growing propensity to drink beer after 1890 created new incentives to replace hand-blown and imported bottles with local, mechanized production. By 1905, entrepreneurs interested in this expanding market could consider adopting automated systems from abroad. This was, most believed, a simple matter of acquiring and importing the relevant hardware and know-how. Mexico, and indeed most of Latin America, witnessed a tremendous flood of technology imports from the North Atlantic between 1870 and 1920, ranging from factory-scale machinery to diverse tools, chemicals, instruments, and hardware. Indeed, technology imports underlay the partial transformation of many Latin American economies, including booming export sectors, expanding transportation facilities, urban development, and the growth of an incipient manufacturing sector. Technology imports had transformed much of the material face of Latin American economies by 1914, but a teleological view of the process is deceptive. Introducing foreign technologies in local environments without well-developed factor and product markets proved exceedingly difficult. The Owens story highlights three particular aspects of technological innovation in countries like Mexico.

First, innovation required the sustained and substantial application of entrepreneurial skills. Potential investors had to adopt business strategies appropriate to the particular market conditions in which they sought to operate; they had to convince others that the new enterprise would be economically viable in a market without an industrial foundation (especially in relation to competing imports); and they had to learn and continually negotiate aspects of the Mexican contextual environment within which the technology would now operate, including the physical environment, the nature of the market, government policy, transport costs, and human capital, and sometimes the technology itself. All three of these entrepreneurial challenges occupied Juan Brittingham and his partners over the long years between the train ride to Toledo in June 1905 and the first commercial run in Monterrey in mid-1912. All three involved the "creation rather than the acceptance of circumstances, the anticipation of future changes in the market . . . in a

[119] Barragan and Cerutti, *Juan Brittingham*, 184; Hibino, "Cervecería Cuauhtémoc."

deeply uncertain world."[120] Brittingham proved a dogged entrepreneur in this endeavor, as in many others, but this part of his character was not clearly exceptional in the broader business culture of northern Mexico. More critical was his ability to exploit a vast cross-border network of contacts, which enabled him and his partners to access information about product and factor markets.

Second, the Owens story suggests that the adoption of technology from abroad did not necessarily yield a Gerschenkronian advantage to relatively late industrializers during the long nineteenth century. Multiple obstacles prevented the easy commercialization of imported machines and processes in new environments. Technologies, designed and produced within a certain socioeconomic environment, frequently proved poorly adapted to very different contextual settings. The imported design was not inflexible; in this case, the Toledo company could (and did) provide machines and parts of alternate specifications to match local conditions, and specifications could be also modified on site. But modifications at either end were not easily recognized and accomplished. Untested aspects of the new environment and informational asymmetries presented intransigent obstacles. Only through protracted efforts, continued use of information-exchange networks, and dogged trial and error were these businessmen able to surmount the difficulties that faced them. Negotiating the necessary adaptations delayed commercialization, and in many cases led to diminished productivity or outright failure. Moreover, many of the industries built on imported technologies would remain dependent on foreign expertise well into the twentieth century.

In this regard, the Vidriera Monterrey proved exceptional. Explaining the Vidriera's success at turning initial dependence on foreign technology into a strong tradition of domestic technological leadership is beyond the scope of this paper, as it constitutes the history of this firm after 1912. The seeds of this success, however, can be glimpsed in the story told here. The partnership between the groups led by Juan Brittingham and Isaac Garza provided a particular concentration of entrepreneurial and mechanical skills, together with a transnational network of contacts and information that proved critical to the firm's success. The density and effectiveness of this informal network precipitated the emergence of a firm that would eventually internalize many of these functions. The particular environment of northern Mexico—its business culture, as well as its more ready access to cross-border factor markets and information networks—enabled the plant directors to make every effort through the first decade of operation to minimize their "dependence

[120] Brown and Rose, *Entrepreneurship*, 3.

upon foreign workmen" by training local workers who had already acquired machine skills and workshop experience in Monterrey's artisanal and workshop sectors.[121]

This story of the initial innovation of the Owens machine in Mexico suggests that the key agents of technological innovation were not foreign technology suppliers, foreign investors, or the Mexican state—although each of these played a role in the process. Instead, local investors and entrepreneurs drove the process to its conclusion through a creative process of innovation that required a tremendous investment of time, energy, and capital. Above all, it required that key entrepreneurs negotiate the obstacles to innovation over a multiyear learning process. Investment in the innovation of foreign technologies in countries like Mexico was an entrepreneurially intensive activity, largely analogous to investment in the invention and development of those technologies in the North Atlantic.

[121] Mora-Torres, *Mexican Border*, 249–52; Hibino, "Cervecería Cuauhtémoc." See also Dithridge to Brittingham and Terrazas, 15 Nov. 1906, AHJB 20-0073. On Monterrey's industrial development, see Mario Cerutti, *Burguesía, capitales e industria en el norte de México, Monterrey y su ámbito reigonal (1850–1910)* (Mexico, 1992); Alexander Saragoza, *The Monterrey Elite and the Mexican State, 1880–1940* (Austin, 1988); Michael Snodgrass, *Deference and Defiance in Monterrey* (Cambridge, U.K., 2003); Aurora Gómez Galvarriato, "El primer impulso industrializador de México: El caso de Fundidora Monterrey" (ITAM, 1990); and Vizcaya Canales, *Los Origines*.