Drawing Capital: Depiction, Machine Tools, and the Political Economy of Industrial Knowledge, 1824-1914

Drawing Capital: Depiction, Machine Tools, and the Political Economy of Industrial Knowledge, 1824-1914

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Abstract

This dissertation treats transformations in the work processes and trade practices of the engineering industries in Britain, the United States, and German-speaking Europe over the long nineteenth century. Using technical print culture and firm archives (William Fairbairn, James Nasmyth, Cockerill, Baldwin Locomotive Works, Pratt & Whitney, William Sellers & Co., Borsig, Gutehoffnungshütte, Ludwig Loewe & Co. Mannesmann, Maschinenfabrik Augsburg-Nürnberg, J.E. Reinecker), the work demonstrates how the shifting locus of control within firms recast the interests and institutions of international trade in capital goods. Whereas British authorities had attempted to police flows of machinery and crafts knowledge embodied in artisans at the beginning of the nineteenth century, German and American capital goods firms would compete to export machine tools globally by its end. Critical to this shift, drafting techniques developed by French Revolutionary mathematician Gaspard Monge spread transnationally via mechanics institutes and military academies, polytechnics and print culture.

Before the advent of Taylorism, engineering employers used design techniques to displace control over work processes from the shop-floor to the drafting room starting in the U.S. Civil War. Philadelphia economist Henry Carey and self-styled "industrial publisher" Henry Carey Baird advocated not only tariffs salutary to the engineering industries but also Greenbacks, free banking, and cheap credit to facilitate the expansion of the capital goods manufacturers and enable trade with debtor states in the South and West. In the deflationary crisis of the 1870s to 1890s, engineering works employed techniques of depiction to redefine industrial labor and industrial property toward a "second enclosure" of knowledge. The things in between, drawings and models were valuated in insurance logs and eventually depreciated on firm balance sheets.

Looking forward in another sense, firms amortized increasingly multi-national patent accounts in the wake of the 1883 Paris Convention for the Protection of Industrial Property. In Imperial Germany, white-collar technical workers unionized to seek individual patent rights against the claims of engineering employers to firm-based intellectual property based on arguments about the organicism of the modern corporation—eventually extending to all activities within a firm, beyond those amenable to drawing.

The dissertation concludes with a case study of capital goods exports to late Qing and Republican China, focused on the German "model colony" of Qingdao and railroad projects such as the Tianjin-Pukou Railway. Engineering interests established technical schools and engaged in debates over currency reform, central banking, and the standardization of measures and technical components. The transition from six imperial powers seeking commercial-territorial "spheres of influence" in China to cooperative financial imperialism in the Consortium Loans helps explain the making of modern forms of development politics and dependency.

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Acknowledgements

This dissertation was inspired by the comments of two mentors: Marcy Warner, my high school art teacher, and Michael Geyer, professor of history at the University of Chicago. The former said, “Look around you. Everything in this room was designed by someone.” *(But who was that someone? Why were they unknown? Was design always separate from and prior to fabrication? Could it ever be democratic?)* The latter encouraged my fascination with the international political economy of “machines that build machines.”

My thinking benefited from the support of my former professors at the University of Chicago: Kathleen Neils Conzen, Leora Auslander, Amy Dru Stanley, and Bill Sewell. Kathy Conzen sparked my interest via a core requirement in nineteenth-century U.S. history and taught me how to write anything approaching social history. Leora Auslander provided shots in the arm at critical junctures; this work would not have existed without her. Ke-chin Hsia and Fei-hsien Wang, now of Indiana-Bloomington, have always been generous mentors, sharing their perspectives and experiences, historical and historiographical knowledge (whether Habsburg or Qing), from a few steps ahead in life. They are better siblings than any only child could ask for.

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I have spent too many months unable to make claims and with no one to talk to. Some have faulted younger historians for disengagement with "theory" or a turn to describing worlds solely on actors' terms, abdicating their roles as arbiters of causation. But I think this hesitation emanates not from a lack of curiosity or conviction but from a surfeit of inquiries-in-parallel and colliding convictions. Alone, that surfeit is difficult to bear and then to grasp, disentangle, and re-entwine--especially in circumstances of material uncertainty. At the "Learning by the Book" conference of the German Historical Institute and Princeton, I had the opportunity to share early work with Angela Creager, Mathias Grote, and Pamela Smith. In addition to Eli Cook, I thank Jamie Pietruska and Richard John for a stimulating AHA panel on "Knowledge Production in the Long Gilded Age." I thank Holly Case, a model of scholarly fearlessness, wit, and good faith, for her well-timed *Winterfrische*. Teaching at the University of Massachusetts--Boston, I had the pleasure of working at the Labor Resource Center, a wonderful environment in which to learn.

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Introduction

We are living through a wide transformation in fabrication and design, from 3-D printing in physical production to object-oriented computing in digital construction. Some scholars theorize the obsolescence of the commodity form as digital goods are reproduced at rapid speeds and negligible costs.[1] Others forecast growing unemployment, inviting charges of neo-Luddism by those who prefer to imagine a future of creative destruction and ongoing up-skilling.[2] Yet further analysts note the increasing role of intellectual property in firm portfolios and valuations, proposing that differences in access to data, forms of immaterial or partly material property, have deepened the divide between large and small firms and contributed to overall economic inequality among individuals.[3]

Think of the manifold political, economic, bodily questions accompanying the rise of 3-D printing, or additive manufacturing: Will 3-D printing be confined to rapid prototyping, or produce the scaffolding of artificial organs *en masse*? Should the code behind CAD drawings be freely available or commoditized? Should we regulate the 3-D printing of guns and if so, how? Are 3-D printers tools for self-described "political romantics" among gun activists, survivalist

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[1] Olga Sezneva and Sébastien Chauvin, "Has Capitalism Gone Virtual? Content Containment and the Obsolescence of the Commodity," *Critical Historical Studies* 1, no. 1 (Spring 2014): 125-150; Jonathan Haskel and Stian Westlake, *Capitalism without Capital: The Rise of the Intangible Economy* (Princeton: Princeton University Press, 2017).

[2] Erik Brynjolffson and Andrew McAfee, *The Second Machine Age: Work, Progress, and Prosperity in a Time of Brilliant Technologies* (New York: W.W. Norton, 2014).

[3] Ugo Pagano and Maria Alessandra Rossi, "The Crash of the Knowledge Economy," *Cambridge Journal of Economics* 33, no. 4 (July 2012): 665–83; Economics and Statistics Administration and United States Trademark and Patent Office, U.S. Department of Commerce, Intellectual Property and the U.S. Economy: Industries in Focus, March 2012, http://www.uspto.gov/about/ipm/industries_in_focus.jsp; Herman Schwartz, "No Growth and No Equality: Supply and Demand in an Intellectual Property Rights World," paper presented before the Seminar on the State and Capitalism since 1800, Center for European Studies, Harvard University (09/25/2015).

groups, and militias (who christened the first 3-D-printed gun the "Liberator")?[4] Do fabrication laboratories (fab labs) and maker spaces offer opportunities for community control and development emancipated from corporate dictates in Chokwe Lumumba's Jackson, Mississippi?[5] Does digital design reinforce a focus on coding as individual skilling within the presumed meritocracy of the creative class?

Drawing Capital examines a previous transformation in fabrication and design, the nineteenth-century revolution in metalworking and machine-building. *Drawing Capital* is not a history of standardization or mass production. Historians note that nineteenth-century governments, often militaries, and firms pursued standardization and mass production through locks, gauges, and jigs as much as engineering drawings. However, the manufacture of metrological tools themselves relied increasingly on drawings at the *fin-de-siècle.* This is a history of drawing capital—transformations in the work practices, legal statutes, political cultures, and economic institutions governing the manipulation of images and forms.

This recasting of work, control, and knowledge equally depended on a translation, transmission, recording, accounting, and control apparatus: the technical drawing based on descriptive geometry. Lathes were not new to the nineteenth century. Drawing was not new to the nineteenth century. Geometry was not new to the nineteenth century. Lathes were not unique to Europe. Drawing was not unique to Europe. Geometry was not unique to Europe. I am interested in tracing the history of a socio-legal knowledge complex that contributed to the making of industrial capitalism and its imperial projections.

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[4] "Meet the man who might have brought on the age of 'downloadable guns,'" *The Washington Post* (July 18, 2018): https://www.washingtonpost.com/news/post-nation/wp/2018/07/18/meet-the-man-who-wants-to-bring-on-the-age-of-downloadable-guns-and-may-have-already-succeeded/

[5] Kali Akuno and Ajamu Nangwaya, *Jackson Rising: The Struggle for Economic Democracy and Black Self-determination in Jackson, Mississippi* (Montreal: Daraja Press, 2017).

Drawing Capital connects visual studies in the history of technology to labor history, business history, and the history of capitalism. Visual thinking has long interested historians of technology, particularly in terms of how inventors conceived mechanisms for power conveyance.[6] Yet, beyond the "mind's eye" of a sole inventor, it has been harder to discern the shifting forms, roles, and purposes of drawing at the firm and social levels.[7] Ken Alder shows French military engineers at the end of the eighteenth-century *ancien régime* attempting the total overcoming of craft methods, using projective drawings "to oblige artisans to produce standardized artifacts."[8]

But historians have rarely told the story of objects and skills transformations over the long nineteenth century. Analyses of practices within single firms such as the German electro-technical giant Siemens and the prominent American machine-tools manufacturer William Sellers & Co. suggest that, while drawings proved crucial to rationalizing the design process and asserting firms' claims to intellectual property, the transition to individual piece drawings to control the work process in fabrication could be partial or halting in the mid-nineteenth century.[9] By the early twentieth century, architectural design work in the United States was itself subject to routinization, prompting protests from draftsmen consigned to mere tracing.[10] Historians of

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[6] Peter Jeffrey Booker, *A History of Engineering Drawing* (London: Chatto & Windus, 1963).

[7] Eugene Ferguson, *Engineering and the Mind's Eye* (Cambridge, MA: MIT Press, 1992).

[8] Ken Alder, "Making Things the Same: Representation, Tolerance and the End of the *Ancien Régime* in France," *Social Studies of Science* 28, no. 4 (August 1998): 499-545; Ken Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763-1815* (Chicago: University of Chicago Press, 2010).

[9] Jürgen Kocka, "From Manufactory to Factory," in *Industrial Culture and Bourgeois Society: Business, Labor, and Bureaucracy in Modern Germany* (New York: Berghahn Books, 1999); John K. Brown, "When Machines Became Gray and Drawings Black and White: William Sellers and the Rationalization of Mechanical Engineering," *IA. The Journal of the Society for Industrial Archeology* 25, No. 2 (January 1999): 29-54; John K. Brown, *The Baldwin Locomotive Works, 1831-1915: A Study in American Industrial Practice* (Baltimore: Johns Hopkins University Press, 2001).

[10] George Johnston, *Drafting Culture: A Social History of Architectural Graphic Standards* (Cambridge, MA: MIT Press, 2008).

German engineering have found a similar political radicalization among draftsmen and *Pauser* (people carrying around blueprints, or *Lichtpausen*) in Imperial Germany's largest union of white-collar technical workers.[11]

Beyond Varieties of Capitalism

German and American industrial histories and forms of political economy are often treated as opposing cases: low versus high wages, skill versus mechanization, the manufacture of customized capital goods versus mass-produced consumer goods.[12] Philip Scranton has questioned these assigned binaries, showing how Philadelphia firms engaged in customizable production within networks of small and medium-sized shops well into the early twentieth century.[13] This "alternatives to Fordism" or "flexible specialization" literature upended the narrative of an inexorable American march toward Taylorism. In the adjoining disciplines of political economy and sociology, this account posited a "path not taken" and heralded a renewal of design creativity, decentralization, and workers' control via digital technologies and networks.[14] But this future has failed to materialize.

Look beyond specialized, batch production versus mass production for a moment, for both depend on drawings and patterns, castings and models. Look behind the custom or

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[11] Kees Gispen, *New Profession, Old Order: Engineers and German Society, 1815-1914* (Cambridge: Cambridge University Press, 2002), 225.

[12] Kathleen Thelen, *How Institutions Evolve: The Political Economy of Skills in Germany, Britain, the United States, and Japan* (Cambridge: Cambridge University Press, 2004); Peter Hall and David Soskice, ed. *Varieties of Capitalism: The Institutional Foundations of Comparative Advantage* (Oxford: Oxford University Press, 2001).

[13] Philip Scranton, *Endless Novelty: Specialty Production and American Industrialization* (Princeton: Princeton University Press, 2000).

[14] Jonathan Zeitlin, *World of Possibilities: Flexibility and Mass Production in Western Industrialization* (Cambridge: Cambridge University Press, 2002); Charles Sabel and Michael Piore, *The Second Industrial Divide: Possibilities for Prosperity* (New York: Basic Books, 1984).

individually designed product and find the tools of design and fabrication to make them. Then find the tools of design and fabrication to make those tools. Long production runs and mass consumption typified the mid-twentieth-century moment. Examining transitions between eras of capitalism, however, requires attention to the subterranean tectonics.

I focus on something more subtle and more pervasive about machine design: how German and American firms pursued knowledge objectification, integration, and securitization and exported industrial infrastructures—armories, railroad shops, and naval yards—to Latin America, East Asia, and Eastern Europe in the years preceding World War I. Connecting such projects, which often contained neo-imperial and anti-colonial elements alike, to the everyday work processes of capital goods firms, *Drawing Capital* illuminates how depiction practices underlay dynamics of innovation and dependency at the center of local and global economic transformations over the long nineteenth century.

Drawing Capital does not present a systematic comparison of national engineering cultures. Policymakers and analysts have stylized industrial regimes into ideal types since the nineteenth century.[15] Alfred Chandler's *Scale and Scope* counterpoised British "personal capitalism" against United States "competitive managerial capitalism" and German "cooperative managerial capitalism."[16] Studies of engineering drawing specifically have shown that draftsmen employed differing angles of projection in the United States and Europe, which complicated the transfer of technologies into effective transnational production—whether through alliance or

[15] See, for instance, Peter Meiksins, Chris Smith, and Boel Berner, eds., *Engineering Labour: Technical Workers in Comparative Perspective* (London: Verso, 1996); Richard Biernacki, *The Fabrication of Labor: Germany and Britain, 1640-1914* (Berkeley: University of California Press, 1995).

[16] Alfred Chandler, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, MA: Belknap Press, 1990).

espionage—during the world wars.[17] Historian John K. Brown has persuasively shown how the level of specification in drawings and the use of precise plans differed between the United States and the United Kingdom by the First World War, with industrial workplaces in the former having shifted significantly more control to the drafting room than those in the latter.[18]

While attentive to national distinctions in such matters as skilling institutions, industrial organization, industry-finance relations, and the social status of engineers as a profession, this study focuses on the workplace level and the trans-Atlantic, eventually global circulation of engineers, technical print culture, patents and licenses, and development agendas. This preference proceeds out of a realization that many of the pressing concerns and debates over industrial technologies —for the nineteenth century as well as our own times—were always already, or quickly became, transnational in scope. Who stood to gain by sharing, exposing, codifying, or specifying the requisite knowledge behind machine technologies in particular ways? How did the export of tools and machines transition from legally forbidden to permissible to highly desirable—backed by financiers, cartels, and governments—in less than a century?

Transnational is not to say uncontested. *Drawing Capital* does not inscribe in history a seamless flow of engineering information among *savants* and *fabricants* in an "industrial enlightenment" or trace the irresistible march of mechanization as modernization around the globe.[19] Instead, this work seeks to enter the core questions of a highly ambivalent "great transformation" through histories of depiction. The shifting constituencies surrounding machine-

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[17] Harold Belofsky, "Engineering Drawing: A Universal Language in Two Dialects," *Technology and Culture* 32, no. 1 (January 1991): 23-46.

[18] John K. Brown, "Design Plans, Working Drawings, National Styles: Engineering Practice in Great Britain and the United States, 1775-1945," *Technology and Culture* 41, no. 2 (April 2000): 195-238.

[19] Joel Mokyr, *The Enlightened Economy: Britain and the Industrial Revolution, 1700-1850* (London: Penguin, 2011) and *The Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton: Princeton University Press, 2002); Peter Jones, *Industrial Enlightenment: Science, Technology and Culture in Birmingham and the West Midlands, 1760-1820* (Manchester: Manchester University Press, 2008).

tool technologies—millwrights, mechanics, inventors, patent agents, machinists, industrialists, draftsmen, and "industrial publishers" in singular, plus unions, cartels, and industrial associations in plural—struggled over forms of knowledge in the control of work processes, the definition and defense of intellectual property, and the terms of international trade in technology. At the center of these industrial questions—questions ultimately of control and dependency, in addition to the distribution of profit, loss, risk, and debt—lay visual schema. Distinct depictive formats and techniques contributed to the separation of mental and manual labor, the making of standards of proof and objectivity in patent disputes, the standardization of components and the concentration of corporate capitalism in the machinery sector, and the growing capacity (and indeed perceived necessity, from the standpoint of organized capital goods industrialists) to export as many machines with as many applications—extractive, agricultural, industrial—as possible on the eve of the First World War.

Platform Capitalism

Drawings constituted the media of "platform capitalism" in the nineteenth-century engineering industries. Examining Philadelphia industries, historian Philip Scranton finds predominantly customizable, design-intensive batch production in the late nineteenth century, calling into question an inexorable path toward Fordism in U.S. industry. From the perspective of "platform capitalism," however, the relevant distinction is not custom batch versus standardized mass production. It may seem strange to invoke "platform capitalism" in the context of heavily capital and plant-intensive industries. After all, such firms as airbnb and Uber own virtually no physical capital stock, instead leveraging the assets of users and, in their account, providing mainly matching functions. Yet Nick Srnicek points out that the lack of ownership and asymmetry between intangible and physical capital are not the sole distinguishing features of platform capitalism. Rather, firms engaged in platform capitalism enclose and structure a market. They forge durable relationships of dependency and realize returns. Platform capitalism can also describe such firms as Amazon Web Services, General Electric, and Siemens, which increasingly offer real-time analytics of the data traffic or plant machinery they host or sell.[20] What is a platform if not an infrastructure, the platform of a railway or the flat bed beneath a machine-tool?

Beyond the information manageralism described by Alfred Chandler in the quest for throughput and stock-turn, "platform capitalism" structures the market.[21] Platform capitalism invites us to consider the salience of intangible assets and the forms they inhabit—the things in between—namely, models, patterns, templates, tables, and plans that enable the performance of multiple acts of mediation. As a communications tool, they guide the recasting of the relation between conception and fabrication, separating mental and manual labor, designers from plan readers, while a delimited and task-specific view of the object at hand.[22]

In the contemporary economy, industrial or service, the user interface enabling (self-)optimization is often interpreted within the framework of "gamification" (sometimes paired with as old regimes as piecework). The 1860s and 1870s witnessed the divergence of distinct genres of technical drawings: design drawings versus working drawings versus piece drawings. Views available to different workers and end-users fractured. This transformation in depiction dovetailed with the transition in metalworking from casting, heating and beating and chipping and chiseling, to precise cutting of cold metal. Whereas fabricating intricate metal parts had

[20] Nick Srnicek, *Platform Capitalism* (Wiley, 2016).

[21] Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Harvard University Press, 1977).

[22] JoAnne Yates, *Control through Communication: The Rise of System in American Management* (Johns Hopkins University Press, 1993).

relied on patternmakers making wooden models to be sent to moulders to cast of molten metal in sand or loam, they could now be precisely cut by machine tools—lathes, drills, milling machines, and boring machines—powered along shafting and belting by steam or eventually by electricity.

What did drafting do between two encyclopedias?

Diderot and d'Alembert's famed *Encyclopédie* sought to unveil and make legible crafts tools and processes to an emerging bourgeois public.[23] Anticipating world revolution at the end of World War I, the Industrial Workers of the World issued a call echoing this enlightened impulse, yet reverberated back through a thick film of nineteenth-century property and dependency relations outfitted in science. The Industrial Workers of the World aimed to assemble a comprehensive industrial encyclopedia such that workers from subdivided trades might reclaim control from managers and run complex systems.[24]

Drawing Capital traces what happened to technical knowledge between these two encyclopedias, one foundational and one never realized. I focus on the myriad uses of a seemingly prosaic technology: technical drawing based on descriptive geometry. A social history of technology, *Drawing Capital* interrogates where knowledge relating to machine-building lived, how it accrued to firms or to what Thorstein Veblen called the "joint stock of technical knowledge," and how knowledge formats and monopolies shaped contested processes of class formation and cascading industrializations. The near weightless schematic was the ultimate capital good—drawings were valuated as assets and even assigned depreciation rates in company

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[23] William Sewell, "Visions of Labor: Illustrations of the Mechanical Arts before, in, and after Diderot's *Encyclopédie*," in *Work in France: Representations, Meaning, Organization, and Practice*, eds. Steven L. Kaplan and Cynthia J. Koepp (Ithaca: Cornell University Press, 1986), 258-286.

[24] "The Industrial Encyclopedia," *The One Big Union Monthly* I, 13 (December 1919): 15.

account books. Drafting sparked new bases of invention via layered abstractions; however, standardized views and projections also constituted a language through which paper flows rather than people connected the drafting room to the machine shop and foundry, separating design from fabrication, holding the latter to increasingly precise standards, and providing a platform for and incentive to interchangeable, scale production at a long distance. *Drawing Capital* argues that nineteenth-century transformations in the international division of labor and the worksite division of labor need to be understood together through the industrial schematic.

Kenneth Pomeranz's account of the "Great Divergence," has explained the *why* of Europe's industrial acceleration ahead of China after 1800 via the cheap availability of coal and the ghost acreage and enslaved labor the American colonies provided European manufactures.[25] Wedded to investment, these resources subsidized production and experimentation departing from the labor-intensive path of industrialization that scholars have described for South and East Asia.[26] Joel Mokyr has attributed European industrial growth to print culture, exchange between savants and fabricants, and institutions, following the property rights argument introduced by Douglass North.[27] Deirdre McCloskey credits bourgeois ideas, values, and culture.[28]

But, with a few noteworthy exceptions, remarkably little attention has been devoted to the actual, everyday politics and political economy engineers, mechanics, and machinists

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[25] Kenneth Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern World* (Princeton University Press, 2000).

[26] Gareth Austin and Kaoru Sugihara, *Labour-Intensive Industrialization in Global History* (Routledge,);

[27] Joel Mokyr, *Gifts of Athena* and *The Enlightened Economy*.

[28] Deirdre McCloskey, *Bourgeois Equality: How Ideas, Not Capital Or Institutions, Enriched the World* (Chicago: University of Chicago Press, 2017).

engaged in the making and business of machinery and machine tools.[29] As soon as one enters their world—the world of the bench in workshops, account books, and apprenticeship contracts as well as that of public experiments at Mechanics Institutes, mass petitions to and marches on state legislatures regarding prison labor, strikes and lock-outs, testimony before parliamentary inquests on patents, lobbying efforts for infrastructure investment and tariff protection—the uselessness of bourgeois values, pure liberal thought, or a single salutary institutional matrix as an analytic, much less a causal force, becomes abundantly clear. Whether or not each of these narratives reifies racist tropes or reprises Western dominance, they miss the great debates and struggles of the nineteenth century, almost all of which engineering milieux contained in microcosm. Among the proletarianizing mechanics and ascendant industrialists, one finds not liberals but advocates of republicanism—of competing individualist, socialist, and utopian varieties. Later, in the world of the engineering industries, their export associations, cartels, and banks, one finds not liberals but modernizers—of nationalist, anti-colonial, and neo-imperial sorts, constantly in contention.

By focusing on the capital goods industries, this study contributes to understanding the history of the *how* of divergence over the long nineteenth century—as well as the dynamics and emerging ideology of "catching up." Starting in the 1960s and 1970s, historical and social scientific studies focused on factors conducive to technology transfer.[30] Alexander Gerschenkron posited the "advantages of backwardness," whereby countries could rapidly reach the industrial

[29] These exceptions include Maxine Berg, *The Machinery Question and the Making of Political Economy, 1815-1848* (Cambridge: Cambridge University Press, 1987); Carolyn Cooper, *Shaping Invention: Thomas Blanchard's Machinery and Patent Management in Nineteenth-Century America* (New York: Columbia University Press, 1991).

[30] Peter Mathias, "Skills and the Diffusion of Innovations from Britain in the Eighteenth Century," *Transactions of the Royal Historical Society*, Vol. 25 (1975): 93-113; David Landes, The Unbound Prometheus; David J. Jeremy, *International Technology Transfer: Europe, Japan and the USA, 1700-1914* (Brookfield, 1991); Chang Jui-Te, "Technology Transfer in Modern China: The Case of Railway Enterprise (1876-1937)," *Modern Asian Studies*, 27, 2 (1993): 281-296; Ralf Banken and Christian Marx, "Knowledge Transfer in the Industrial Age: The Case of Gutehoffnungshütte, 1810-1945," *Jahrbuch für Wirtschaftsgeschichte* 56, no. 1 (2015): 197-225.

state-of-the-art without replicating the entire development path behind the imported technologies.[31] More recently, Michael Adas has shown how European and American governments relied on "machines as the measure of men" in the era of the new imperialism to legitimate projects of formal and informal conquest.[32]

The lathe is, in its essentials, an approximately 2700-year-old technology.[33] Lathes—worked by hand, foot, or eventually electricity—could be found most everywhere in the world. But rarely were there firms, much less industries, focused wholly on tool-making or the manufacture of machines to make machines. In 1800, the world over, craftsmen usually fashioned their own tools. Similarly, early modern artisans kept internal stocks of patterns, while virtually no one defined himself as, or had his activities confined to, draftsman alone. So this is neither a story of the diffusion of mechanization, West to East, nor one of the diffusion of knowledge, North to South—all time-worn imperialist tales. This is a story of a particular social relation rendered most visible in the act of drawing and the fate of its product.

The shifting forms of knowledge monopolies were reflected in the changing terms and regulatory mechanisms of global trade. Between 1750 and 1795, Britain passed a series of statutes against the emigration of artisans, the shipment of models and drawings, and the export of tools and machines, strengthening the penalties after American independence. Emigrating

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[31] Alexander Gerschenkron, *Economic Backwardness in Historical Perspective* (Cambridge, MA: Belknap Press, 1966).

[32] Michael Adas, *Machines as the Measure of Men: Science, Technology and Ideologies of Western Dominance* (Ithaca: Cornell University Press, 2015) and *Dominance by Design: Technological Imperatives and America's Civilizing Mission* (Cambridge, MA: Harvard University Press, 2009).

[33] Torsten Capelle and Hans Drescher, "Drehbank und Drechslerei," in Germanische Altertumskunde Online: Kulturgeschichte bis ins Frühmittelalter--Archäologie, Geschichte, Philologie, eds. Heinrich Beck et al., accessed September 14, 2017, https://www.degruyter.com/view/db/gao; the discussion of Jacques Besson's lathe in the making of items for royal Kunstkammern and instrument collections in "Drehbank," Enzyklopädie der Neuzeit Online, accessed September 14, 2017, http://referenceworks.brillonline.com/browse/enzyklopaedie-der-neuzeit; Liliane Hilaire-Perez, "Dissemination of Technical Knowledge in the Middle Ages and the Early Modern Era: New Approaches and Methodological Issues," *Technology and Culture* 47, no. 3 (2006): 536-565.

craftsmen risked forfeiture of citizenship and charges of treason. Recruiters of skilled labor faced fines of £500 and yearlong imprisonment (try it a second time, and you were liable for double the fine and time imprisoned).[34] Models, drawings, and machines were, of course, confiscated by the state. Yet knowledge pirates, foremost among them Alexander Hamilton, were undeterred. Seeking to stimulate the development of American manufactures, Hamilton lobbied for measures to induce artisanal migrations from Britain in hopes of achieving technology transfers.[35] Industrial innovation still lay in largely tacit knowledge of millwrights and shipwrights, so economic policy continued to revolve around the policing of footloose artisans.

One by one, with ongoing and vociferous public debate over the sources of national economic supremacy, the British parliament repealed these statutes: the migration restrictions in 1825, the ban on machinery exports in 1845. Though riding the more general wave of Free Trade culminating in the abolition of the Corn Laws, these policy shifts reflected a deeper social transformation.[36] Artisanal knowledge was being corralled, codified, and ultimately displaced; the impulse to monopolize machines in secrecy was being challenged by a desire to sell them. Tellingly, the drawings and models experienced a somewhat different fate. Following

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[34] Joseph Shaw, *The Practical Justice of Peace, and Parish and Ward-officer: Or, a Treatise Shewing the Present Power and Authority of These Officers, in All the Branches of Their Duty, Volume 1* (London: Henry Lintot, 1756), 86-87. Joseph Chitty, *A treatise on the laws of commerce and manufactures, and the contracts relating thereto: with an appendix of treaties, statutes, and precedents, Volume 1* (London: A. Strahan, 1824), 580-582. For a recounting of one such incident of industrial espionage and debate over how to prevent it, see Isaac Kimber and Edward Kimber, "Debates of a Political Society," *Gentleman's Monthly Intelligencer*, vol. 44 (R. Baldwin, 1775), 221.

[35] Doron Ben-Atar, *Trade Secrets: Intellectual Piracy and the Origins of American Industrial Power* (New Haven: Yale University Press, 2008); Doron Ben-Atar, "Alexander Hamilton's Alternative: Technology Piracy and the Report on Manufactures," *The William and Mary Quarterly* 52, No. 3 (July 1995): 389-414; David J. Jeremy, "British Textile Technology Transmission to the United States: The Philadelphia Region Experience, 1770-1820," *Business History Review* (Spring 1973); David J. Jeremy, "Damming the Flood: British Government Efforts to Check the Outflow of Technicians and Machinery, 1780-1843," *Business History Review* 51, no. 1 (Spring 1977).

[36] Labor was by no means free, though. Master and Servant Law (1823) criminalized breach of contract while the Poor Laws (1834) forced the unemployed into the workhouse; similar restrictions on labor mobility, behavior, and the question of contract also typified Reconstruction in America—see Amy Dru Stanley, *From Bondage to Contract: Wage Labor, Marriage, and the Market in the Age of Slave Emancipation* (Cambridge: Cambridge University Press, 1998).

widespread technology piracy at the 1851 Crystal Palace and subsequent World's Fairs, international congresses convened to establish reciprocal patenting codes and licensing procedures. An international legal infrastructure and expanding patent cartels would protect the rights of inventors and increasingly large corporations as the relays of global trade multiplied.[37]

By the end of the nineteenth century, machine-building firms in the two nations which had caught up industrially, Germany and the United States, were vying to *export* capital goods and expertise, believing they could sell and install industrial machinery while preserving knowledge monopolies—or even profit on the transfer of patents and skills themselves while somehow retaining an industrial edge. Whereas Samuel Slater had had to memorize the design of cotton textile machinery to smuggle it out of Britain and into New England, a handful of German firms alone shipped the plans and components for everything from Siemens-Martin furnaces to complete glass factories and beet sugar refineries to Qing and Republican China within just a few years preceding World War I.[38]

Drawing Capital argues that nineteenth-century transformations in class politics, global trade, and forms of imperialism need to be understood together through the reformatting of technical knowledge. It examines the contested process of breaking craft monopolies, establishing engineering hegemony, and commodifying technical know-how via the print cultures, educational institutions, and legal norms surrounding the industrial schematic. On the one hand, employing descriptive geometry alongside Newtonian physics, it sparked a cascade of abstractions and enabled new bases of invention. On the other, standardized views and

[37] Edith Penrose, *The Economics of the International Patent System* (Baltimore: Johns Hopkins University Press, 1951).

[38] "German Machinery in China: Glass Factory," *The Far Eastern Review* (August 1906); "Smokeless Powder Machinery For China," *The Far Eastern Review* (May 1907); see also, Dirk van Laak, *Ueber Alles in der Welt: Deutscher Imperialismus im 19. und 20. Jahrhundert* (Munich: Beck, 2005).

projections—the section, plan, and elevation—constituted a language through which paper flows rather than people connected the drafting room to the shop floor.

Although the turn to standardized and proprietary technical drawings proceeded at different paces in different firms, industries, and locations, productive knowledge came to no longer resided in the tacit, relational understandings ensconced within guilds with particularistic legal recognition to practice a craft or in the small, multipurpose "jobbing" shops of proprietary capitalists but rather in drafting systems legible to experts, owned by firms, and alienable for profit. The results varied. Technical drawing did not always lead to centralized mass production. In the nineteenth-century clothing industry, for instance, commercial patterning was indeed used to separate the mental work of design into a "scientific" male realm, leaving women with increasingly menial sewing assignments. However, mass patterning also revived home production with average women feeling increasingly capable of taking on complex dressmaking with the aid of formula-based paper patterns.[39]

Drawing also featured prominently in the eighteenth and nineteenth-century consumer goods industries. Eighteenth-century France, competing on design quality in global markets, instituted drawing programs for its artisans as did William Morris and John Ruskin a century later in Britain. Although clothing and other consumer goods were major parts of eighteenth and nineteenth-century world economies, this dissertation does not focus on drawing as it relates to tailoring cloth to bodies or ornamenting the surfaces of ceramics, textiles, or wallpaper. Rather, it focuses on capital goods (machinery) and drawings of "machines that make machines." Historian

[39] Michael Zakim, "Customizing the Industrial Revolution: The Reinvention of Tailoring in the Nineteenth Century," *Winterthur Portfolio* 33, No. 1 (Spring 1998): 41-58; Wendy Gamber, "'Reduced to Science': Gender, Technology, and Power in the American Dressmaking Trade, 1860-1910," *Technology and Culture* 36, No. 3 (July 1995): 455-482; Margaret Walsh, "The Democratization of Fashion: The Emergence of the Women's Dress Pattern Industry," *The Journal of American History* 66, No. 2 (September 1979): 299-313; on gender and machine technology in general, see Cynthia Cockburn, *Machinery of Dominance: Men, Women and Technical Know-How* (Boston: Northeastern University Press, 1988).

of technology Nathan Rosenberg argued that the capital goods industry functions as the spur to common process developments from which diverse innovations in application emerge.[40] Accordingly, Rosenberg expressed concern that developing countries directly importing machinery may not have the opportunity to develop domestic capital goods industries, resulting in an inability to sustain innovation and the prolongation of dependency.

Moreover, while commodity histories have experienced a revival within the "history of capitalism," fewer historians have investigated the shared technologies behind the processing and distribution of diverse raw goods (excepting, of course, the railroad).[41] *Drawing Capital* focuses squarely on the drawing and design, manufacture and sale, of mill components, steam engines, and eventually the machine tools—such as lathes, steam hammers, milling machines, and boring machines—to make them. Like nineteenth-century mechanics, machinists, and engineers, it recognizes that an array of common mechanical relations and physical systems lay behind the initial processing and extraction of raw goods (cotton, sugar, ore), their locomotion (by steamboat or railroad), and secondary transformations (textiles, confections, or steel). It then asks: How were these systems formalized, standardized, and transferred? How were they owned, managed, and profited upon? Economic historians have drawn a distinction between consumer goods' producers with incentives to hoard mechanical process innovations versus capital goods' producers whose very business is in selling innovative production tools. I build on and complicate this notion by embedding it within contemporary debates over international economic competition, workplace divisions of labor, and forms of empire.

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[40] Nathan Rosenberg, "Economic Development and the Transfer of Technology: Some Historical Perspectives," *Technology and Culture* 11, no. 4 (October 1970): 550-575.

[41] Sven Beckert, *Empire of Cotton: A Global History* (New York: Knopf, 2015); on recent railroad historiography, see Richard White, *Railroaded: The Transcontinentals and the Making of Modern America* (New York: Norton, 2011); for railroading in labor history, see Walter Licht, *Working for the Railroad: The Organization of Work in the Nineteenth Century* (Princeton: Princeton University Press, 1983).

The revolutionary era of the late eighteenth-century did not mark the advent of drawing machines, nor did the period's inventors and *philosophes* initiate the collecting, collating, and printing of machine drawings. The long nineteenth century did witness, however, connections both wide and deep between novel ways of seeing and irrevocable renovations in social relations of production.[42] As art historians such as Celina Fox have pointed out, drawings were not merely reflective but productive of industrial change.[43]

Machine drawings from the later Middle Ages employed a variety of indeterminate, mixed viewpoints, which, rather than indicating a childlike inability to draw in perspective, assumed a high degree of mechanical knowledge on the parts of the artisans involved in building projects. Medieval and early modern designers produced no finished shop drawings; all plans were essentially provisional and experimental, a fact evinced by their lack of measurements and notation. They were neither standardized nor accurate, so there was instead a constant exchange between the designer and whatever cutters, carpenters, masons, and molders involved in construction. Historian of technology Rainer Leng explains that "detailed information about materials, measurements or any special mechanisms could be omitted" because "before early industrial mass-production, every craftsman had to develop made to measure solutions for each single device to make it work."[44] Even at the end of building processes, this practice did not typically yield complete designs. Many early geometrical approaches, such as those in stone-cutting, were very literal in the sense that drawings became full-scale patterns traced directly

[42] Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, MA: MIT Press, 1992).

[43] Celina Fox, *The Arts of Industry in the Age of Enlightenment* (New Haven: Yale University Press, 2009).

[44] Rainer Leng, "Social Character, Pictorial Style, and the Grammar of Technical Illustrations in Craftsmen's Manuscripts in the Late Middle Ages," in Wolfgang Lefèvre, ed. *Picturing Machines, 1400-1700* (Cambridge, MA: MIT Press, 2004), 92.

onto materials, then chiseled, hewn, or set into place. As a consequence, crafts drawings were not usually kept beyond particular projects and rarely disseminated.[45]

While individual architects, engineers, and inventors collected sketchbooks of impressive buildings or machines they had seen while traveling ("private archives," as historian Marcus Popplow puts it), only in the early modern period did printed works of marvels such as "theatres of machines" circulate ever more widely and systematic or concerted preservation of productive knowledge on paper begin.[46] Mercantilist states led many information collection efforts in hopes of promoting economic success by encouraging technological innovation, regulating guild activities, and exercising fiscal control. French finance and naval minister Colbert commissioned from the *Académie des Sciences* the *Descriptions des Arts et Métiers* in 1693, intended to be "a complete review of the mechanical arts."[47] It was supposed to follow a double-entry system, logical and classificatory; however, the final version published in 1761 offered merely a "juxtaposition of descriptions."[48] Seventeenth and eighteenth-century excise officers in Britain made detailed recordings of the stocks, tools, methods, and layouts of workshops.[49] In some ways, drawings of craft production in Diderot and d'Alembert's *Encyclopédie* and Johann Beckmann's *Beyträge zur Geschichte der Erfindungen* in cameralist Central Europe continued these activities and visual norms, presenting inventories of tools or showing men and women at

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[45] On secrecy and ownership ideas from classical times to the early modern period, see Pamela O. Long, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore: Johns Hopkins University Press, 2003).

[46] Bertrand Gille, *History of Techniques* (New York: Gordon and Breach Science Publishers, 1986), 1151; Marcus Popplow, "Why draw pictures of machines?: The Social Contexts of Early Modern Machine Drawings," in Wolfgang Lefèvre, ed. *Picturing Machines, 1400-1700* (Cambridge, MA: MIT Press, 2004), 17.

[47] Gille, *History of Techniques*, 1151.

[48] Ibid., 1152.

[49] William J. Ashworth, "Quality and the Roots of Manufacturing 'Expertise' in Eighteenth-Century Britain," in *Expertise: Practical Knowledge and the Early Modern State* (Chicago: University of Chicago Press, 2010).

work in particular tasks. However, they pushed further by introducing technical knowledge into an emergent public sphere and attempting to identify common principles behind multiple trades.

Renaissance advances in perspectival drawing are a familiar tale running through Filippo Brunelleschi, Leon Battista Alberti, and Leonardo da Vinci. Engineering drawing, however, depends not on realistic rendering but rather on accurate measurement in orthographic projection (three sections or elevations at right angles from one another, also reinvented during the Renaissance).[50] Indeed, engineers elevated orthographic projection over more visually convincing and painterly approaches to perspective in an attempt to wrest production processes from artisans and exert greater control over their work processes.[51]

Bruno Latour calls such plans "immutable mobiles," or invented objects having "the properties of being mobile but also immutable, presentable, readable and combinable with one another."[52] The *Encyclopédie* sought a generalization of principles inherent in a diverse array of arts and manufactures. To this end, it aimed to catalogue: "the material, the places where it is located, the manner in which one prepares it, its good and bad qualities"; "the principal works that one can make of it, and the manner of making them"; "the name, the description, and the number of tools and of machines, by detached pieces and by assembled pieces; the cross-section of the mills and of other instruments, in which it is appropriate to know the interior, their profiles, etc."; and "the proper terms of the art." Taking snapshots of a fluid process, Diderot and d'Alembert were creating an item-by-item inventory, supply chains, and web of potential production pathways—wrenching knowledge out of guilds and into the bourgeois public

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[50] Peter Lloyd Jones, "Drawing for Designing," *Leonardo* 17, no. 4 (1984): 269-276.

[51] Ken Alder, "Making Things the Same: Representation, Tolerance and the End of the *Ancien Regime* in France," *Social Studies of Science* 28, no. 4 (August 1998): 499-545.

[52] Bruno Latour, "Drawing Things Together," in Michael Lynch and Steve Woolgar, eds., *Representation in Scientific Practice* (Cambridge, MA: MIT Press, 1990)

sphere. Diderot and d'Alembert sent draftsmen into workshops to sketch machines and tools, omitting nothing. Yet unlike later shop drawings, the illustrations in the *Encyclopédie* could not define the actual production process in its authors' view, for it was "the *main-d'oeuvre* which makes the artist, and it is not at all in books that one can learn to maneuver."

The triumph of the machine in printing influenced the course of the machine industry itself. Stereotyping and advances in lithography rapidly cheapened the printing of tables and aided in the reproduction of images production.[53] While a subscription to the *Encyclopédie* would have cost the entire annual wages of an average Parisian artisan, works such as Oliver Evans's *The Young Mill-wright and Miller's Guide* and Egbert Pomeroy Watson's *The Modern Practice of American Machinists & Engineers* as well as J.N.P. Hachette's *Applications de géométrie descriptive* and Franz Reuleaux's *Theoretische-Kinematik: Grundzüge einer Theorie des Maschinenwesens* were readily accessible to the middling sorts from the 1830s onward.[54]

Such guides simultaneously reformed the bases of technical knowhow while constituting a significant part of attempts to counter proletarianization via self-uplift. They fostered types and degrees of numeracy, understandings of materials, and the categories underlying engineering specializations. They provided a means for the autodidact, the student, or the apprentice to navigate between the legible and the encoded. Over the nineteenth century, three trends are significant in this genre of guides and manuals. First, they increasingly separated machine drawing from machine design. Second, they fractured from a universal set of basic machine designs into various technical specializations.

[53] Erika Piola, ed., *Philadelphia on Stone: Commercial Lithography in Philadelphia, 1828-1878* (University Park, PA: Pennsylvania State University Press, 2012).

[54] Oliver Evans, *The Young Mill-wright and Miller's Guide* (Philadelphia: Carey and Lea, 1832 [1795]); Egbert Pomeroy Watson's *The Modern Practice of American Machinists & Engineers* (Philadelphia: Henry Carey Baird, 1867); J.N.P. Hachette, *Applications de géometrie descriptive* (Paris: Corby, 1822); Franz Reuleaux, *Theoretische-Kinematik: Grundzüge einer Theorie des Maschinenwesens* (Braunschweig: Friedrich Vieweg und Sohn, 1875).

Chapter Outline

Chapter one, "Prime Movers," examines debates over the repeal of Britain's laws forbidding the emigration of artisans and the export of tools and machines. Using parliamentary inquests regarding the reform of the patent laws alongside the firm records and engineering drawings of James Nasmyth and William Fairbairn, I reconstruct understandings of where the locus of technical knowledge lay and how such understandings changed with the engineering industries' relocation from London to Lancashire. Altered approaches to machine-tool design and use, not merely the overall growth of the capital goods sector, enabled constituencies of machine-builders and machine-users in Manchester to rally behind the repeal of the export restrictions and the strengthening of British patent law to protect strictly defined intellectual commodities.

Chapter two, "Power Conveyance," looks at how, contemporaneously with the shifts in machinery building in Britain, French revolutionary mathematician Gaspard Monge's descriptive geometry, the basis for the projections employed in all modern drafting, began a transnational afterlife. It seeks to uncover the uneven routes through which the first generation of mechanical engineers learned to draw according to Mongean principles in institutions from polytechnics in the German states to military academies and mechanics institutes in the United States. Technological print culture furthered the epistemic transformation of the trades. Using correspondence, account books, and works published, I show how self-styled "industrial publisher" Henry Carey Baird integrated the findings of craftsmen-inventors, scientists, frontier surveyors, and armories across the Atlantic while lobbying for a political economy favorable to capital goods—from tariff regimes to a combination of weak (international and authorial) copyright and strong patent law.

Chapter three, "The Lathe of Heaven" treats visual techniques in capital standardization and concentration during and after the U.S. Civil War—from the setting of the Sellers standard screw-thread for the American continent by Philadelphia's Franklin Institute to $1.28 million (today $27.6 million) in orders from the Prussian armories to Pratt & Whitney. Baldwin Locomotive Works, for instance, expanded enormously, re-outfitting itself with heavier machinery and a catalogue of six thousand piece drawings as an information infrastructure to enable scale production with flexibility.

Chapter four, "The Caged Simulacrum," examines debates over industrial education and the manual training movement in the United States during the Long Gilded Age. Following the erosion of the apprenticeship system, labor organizations, industrial associations, and education reformers weighed introducing depictive and design skills into schooling as a means to reunite head and hand in industrial capitalism. But they operated neither on a tabula rasa of cultural, racial, and colonial politics nor within a hermetic capsule of the nation-state. Within the United States, manual training regimes circulated among diverse Eastern and Midwestern cities, the Indian School Service, and New South industrialization projects. Elite reformers and export promoters crossed the Atlantic in search of the best way to achieve social progress or competitive products through education; long before those journeys, however, German immigrants had arrived in the United States with distinct notions of the breadth of education and its bearing on citizenship. Bringing together the history of German immigration, Native American history, and the history of New South industrialization, this chapter explains how despite widespread German influence on pedagogy, the United States developed skilling institutions and a system of political economy quite different from those of Germany.

Chapter five, "Drafting Protection for Immaterial Property in the Age of Heavy Industry," investigates how machinery firms responded to the deflationary crisis from 1873 to 1896 by engaging depiction to redefine industrial property in patent law and materials science. In the context of an internationalizing patent regime and the establishment of multinational industrial branch-works, it examines how German and American machinery firms sought to establish a norm of firm-based intellectual property. Struggles over the idea of the "company invention" culminated in debates over the meaning of the person in industrial society. They encompassed contests over the definition of contract and rights to organize in corporate capitalism, the just allocation of intellectual property rights versus the public good or the bodily security of shop-floor workers, as radicalization grew among technical white-collar workers. Efforts intensified to gather visual evidence of each step or material left in the wake of production. Changing visual regimes altered the nature of testimony in intellectual property disputes. Materials science ("strength of materials") emerged from processes of class formation and class conflict.

Chapter six, "Drafting Empire," analyzes how, once consolidated or cartelized, German capital goods firms undertook such projects as shipping the behemoth Yellow River Bridge for the Tianjin-Pukou Railroad from the 1890s to World War I. Firms such as Maschinenfabrik Augsburg-Nürnberg exported tools while attempting to ensure through treaty terms, the setting of standards, and language training for local technicians, that future orders would flow back to the machining metropoles. German engineers, naval authorities, and diplomats attempted to develop the Chinese province of Shandong, adjacent to their "model colony" of Qingdao, into an industrial and commercial zone with a focus on expanding local rail transport and purchasing power to further German machinery exports and capital accumulation.

This chapter and the next introduce the history of technology into that of German "soft power" imperialism in the era of the First Globalization.[55] To reflect the indeterminacy and inequality of this project—which involved gruesome labor exploitation by German engineers and donations to Chinese technical education by Rhenish firms, the destruction of Chinese familial gravesites for railroad rights of way and Boxer Movement resistance in western Shandong province—I call the ideology emergent within the political economy of capital goods-based development a "mission industrialisatrice."

Although it held the potential to disrupt the binary, Ricardian view of the global economy as divided into fixed zones of raw goods production versus industrial manufacture, the "industrializing mission" relied on premises as racialized as those in the civilizing mission. German press organs and imperialist associations celebrated overseas infrastructure projects as exemplars of "deutsche Arbeit," while company newspapers such as the *M.A.N.-Zeitung* published speeches by engineers and dignitaries and photo spreads about its projects abroad in an attempt to inspire an *esprit de corps* immune to class conflict among the firm's workers.[56]

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[55] H. Glenn Penny, "Material Connections: German Schools, Things, and Soft Power in Argentina and Chile from the 1880s through the Interwar Period," *Comparative Studies in Society and History* 59, no. 3 (July 2017): 519-549; Stephen Gross, *Export Empire: German Soft Power in Southeastern Europe, 1890-1945* (Cambridge: Cambridge University Press, 2016).

[56] Julius Dorpmüller, "Ein deutsches Bauwerk in China, Rede des Chefingenieurs Baurat Dorpmüller zur Feier des letzten Nietschlags der Hoanghobrücke am 16ten November 1912," *Der Ostasiatische Lloyd* 49 (December 6, 1912); "Die neueste Hoangho-Brücke," *Frankfurter Zeitung* (December 30, 1912); "Die Einweihung der Hoangho-Brücke am 16. November 1912, aus der 'Deutschen Japan-Post vom 7. Dezember 1912," *Der Auslandsdeutsche, Illustrierte Vereinszeitschrift des Hauptverbandes Deutscher Flottenvereine im Auslande* 2, no. 1 (January 1913); "Fertigstellung der Hoangho-Brücke in China," *M.A.N.-Zeitung* 6 (November 1912): 17; "Die Hoangho-Brücke, bearbeitet von Regierungsbaumeister a.D. Bruno Schulz"; "Asien: Erfolge der deutschen Industrie in China," *Kölnische Volks-Zeitung* (December 3, 1912).

Chapter seven, "Machining the *Mission Industrialisatrice*," analyzes how multiple railroading powers in late Qing and Republican China transitioned from seeking to establish territorial "spheres of influence" for commerce to a form of collaborative financial imperialism based on the construction of networked industrial infrastructure itself. Historians of American imperialism have argued that the *fin-de-siècle* "search for markets" should instead be understood as a search for investment opportunities, a view theorized by contemporary economists, economic journalists, and "money doctors."[57] German capital goods exports and infrastructure-building were watched keenly by American industrialists, commercial chambers, and consular services. These infrastructure-building efforts prompted a rethinking of the U.S. "Open Door" policy, which resulted in a willingness to take up the economic "re-awakening" of China—even if it involved participation in multilateral loans such as the Chinese Consortium Loans or organizing export cartels such as the American International Development Corporation.

[57] Carl P. Parrini and Martin J. Sklar, "New Thinking about the Market, 1896-1904: Some American Economists on Investment and the Theory of Surplus Capital," *The Journal of Economic History* 43, no. 3 (September 1983): 559-578.

Chapter One: Prime Movers

Knowledge Politics of Revolutions in Skill, Tools, and Trade in Britain, 1824-1852

"Which is worth most to the country, the tools and machinery exported, or the men who make them?" asked Christian socialist and cooperative promoter John Malcolm Forbes Ludlow on the occasion of the January 1852 lockout throughout British engineering firms—Maudslay and Field, J. Penn, Miller & Ravenhill, Fairbairn, Nasmyth, Whitworth, Vulcan Foundry, Sharp, Roberts, & Co., and the Oldham firm Hibbert & Platt among them.[1] The engineering employers had launched a coordinated and calculated response to the Amalgamated Society of Engineers' strike extending from London to Lancashire.[2] The three London-based firms of Maudslay & Field, J. Penn, and Miller & Ravenhill locked out 2100 men alone. In Lancashire, thirty-six engineering works locked out over ten thousand. In striking, the Amalgamated Society, comprised of 11,829 engineers, machinists, millwrights, and boilermakers in over a hundred towns, objected to piecework, working hours, and overtime, criticized the employment of semiskilled workers, mounted a defense of the apprenticeship system, and called for the abolition of self-acting machines.[3] According to engineering employer and steam-hammer inventor James Nasmyth, "everything was paralysed for a time."[4]

In the 1860s, Karl Marx would describe Nasmyth's steam-hammer in dramatic prose:

> …the steam-hammer works with an ordinary hammer head, but of such a weight that not Thor himself could wield it. These steam-hammers are an invention of Nasmyth, and

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[1] John Malcolm Forbes Ludlow, "The master engineers and their workmen: Three lectures, on the relations of Capital and Labour delivered by request of the Society for Promoting Working Men's Associations, at the Marylebone Literary and Scientific Institution, on the 13th, 20th & 27th of February, 1852" (London: J.J. Bezer, 1852).

[2] "Fifty Years of Unionism: A Retrospect," *Engineering*, December 10, 1897.

[3] Ainsworth Rand Spofford, *An American Almanac and Treasury of Facts, Statistical, Financial, and Political* (American News Company, 1878); Kathleen Thelen, *How Institutions Evolve: The Political Economy of Skills in Britain, Germany, Japan, and the U.S.* (Cambridge: Cambridge University Press, 2004).

[4] James Nasmyth, *James Nasmyth: Engineer, An Autobiography*, ed. Samuel Smiles (London, 1883), 311.

> there is one that weighs over 6 tons and strikes with a vertical fall of 7 feet, on an anvil weighing 36 tons. It is mere child's-play for it to crush a block of granite into powder, yet it is no less capable of driving, with a succession of light taps, a nail into a piece of soft wood.[5]

Rather than its novel design, indefatigability, or pure force, the most salient feature of the steam-hammer for Marx was its flexibility in intensity. He called the mechanical lathe "only a cyclopean reproduction of the ordinary foot-lathe" and the planing machine merely "an iron carpenter, that works on iron with the same tools that the human carpenter employs on wood; the instrument that, on the London wharves, cuts the veneers, is a gigantic razor; the tool of the shearing machine, which shears iron as easily as a tailor's scissors cut cloth, is a monster pair of scissors." Far from novel in Marx's assessment, these tools were simply the "the manual implements re-appearing, but on a cyclopean scale."

For Marx, the steam engine constituted the revolutionary prime mover behind these machine tools: the "most essential condition to the production of machines by machines" was "a prime mover capable of exerting any amount of force, and yet under perfect control."[6] Yet he noted an interdependence between the technologies, writing that the "operating part of the boring machine is an immense drill driven by a steam-engine; without this machine, on the other hand, the cylinders of large steam-engines and of hydraulic presses could not be made."

Subsequent commentators have shown how fundamental the cylinder and the lathe—as an abstract cylinder—were to the widespread reformatting of industry in the nineteenth century. At its base, Helmut Müller-Sievers observes, perfect, ceaseless rotation is not a human motion, nor one found elsewhere in nature. Yet cylinders were ubiquitous in the nineteenth century: "locomotives and paper machines, gas holders and Yale locks, sanitation pipes and wires, rotary

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[5] Karl Marx, "The Development of Machinery," *Capital, Vol. I* (1867), https://www.marxists.org/archive/marx/works/1867-c1/ch15.htm#S1, accessed April 6, 2019.

[6] Marx, "The Development of Machinery," *Capital, Vol. I*.

printing presses and phonographs, panoramas and carousels, tin cans and top hats." [7] The cylinder was also a form most amenable to comprehensive specification, of lines and intersections, via technical drawing by descriptive geometry (see chapter two).

In the 1851-1852 strike engineering employers prevailed when the Amalgamated Society ran short of funds, strikebreakers occupied their positions, and owners such as Nasmyth "largely increased the number of self-acting machines, and gave a still greater amount of employment to…unbound apprentices." Nasmyth understood this as a critical juncture in the development of his firm when he placed himself "in an almost impregnable position" to pursue, in his view, his "business with full activity and increasing prosperity, and at the same time maintain good-feeling between employed and employer."[8] Smaller engineering enterprises outside of the conflict submitted few orders to Nasmyth, but other large-scale Lancashire firms engaged in the lockout rapidly filled his order books for machine tools.[9] Nasmyth wrote conclusively in his memoirs (edited by Samuel Smiles): "This was the last contest I had with Trades' Unions."[10]

On an 1884 visit to British machinery manufacturers, Philadelphia engineer Coleman Sellers received a tour of the Oldham works of Platt Brothers outside of Manchester from their chief draftsman. Sellers wrote that the dominant textile machinery firm, "employ over 5000 men and they at the time of the great strike in '51 and '52 held out the longest and so far as they are concerned they broke the back bone of the Union." Sellers recounted that Platt Brothers claimed "to be free from all complication of that kind and to have very good control of their men." When

[7] Helmut Müller-Sievers, *The Cylinder: Kinematics of the Nineteenth Century* (Berkeley: University of California Press, 2012).

[8] Ibid., 311.

[9] Keith Burgess, "Technological Change and the 1852 Lock-out in the British Engineering Industry," *International Review of Social History* 14, no. 2 (1969): 236.

[10] Nasmyth, *Autobiography*, 311.

Sellers asked the smith "how many men he had," his answer was two hundred and twenty-two. Of this number, however, the smith denominated "16 smiths and the rest are scabs." The majority worked as "men and boys to any amount, who have no skill but the skill that has been given them in one single art and to that they stick their whole life."[11] In *Condition of the Working Class in England*, Engels had found "countless persons who have, from perpetually filing at the lathe, crooked backs and one leg crooked, 'hind-leg' as they call it, so that the two legs have the form of a K."[12]

Commenting on Andrew Ure's observation that a machine-factory "displayed the division of labour in manifold gradations – the file, the drill, the lathe, having each its different workman in the order of skill," Marx called "the workshop for the production of the instruments of labour themselves" one of the "most finished creations" of capitalism. Via their internal division of labor, machinery workshops would proceed to "sweep away the handicraftsman's work as the regulating principle of social production." Marx noted a deep irony or pyrrhic paradox in this particular development: "on the one hand, the technical reason for the life-long annexation of the workman to a detail function is removed. On the other hand, the fetters that this same principle laid on the dominion of capital, fall away."[13]

It is telling that the Sellerses received their 1884 tour of Platt Brothers according to the historical understanding and workshop itinerary of the chief draftsman, the manager of an institution, the drafting room, barely two decades old. Fin-de-siècle labor writers and New Social Historians alike interpreted the 1851-1852 engineers' strike as a conflict over the transition from

[11] Coleman Sellers Letter-book, 317, American Philosophical Society.

[12] Friedrich Engels, *Condition of the Working Class in England* (1845), https://www.marxists.org/archive/marx/works/1845/condition-working-class/, accessed April 6, 2019.

[13] Karl Marx, *Capital, vol. I*.

labor-intensive to capital-intensive production in the machine-building industries of Britain. This is true, but it was no mere echo of the transformation that had engulfed the textile industries a few decades earlier. An important contributor to that prior transformation, the machinery industries instead invited a wide-ranging dispute over the social and legal relationships governing everything from invention to the diffusion of knowledge in international trade.

From the 1820s to 1840s the British parliament convened to investigate repealing the restrictions on the emigration ("enticement") of artisans, the laws against the export of tools and machines, and the Combination Laws forbidding unionization and employer collusion alike.[14] These discussions overlapped with secret parliamentary meetings, which never published findings, on reforming the patent laws in 1829, 1835, and 1851.[15] What these efforts shared was a shift in and concurrent debate over the sources of economic power, linking knowledge within local work processes to transnational commerce in machinery.

Accordingly, in a single missive, the House of Lords requested that the Commons send them copies of reports from the "Select Committee appointed by that House to enquire into the state of the Law in the United Kingdom, and its consequences, respecting Artizans leaving the Kingdom, and residing Abroad; also, into the state of the Law, and its consequences, respecting the exportation of Tools and Machinery; and into the state of the Law, and its effects, so far as related to the Combination of Workmen, and others, to raise Wages, or to regulate their Wages and Hours of Working; together with the minutes of Evidence taken before the Committee."[16]

[14] Maxine Berg, *The Machinery Question and the Making of Political Economy, 1815-1848* (Cambridge: Cambridge University Press, 1982), 204.

[15] I.H. Dutton, *The Patent System and Inventive Activity during the Industrial Revolution, 1750-1852* (Manchester: Manchester University Press, 1984), 7.

[16] 31 May: 599, "Message to House of Commons for Reports on Combination Laws," Lords Journals lvi, 294. British Parliamentary Archives.

This chapter analyzes how contemporaries understood these relationships and seeks to uncover the social causes and consequences of a mercantilism with considerable success unraveling alongside the growth of the capital goods sector—with something less than unadulterated Free Trade following in its wake.[17] Historians have attributed Britain's repeal of restrictions on machinery exports to the interests of the capital goods industries in assuring themselves the widest market; however, this in turn depended on qualitative shifts in the work process and technical knowledge—and the politics surrounding them—which accompanied the relocation of Britain's engineering center from London to Lancashire and the Midlands.

A focus on the workers whose products put other workers out of work highlights a form of work-process dissociation beyond alienation from the means of production yet before the rise of a formal "school culture" of scientific, managerial engineering.[18] Engels described the factory districts of Lancashire as possessing the "essential peculiarity of which is the production of machinery by machinery, whereby the workers, crowded out elsewhere, are deprived of their last refuge, the creation of the very enemy which supersedes them." "Machinery for planing and boring, cutting screws, wheels, nuts, etc., with power lathes," Engels wrote, "has thrown out of employment a multitude of men who formerly found regular work at good wages; and whoever wishes to do so may see crowds of them in Manchester."[19]

In 1851 and 1852, knowledge politics brought William Fairbairn, James Nasmyth, and Joseph Whitworth to lock their men out and to testify before the parliamentary commission on

[17] For recent and classic accounts of British mercantile ideology and policy, see Sophus Reinert, *Translating Empire: Emulation and the Origins of Political Economy* (Cambridge, MA: Harvard University Press, 2011) and Friedrich List, *Das nationale System der politischen Oekonomie* (Stuttgart: Cotta, 1841).

[18] On "shop culture" versus "school culture," see Monte Calvert, *The Mechanical Engineer in America, 1830-1910: Professional Cultures in Conflict* (Baltimore: Johns Hopkins University Press, 1967).

[19] Engels, *Condition of the Working Class in England*.

reforming the patent laws within months of each other, all in the shadow of the Crystal Palace and the era of global trade competition it portended.

"Free Trade in Ability" and Competing Narratives of Knowledge, Work, and Industrialization

Engineering employers such as James Nasmyth cast their position as "Free Trade in Ability" at the time of the 1852 lockout and in later memoirs. According to Nasmyth, "Free Trade in Ability" meant that where workers "showed the possession, in any special degree, of a true mechanical faculty," the employer "was enabled to select from the working labourers the most effective men to take charge of the largest and most powerful machine tools—such as planing machines, lathes, and boring machines."[20] These were the core processes and products of the nascent capital goods industries, true machines-that-make-machines.

But rather than focus on the alienation of craft skill to the machine, Nasmyth chose to focus on latent talent. The "ease and rapidity with which" the Worsley labourers (those from whom the unionization drive had not emanated), Nasmyth wrote, "caught up all the technical arts and manipulations connected with the effective working of these machines was extraordinary." Through a process of "selection of the fittest," Nasmyth concluded, a "substantial rise in wages…followed their advancement to higher grades of labour." Moreover, pairing shop-floor management and political economy, he underscored that such "free trade in ability" formed the "true source of the prosperity of every large manufacturing establishment." He therefore suggested, "Free Trade in Ability has a much closer relation to national prosperity than even Free Trade in Commodities."[21]

[20] Nasmyth, *Autobiography*, 217.

[21] Nasmyth, *Autobiography,* 217-218.

Turning to his opponents, Nasmyth referred to "another class of workmen" who were of the "opinion that employers should select for promotion, not those who are the fittest and most skilful [sic], but those who have served a seven years' apprenticeship and are members of a Trades' Union." Nasmyth held that such a system would "destroy the emulative spirit which forms the chief basis of manipulative efficiency and practical skill, and on which…the prosperity of our manufacturing establishments mainly depends."[22]

Denying that crafts institutions had fostered innovation, Nasmyth claimed that inventors of renown "owed very little to the seven years' rut in which they were trained." Rather, Nasmyth contended, they owed "everything to innate industry, energy, skill, and opportunity." He pointed to Rennie's and Fairbairn's beginnings as millwrights and Smeaton's and Watt's as mathematical instrument-makers, but stressed that these were naturally "many-handed" men who possessed "many sides to their intellect." Nasmyth did not attribute recent technological breakthroughs to the dense web of interaction between *savants* and *fabricants* which historians such Joel Mokyr have emphasized; for Nasmyth, the select were one and the same.[23] Invoking "Free Trade in Ability" as a rallying cry in the 1850s, Nasmyth gloried in the accomplishments of the first two generations of mechanical engineers while eliding that much had changed since the days of James Watt.

Nasmyth's own career exposes the brittleness of this elision. He began as a draftsman in the London workshop of Henry Maudslay when the city was still the country's engineering capitol dominated by a bevy of firms light on capital, workforce, and space and heavy in the skill

[22] Ibid., 218.

[23] Joel Mokyr, *The Enlightened Economy: Britain and the Industrial Revolution, 1700-1850* (New Haven: Yale University Press, 2011) and *Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton: Princeton University Press, 2009); Peter Jones, *Industrial Enlightenment: Science, technology, and culture in Birmingham and the West Midlands, 1760-1820* (Manchester: Manchester University Press, 2013); Margaret Jacob, *Scientific Culture and the Making of the Industrial West* (Oxford: Oxford University Press, 1997).

of scarce, highly-paid "all-round" millwrights. Well over four hundred London engineering masters employed fewer than ten thousand men in 1825.[24] These millwrights often owned their own hand-tools, using chisels and files to manufacture screws and steam engine parts alike. William Fairbairn, who employed between sixty and seventy men in 1824, noted in his memoirs that

> Down to a late period no operation at all analogous to the planing of wood was practiced with iron; for although a good steel tool could be made to cut iron with the aid of a lathe, it was beyond the power of man to make such a tool take shaving off iron in a right line. The usual mode of getting plane surfaces was by what was called 'chipping and filing.' The iron was first brought to something like a level form by chipping little bits off it with a steel chisel, and it was afterwards worked down by large files till a smooth surface was gained. It need hardly be said that such a plan was very laborious and troublesome, and also very likely to be inaccurate.[25]

Chipping and filing under little supervision, millwrights collaborated on projects of their own account, doing "corporation work" on their employers' time.[26] Describing the clout of millwrights' societies when he entered the trade in 1813, Fairbairn noted that

> all of them, however, took cognizance of the hours of labor, which at that time were from light to dark in winter and from six to six in summer, with two hours for refreshment. They also regulated the rate of wages, and no man was allowed to work for less than seven shillings a day, and as soon as he entered the Society he was bound by the rules to maintain the rights and privileges of the trade in their full integrity.[27]

Due to their reliance on millwrights' skill, small engineering shops spent considerably more on circulating than fixed capital, a situation offering no strong impetus to implement overtime or shift work. Engineering employers could not easily institute a minute division of

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[24] Burgess, "Technological Change," 221.

[25] "Minutes of Evidence," *First Report from the Select Committee* (1824), Online House of Commons Parliamentary Collection; William Pole, ed., *The Life of Sir William Fairbairn* (London, 1878), 43.

[26] Thomas Wright, *Some Habits and Customs of the Working Classes* (London, 1867), 84-85.

[27] Cited in Burgess, "Technological Change," 219-220.

labor or exert full control over work processes.[28] The millwright of Fairbairn's youth "was well-educated, and could draw out his own designs and work at the lathe; he had a knowledge of mill machinery, pumps, and cranes, and could turn his hand to the bench or the forge with equal adroitness and facility."

Consonant with the era's restrictions on skilled emigration, Fairbairn explained, "all the great works of the country connected with practical mechanics were entrusted to his skill" and that, in "the expression of the shops, the men were masters, all having the same wages—seven shillings a day and their drink, and it was then, or some time before, that the societies…were formed, and continued for years to exercise an unlimited sway over the talent and industry of the metropolis and other corporate towns."[29] Entry into such a trade demanded steep investment; Maudslay took high premiums for accepting apprentices, while in 1831 at least one father paid Nasmyth £50 to introduce his son into his Edinburgh workshop for a year. Declaring themselves their masters, millwrights distinguished themselves and were distinguished from other crafts workers.[30]

With the turn of a screw, Maudslay initiated the contested erosion of this system and the long transition from the workmanship of risk to the workmanship of certainty, wherein guides and strictures inevitably determine the form of the ultimate product.[31] His perfection of the screw-cutting lathe enabled the mass production of interchangeable screws, which had formerly been "for the most part cut by hand; the small by filing, the larger by chipping and filing…and

[28] Burgess, "Technological Change," 219.

[29] William Fairbairn, *Useful Information for Engineers* (London: Longman, Green, Longman, and Roberts, 1860), 212-213.

[30] Burgess, "Technological Change," 220.

[31] David Pye, *The Nature and Art of Workmanship* (Cambridge: Cambridge University Press, 1968).

each manufacturing establishment made them after their own fashion."[32] Unlike the later Whitworth and Sellers (Franklin Institute) standards, there was no systematic approach to pitch, the shape of threads, or the number of threads per inch across, or even within, workshops.

Moreover, as Marx would observe, Maudslay's invention of the slide rest would enable the production of "geometrically accurate straight lines, planes, circles, cylinders, cones, and spheres, required in the detail parts of the machines" of steam technology. The slide rest, "a tool that was soon made automatic, and in a modified form was applied to other constructive machines besides the lathe, for which it was originally intended," replaced "not some particular tool, but the hand itself, which produces a given form by holding and guiding the cutting tool along the iron or other material operated upon."[33]

Inspired by Maudslay, Nasmyth continued to pursue machine tools fabrication and the mechanization of millwright work. Engineering employers who adopted the new machine tools quickly reformulated job categories, introducing task-based identities such as the planer.[34] Polemicist and prophet of the machine age Andrew Ure expounded that the skilled worker was "self-willed and intractable" and thus "less fit a component of a mechanical system, in which, by occasional irregularities, he may do great damage to the whole."[35] Despite his advocacy of "Free Trade in Ability" for individuals, Nasmyth doubtless concurred for the mass.

Along with Joseph Whitworth's Manchester works, Nasmyth's Bridgewater Foundry, established in 1836, was among the earliest shops devoted to the scale construction of machine tools. While earlier workshops such as Maudslay's had produced a diverse array of machines,

[32] Samuel Smiles, *Industrial Biography: Iron-workers and Tool-makers* (London, 1863), 136.

[33] Karl Marx, "The Development of Machinery," *Capital, Vol. I.*

[34] Burgess, "Technological Change," 229.

[35] Cited in Berg, *Machinery Question*, 199.

from steam engines to minting machinery, works such as Whitworth's and Nasmyth's reoriented the engineering industry toward capital intensive production through general and specialized machine tools, economies of scale, and heightened divisions of labor.[36] Thanks to the rise of power-looms in the cotton textile factories and steam engines in the transport industries—both premised on the expansion of slavery and racial capitalism into the American Deep South—1835 to 1850 marked the most rapid increase in demand for engineering products in nineteenth-century Britain.[37]

As early as the 1810s and 1820s, machinery consumer John Marshall, owner of a Leeds flax spinning mill, kept notebooks containing an index of specialized machine-makers, power calculations, and a typology of textile machinery of differing sizes as well as data on strokes per minute, diameter dimensions, and coal consumption.[38] Challenging the old engineering metropole of London though tight links to the growing textile and rail centers, the engineering shops of the Midlands already had a general skills hierarchy by the 1820s and 1830s, extending from principal engineers, draftsmen, and clerks at the top to engineers, millwrights, pattern makers, fitters, turners, molders in brass and iron, and boilermakers below.[39]

Nasmyth wrote that the "rapid extension of railways and steam navigation, both at home and abroad, occasioned a largely increased demand for machinery of all kinds," which in turn "increased demand for skilled mechanical labour—a demand that was in excess of supply." This offered him the opportunity to respond to ever-greater "demand for self-acting tools, by which

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[36] Burgess, "Technological Change," 221, 227.

[37] Sven Beckert, *Empire of Cotton: A Global History* (New York: Norton, 2014); Adam Rothman, *Slave Country: American Expansion and the Origins of the Deep South* (Cambridge, MA: Harvard University Press, 2005).

[38] Berg, *Machinery Question*, 192; on coal and industrialization, see E.A. Wrigley, *Energy and the Industrial Revolution* (Cambridge: Cambridge University Press, 2010) and Kenneth Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2000).

[39] Berg, *Machinery Question*, 153.

the employers might increase the productiveness of their factories without having to resort to the costly and untrustworthy methods of meeting the demand by increasing the number of their workmen."[40] Nasmyth recounted that immediately "after the opening of the Liverpool and Manchester Railway," a corridor between the erstwhile slaving port and the satanic mills, there "was a largely increased demand for machine-making tools" and that the "success of that line led to the construction of other lines, concentrating in Manchester; and every branch of manufacture shared in the prosperity of the time."[41] In 1839, Nasmyth's price circular included a self-acting shaping machine, a self-acting nut-cutting and facing machine, and a lathe with self-acting slide rest, which enabled operators to turn locomotive engine wheels seven feet in diameter; a decade later, Nasmyth advertised over a half dozen sizes of self-acting planing machines costing £75 to £270.[42] Backed by demand from the firms servicing the mill-owners and railways, Whitworth's workforce grew from 172 to 636 men in the single decade from 1844 to 1854. [43]

Firms such as Whitworth's and Nasmyth's replaced the older unspecialized workshops they had trained in, while newer shops such as Oldham-based Hibbert and Platt specialized in a single application—cotton textile machinery—using the machine tools Whitworth's and Nasmyth's firms produced at scale and, by 1850, a workforce of over 1,500 men.[44] Maudslay's shop survived by joining the trend; as Maudslay, Sons and Field, the firm employed 1,200 men in 1850 (compared to 200 in the 1820s) and concentrated solely on shipbuilding. [45] The vertical

[40] Nasmyth, *Autobiography*, 307.

[41] Ibid., 192.

[42] Burgess, "Technological Change," 227.

[43] Ibid., 229.

[44] Ibid., 225.

[45] Ibid., 229.

disintegration of the machinery industries into firms making machines-that-make-machines and firms making machinery for consumer goods' producers fueled further demand for machine tools and the predominance of larger-scale, capital-intensive works sharing comparable production techniques. For instance, historian Keith Burgess notes that planing techniques "used in the manufacture of textile machinery…came to resemble those used in a locomotive workshop."[46]

The widespread adoption of self-acting machines in response to rapid demand downstream as well as employers' inability to control millwrights reshaped both individual firms and the capital goods industry as a whole. Employers shifted to piece-rate systems, contracting with intermediary piece-masters to hire and oversee workers paid by the piece for the parts comprising orders.[47] In 1856, Whitworth estimated that the cost of leveling a cast-iron surface had fallen from twelve shillings to a single penny per square foot due to the replacement of chipping and filing with the planing machine. Contrasting fixed and variable costs, he admitted that "the labour being lowered to 1d. per foot, a capital in planing machines for the workman is required, which often amounts to 500 pounds…This large outlay of capital invested in machinery to increase production, makes it impossible to curtail the hours of working machinery."[48] Piece-work and self-acting machines, capital concentration and overtime. By the time of the national engineering workers' strike and lockout, the 1851 Census had revealed that a mere 168 engineering masters in London employed 6,583 men and that the center of the capital goods industry had shifted decisively from London to Lancashire.[49]

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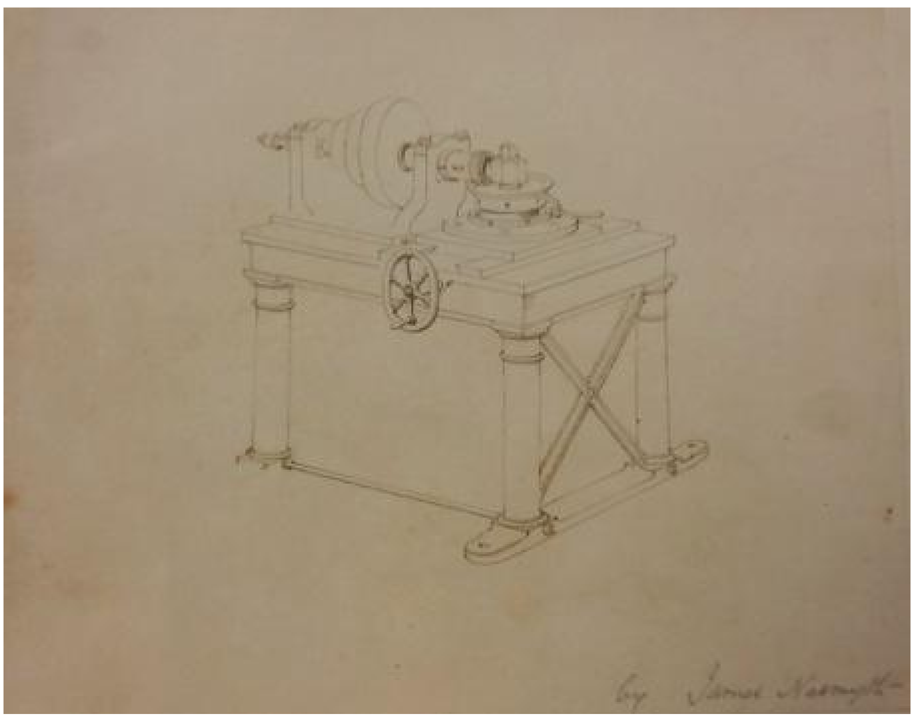
[46] Ibid., 225.

[47] Ibid., 229.

[48] Joseph Whitworth, *Papers on mechanical subjects* (London, 1882), 40.

[49] Burgess, 221.

During these years, James Nasmyth drew capital in more than a single sense. For instance, he drew an isometric projection of a lathe. He did not specify the dimensions, nor could they have been accurately gleaned from the three-quarters view, a sort of machine portraiture. Machinery firms in the Midlands had employed such lathes to revolutionize production in the textile industries, casting out an anonymous "Stranger at Home" who wrote to the British Home Office in October 1830 to argue that machine-made goods should be produced solely for export by citing concerns over rising unemployment and "idleness."[50] The capital goods industries were themselves experiencing a transformation from labor-intensive to capital-intensive production, but it was not merely self-acting machinery that mattered.



Fiture 1: James Nasmyth, Drawing of a lathe, Institution of Mechanical Engineers Archive, London

While engineering drawings of the era did not yet harness the clarity of design afforded by descriptive geometry (see chapter two), Nasmyth admired a foreman with an unusual knack

[50] Stranger at Home to the Home Office, October 31, 1830, British National Archives, HO 44/21/117.

for producing full-scale drawings and, in 1867, told a parliamentary committee on trade unions that he was

> fortunately the contriver of several machines for giving geometrical forms to metal work with such precision and rapidity, by certain modification of the planing machine, that all that class of men who depended upon mere dexterity were set aside altogether…Instead of having the old proportion of one boy to four mechanics, I had four boys to one mechanic nearly.[51]

He had, in a sense, embedded the practice of design geometry within the machine to reverse the proportion of skilled and unskilled labor. Similarly, 1860s geometric chucks for ornamental turning in wood and leather prescribed formulae applied to slides and screws to achieve hundreds of patterns, taking fifteen seconds to five minutes to cut. These were then reproduced as printed samples within a manual.[52]

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[51] Nasmyth in Parliamentary Papers, Select Committee on Trade Unions (tenth report), 1867-8 (XXXIX), 513-4, cited in Burgess.

[52] H.S. Savory, *Geometric turning* (London: Longmans, Green, and Co., 1873). Library Company of Philadelphia.

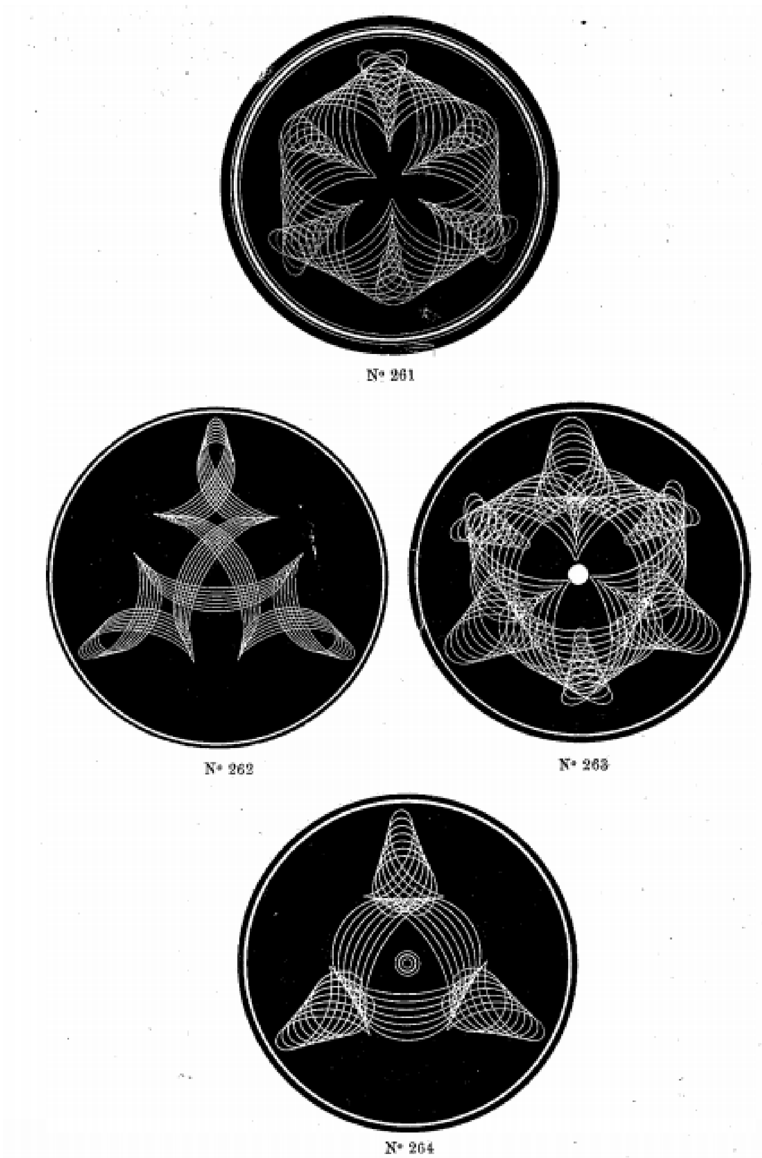

Figure 2: Pages from H.S. Savory's guide to geometric turning, Library Company of Philadelphia

Addressing the institutional separation of mental and manual work, Fairbairn recalled that "the designing and direction of the work passed away from the hands of the workmen into those of the master and his office assistants," which "led also to a division of labor; men of general knowledge [ie the millwrights] were only exceptionally required as foremen or out-door superintendents; and the artificers became, in process of time, little more than attendants on the machines."[53] Yet as late as 1860 a British engineer explained that "a great many little details were left out of the plans to save expense in the office, and thus the foremen had often to use their own discretion in giving the necessary instructions to machine hands, fitters, etc."[54] The office was not a drafting room dominating and directing the shop floor.

Historians of technology such as John K. Brown have observed that British metalworking establishments relied little on precision shop drawings as late as World War I. [55] They certainly did not utilize drafting as a means of labor management or work-process control in Nasmyth's time. Instead, British engineers in the machinery industry drew to design, to record and disseminate designs as what Bruno Latour has called "immutable mobiles," and to communicate with pattern-makers who would ultimately translate them into workable forms and models for foundry workers.[56] After the pattern-makers had completed their task, British metalworking firms ensured that "copies of every part were hand sketched and…the sheets were stitched together." [57] Dependent on the craft skill of the pattern-maker, this drafting system, reflected in the inclusion of a £14 drawing office cupboard in Whitworth's 1837 tool inventory, offered a potential means of design accounting and accumulation, like the stock of patterns kept by master tailors, but not one of control.[58]

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[53] Cited in Burgess, 229-230.

[54] John K. Brown, "Design Plans, Working Drawings, National Styles: Engineering Practice in Great Britain and the United States, 1775-1945," *Technology and Culture* 41, no. 2 (April 2000): 195-238.

[55] Ibid.

[56] Bruno Latour, "Drawing things together," in *Representation in Scientific Practice*, ed. Michael Lynch and Steve Woolgar (Cambridge, MA, 1990), 19-68.

[57] Brown, "Design Plans, Working Drawings, National Styles," 202.

[58] Whitworth Tool Inventory, Joseph Whitworth & Co. Capital Valuation (1837), Institution of Mechanical Engineers, London, IMS 206-209; Michael Zakim, "Customizing the Industrial Revolution: The Reinvention of Tailoring in the Nineteenth Century," *Winterthur Portfolio* 33, no. 1 (Spring 1998): 41-58.

Certain millwrights, shipwrights, architects, and civil engineers had designed solely on paper in the eighteenth century, but British engineering establishments of the first half of the nineteenth century rarely possessed the knowledge to employ the descriptive geometry developed by French military engineers, a state secret for over two decades, to work out precise production drawings.[59] Fabrication in metal remained costly, so machinery firms had full reason to shift to paper-based methods in both design and production plans; however, as John K. Brown points out, drawings "amounted to a novel language for articulating a novel form of knowledge," impossible to parse without a standardized and legible syntax. Boulton and Watt utilized what John K. Brown has called "sophisticated scale drawings" in the manufacture of condensing steam-engines in the 1770s, but it would not be until the 1840s that most British metalworking establishments relied on dimensional plans in design as well as production.[60]

Art historians such as Celina Fox have emphasized that drawings were not merely reflective of but also productive of technological change in eighteenth-century and early nineteenth-century Britain.[61] Realistic mechanical drawings, rendered in perspective with watercolor washes to indicate materials, aided mechanical engineers in sales pitches to potential customers. Equally significantly, mechanical sketching enabled engineers to devise means of power conveyance from the "mind's eye."[62] Envisioning systems of gearing and transmission did not preclude wider views of workshop reform. People, machinery operators and floating faces, dotted the engineering designs that James Nasmyth sketched from 1838 to 1840. Nasmyth's

[59] Brown, "Design Plans, Working Drawings, National Styles," 200; Peter Jeffrey Booker, *A History of Engineering Drawing* (London: Northgate, 1979).

[60] Brown, "Design Plans, Working Drawings, National Styles," 200.

[61] Celina Fox, *The Arts of Industry in the Age of Enlightenment* (New Haven: Yale University Press, 2009).

[62] Eugene Ferguson, *Engineering and the Mind's Eye* (Cambridge, MA: MIT Press, 1994).

sketches were neither the full, socially contextualized images printed in early modern Theatres of Machines nor the more schematized inventories of tools and processes in the enlightened managerial vision Diderot and d'Alembert's *Encyclopédie*.[63] Rather, as in technical print culture of the late eighteenth and early nineteenth century, such as Oliver Evans's *Young Millwright's Guide,* Nasmyth's imaginings often depicted people as sources of motive force or action embedded within a series of mechanisms.[64] He pioneered self-acting tools without entirely eliminating people from his drawings and without drafting according to the principles of descriptive geometry. His drawings inconsistently indicated dimensions and often rendered objects and scenes with the depth of perspective.

[63] William Sewell, "Visions of Labor: Illustrations of the Mechanical Arts before, in, and after Diderot's Encyclopédie," in *Work in France: Representations, Meaning, Organization, and Practice*, eds. Steven Kaplan and Cynthia Koepp (Ithaca: Cornell University Press, 1986).

[64] Oliver Evans, *The Young Mill-wright and Miller's Guide* (Philadelphia, 1795).

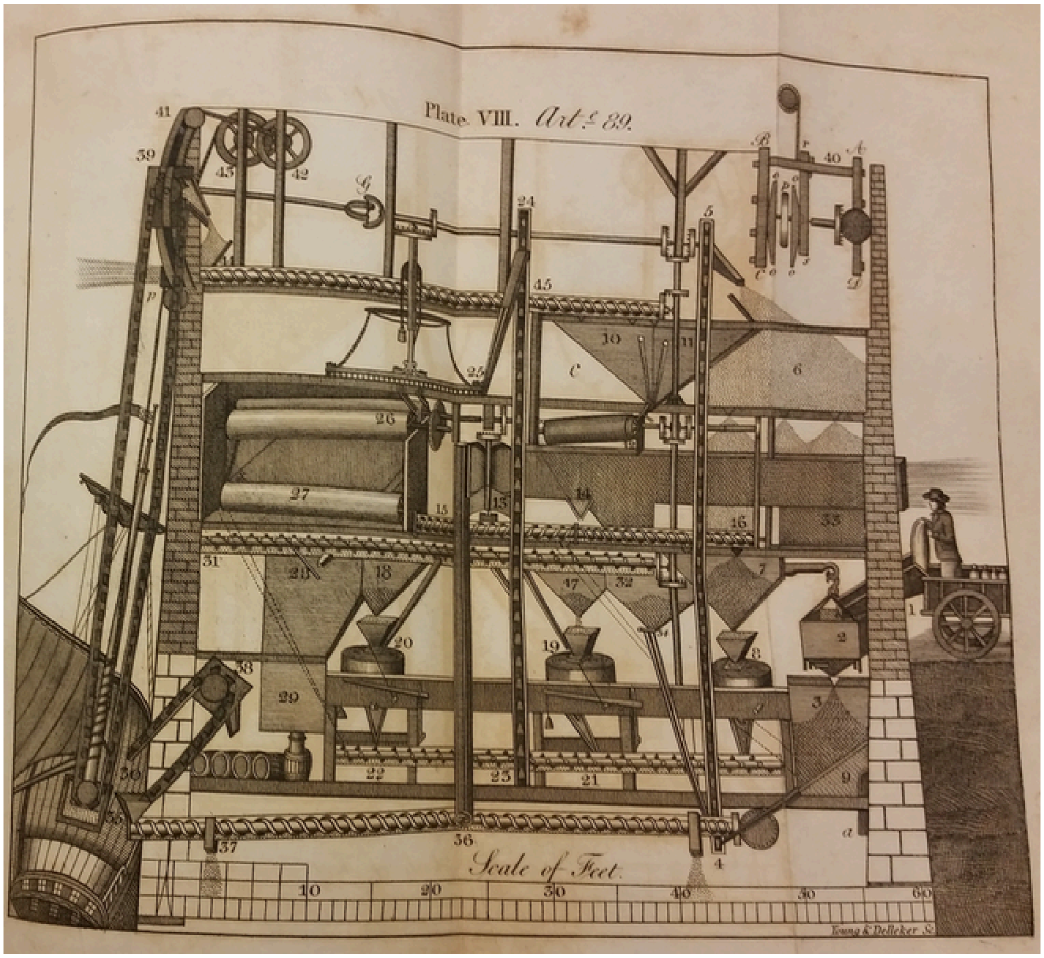

Figure 3: Oliver Evans, *The Young Mill-wright and Miller's Guide* (Philadelphia: Carey, Lea & Blanchard, 1836 [1795]), Library Company of Philadelphia

But as early as 1834, an apprentice mathematical instrument-maker in London had disagreed with James Nasmyth's and Andrew Ure's vision of industrializing Britain in an essay responding to a 10£ prize question posed by J.M. Morgans, Esq., author of the anti-Mandeville tract *The Revolt of the Bees* (1826)—itself serialized by *Co-operative Magazine* and widely read by workmen via Mechanics Institutes—to the members of the London Mechanics' Institution.[65] Morgans had asked, "Whether does the principle of Competition with separate Individual

[65] W.H.G. Armytage, "The Rôle of an Education Department in a Modern University: Inaugural Lecture Delivered 8th December, 1954," University of Sheffield (1954), 7.

Interests; or, the Principle of United Exertions, with combined and Equal Interests; form the most Secure Basis for the Formation of Society?"

In the 1820s middle-class reformers had established the Mechanics Institutes, equipped with libraries and offering courses, lectures, and experiments in drafting, physics, and chemistry, to enable artisans to discover the scientific precepts behind their daily practices.[66] They envisioned the institutes as a means to foster the fusion of skill and science in pursuit of national wealth. Holding the Smithian view that improvement in manufactures happened in a "piecemeal and empirical fashion," they believed in popularizing experimental pursuits. Historian Maxine Berg explains that the "demands for both an ingenious artisan and a disciplined labour force were not contradictory" since "the ingenious artisan which the Mechanics Institute Movement aspired to create was in fact functionally identified with demands for a newly labour force and with the hardening of social hierarchies within the work process."[67]

Mechanics Institute promoters nevertheless saw their democratization of science as counteracting the growing division of labor, or as James Hole put it, achieving a "*synthesis* of labour" by "bringing together the knowledge required in each department of industry."[68] When this aim failed to forestall the dissociation of mental and manual tasks and the specialization of distinct lines of manufacture, they comforted themselves that "if from such classes does not spring a James Watt, or a Christopher Wren, a Simpson or a Davey, yet from them come

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[66] Berg, *Machinery Question*, 146; on the Manchester Mechanics Institute, see Julia Wrigley, "The Division between Mental and Manual Labor: Artisan Education in Science in Nineteenth-Century Britain," *American Journal of Sociology* 88, Supplement: Marxist Inquiries: Studies of Labor, Class, and States (1982): S31-S51.

[67] Berg, *Machinery Question*, 147.

[68] Hole quoted in Berg, *Machinery Question*, 150.

supervisors of railway works, foremen of foundries and machine makers' establishments and 'clerks of the works' at the erection of great public buildings." [69]

The apprentice mathematical instrument-maker, a member of the London Mechanics Institute, refused to resign himself to the patrons' vision of fostering social mobility while accepting subdivided terminal tracks. Yet rather than oppose technological change, he condemned the competitive society itself, stating simply: "The legacy left to mankind by the genius of Watt and Arkwright, is monopolized by a few, who convert it into an instrument of tyranny, a source of the extremest evil."[70] The apprentice mathematical instrument-maker's discourse attempted to display the true relations among scientific knowledge, technological development, economic competition, and social decay.

He began by requesting that readers remember that "this is not the production of one who, with his study-door closed on the cares of the world, can amply collect and digest information on the subject of his enquiry, and arrange and mature his ideas at leisure," but rather was written "at the close of an apprenticeship, when fourteen hours of each daily twenty-four, were passed in close application to a business which will not permit of undivided attention."[71] Preparing readers for the radical reformulation of society along Owenite lines that he angled to promote, he coopted the complaint of the capitalist technologists, deploring that time after time "innovations and innovators are regarded with suspicion and contempt."

An avowed Utilitarian, the apprentice mathematical instrument-maker believed that a rigorous accounting of the merits and faults of competitive society must start with a definition of

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[69] Berg, *Machinery Question*, 159.

[70] "An Essay, in answer to the question: whether does the principle of competition, with separate individual interests" (Philadelphia: 1838), Library Company of Philadelphia.

[71] Ibid.

happiness. “Attaching to sensual pleasure, then, all the importance which its votaries can demand, acknowledging the addition to our happiness from wealth, as productive of elegance of taste, or of whatever can gratify the senses,” he wrote, “it is evident that these alone cannot render a being happy.”[72] He concluded that the “vacant mind which in itself possess no resources may, when no longer under the influence of external excitements sink into a state of listlessness and feel existence a burden.”[73] Moreover, he asserted that the “most prolific source of pleasure or pain which can operate on a human being is the relation in which he stands with his fellow-creatures,” and stressed that the fundamentally social nature of man could no longer be ignored.

Criticizing the system of competition as averse to human nature *and* poorly designed, the apprentice mathematical instrument-maker cast it as “the sediment left by a jumble of adventitious circumstances, each of which has left its scar, and contributed to form the heterogeneous mass of congregation miscalled society.”[74] Like many of his contemporaries, he located the source of vice and crime in the competitive industrial order. With its “wealth and excessive poverty,” he concluded “gaols and the gallows must accompany the system which places men in a state of war with each other, that system which is so aptly supported by the public executioner.”[75]

His writing allegorized and juxtaposed physical, commercial, and social fabrication processes. He observed that in “the construction of the meanest and most inconsiderable article, a considerable degree of skill and method is employed, while the most important earthly affairs—the constitution of human society—is left to the control, and suffered to be formed by

[72] Ibid.

[73] Ibid.

[74] Ibid.

[75] Ibid.

unconnected circumstances." Examining the effects of production on the constitution of the human polity, he found the "progress of the division of labour, the employment of the far greater part of those who live by labour, that is, of the great body of the people, comes to be confined to a few very simple operations; frequently to one or two."[76] Without government intervention, the apprentice mathematical instrument-maker foresaw a dependent and depraved state for the laboring poor, as a "man whose whole life is spent in performing a few simple operations, of which the effects, too, are perhaps always the same, has no occasion to exert his understanding, or to exercise his invention in finding out expedients for removing difficulties which never occur."[77]

Like many of his contemporaries, he stamped these conditions on the bodies and minds of the poor, convinced that mental "torpor" would render them "incapable of…conceiving any generous, noble, or tender sentiment, and, consequently, of forming any just judgment concerning many even of the ordinary duties of private life," much less the "great and extensive interests of…[the] country."[78] The apprentice mathematical instrument-maker found such manufactured ignorance all the more appalling within a state of advanced science and highly productive industry, concluding that competition "with individual and separate interests is selfishness" and "cannot, applied as the prime mover of society, develop to the full extent the talents of its members, so as to produce the greatest general good."[79]

The apprentice mathematical instrument-maker opposed neither progressive knowledge and Baconian science nor technology as such. He condemned the principle of competition as

[76] Ibid.

[77] Ibid.

[78] Ibid.

[79] Ibid.

converting machine industry, "the greatest instrument man can possess to secure his happiness, into a curse, a source of poverty, of crime, and of misery." Since the capitalist "can exist for some time on his capital without the aid of the labourer, who, cannot exist at all without the capitalist," he reasoned, the "true spirit of competition" meant that the "wages of labour are reduced to that sum which will just maintain life."[80] Tracing the structural changes wrought by the rising capital goods industries, he explained that when a "machine is introduced which supersedes the necessity of manual labour, that labour is cheapened in the market," and

> by competition, their wages are decreased in the same proportion as the powers of production increase. Machinery, it is true, cheapens the necessaries of life, but it also cheapens the labourer, that the alteration of price becomes merely nominal; his wages never remain permanently above the level of mere existence.[81]

Consequently, the apprentice mathematical instrument-maker would not deny workmen the right to unionize, emphasizing that "I speak not in censure of this weak attempt of the workmen to guard themselves; they have a right to combine and in many cases to prevent being further trampled upon, I but complain of the wretched form of society which renders such combinations of men against men necessary."[82]

To throw what he interpreted fundamentally as the misuse of knowledge under the competitive system into stark relief, the apprentice mathematical instrument-maker proposed that "well might some of the highly polished and civilized nations of Europe exchange situations with the misguided and bigotted [sic] Shaking Quakers," whose "simple polity" had proven "more productive of happiness than all the complicated machinery of competitive society."[83] Never

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[80] Ibid.

[81] Ibid.

[82] Ibid.

[83] Ibid.

abandoning the Baconian credo, Knowledge *was* power for the apprentice mathematical instrument-maker; however, the Shakers illustrated that even a society that "studiously check[ed] the increase of knowledge" due to its religious fervor could, thanks to the "superiority of united exertions and interests over individual arrangements," achieve a state wherein "amicably men can act together in a state of equality" without undermining "industry, perseverance, and virtue."[84]

A sharp rebuke, his example of the Shakers echoed the London Mechanics Institute's previous prize question, which coincided with the debates leading to the 1834 Poor Law: "If knowledge be power, and that power be employed in the extension of the mechanical and commercial resources of a kingdom like Great Britain, how does it happen, that such a nation does not command the commerce of the world, and find its resources sufficient to keep its laborious population out of a state of poverty?"[85] The apprentice mathematical instrument-maker marveled that knowledge as power had enabled the "working classes of Britain and Ireland…aided by mechanical and chemical improvements" to "finish as much work of the kind to which their labour is applied as could be completed forty years ago by three times whole manual power of the world."[86] Yet the workhouse beckoned nonetheless.[87]

Writing as London engineers lost ground to Lancashire works, the apprentice mathematical instrument-maker perceived interlocking antagonisms between Britain's international and domestic mercantilist policies as part and parcel of an unavoidable crisis of the

[84] Ibid.

[85] Ibid.

[86] Ibid.

[87] On the 1834 Poor Law and the creation of a flexible market in (fictively) commodified labor, see Karl Polanyi, *The Great Transformation* (New York: Rinehard & Co., 1944).

competitive order itself. “Every improvement in the powers of production from want of correspondent improvement in our social system, is a cause of distress,” he contended, “patch upon patch may be applied, till we are lost in the labyrinth of our regulations, but while we build upon a sandy foundation, the superstructure cannot be secure, we shall ever be alarmed by the convulsive throes of a misformed, misgoverned, and wretched society.”[88]

At home, he found “many workmen who are as ignorant of the causes of those effects which daily and hourly take place around them as is the machinery and these are the very men from whom we might under other arrangements expect the greatest improvements in the arts of production, the men who practise those arts.”[89] Abroad, he noted, every

> invention or improvement in one nation, is a source of jealousy and grief to another, because they lose thereby; for the labourers whose labour has been thereby displaced, can apply themselves to the manufacture of articles which heretofore they had purchased of their neighbors. Our foreign policy is indeed but a mass of counteraction.[90]

It is to that intricate mass of counteraction—the laws forbidding, selectively sanctioning, and periodically turning a blind eye to the exportation of tools and machinery, the emigration of artisans, and their “combinations”—that we now turn.

Flight of the Cockerills—Embodied Knowledge and International Trade in Capital Goods

A point emphasized by John Malcolm Forbes Ludlow reveals the subterranean tremor working its way through British, and eventually global, political economy. In his 1852 address, Ludlow remarked that “it is frequently alleged during the course of the present dispute [between

[88] “An Essay, in answer to the question: whether does the principle of competition, with separate individual interests” 1838), Library Company of Philadelphia.

[89] Ibid.

[90] Ibid.

the engineers and engineering masters], though I gladly admit not by the masters in their Representation, that if they are not, to use their famous words, 'let alone to do what they like with their own' in this country, they will try to have their own way in another—that capital will emigrate and that dozens of new Cockerills will set up dozens of new Seraings."[91] Responding to this threat of impending capital flight, Ludlow counterpoised a seemingly outdated point: the degradation of British engineering and metalworking labor would spur ambitious mechanics to emigrate overseas.[92]

They already had for decades; indeed, parliament had legalized their outflow by abolishing laws against the enticement of "artificers of Britain" and providing discretionary powers to the Board of Trade to license machinery exports in 1824—a year after the British-born, Belgian-based John Cockerill's Seraing workshop had written coyly to ironworks in Bradford and Sheffield that "as we do no business with England, we beg leave to refer you to any House in Rotterdam or Antwerp from which we flatter ourselves you will receive satisfactory information with respects to our solidity."[93] Smuggling networks had become the norm; so many technologies flowed toward the Continent this way that the Board of Trade found itself forced to deny only twenty to thirty percent of special export applications in the 1820s and 1830s, well before the ascendance of Free Trade ideology. When Joseph Hume, chair of the 1824 Select Committee on Artisans and Machinery, asked engineer John Martineau to state "what additional price you calculate is put on the machinery which is sent out of this country, by the

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[91] Ludlow, "The master engineers and their workmen."

[92] David J. Jeremy, "Damming the Flood: British Government Efforts to Check the Outflow of Technicians and Machinery, 1780-1843," *Business History Review* 51, no. 1 (Spring 1977): 1-34.

[93] Cockerill of Seraing to Messrs Jarratt, Damson & Hardy, Whitney Low Moor Iron near Bradford, Yorkshire; Messrs Booth & Cie, Park Iron Works, Sheffield; Messrs Oakes & Co., Somerfield Iron Works, Alfreton; Mssrs Hardop & Sorby, Milton Iron, December 12, 1823, Archives de l'Etat, Liege, 2188-2190.

risk of smuggling," Martineau replied, "I think that would not amount to much, from its being so very seldom detected; the risk is not considered great."[94]

Napoleonic forces had conquered the Rhineland, instituting broad social and economic reforms.[95] Guilds were disestablished, units standardized, administrative borders redrawn. In Prussia, state administrators had begun pursuing an agenda of industrialization as early as the 1770s, introducing modern ironworks as well as steam and atmospheric engines imported and copied from England.[96] Geheimrat Gansauge installed an English machine as Prussia's first atmospheric engine in a coalmine near Magdeburg. Prussia's monarch sent Carl Friedrich Buckling and a mining official to England in 1779 for industrial reconnaissance on atmospheric engines as well as Boulton and Watt's plant at Soho, of which they made extensive notes and drawings.[97] By 1783 Buckling had built a model of Watt's atmospheric engine in Berlin from parts founded and wrought in an array of workshops, including a bronze cylinder from the Royal Cannon Foundry, and installed it in the Graftschaft Mansfeld.[98] On a second trip to England in 1786, Buckling enticed an English artisan, William Richard, to illegally emigrate to serve as a *Maschinenmeister* in Thuringia. After Richard had constructed an engine, Buckling employed the experience gained to establish an engineering workshop in Rothenburg. Buckling's workshop

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[94] "Minutes of Evidence," *Report of the Select Committee on State of Law in United Kingdom respecting Artisans leaving Kingdom, and Exportation of Tools and Machinery, and Combination of Workmen to raise Wages* (London, 1824), ProQuest U.K. Parliamentary Papers, accessed September 25, 2017, https://parlipapers-proquest-com.ezp-prod1.hul.harvard.edu/parlipapers/docview/t70.d75.1824-008876?accountid=11311.

[95] Timothy Blanning, *The French Revolution in Germany: Occupation and Resistance in the Rhineland, 1792-1802* (New York: Oxford University Press, 1983).

[96] Fritz Redlich, "The Leaders of the German Steam-Engine Industry During the First Hundred Years," *The Journal of Economic History* 4, No. 2 (Nov. 1944): 121-148.

[97] Ibid.

[98] Ibid.

delivered its first engine to Eisleben; by 1788, he had been promoted to oversee all machinery work for Prussia's ministry of mines and metallurgy. [99]

Historians have argued that the mobility of technicians and capitalists had a greater effect on the development of German industry than foreign capital flows.[100] In 1786 Stein, director of mines in Westphalia, traveled to England to gather information on steam engineering and negotiate agreements with machinery makers to start a state engine industry in Prussia. [101] Stein visited London breweries to witness Watt's early steam engines at work and secretly commissioned drawings of the machine's significant parts governing rotation and regulation of the piston. He also attempted to hire English mechanics. When discovered, Stein's industrial espionage efforts provoked Boulton and Watt's ire. Eventually entering discussions, however, Boulton considered aiding Stein in exchange for either a Prussian patent or a large sum in its stead. With many engines sold and drawings circulating, Boulton acknowledged that it would be impossible for him to maintain secrecy and monopoly for any extended period.[102] By 1798, the Prussian state workshops at Rothenburg and Gleiwitz would provide the first steam engines in Westphalia for the Konigsborn Royal Salt Works.[103]

In 1794, a New York textile mill employed over a dozen Manchester workers to replicate machinery from models exported (illegally) from Scotland and England. In Philadelphia, immigrant artisan James Davenport had constructed spinning and power loom machinery by

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[99] Ibid.

[100] Martin Schumacher, *Auslandsreisen deutscher Unternehmer 1750-1851 unter besonderer Berücksichtigung von Rheinland und Westfalen* (Köln: RWWA, 1968), 234.

[101] Redlich, "Leaders."

[102] Ibid.

[103] Ibid.

1796.[104] In 1824 and 1825, William Strickland visited England on behalf of the Pennsylvania Society for the Promotion of Internal Improvements. Reaching readers on both sides of the Atlantic, Strickland's widely-circulated report and drawings advocated further transnational trips in search of inventions.[105] Having worked with cotton textile machinery in Britain, Samuel Slater immigrated to Pawtucket, Rhode Island in 1789 and proceeded to construct spinning machinery for mills. Slater's mill served as a model factory for emerging textile capitalists in the United States.[106]

Ignoring the injunctions against the export of tools and machines that remained until the 1840s, Cockerill proceeded to purchase over eight hundred hand tools—flat bastard files, round bastards, smooth three squares—from the Sheffield ironworks of Spear, Jackson, & Co. and boiler plates from Mssrs. Samuel, Walker, & Co.'s Gospel Iron Works, Staffordshire via their intermediary Mr. Pastor, Cockerill's relative by marriage, and financial circuits such as "Beering [sic] Brothers & Co., London."[107] Cockerill of Seraing requested prices of iron "best quality for Chain-Cables, Piston Rods, Boiler plates after dimentions [sic] for Boat Engines etc. and also the price of Pig metal" from a Mr. Crawshay, Cyfarthfe Iron Works, Merthyr Tydell, Glamorganshire, while also signaling the works' "habit of using 10 to 12 tons a week" and policy of only making "remittances after reception of the goods."[108] Diversifying the family's

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[104] Darwin H. Stapleton, *The Transfer of Early Industrial Technologies to America* (Philadelphia: American Philosophical Society, 1987), 15.

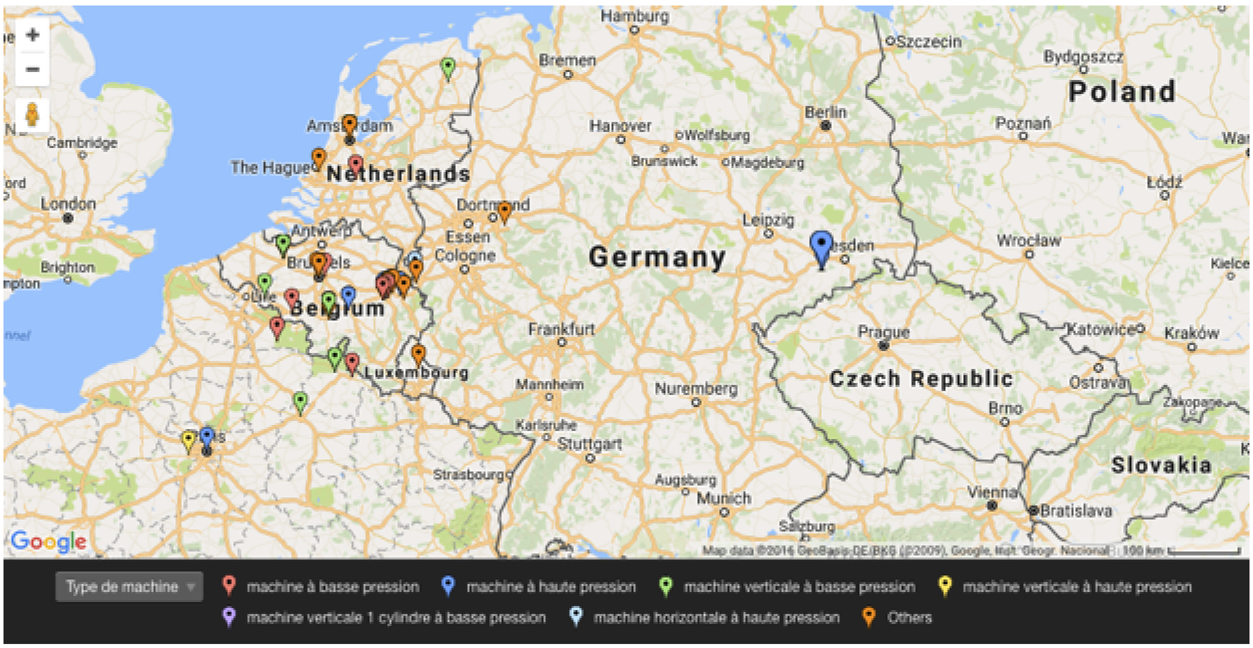
[105] Ibid., 21.

[106] Ibid., 14.

[107] Cockerill of Seraing to Mssrs Spear Jackson & Co, Manufacturers of Saws, Files etc., Sheffield, 11 December 1823; Cockerill to Mssr Samuel Walker & Co, Gospel Oak Iron Works, 6 April 1824, Archives de l'Etat, Liege, 2188-2190.

[108] Cockerill to Mr. Crawshay, Cyfarthfe Iron Works, Merthyr Tydell, Glamorganshire, Angleterre; Mr. Forster, Stowbridge, Staffordshire, 17 August 1823, Archives de l'Etat, Liege, 2188-2190.

enterprises in the 1820s, John Cockerill commissioned a smuggler to deliver two cylinders of engraved copper according to specified dimensions, presumably for the paper and cloth-printing factory he had established at Andennes.



Fiture 4: Cockerill Engine Sales in Europe, 1828-1833 (n=96). Data gathered from manuscript order books at the Archives de l'Etat, Liège.

By 1838, Victor Hugo wrote in *Le Rhin,* "This spectacle of war is given by peace; this terrifying copy of devastation is made by industry. You have, simply before your eyes, the furnaces of Mr. Cockerill."[109] At the firm's liquidation and reincorporation following John Cockerill's death in 1840, the Cockerills owned two main machinery-building establishments with attached coal mines at Seraing and Liege valued at 9, 056,940.26 francs and 3,086,444.15 francs, respectively, and employing 2400 workmen; a paper and cloth-printing factory at Andennes valued at 418,026.23 francs; a woolens factory in Aix-la-Chapelle (Aachen) valued at 368,314.72 francs, a netting factory in Cottbus valued at 600,000 francs, and a linen factory in St. Denis valued at 1,019,438.12 francs; and sugar plantations and mills in Surinam valued at

[109] Victor Hugo, *Le Rhin, vol. 1: Lettres à un ami* (Paris: Nelson, 1838), 102.

29,827.17 francs.[110] By the time Ludlow invoked the Cockerill name in reference to the risk of capital flight in 1852, Cockerill was indeed synonymous with capitalist.

But John Cockerill's father William, a skilled artisan specializing in carding, spinning, and weaving machinery, had carried little capital when he traveled first to Russia and then to Verviers in 1798. His trajectory hewed closer to the one Ludlow envisaged in order to caution engineering masters and their political allies against overreach —the transfer of entire industries by mechanics possessing tacit knowledge. William's sons, James and John Cockerill, set up in Berlin and Liège respectively, the latter relying on the fulfillment of his nigh insatiable demand for funds and credit from a Belgian state keen to industrialize.[111]

As James and John Cockerill became the best-known exporters of steam engines and textile machinery to the Rhineland, German mechanics soon took pilgrimages to Cockerill's works at Seraing in addition to the established espionage route to Manchester. Gottlieb Schuster, a mechanic from Neusalzwerk bei Minden, entered as a draftsman with a wage of 12 Francs per week in 1824 and found himself "very satisfied with the opportunity to learn and improve himself"; casting founder Gustav Becker from Aachen pursued the same strategy.[112] A German manufacturer wrote that despite the fact that the large flax mill of the Société de St. Leonard was closed to visitors, Cockerill had nevertheless delivered the mill's machinery (a "machine conjuguée" in 1826 and a low-pressure engine in 1839, according to their order books), so he

[110] Cockerill account books, Archives de l'Etat, Liege, 1244-1252 and 2499-2506.

[111] Richard Westebbe, "State Entrepreneurship: King Willem I, John Cockerill, and the Seraing Engineering works, 1815-1840," *Explorations in Entrepreneurial History* 8, no. 4 (April 1956): 205-233.

[112] Peter Lundgreen, *Techniker in Preussen während der frühen Industrialisierung* (Berlin: Colloquium Verlag, 1975), 167.

could through a former apprentice “obtain so many sketches and descriptions of it, that it was not necessary to see it with my own eyes.”[113]

In exchange for ongoing financial support, the Belgian state had demanded that Cockerill run his establishment as a model plant. Foreign industrialists positioned up and downstream took note, savoring a glimpse of the epicenter of continental capital goods production for tools and methods that might be implemented in different applications. They found the English technicians sent to install machinery quite open, in contrast to British and Belgian capitalists and manufacturers.[114] However, the transfer of techniques in machinery making via state-sponsored establishments in continental Europe meant that a wider gap existed between the latest technologies and general practice in workshops than in Britain.[115] Nevertheless, the German mining and machinery firm Gutehoffnungshütte held price-currents from 1820 and 1834 of Cockerill’s low-pressure engines, high-pressure engines, and engines with and without balanciers or horizontal cylinders, ranging from three to thirty horsepower in 1820 and six to twenty horsepower in 1834. In 1820, a twenty HP engine cost no less than 40,000 francs; in 1834, having diversified their lines, expanded operations, and begun to face competition, a variety of twenty HP engines cost between 5,620 and 10,690 francs.[116]

Seemingly having forgotten the artisan roots of the Cockerill’s behemoth enterprise, Ludlow doubled down on the value and necessity of skilled labor to national prosperity:

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[113] “Construite par la Société Cockerill depuis l’année 1824” and Cockerill order books, Archives de l’Etat, Liege, 2931; Lundgreen, *Techniker in Preussen*, 176.

[114] Lundgreen, *Techniker in Preussen*, 176.

[115] Peter Mathias, “Skills and the Diffusion of Innovations from Britain in the Eighteenth Century,” *Transactions of the Royal Historical Society* 25 (1975): 93-113.

[116] “Preiskourant der Dampfmaschinen” (1820, 1834), Gutehoffnungshütte, Rhine-Westphalia Business Archive (RWWA), 130-200200/0.

> But cannot labour emigrate and skill as well as capital? Do they not emigrate already? Even now we hear of offers pouring in to the members of the Amalgamated Society thrown out of work from Belgium, from America, of 200 of them having already left for Belgium. Is it supposed that they are the first emigrants of the kind? Is it supposed that they need be the last? Is it supposed that for one engineering establishment abroad founded with English capital, there are not a dozen in which English foremen and workmen are employed, in which consequently English skill and English labour go to enable foreign capitalists to compete with our own in the markets of the world? Is it supposed that there is not from America a constant demand for these English mechanics and for themselves every inducement to supply it?[117]

Ludlow saw William Cockerill more as shrewd capitalist than canny craftsman, yet he still felt compelled to stress the importance of skilled artisans despite the fact that emigration restrictions had been discarded nearly three decades earlier. He echoed a Capt. Fleming who had reported on the illegal export of machinery to Flanders, William Gibbons, mayor of Bristol, who had sounded the alarm over the emigration of artificers to America, noting that existing obstacles to it proved ineffective since they depended on oaths from captains with an interest in ignoring the law, and Rev. John Clare, a Wolverhampton magistrate, who had written to the British Home Office in July 1822 about a Frenchman "making to seduce manufacturers and artificers from this neighborhood to France," whose number "gone and engaged to go to France from this district is said to amount to between two and three hundred."[118]

In January 1823, Whitehall issued a notice to Sheffield manufacturers reminding them of the laws relating to the export of machines: those sending abroad wool, iron, steel, brass, or other metal as well as clock-makers, watch-makers, or any other "artificers of Great Britain" would be imprisoned three months and, on the second offense, a year.[119] Concerns had applied equally to

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[117] Ludlow, "The master engineers and their workmen."

[118] Letter from William Gibbons, Mayor of Bristol [Gloucestershire], to Home Office, on the subject of emigration of artificers to America, 18 April 1801, British National Archives, Kew, HO 42/61/212; see also, David J. Jeremy, "British Textile Technology Transmission to the United States."

[119] J. Wilson, Sheffield, to Home Office, advising that notice of laws relating to export of machines, January 27, 1823, British National Archives, HO 44/13/8.

mechanisms for infrastructure-building, beyond the establishment or improvement of a particular trade. The British government regulated Thomas Telford's sending "from this country to Sweden sundry tools and drawings necessary in the construction of Canals."[120] But artisans had continued to move.

The resurgence of debate during the 1851-52 engineering conflict reflected the fact that British manufacturers had become increasingly attuned to the role of the capital goods industries in assuring their lead over Continental industrializers.[121] This presented a paradox for machine-tools manufacturers and policymakers, the Board of Trade and the Home Office: How to profit by exporting the newly commodified inputs for production processes—tools, machinery, and expertise—without losing ground to one's foreign consumers in markets for manufactured goods or for machinery itself?

During the debates in 1824 and 1825, British policymakers had weighed the repeal of both the 1785 ban on export tools and machinery used in iron, steel, woolen, cotton, and silk manufacture as well as the 1719 and 1750 laws against the emigration of artisans. It is telling that the Select Committee on Combination Laws, Artisans and Machinery repealed the emigration restrictions alone, leaving in place the export ban and the curtailment of unionization—both of which had been deemed ineffectual by many, though not all, engineering employers in the course of hearings. British policymakers based their decision on the premise that controlling the international expansion of the capital goods industry would serve to protect every British industry; by 1841, however, they had turned toward promoting the profitability of the capital goods sector through exports.[122]

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[120] De Brinkmann to Telford, December 7, 1809, Institution of Civil Engineers, London, T/GC.28.

[121] Berg, *Machinery Question*, 205.

[122] Ibid., 209.

While historians have focused on the outcomes of the parliamentary debates, a closer look at the testimony given before the Select Committee over a two-month period from February to April 1824 reveals the underpinnings of a wider shift in arguments about the balance of power in workshops transitioning to piecework regimes, timelines of international industrial development, and the nature of producing, replicating, and selling capital goods in contrast to consumer goods.[123] The hearings essentially comprised a social survey of workplace routines and perceived interests among constituencies as diverse as engineers in London, cotton spinners and power-loom manufacturers in Manchester and its environs, handloom and mechanized weavers in Nottingham and Leicestershire, sawyers and shipwrights in Liverpool, and brass founders in Birmingham. These testimonies provide hints as to where exactly engineers who swore "knowledge is power" thought that knowledge lived—and whether or not it was advantageous, to key industries or to the nation, to share it.

The 1824 debates, though ultimately repealing the emigration restrictions, involved close scrutiny of artisans as factors of technological development via their mastery of defined, yet not codified, techniques.[124] Policymakers fractured over whether machines should be understood as artifacts independently carrying knowledge or as appendages of the mechanic himself. On the issue of industrial development in continental Europe, some engineers argued that foreigners could not reproduce machinery from plans alone, while others suspected that machinery exports would enable the construction of models to identify key principles. Yet others assured parliament that building on the basis of such models relied on the participation of émigré artisans.[125]

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[123] "Minutes of Evidence," Report of the Select Committee (1824).

[124] Berg, *Machinery Question*, 209.

[125] Ibid., 212.

Most witnesses called before the Select Committee stressed both. For instance, sugar refiner and engineer John Martineau (cousin of social theorist and popularizer of political economy Harriet Martineau) told Joseph Hume, presiding over the Select Committee, that he had conversed "last week with a large cotton manufacturer from France, who stated distinctly, that there was no model or machine in existence in England which he could not obtain a model or drawing by paying for it."[126] Hume asked whether those "models, drawings, and specifications [were] such, that when carried abroad they may by expert English artisans be made up and completed?" Martineau responded, "Certainly they may be."[127]

Engineer Alexander Galloway confirmed that foreigners could easily procure drawings and models "with the greatest of facility," for "with all our patents there are regular drawings obliged to be made, any man who will go the expense of paying for them, will get them; and in many instances we have specifications, where they may gain possession of them for a couple of shillings; drawings may be obtained to almost any extent, by those who will pay for them."[128] In the case of the Newcomen engine, an accurate engraving had been published as early as 1717, followed by designs in a German journal in 1727 and one in France in 1735.[129] British patents indeed contained printed specifications and plans, circulating beyond borders. Beginning in the early nineteenth century and continuing until the advent of international accords for intellectual property in the 1880s, British engineers took out patents in France to circumvent French piracy

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[126] "Minutes of Evidence," Report of the Select Committee (1824).

[127] Ibid.

[128] Ibid.

[129] Mathias, "Skills."

attempts via openly available patent specifications in London. These likewise diffused outward, detailing key components of their inventions.[130]

However, when Hume inquired whether the "very best English machine maker [could] make a machine from a model or drawing," Galloway replied, "Certainly not."[131] Galloway explained that "no drawing or model, except it was as large as the machine itself; not a model but a machine can possibly point out the parts where the best work is necessarily to be applied, in order to adapt the machine to its purpose."[132] By "the best work," Galloway likely meant the degree of precision finishing applied to the metal components of a machine, qualities neither depicted nor consistently measured at the time. For Galloway, indications of form and formal arrangements, especially when rendered at a smaller scale, were not enough to replicate a machine, much less one competitive in global markets.

Pressing further, Hume asked, "Even with the pattern machine, could the French machine maker make a machine to rival ours?"[133] Galloway took up the question to point out that the "first machines they make from the pattern machine, would not be equal to ours; and it would be a very long time before they could make them so cheap, and so well adapted to the purpose as ours."[134] A pattern machine might indicate textured details and finishes that eluded drawings of the era and enable the replication of castings in sand or loam. But a disassembled pattern machine, typically "embedded in saw dust when brought into the Custom-house" with "nothing

[130] Ibid.

[131] Ibid.

[132] Ibid.

[133] Ibid.

[134] Ibid.

but the very surface of them seen," would not transport the assembly of elaborate workplace divisions of labor that sustained British machinery makers' cost advantage.[135]

Martineau and Galloway were among the first promoters of the London Mechanics Institute; as Mechanics Institutes were intended to resist the stultifying aspects of the industrial regime while accommodating the demands of capital goods production, they conceived of the machinery industries within a paradigm of at least semiskilled workmen occupied with the progressive improvement of a growing shop. Galloway attributed the superiority of British machinery industry "to the high state of the subdivision of labour to which it is carried…owing to the extent in which it is carried on" and affirmed that its advantage in global markets would continue "till that extent and that consequent subdivision takes place in France."[136]

This sense of recent industrial history and the temporality of shifts in fabrication and invention, which Nasmyth would later deny via his notion of "Free Trade in Ability," inflected both the questions Hume posed and the answers he received from engineers engaged in the manufacture of textile machinery and machine tools. Moreover, both sides of the hearings connected the temporal issue to mercantile concerns over international competition in industrial development. For instance, Hume asked Martineau, "Is it not difficult, and does it not take a considerable time, to set up any manufactory for machinery?"[137] Pointing to the effects of a half-century of capital accumulation in the British machinery-making branches, Martineau answered, "In this country it does not take a considerable time because we have such facilities of obtaining

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[135] William Brunton to Hume, "Minutes of Evidence," (26 March 1824), 333. Online House of Commons Parliamentary Collection.

[136] "Minutes of Evidence," Report of the Select Committee (1824), 251.

[137] Hume to Martineau, "Minutes of Evidence" (1824).

tools of every description; in France it would take a considerable time."[138] William Fairbairn concurred that, while the French were " most anxious to get our improved machinery" and the acquisition of machinery would fuel a complementary demand for "our best workmen, in order to set that machinery to work, keep it in repair, and ultimately to do without us altogether," the bribing of "several mechanics from Manchester, excellent workmen," to go to France had not resulted in a situation where France possessed or could quickly develop what Hume called "that sub-division of labour among themselves, which is essential to the perfection of machinery."[139]

The Select Committee identified print culture as a potentially dangerous means of diffusing technical knowledge. Encyclopedias and technical dictionaries sold transnationally included engravings and details. [140] Questioning engineer Alexander Galloway, a member of the Society for the Encouragement of Arts and Sciences, Hume criticized the Society for publishing "annually a volume containing every discovery of importance that they can possibly include," which contained "drawings and descriptions, that would enable an English workman abroad, to make the very articles which are there detailed."[141] Galloway confirmed that the Society's publications were "specifically made for the purpose of directing a workman in any country; even a man who does not understand a word of English, would be able to fabricate those machines from the drawings."[142]

Hume asked whether this necessarily meant that the "publications of that society, and every other tending to extend science, are in contradiction" to the laws forbidding the exportation

[138] "Minutes of Evidence" Report of the Select Committee (1824).

[139] "Minutes of Evidence," Report of the Select Committee (1824).

[140] Mathias, "Skills."

[141] "Minutes of Evidence," Report of the Select Committee (1824).

[142] Ibid.

of machinery and the emigration of artisans. Galloway seemed to relish the opportunity to affirm his commitment to the Republic of Letters, responding they "give foreigners all the advantage of our own knowledge, and give them the means of fabricating all which we know, with as much readiness as any native of this country can possess; and in many instances, patent machines are known sooner in France than they are in this country."[143] Moreover, he confessed that French engineer Charles Dupin, a student of Gaspard Monge who had published plans of every type of machinery in British naval and military arsenals after a grand tour, had applied to him for drawings. Galloway supposed Dupin had witnessed every form of complex machinery in the factories and dockyards of Britain.[144]

Nevertheless, manufacturers outside the engineering shops of the London capital goods industries expressed reservations about the free exportation of machinery. Manchester textile interests opposed the free exportation of machinery during the 1824 debates, stressing the differences between capital and consumer goods, namely textiles.[145] In an 1824 pamphlet, engineer and cotton spinner John Kennedy, who testified alongside cotton manufacturer Peter Ewart before the Select Committee, pointed out that in the case of consumer goods, "what is necessary for the sustenance of man must be procured by a continued supply, and a worn out garment must be replaced by a new one."[146] However, the export of machinery, he contended, "compels the foreign manufacturer to possess the means of becoming his own machine-maker;

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[143] Galloway, "Minutes of Evidence," Report of the Select Committee (1824).

[144] Ibid.

[145] A.E. Musson, "The 'Manchester School' and the Exportation of Machinery," *Business History* 14, no. 1 (January 1972): 17-50.

[146] John Kennedy, "On the Exportation of Machinery: A Letter Addressed to the Hon. E.G. Stanley, M.P. by John Kennedy, Esq. of Manchester" (London: Longman, Hurst, & Co. 1824), 17.

and the more machines you send abroad, the greater number of mechanics become necessary to keep their parts in order."[147]

Kennedy suggested that this scenario had already played out within the United Kingdom. Scotland, having received machinery from English shops, had begun to manufacture machines locally and compete in English and Irish markets. Though later synonymous with Free Trade, Manchester had long stood by patent and trade restrictions, as in June 1785 when a group of patentees authored a petition opposing Pitt's Irish Commercial Treaty, which would have permitted workshops in Ireland to manufacture English inventions patented before 1785 and resell them, duty-free in England. James Watt, one half of the most secretive of machinery establishments, testified to the House of Lords that such legislation would void "the whole patent rights of this country, and thereby to do an act of the greatest injustice to a few individuals whose labors deserved better treatment."[148] When Richard Arkwright's patent failed to be extended the same year, Watt inferred that "Perhaps Mr. A[rkwright]'s cause was determined before it came into court…I had a suspicion at the time that A[rkwright] was given up as a sugar plum by the M[inister] to the men of M[a]n[chest]er to slacken their opposition to the Irish proposition."[149] Anticipating the precise symmetry Kennedy would see in the trade and patent issues four decades later, Watt wrote to Josiah Wedgwood that

> I agree that by the late decisions we have seen to what lengths the arm of despotic law may be stretched to undo any man who is suspected of the heinous crime of getting rich by his ingenuity. The same spirit of leveling prevailed there that has shown itself in forming the Irish resolution. The one was taking away the exclusive right of a private

[147] Ibid.

[148] H. I. Dutton, *The Patent System and Inventive Activity during the Industrial Revolution, 1750-1852* (Manchester: Manchester University Press, 1984), 36.

[149] Quoted in Dutton, *Patent System*, 37.

> person to the productions of his own ingenuity and the other was the wholesale taking away the exclusive privilege of the nation.[150]

Indeed, a consistent leitmotif to Kennedy's argument in opposition to free machinery exports was that of patent rights. He argued, for instance, that a "a patent granted to an individual operates, in the same manner, both as an incentive and as a remuneration, that restrictive laws do when considered in reference to the entire nation"—namely, to "encourage the exercise of ingenuity in the whole community."[151]

His analysis relied on particular understandings of technology as supra-commodity as well as an account of the process of invention as it was practiced. Kennedy posited "it is the productive value of the machine which gives it its value, not its absolute and intrinsic cost." Similarly, civil and mechanical engineer William Brunton testified before the Select Committee that there would be "great injury to this country from sending away, for instance, an iron mill, which would cost perhaps three thousand pounds, that would manufacture in this country its own value in less than a fortnight in iron."[152]

Engineers such as Brunton embraced mercantilist logic in 1824. When questioned as to whether he would restrict the export of all tools, Brunton replied that the "line of demarcation is rather of difficult finding; but there is clearly a difference between an anvil, a vice and a hammer, on the one hand; and a cotton machine on the other."[153] Nonetheless, he pronounced himself "for protecting every kind of manufactory in this country, which may be kept,"

[150] Quoted in Dutton, *Patent System*, 37.

[151] Kennedy, "On the Exportation of Machinery," 15.

[152] William Brunton, "Minutes of Evidence," First Report of the Select Committee (1824).

[153] Brunton, "Minutes of Evidence," Report of the Select Committee (1824), 331

especially complicated machinery which had not invariably made its way abroad.[154] Brunton noted that he would have extended his point to anvils, hammers, and vices, in the interest of Sheffield, if their export had not been so widespread already. Kennedy and Brunton inscribed within the definition of capital goods the necessity of monopoly.

As a representative of the Manchester manufacturing interests, Kennedy also sought to assert the textile manufacturers' rights in invention as a corollary to their rights in machine-based production. He observed that "it is a curious, but well-established fact that machine-makers as they call themselves in this country, or engineers as they style themselves in London, do but very seldom invent machines for the manufacturer." Guarding against claims from workmen involved in the fabrication of machines, he emphasized that "the smith, when he has made a machine, has, after all, contributed to no more than a part of its production; his, indeed, was the hand which wrought, but his was not the head which contrived the work; the inventor is not to be deprived of the reward of his ingenuity, because he has employed an inferior agent to embody his thoughts, and to assist in bringing his skill to a practical result."[155] On trade and patent rights, textile manufacturers such as Kennedy looked on engineers upstream and the artisans they employed with suspicion.

Kennedy understood invention in terms of risk and remuneration as well as the accretion of long-term experiment. He claimed it was "wisely forbidden, that as soon as a machine has been brought to perfection, at a great expense of time, and money, and talent, it should be immediately placed in the hands of those foreigners who are pursuing a similar manufacture with ourselves, but who have contributed nothing to the discovery or formation of the machine, and

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[154] Brunton, "Minutes of Evidence," Report of the Select Committee (1824).

[155] Kennedy, "On the Exportation of Machinery," 20.

who would thus, without the cost or the skill necessary for its production, reap its advantages, in common with ourselves, to the manifest injury of the inventor."[156] Kennedy acknowledged the possible contradiction between his positions on trade and patent, since the patent laws required disclosure of specifications, equally open to foreigners.

However, he believed the cost of attempting "to make a machine from such sources would often equal the expense of its invention here; at all events, much time would be required in order to get it into work so as to be practically serviceable, whilst we should in the mean time be ourselves, enjoying all the benefit derivable from its exclusive possession."[157] For Kennedy, Manchester's technical advantage as a textile-producer hinged on the limitations of the medium rather than the availability of the message.

Kennedy also distinguished between consumer and capital goods on the basis of elasticity in demand and the knowledge (or lack thereof) embedded in the commodity itself. He proposed that the "wrought products of our industry and skill, we are ready to exchange with all the world; but not to forego the use of those improvements which alone render our industry and skill, in any particular manufacture, available to us." Machinery itself, Kennedy argued, comprised Britain's sole comparative advantage when one considered the weight of taxation and the Corn Laws.[158] Moreover, Kennedy attempted to cast machinery as intrinsically less suited to trade than textiles, arguing that the "steam engine—millwork—gas apparatus—the hydraulic press—these do not produce fabrics suited to every country, climate, and condition of man; their products, singly considered, can never interfere with ours in the general market of the world."[159] Although

[156] Ibid., 12.

[157] Ibid., 19.

[158] Ibid., 14.

[159] Ibid., 24.

legislators such as Joseph Hume and witnesses such as John Martineau repeatedly wondered whether the restrictive trade regime would in fact spur—or had already spurred—other countries to develop their own capital goods sectors (when Britain could have otherwise stymied their growth through a deluge of machinery exports), Manchester prioritized enshrouding textile manufacture in as much mystery as possible in 1824.

By 1841, however, the Manchester interests had come to oppose the laws prohibiting the exportation of machinery.[160] Suddenly seeing the interests of consumer and capital goods producers as consonant rather than conflicting, they accused the trade prohibitions of depriving the "the laborer of an opportunity of procuring employment, by the curtailment of trade, either as a Mechanic or a Miner" and the "Machine-maker of extensive and profitable markets," while preventing the "Inventor and Engineer from reaping the reward for their ingenuity to which they are so justly entitled."[161] They began by commenting on the inefficacy of the restrictions, pointing out that the "obvious evil arising from the present law, has been, to encourage the Exportation of Machinery, by all the illegal and deceptive measures, which the chicanery and cupidity of man can devise." They charged that, by the aid of "the smuggler or the draftsman," almost "every improvement is transferred as soon as it is discovered" at premiums of 40 to 50 percent for heavy machinery and 10 to 25 percent for smaller machines. [162] They estimated the premium for smuggling all of the machinery necessary to construct a cotton mill at 25 percent, wincing at the lost sales opportunities if they abided by the law and the lost profits to middlemen if they did not.

[160] Joseph Hume, "Facts and Observations illustrative of the Evils of the Law, which prohibits the Exportation of Machinery" (Manchester: James and Joseph Thomson, 1841).

[161] Ibid.

[162] Ibid.

Moreover, the early waves of successful smuggling ventures meant that shipments had begun to wane as firms such as Cockerill grew to compete with the fifty percent mark-up British machines faced when smuggler fees, shipping and packaging, and tariff duties were factored in. Hinting at Seraing with all but name, the Manchester interests noted that

> all our best improvements are known, and may be purchased from Foreign Machine Makers, made from English models, by English workmen, and with English tools, at 20 to 30 percent above the Manchester prices. A list of the prices of Machinery, by official documents in Belgium… by which it may be seen how entirely our Machinery has passed into the possession of Foreigners.[163]

Smuggling exports had slowed to a trickle of patented new machines purchased as models. In the earlier case of the steam engine, Matthew Boulton of the highly secretive Boulton & Watt had likewise eventually conceded the inefficacy of controlling knowledge flows. Switching course to seek out foreign trade, he wrote to his son, Matthew Robinson Boulton, then studying in Germany, "In the course of all your travils, & acquaintance Pray enquire if any Steam Engines are wanted in Saxony or any other parts of Germany as I wish to cultivate a foreign trade in that Branch."[164]

From staunch mercantilists during the 1824 debates, the Manchester interests transitioned in the 1830s and 1840s toward seeking profits in industrial developmentalism and eventually the imperialism of Free Trade. Echoing Joseph Hume's line of questioning, they came to the conclusion that "We have forced other nations to become their own Machine makers, who would gladly have purchased them at our hands…We have contributed to the establishment of those great rival manufactories abroad, by our very efforts to prevent them."[165] At last they recognized

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[163] Ibid.

[164] E. Robinson, "The International Exchange of Men and Machines, 1750-1800: As Seen in the business records of Matthew Boulton," *Business History* 1 (1958): 3-15.

[165] Ibid.

that it was "an Utopian scheme at first to limit the fruits of inventive genius by legislative enactments, and would be increasingly so in the present age" when "Literature and Science have become the property of the world" and the attempt to

> confine any mechanical device to our own shores, has hitherto baffled all our vigilance and skill, and could we succeed in this, we could not prevent the spread of knowledge and discovery by public and scientific journals and human intercourse.[166]

Peter Jones' recent work on the Lunar Society and Birmingham notwithstanding, the enlightenment part of the Industrial Enlightenment had come late to Manchester.[167]

Their 1841 pamphlet continued to mourn the loss of "hundreds of our most valuable mechanics" through emigration, suggesting that the 1824 repeal of the emigration restrictions should not have been undertaken without a consistent policy as to the "articles of their production."[168] They conceded the point was now moot, for, though "we might, by violent measures, frighten back some of our artisans,…the Tools and Models would remain."[169] Consequently, the Manchester interests determined to seize the opportunity to assist "every country…anxious to become its own manufacturer," believing each would "to a certain extent…attain its end, whatever its natural disadvantages may be." This entailed abandoning the mercantilist division of the world into pure zones of cash crop cultivation, sheepherding and transhumance, or mineral extraction versus regions of refining, fabrication, and manufacture—a view the London engineers such as Galloway and Maudslay had never held sacred, involved as

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[166] Ibid.

[167] Peter Jones, *Industrial Enlightenment: Science, technology and culture in Birmingham and the West Midlands 1760–1820* (Manchester: Manchester University Press, 2013).

[168] Hume, "Facts and Observations."

[169] Ibid.

they were in furnishing machinery for mints in Algiers, Bombay, and Calcutta as well as Chile and Colombia.[170]

Now Lancashire concurred that the

> time cannot be far distant, when, in addition to the present markets, there will be New Continents of vast and unknown extent, as well as the numerous Islands of Polynesia, where civilization and inquiry have begun to dawn; and who will seek to avail themselves of the power of Machines, to effect local improvements in their country, as well as for the purposes of trade.[171]

The question was therefore: "Who are to become their Machine Makers?"[172] Reflecting Manchester's change of opinion, not merely the general growth the capital goods sector itself, Britain dismantled its restrictions on the export of machinery the next year in April 1842.

Patent Monopolies, Democratized Fees, and the Regulation of Specifications

Annual British patents increased from seven in 1750 to 455 in 1851. However, calls for reform or abolition of the patent laws had become widespread by the time Charles Dickens published *A Poor Man's Tale of a Patent* in 1850.[173] The Manchester interests had long been attentive to the rights of the inventor (except when they desired the open proliferation of his technology, as in Arkwright's case) and the cost of invention. Their 1841 tract favoring the repeal of the export restrictions, having brought notice to the ongoing smuggling of patented new machines, emphasized that inventors could also "transmit accurate working drawings, with a full description of the various parts, by which any engineer of moderate capacity will readily cause

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[170] "Minutes of Evidence," Report of the Select Committee (1824).

[171] Hume, "Facts and Observations."

[172] Ibid.

[173] Dutton, *Patent System*, 1; Charles Dickens, *A Poor Man's Tale of A Patent* (London, 1850); see also, Christine MacLeod, "The Paradoxes of Patenting: Invention and Its Diffusion in 18th- and 19th-Century Britain, France, and North America," *Technology and Culture* 32, no. 4 (October 1991): 885-910.

one to be constructed; or he may himself accompany them, along with some of his workmen, and superintend its erection."[174] This resulted in a "twofold injury" to the country via the "loss of the trade and the instruction of foreign workmen." Yet they asked: "But who will blame the man?" Reaching foreign markets seemed the only way to find recompense for inventive and patenting processes, the invention being the "only fruit of a life of labour, and a fortune spent in repeated experiments."[175]

Having upended the former trade regime, Manchester turned to advocate reform of the British patent system, which included no less than eight steps (if unchallenged) and ten offices—such as the Home Office, the Attorney General, and the Queen's Warrant—and could cost up to £400 for all three kingdoms, with a single one costing around £100.[176] Meanwhile, patent applications in the U.S. cost \$30 (about £7) and those in France 300 livres (approximately £13).[177] In Prussia, they cost no more than their postage according to Prussian Patent Commission and Board of Trade and Commerce member Wilhelm Wedding, who testified before the 1851 British inquest regarding patent reform.[178]

As early as 1807 journalist John Clennell critiqued the patent laws, not only for their high cost and administrative complexity but also for the propagation of "mystery" as such. He deplored the irrevocable loss of ancient techniques such as the formula for cement and lambasted the secrecy clauses in apprenticeship contracts. He wrote "it is much to be regretted that no

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[174] "Facts and Observations illustrative of the Evils of the Law, which prohibits the Exportation of Machinery."

[175] Ibid.

[176] Thomas Webster, "Minutes of Evidence," (1851). British Parliamentary Archives.

[177] MacLeod, "The Paradoxes of Patenting: Invention and Its Diffusion in 18th- and 19th-Century Britain, France, and North America," 893.

[178] William Wedding, "Minutes of Evidence," (1851). British Parliamentary Archives. On the U.S. patent system, see B. Zorina Khan, *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790-1920* (Cambridge: Cambridge University Press, 2005).

earlier intercourse had taken place between the European and Asiatic nations; or rather, that a desire to penetrate into their sciences had not sooner unfolded itself."[179] He compared those who feared that dispensing with the patent laws wholly would disadvantage Britain in global markets to those who had made the same argument regarding the abolition of the slave trade. And he was not entirely alone—at the high tide of Free Trade sentiment, the Netherlands abolished its patent laws completely in 1869.

Proponents of a patent system—political economists, engineers, patent agents, inventors, manufacturers, and lawyers justified their plans by four distinct arguments: natural law; the reward-by-monopoly thesis; the monopoly-profit; and exchange-for-secrets. Though advocated by J.R. McCulloch during the patent reform campaign of the 1820s, British legislators (like their American counterparts) never adopted the natural-law thesis of inventor's inherent and inalienable rights by labor, the basis of the French patent law of 1791, as a valid foundation for intellectual property.[180] Although inventors never tired of referring to rights, patent law would be a matter of purely instrumental reasoning in American and British policymaking alike.[181] Accordingly, W.H. Wyatt, editor of the of the *Repertory of Arts*, called the patent system the most significant "spur to the improvements of the arts and manufactures in this country."[182]

Conceived to promote invention and the widespread adoption of techniques, the British patent laws had prior to 1734 required that a certain number of apprentices be taught the particular art for which the patent had been accorded. The 1778 Liardet case established that this

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[179] John Clennell, "Thoughts on the expediency of disclosing the process of manufactories: being the substance of two papers lately read before the literary and Philosophical Society of Newcastle upon Tyne" (1807), 3. International Institute of Social History, Amsterdam.

[180] Dutton, *Patent System*, 17.

[181] James Boyle, *The Public Domain: Enclosing the Commons of the Mind* (2008); Peter Baldwin, *The Copyright Wars* (Princeton: Princeton University Press, 2014).

[182] Dutton, *Patent System*, 21.

requirement would be replaced by filing a specification, available in a central repository to common use.[183] Inventors soon objected to the result of Liardet, as in 1793 when the House of Commons considered a bill for the concealment of specifications, especially from foreigners, for the duration of a patent. But the bill failed along with two bills proposed by inventors, manufacturers, and engineers in 1820-21 for provisional protection during experimentation.[184] Individual inventors such as James Booth (1792) and James Lee (1812), however, succeeded in preventing the disclosure of their specifications for seven years through special proceedings.

The 1829 inquest into reforming the patent laws had included no representatives from the cotton, chemical, or machine-making industries.[185] By 1851, in the wake of the Crystal Palace exhibition and attendant fears that unpatented technologies would by pirated by foreign visitors, the parliamentary investigation relied on the testimony of individual inventors such as I.K. Brunel and Richard Roberts as well as the Patent Law Reform Association (Manchester) under the leadership of William Fairbairn, Frederick Campin of the United Inventors' Association, and Henry Cole of the Society of Arts.[186] In the course of testimony, Fairbairn observed that inventors of improvements were "chiefly mechanics and people connected with practical chemistry," agreeing with the committee chair, Granville, that most improvements "emanate from...individuals to relieve themselves or to forward their own efforts in the conduct of their own business."[187] Fairbairn's allusion to inventive "mechanics" was already an ambiguous statement by 1851, for the engineering industries had undergone the transformation to capital-

[183] Ibid., 39.

[184] Ibid., 41.

[185] Ibid., 44.

[186] Ibid., 58-60; Henry Cole, Minutes of Evidence—Patent Law (May 1851), 1. British Parliamentary Archives.

[187] Fairbairn, Minutes of Evidence—Patent Law (1851), 27. British Parliamentary Archives.

intensive production and would within months be embroiled in a nationwide battle between organized engineering employees and their employers. But his meaning would become clear in the course of the patent debate.

In 1850 the Manchester Patent Law Reform Association had sent a resolution to the Board of Trade calling for a single patent office and the extension of patents to the entire dominion for up to twenty-one years. They also proposed that charges levied to inventors should be £5 at the time of granting and each year thereafter; that plans and specifications should be deposited when the application is made and the inventor's right to date from that time; that the stamp duty on specifications be abolished; that an authorized printed copy of all plans and specifications in full, along with lists of expired and forfeited patents be published weekly; that in all cases of disputed patent rights, "be authorized and registered, on the affidavit of the party aggrieved, to issue warrant to the judge of the county court of the district in which the supposed infringement or disputed right has taken place, ordering him to summon a jury, consisting of twelve persons familiar with the subject, to decide the matter in dispute, a majority of not less than three fourths of the said jury to be decisive"; and that the applicant or applicants for a patent should make a "declaration that the invention is his or theirs, or that it is a communication from another person, and if it be a communication from a resident within the United Kingdom, the name of such person should be mentioned and appear in the grant."[188]

Commentators such as jurist Thomas Webster perceived that an annual fee might be a "perpetual tax upon people" and would "enable capitalists to get a large number of patents into

[188] Thomas Webster, Minutes of Evidence—Patent Law (15 April 1851), 44-45. British Parliamentary Archives.

their hands"—it would in essence "operate rather as an oppression to the poor man, than for his benefit."[189]

Facing this critique, the Manchester interests gave up the annual fee, replacing it with a recommendation for a system perhaps more onerous: a "small sum" of £20 upon granting and a payment of £40 at the end of the third year to extend it four years and another of £70 at the end of the seventh to extend it a further seven. They proposed that such a measure would "lead to the abandonment of patents which were not actually useful and to getting rid of those suggestions which have been made by various patentees for the amendment of patents."[190]

William Fairbairn claimed that "most of the inventors in Manchester" were of the opinion "that we should give every possible facility to the working classes to come forward with inventions by make the cost of obtaining a patent as cheap as possible." Elaborating on this democratic impulse, he recounted that the Manchester committee had gone almost as far "as to wish to have Patent here as cheap as Patents in America and in France." Nevertheless, the Manchester committee had ultimately settled on a proposal wherein the cost of a patent for the three kingdoms would be between £120 and £130.[191] When asked to justify this determination, Fairbairn parried that making patents too cheap "might load the Patent Office with a number of useless inventions."[192] Perhaps the Manchester engineering employers hoped to maintain the disjuncture between who invents and who patents.

[189] Ibid., 46-48.

[190] Thomas Webster, Minutes of Evidence—Patent Law (15 April 1851). British Parliamentary Archives.

[191] William Fairbairn, "7th day," Minutes of Evidence—Patent Law (19 May 1851), 3-4. British Parliamentary Archives.

[192] Ibid., 4.

Paul Kapsey Hodge, a civil engineer, inventor, and patent agent who had worked in the U.S., directly contradicted Fairbairn's claim, asserting that under the American system patents "are very numerous, but they are generally for useful inventions." Again casting Fairbairn's depiction of invention into doubt, Hodge stated that the "real inventors are generally operatives—practical men" and gave the example of a spinning machine invented by one of his American journeymen "which has been bought for £66,000" and was "now in the Exhibition."[193] Hodge noted that it would have been impossible for the journeyman to afford a patent in Britain.

Hodge agreed with most commentators in observing that the patent laws were too complicated and too expensive. Admiring the American system, he predicted that if "we had a cheap patent law, many inventors among the operatives of the country who are very often the real inventors of the country would be encouraged to take out patents."[194] Hodge underscored the importance of patent protection for incentivizing invention among laborers.[195] He testified that, though "sometimes the workman meets with a liberal employer" such as "Mssrs. Sharp of Manchester who gave Mr. Hill at the head of their loom department 2 or £3000 for an improvement in a carpet loom," more often the employer benefitted from the invention rather than the workman-inventor.[196] Hodge believed that inventions came primarily from operatives, but were frequently not acknowledged as such.[197] When workmen notified their masters of initiatives, the masters would take out a patent and risk a trial, for "the decisions in the courts of England are such as to deprive the operative of having any advantage provided it is proved if it is

[193] Paul Kapsey Hodge, Minutes of Evidence—Patent Law (1851), 34-35. British Parliamentary Archives.

[194] Paul Kapsey Hodge, "4th Day," Minutes of Evidence—Patent Law (12 May 1851), 2. British Parliamentary Archives.

[195] Ibid., 36-37.

[196] Ibid., 37.

[197] Ibid., 39-40.

his invention that he is the servant of the manufacturer."[198] Given that a "great number of improvements made by workmen become patented by the masters," jurist Thomas Webster concluded simply, "it is hopeless for a workman to take out a patent."[199]

Debates over specific issues, such as provisional patenting and the necessary comprehensiveness of specifications submitted, reveal the epistemic and depictive dimensions of class conflict alongside more visible inequalities within Britain's engineering industries. Webster believed that provisional patents were essential to enabling "the workman to make his bargain with the capitalist" since unless "he can go and get protection at a cheap rate he will not be on an equal footing."[200] But Fairbairn objected to provisional patents. He stated flatly that they "should specify and take their drawings to the office, and by paying the money receive the Patent."[201] Fairbairn thought that provisional patents, rather than "giving a man an opportunity of making bargains with Capitalists," promoted vagueness and offered other parties the chance "to come forward hearing of such inventions and claim them as their own."[202] Instead, Fairbairn envisioned a system wherein "any person coming forward with an invention matures that invention as far has he can before he applies for a Patent."[203] Confident in his abilities to navigate the scientific and legal requirements of patenting yet wary of workmen, competitors, and patent sharks alike, Fairbairn demanded a patent system of clarity and explicitness in designs and immediate, one-time conferral of rights.

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[198] Ibid., 41.

[199] Thomas Webster, "1st Day" Minutes of Evidence—Patent Law (15 April 1851), 92. British Parliamentary Archives.

[200] Ibid., 128-129.

[201] William Fairbairn, Minutes of Evidence—Patent Law (1851), 7-8. British Parliamentary Archives.

[202] Ibid., 10-12.

[203] Ibid., 14.

"Maturing" an invention required capital and time for experiments (witnesses suggested six months to three years on average) unavailable to most workmen; however, Webster pointed to another difficulty, that of specification itself. He argued that poor inventors "are very often unable to write at all adequate descriptions of their inventions." "When their attention has been called to the insufficiency of a description," he continued, they have "had it altered and it has turned out that inventions which would have been rejected upon the plea of insufficient specification as they originally sent it in have been very useful and very important inventions."[204]

Presiding over the inquest, Lord Granville further wondered whether "there still is a period during which it is necessary for him [an inventor] more or less to divulge that invention to other parties to facilitate him in completing the details for the purpose of the specification" after he had "very clearly conceived in his own mind all the essential principles of an invention."[205] Unmoved, Fairbairn replied, "If he has completed the idea and has the invention distinctly and clearly in his mind he has perfected the invention and I do not see why he should not specify it at once."[206] Whether out of interest or ideology, Fairbairn refused to concede the existence of other forms of mechanical knowledge or ways of conveying it, or other means, though difficult, of bringing a machine into operation. His testimony collapsed capital availability, drafting norms, professional networks, and socio-legal institutions into the "mind's eye" of the engineer, seamlessly leading from idea to patent and practice.

When Granville inquired whether manufacturers received "assistance and suggestions from their workmen," Fairbairn claimed a relation of reciprocity predominated, wherein "we are all largely indebted to each other for discoveries of that kind." Denying the salience of class,

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[204] Thomas Webster, "2nd Day," Minutes of Evidence—Patent Law (5 May 1851). British Parliamentary Archives.

[205] Lord Granville, Minutes of Evidence—Patent Law (1851), 16. British Parliamentary Archives.

[206] William Fairbairn, Minutes of Evidence—Patent Law (1851), 16. British Parliamentary Archives.

Fairbairn invoked the universality of mechanic pursuits in which an "idea applied to any particular subject may sometimes suggest its application to another subject which is diametrically opposed to it."[207] Granville continued his line of questioning, asking whether workmen were "very apt to consider the inconvenience which they practically meet with in manufacturing whatever is before them and to attempt to remove it." Fairbairn's answer reveals watchfulness reminiscent of Nasmyth's sketchbook: "Yes, in the manipulation of the workmen you often see a great many processes which you can improve."[208] For Fairbairn, the social relations of production comprised a mechanism, one from which technical innovations could be envisioned and culled. Attributing invention to insight within and over production, I.K. Brunel claimed that improvements come "generally from a man of observation" when "circumstances attract his attention—he sees results produced which did not occur to him before, and being an intelligent man he sees how it may be applied and some opportunity occurs by accident by which he can apply it."[209]

Financing invention and patenting was a different matter. Fairbairn explained that in the manufacturing districts of Lancashire, there were many cases when "only one person comes forward as a capitalist and the profit is divided equally between him and the inventor," while in other instances investors would "form a sort of company" with "four or five or six capitalists having different shares" in the patent.[210] Most patent applications, he argued, emanated from persons who were simultaneously capitalists and inventors.[211] He doubted whether an "accidental

[207] Ibid., 31.

[208] Ibid., 31.

[209] I.K. Brunel, Minutes of Evidence—Patent Law (1851), 67-68. British Parliamentary Archives.

[210] William Fairbairn, Minutes of Evidence—Patent Law (1851), 61. British Parliamentary Archives.

[211] Ibid., 61.

idea suggesting itself to the mind of a workman" lay at the root of many inventions, objecting to popular opinion on the matter—"I do not think those cases are so numerous as many persons imagine." The majority of those cases, he found, were in engineering shops and manufacturing establishments which had implemented piecework regimes; as a result, the workman "to save his time and labour" suggested "improvements which are adopted by his employer." Fairbairn claimed that most inventions came from working partners, or men who began as workmen but had "gone up progressively by step" until they had "become the junior partner."[212] He nonetheless remarked, "very often I have known cases where the manufacturer has taken the advantage of the workman and used his patents and has not remunerated him except by a very small sum indeed."[213]

Passed in July 1852, three months after the engineering employers had smashed the Amalgamated Society of Engineers through a lockout, the Patent Law Amendment Act implemented three of Lancashire's main requests: a single patent for the three kingdoms, the establishment of a unified patent office, and the reduction of a patent's cost to £180 payable in three installments over seven years.[214] Fairbairn publicly praised the government for, as historian H.I. Dutton put it, "fully recognizing the link between intellectual creativity and the 'products of national industry.'"[215]

Somewhere between the two stood the engineering workers, such as the boilermakers who had struck for two months at Fairbairn's steam engine works over a decade before the 1851

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[212] Ibid., 64.

[213] Ibid., 66-67.

[214] Christine McLeod, *Heroes of Invention: Technology, Liberalism and British Identity, 1750-1914* (Cambridge: Cambridge University Press, 2007); Dutton, *Patent System*, 63.

[215] Dutton, *Patent System*, 64.

inquest. In his testimony, Fairbairn pointed to this event as a representative stimulant to invention since he had resolved to "do without them altogether."[216] He "produced the machine which now rivets the boilers," which meant that "in the course of two days we can do as much work as we could have done otherwise in two months," putting "twelve rivets by compression in one minute with two men and a boy whereas it took one minute to put in one rivet with three men and a boy before."[217] Fairbairn's riveting machine and process were in 1851 the national standard.

Facing the advent of a global capital goods trade with anticipation and a defeated cohort of mechanics at home with vigilance, Joseph Whitworth wrote in 1853 to the Committee for Superintending the Construction of Standards of Length and Weight to argue that the "value and importance of exact measures of size to many of our Manufacturers can hardly be over estimated."[218] Even before the Crystal Palace had displayed the rapid advances of American engineering, trade fairs in Paris and Ghent in 1849, where "inquiries into the properties of an object, indications of forms, dimensions, etc. were with overwhelming fearfulness prohibited," had revealed the full extent of Continental copying. One visitor, Wilhelm Oechelhäuser from Mülheim an der Ruhr, reported that the original construction of James Nasmyth's steam-hammer was copied everywhere in Germany, whereas the French took the design and experimented with diverse modifications to it. Oechelhäuser found "impeccable execution" among the machinery

[216] William Fairbairn, Minutes of Evidence—Patent Law (1851), 29-31, British Parliamentary Archives, London.

[217] Ibid., 29-31.

[218] Joseph Whitworth, Letter from Joseph Whitworth to the committee for superintending the construction of standards of length and weight, Manchester (16 Feb 1853), British National Archives, Kew.

exhibited, noting that in many "practicable machine tools, one can currently outfit oneself almost as well in Paris as in Manchester, and certainly at much cheaper prices."[219] He admitted

> to the Englishmen remains the merit of having raised the development of this important species of machine to its current high level; the prevailing direction in the French and German constructions is the imitation of the models of Whitworth, Nasmyth, Collier, Sharp Brothers and other famous English engineers.[220]

Such laudatory observations were presumably cold comfort to Whitworth.

Pressures from within and without shoved Whitworth in the direction of state reform of industrial measure. "It may be assumed," he reasoned "that any adopted Standard of length should, if possible, be of such construction that *exact* copies could both now and at any future time be made."[221] Unfortunately, Whitworth noted, the Committee had so far failed to produce two standard yards of equal length at the same temperature under the microscope. Britain had yet even to decide on the adoption of end measure, though France, Russia, and Prussia had long used it and "the great simplicity of the means which have been successfully employed in the production of any number of Bars of identical length…attests its superiority and value."[222]

Pushing for precision within his own works, Whitworth updated his manufactory by "making several thousand Standard Gauges of size for Engineers; and with such success that the Admiralty, and many other public bodies as well as private individuals, now stipulate in their contracts for steam and other machinery that my Standards of size shall be used."[223] Such devices and systems would resolve the problems faced "in many of the important trades," where

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[219] Wilhelm Oechelhauser, *Bericht über die auf den diesjährigen Gewerbeausstellungen zu Paris und Gent ausgestellten Maschinen, Metalle, Metallwaaren und Papiere* (Frankfurt a.M.: Saulerländer's Verlag, 1849).

[220] Ibid.

[221] Whitworth, Letter from Joseph Whitworth to the committee for superintending the construction of standards.

[222] Ibid.

[223] Ibid.

it remained "necessary to send the sample itself in giving the order, because the Manufacturer is not in possession of any means to enable him to ascertain and therefore to express its size."[224]

Having ousted the state from regulating international trade and asserted their right to "do as they will" with their employees, engineering employers such as Whitworth now asked that the "Government…be urged to require that Standards of size, to which all parties might have free and constant access, should be placed in the Town Halls of our Manufacturing Towns."[225] Whitworth suggested himself as "prepared to undertake, if required, to furnish you with a 3 feet Standard Yard, and also with a Standard Foot, and Standard Inch, as well as with one or more identical copies of each such Standard."[226] Operating successfully between public and private interest, he would also define the standard British screw thread, now that screws exceeding one and a half inches in diameter were allowed for export.

Commercial monopolies in bodies and machines policed at the Customs House, however ineffectually, had with the rise of self-acting tools and piecework in the capital goods industries given way to a renovated, yet reinforced system of legal rights in invention and the lock-in of technical complementarities. Having transformed significantly in their relocation from London to Lancashire, British engineering shops successfully lobbied the Manchester interests to support Free Trade for machinery; for technical knowledge, however, they resisted full Free Trade in favor of efficient state regulation of rights in well-defined intellectual commodities. But across

[224] Ibid.

[225] Ibid.

[226] Ibid.

the Channel, French engineers had decades before attempted the standardization and control of millwright and mechanic work through not only law and measure but also drawing itself.[227]

[227] Ken Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763-1815* (Chicago: University of Chicago Press, 2010); on French engineering, see Antoine Picon, *French Architects and Engineers in the Age of Enlightenment* (Cambridge: Cambridge University Press, 1992).

Chapter Two: Power Conveyance

Afterlives of Géométrie Descriptive and Mechanic Republicanism in the Atlantic, 1815-1848

Many accounts of economic change over the nineteenth century focus on the substitution of fossil fuels for human and animal-power, and rightly so. At the sale of John Cockerill's Seraing factory on the river Meuse near Liège in April 1840, it became clear that the motive force of his works, totaling nearly 784 horsepower with 19 steam engines and workshops capable of employing 5300 workers, reled on a colliery of over 195 hectares in "full exploitation." [1] With exclusive rights to the coal accorded to John Cockerill & Co. by royal concession in 1828, the Cockerill works extracted around 500,000 kilograms of coal daily via three shafts. This prodigious quantity of coal of the "best quality" fueled an iron factory with two furnaces equipped with steam engine blowers, giving a product of 160,000 kilograms.[2] The Cockerill works also served as the most important way station for English technology diffusing onto the European continent (see chapter one).[3]

Beyond the advent of the coal-based anthropocene, a more subtle form of power conveyance was interwoven into the trends of growing urbanization, network expansion, and market dependency.[4] This power conveyance included the initial conquest of industrial processes by image, accompanied by the envisioning of continental forms of political economy and national industrial development. The latter had been temporarily realized for both continental

[1] Dossier relatif à la vente publique de l'établissement de Seraing: annonce de la vente, description du bien à vendre et cahier des charges (24 février 1840), Archives de l'Etat, Liège, 1383.

[2] Ibid.

[3] Martin Schumacher, *Auslandsreisen deutscher Unternehmer 1750-1851* (Köln: Rheinisch-Westfalischen Wirtschatsarchiv zu Köln, 1968), 132.

[4] For coal-centric accounts, see E.A. Wrigley, *Energy and the English Industrial Revolution* (Cambridge: Cambridge University Press, 2010); Kenneth Pomeranz, *The Great Divergence: China, Europe, and the Making of the Modern World Economy* (Princeton: Princeton University Press, 2009); Andreas Malm, *Fossil Capital: The Rise of Steam Power and the Roots of Global Warming* (London: Verso, 2016).

Europe and the United States in the context of the tariff system of Napoleonic Europe and the disruptions in international trade resulting from the Napoleonic wars. Continentalist national political economy found staunch advocates in "industrial publishers" such as economist Henry Carey in the United States and among popularizers of Friedrich List's political economy in continental Europe.[5]

Conquest by Image

Born in Beaune in 1746, engineer and mathematician Gaspard Monge invented, theorized, and promoted the methods, which would underlay all forms of modern drafting. Monge had entered the *Ecole Royale du Génie* at Mézières in 1764 with a plan he had made of his hometown. Officials at the military engineering academy quickly recognized his talent and hired him as a draftsman to work on calculations for fortifications. At this post, Monge developed a more efficient method for defilading, or design calculations to protect the external lines of forts from the frontal fire of adversaries and the internal ones from reverse fire. From 1775 to 1784, Monge developed this method into descriptive geometry as royal professor of mathematics and physics at Mézières. The stonecutters at the site were willing to adopt his technique, but the carpenters resisted the transition away from crafts methods for a full twenty years. They recognized the risks entailed within a mathematical drawing technique enabling the generation of curved surfaces from lines, with the intersection of planes clearly portrayed on paper.[6]

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[5] Henry Carey, *The Harmony of Interests: Agricultural, Manufacturing, and Commercial* (Philadelphia, 1851); Friedrich List, *Das nationale System der politischen Oekonomie* (Stuttgart: Cotta, 1842).

[6] Peter Jeffrey Booker, *A History of Engineering Drawing* (London: Chatto & Windus, 1963), 95.

1784 marked Monge's departure from Mézières to engage in the education of naval cadets and the study of experimental physics and chemistry.[7] Following the Revolution, when he served as a member of the Executive Council at Louis XVI's execution, Monge worked briefly as naval minister before being appointed in 1794 to the commission planning the *Ecole Centrale des Travaux Publics*. This school eventually became the *Ecole Polytechnique*, where he taught descriptive and differential geometry to a generation of engineering students. These students became military cadets with the Napoleonic conversion of the school into a military academy in 1804. Monge advocated the reestablishment of the *Académie des Sciences* and the *Institut de France*, previously eviscerated by revolutionary authorities, served on the commission selecting works of art to transport from Italy to France, and, through his good relationship with Napoleon, participated in the scientific aspects of the expedition to Egypt in 1798 and 1799. With Napoleon's defeat in 1812, Monge's health deteriorated. He died in 1818, on the wrong side of contemporary politics. Although fellow mathematicians, engineers, and officers paid their last respects, the restored monarchy refused him a funeral with fanfare.[8]

Both nationalism and universalism lay within the Enlightenment project of reforming useful knowledge, in general and machine design in particular. A French revolutionary engineer who authored standard works on the production of iron, steel, and cannon, Monge saw his nation's territorial sovereignty as threatened by Prussia and economic security facing the risk of industrializing Britain. For the promotion of national industry, he advocated technical education for workers at all phases in the production of manufactures.[9]

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[7] Jeremy Gray, "Mathematics in the French Revolution," in *Worlds Out of Nothing: A Course in the History of Geometry in the 19th Century* (London: Springer, 2007).

[8] Ibid.

[9] Booker, *History of Engineering Drawing*, 103.

Yet historian Ken Alder has shown that military engineers at the end of the *ancien régime* were attempting precisely that total overcoming of craft-based methods. Alder argues that engineers used projective drawings and capital goods together "to oblige artisans to produce standardized artifacts," which they then "refined in increasingly rule-bound ways to forestall further subversion by artisans."[10] According to a more functionalist interpretation, the industrial revolution "required new graphic conventions to communicate its need for precision, and, therefore, many books and pamphlets on drawing were written in the first decades of the nineteenth century."[11] Alder rightly rejects this approach. Unlike recent historians of the British Industrial Revolution, he views the "objectivity" of schematics as "the outcome of social conflict and negotiation over the terms of an exchange."[12] According to Alder, this process, not the more commonly cited advent of Taylorism and the large bureaucratic corporation of the early twentieth century, is the real taproot of "making things the same"— or how we reached a "world in which 10,000 bicycle gears cut in Japan can be shipped halfway around the world to Mexico and fastened successfully to 10,000 hubs."[13]

In revolutionary France, engineers and mathematicians had pursued two main techniques of reformulating and reforming artisan work processes. One route lay in the attempt of artillery officer Lt. General Jean-Baptiste Vaquette de Gribeauval (1715-1789) to achieve

[10] Ken Alder, "Making Things the Same," *Social Studies of Science* 28, no. 4 (August 1998): 499-545.

[11] David Brett, "Drawing and the Ideology of Industrialization," *Design Issues* 3, no. 2 (Autumn 1986): 59-72.

[12] Alder, "Making Things the Same."

[13] Ibid.

interchangeable parts in the production of arms via locks, jigs, and templates.[14] In 1765 Gribeauval had commenced an agenda to make arms as easily switched as soldiers. [15]

Gribeauval's pursuit of interchangeable parts spread to the United States via the interest of the War Department in Honore Blanc's experiments in producing uniform musket parts.[16] A major advocate of Gribeauval's program, Thomas Jefferson asked Blanc to transplant the experimental endeavor to the United States. Writing to Secretary of War Henry Knox, Jefferson explained that Blanc's "method of forming the firearm appears to me so advantageous, when repairs become necessary, that I have thought it my duty not only to mention to you the progress of this artist, but to purchase and send you half a dozen of his officers' fusils [light muskets]." [17] Within the U.S. War Department, the French artillerist and military engineer Major Louis de Tousard advocated interchangeable parts manufacture. In 1798 he submitted a proposal for the formation of a school of artillerists and engineers to Secretary of War James McHenry, which laid the foundation for West Point. [18] In 1809 Tousard published three volumes of the *American Artillerist's Companion*, which served as West Point's main textbook and inspired ordnance officers in particular to aim passionately for interchangeability.[19]

Although policymakers beginning with Jefferson had proposed conveying the Gribeauvalist agenda "to our own workmen," cultural factors among artisans and mechanics

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[14] Ken Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763-1815* (Princeton: Princeton University Press, 1997).

[15] David Hounshell, *From the American System to Mass Production, 1800-1932* (Baltimore: Johns Hopkins University Press, 1997), 25.

[16] Ibid., 25.

[17] Ibid.,26.

[18] Ibid.,26.

[19] Ibid.,27.

could—and did—complicate the U.S. military's push for interchangeability. The "American System" of interchangeable parts would be decades in the making, owing much to state (military) support.

Gribeauvalist reforms did not necessarily demand mechanization, as interchangeable parts can be produced with hand tools.[20] But machine tools—lathes, milling machines, grinding machines, boring machines—proliferated over the course of the nineteenth century. The design and manufacture of machine tools came to depend increasingly on the other French revolutionary innovation in engineering: drafting according to descriptive geometry.

That other path led through the efforts of Gaspard Monge, instructor at the *Ecole Polytechnique*, to compel artisans to produce standardized artifacts via depictive techniques based on descriptive geometry.[21] Over the course of the nineteenth century, Monge's system of projection would become the dominant drafting norm, as decision-making power shifted from shop floor to drafting room.

Monge's descriptive geometry contributed to this process by solving the problem of depicting the position of a point in space and from there generating lines and curves, and enabling one to find the intersections of two surfaces in space. The main advantage offered by a graphical method for solving such problems was that true lengths for parts could be easily preserved and inferred—and easily read by operatives.

Monge's method fails for surfaces where points cannot be depicted on the corresponding perpendicular planes. However, surfaces where the lines of intersection with the two perpendicular planes, or "traces," can be comprehensively shown with ease include spheres and

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[20] Ibid.,27-28.

[21] Alder, "Making Things the Same."

cylinders—their traces being lines and circles. They also comprised some of the core forms of nineteenth-century steam and other industrial technologies.[22]

Memorializing Monge upon his death in 1818, Barnabé Brisson argued that Monge had recovered, revealed, and systematized crafts work processes rather than upended them entirely. Emphasizing descriptive geometry as conducive to the general good, Brisson wrote, "it was mainly in practical research in the arts, and applications immediately good for the society, with which Monge found pleasure in consecrating this mental force and this sagacity with which nature had endowed him."[23] Brisson navigated the politics of era, between the rationalizing impulse of Enlightenment universalism and the crafts-based *sans-culotteism*, which formed a crucial constituency for the Napoleonic regime and the Bourbon monarchy alike.[24] Brisson claimed that Monge's insight stemmed from delving into "a branch of the science of length disdained until then by the *savants*, and which vegetated ignored in the shadow of the workshops of several arts for which it is indispensable to establish precision in the traces [*tracés*] which direct their operations."[25] According to Brisson, this began as a distinctly inductive process, echoing the transcription undertaken by the authors of *Encyclopédie*. Monge "collected the exact processes, discovered and put into practice by obscure men, who, from time immemorial,

[22] Helmut Müller-Sievers, *The Cylinder: Kinematics of the Nineteenth Century* (Berkeley: University of California Press, 2012).

[23] Barnabé Brisson, *Notice historique sur Gaspard Monge* (Plancher: Paris, 1818), 19-20, APS.

[24] Ken Alder, *Engineering the Revolution: Arms and Enlightenment in France, 1763-1815* (Chicago: University of Chicago Press, 2010); Leora Auslander, *Taste and Power: Furnishing Modern France* (Berkeley: University of California Press, 1996).

[25] Brisson, *Notice historique sur Gaspard Monge*, 19-20, APS.

practiced them and transmitted them in secrecy."[26] Then he "perfected them, extended them, and coordinated them in a general theory," forming this "science into descriptive geometry."[27]

Monge intended "*la géométrie modern*" to provide a unified theory for the practical knowledge already held by architects, locksmiths, and carpenters. Descriptive geometry would, as historican of mathematics Christopher Philips explains, ground "concrete reasoning in sensory experience" by teaching students to "draw a series of planes cutting the surfaces and then find the points common to both surfaces in order to construct any curves of intersection" rather than employing equations to identify solutions algebraically. Beyond the geometry's uses in computation and measurement, Monge's epistemic and sensualist focus on the construction of forms cast drafting according to descriptive geometry as a "mathematical discipline of visualization."[28] Monge's method was as proscriptive as descriptive.

Brisson acknowledged that Monge had recast manufactures by introducing descriptive geometry into education and had embarked on a plan to write a work "equally interesting for the professions of industry," promising "a theory of the elements of machines."[29] But for Brisson descriptive geometry itself constituted an extension, clarification, and theorization of crafts knowledge. Rather than portray this process necessarily as an appropriation, Brisson implied that Monge had parlayed his gift for envisioning three-dimensional structures in his "mind's eye" and expressing these images to his students into a bridge between the arts of scientific study and those of the artisan working classes.[30]

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[26] Ibid.

[27] Ibid.

[28] Christopher J. Phillips, "An Officer and a Scholar: Nineteenth-Century West Point and the Invention of the Blackboard," *History of Education Quarterly* 55 (2015): 82-108.

[29] Ibid.

[30] Ibid., 9.

One of Monge's engineering students, Charles Dupin, gave a rather different account of the origins and significance of descriptive geometry. [31] Dupin had authored books on geometry's application to statics, mechanics, and optics. Lauding Monge for studying "phenomena of nature and phenomena of industry with equal ardor," Dupin stressed that his "diverse works…did not make Monge neglect research in mathematical truths" in analytic geometry and in completing problems initially conceived by Descartes.[32] Accordingly, Dupin cast descriptive geometry as a method, which Monge had pursued by reducing "each machine to its simplest elements" and "in each element" considering "the movement impressed and the movement communicated." [33] This pursuit, according to Dupin, led Monge to the insight that "machines, due to their forms, are not only proper to receive certain movements and to transmit them in certain directions; all of the parts of the space that their elements traverse, are naturally to be determined according to the sole knowledge of the shape of its elements; envisaged this way, the description of machines is the responsibility of the science of length." [34]

This was not a process of assiduously gathering diverse and unifying crafts knowledge per se. It was mechanics. It was ideology. And it was a way of seeing the world. Consequently, Dupin asserted that in "considering the relations of the causes and the effects in the movements of machines," Monge "had grasped, to trace the infinite variety that they present, a thread that could guide with surety, and simultaneously render easy and methodical, the study of a multitude

[31] Charles Dupin, *Développements de géométrie, avec des applications à la stabilité des vaisseaux, aux déblais et remblais, au défilement, à l'optique, etc.* (Paris: V. Courcier, 1813).

[32] Charles Dupin, *Essai historique sur les services et les travaux scientifiques de Gaspard Monge* (Paris: Bachelier, 1819), 18.

[33] Ibid., 25-26.

[34] Ibid., 25-26.

of seemingly incoherent means."[35] He concluded that Monge's "manner of considering" the action of machine parts was "simple and beautiful."[36]

In Dupin's account, drawing based on descriptive geometry became the core method for knowing the world, one especially useful to engineers. Learning drafting meant acquiring "the means of representing bodies, the students representing in effect on paper the primordial forms, and the mathematical constructions that are suited to executing on these bodies."[37] He placed drawing on a seamless continuum with physics, positing that drawing could accurately reflect and predict mechanical relationships in design processes. Accordingly, Dupin asserted, "regular operations that must be effectuated on the body of any form depend almost always essentially on the shape of this body, to which these operations must…be adapted."[38]

In making such claims, Dupin layered the natural, mechanical, and social dimensions of engineering with distinction into an exercise in pure comparative statics. For example, he offered the example of designing fortifications, where "all the traces…made on terrain…depend on the configuration of this terrain, and must vary with it" and the "defensive operations for a place depend themselves on the form of its fortifications." He simultaneously crossed two boundaries, an ontological one between the natural forms and works of artifice as well as an epistemic one from physical truth to sense perception to depictive practice: "I could cite a thousand other examples of this intimate connection between the shape of the works of art or of nature, and the results that man can obtain in working on these works" by drawing.[39]

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[35] Ibid., 25-26.

[36] Ibid., 25-26.

[37] Ibid., 57-58.

[38] Ibid., 175.

[39] Ibid., 175.

Dupin's theorization of drawing based in descriptive geometry was no simple positivism, however. Instead, like many of his Enlightenment contemporaries such as Condorcet, he envisaged a process of progressive development through experiment and correction, tempering and honing. Dupin argued that practice in drafting would train the eye, contributing to perceptual acuity and bodily reform among French engineers and cadets. He wrote that "portrait and landscape drawing gives them lessons of taste, and forms their eye to the comparative measure of distances, of curves, of angles, of gradations of saturation, of size."[40] Drafting according to descriptive geometry would render "the great majority of men" more "sensitive to the precision of forms and to the laws of their harmony," and "necessitate artisans [*artistes*] who are more and more attuned to the wisdom of conception and to this superiority of execution, for which the sciences smooth the path, in their spirit and in their dexterity."[41] A pursuit jointly epistemic and ethical in Dupin's account, the "new geometry, via its intellectual considerations and its graphical operations, is eminently suited to fortify one's reason and to perfect one's senses."[42]

Where Dupin seemingly agreed with Brisson was on the subject of the conceptual unification of the trades. Yet Dupin firmly ensconced this effort toward legibility between formerly distinct practices within the occupational purview of trained engineers. Drafting according to the rules of descriptive geometry provided a means with which

> we [engineers] extend, we generalize on the ideas of the engineers of each corps in particular; we speak to them a common language, and each of the students enriches himself with the ideas and methods which previously had been specially reserved to diverse corps to which he was not called to take part.[43]

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[40] Ibid., 57-58.

[41] Ibid., 39-40.

[42] Ibid., 39-40.

[43] Ibid., 58.

He offered the examples of "special courses of military arts, civil architecture, the construction of bridges and highways, the work of mines and operations of geodesy" as sharing the same entry point for understanding "a general knowledge of the principles, the givens and the means that constitute the basis of the other services"—namely that "all of the graphical methods of these diverse works are linked by the thread of descriptive geometry."[44] This same thread wound its way through "frame-work [*charpente*]" to a discussion "of stonecutting, of perspective, of theory of shadows and of light." In each case engineering students were called upon to "make rigorous traces, drawings treated with hatches, washes, which accord with each of these parts."[45]

As for Monge's published works, Dupin pointed out that his treatise on fabricating cannons had become the standard manual for "directors of factories and to artisans."[46] In Dupin's estimation, Monge had set out to achieve a "description of machines" in order to "reduce…all the means of transmitting force and movement to elements perfectly known, classified and available like the instruments of an excellent artisan in a well-organized workshop [*atelier*]."[47] For Dupin, the crafts workshop was neither the original source of Monge's method nor the main audience he had intended to reach; craftsmanship served only as a metaphor.

Dupin's account of descriptive geometry reveals an inflection of romanticism, which Brisson's does not.[48] Although Dupin called descriptive geometry a "general and purely rational," form of geometry, which "is not only the graphical translation [*traduction graphique*]," the conclusion he reached with this claim marked a turn inward: "One must be able to represent

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[44] Ibid., 58.

[45] Ibid., 57-58.

[46] Ibid., 32-33.

[47] Ibid., 39-40.

[48] John Tresch, *The Romantic Machine: Utopian Science and Technology After Napoleon* (Chicago: University of Chicago Press, 2012).

the forms of bodies in space and to ideally combine these forms with the sole power of the imagination."[49] The rational and romantic proved indistinguishable for Dupin, once the engineer had undertaken to inscribe the logics of descriptive geometry in the "mind's eye":

> The spirit learns to See interiorly and with a perfect cleanliness of individual lines and surfaces, families of lines and surfaces; it acquires the feeling [*sentiment*] of the character of these families and of these individuals, it learns not only to see them in isolation or by analogous groups, but it connects them and combines them and can see in advance [*prévoit*] the results of their intersections, of their contact more or less intimately.[50]

Brisson acknowledged the crafts roots of the depictive and calculative processes awaiting Monge's rationalizing impulse; Dupin did not. In Dupin's account, the "mind's eye" became the territory of the romantic engineer alone, an inner sight to be cultivated with the Cartesian tools forged by Gaspard Monge.

Despite the fact that the authorities at Mézières had forbidden Monge from publishing his ideas and the revolutionary French state initially categorized descriptive geometry as a military secret, British espionage soon accessed certain aspects of his method.[51] Gaspard Monge's student, Jean Nicolas Pierre Hachette, then published the canonical edition of *Géometrie Descriptive* in 1810, which soon underwent multiple translations. Descriptive geometry fanned outward into civil society via mechanical drawing guides. Literary societies and mechanics institutes on both sides of the Atlantic collected and disseminated French engineering works. Charles Dupin presented his work on Monge to the American Philosophical Society in Philadelphia in May 1819, a year after Monge's death. In 1827, George Birkbeck published an

[49] Charles Dupin, *Mathematics practically applied to the useful and fine arts: Geometry of the arts* (London, 1827), 177.

[50] Ibid.

[51] Booker, *History of Engineering Drawing*, 92.

English edition of Dupin's works on geometry applied to manufactures.[52] A German translation of Monge's *Géométrie Descriptive* appeared as soon as 1828. In 1835, Philadelphia's Library of Foreign Literature and Science held French mechanical, astronomical, chemical, physical, bridge-building, mathematical, meteorological, and mineralogical texts, including Brisson's *Géométrie Descriptive*.[53]

Historian of technology Eugene Ferguson argued that the development of orthographic projection with three views over the nineteenth century was not a linear diffusion of Monge's method of descriptive geometry from on high; rather, the rise of drafting norms reflected the wide-ranging efforts of "teachers, textbook writers, and anonymous draftsmen in Europe and America."[54] Likewise, Booker asserts, "Monge's book" exerted "little influence on drafting practice in Great Britain or United States."[55] They are right, in a sense and to an extent. Learning to draw according to the principles of descriptive geometry in military academies, mechanics institutes, and "jobbing" shops for machinery did not follow one simple, single act of conveyance from Gaspard Monge. But this should not be understood to discount the influence of revolutionary France. Only by engaging in the circum-Atlantic repercussions of the French Revolution can we chart the sinews of influence and discover how republicanism, slavery, religious reform, and the science of mechanism linked engineering cultures learning to draw.

Following the Napoleonic conquest of the Rhineland, Prussia and other German states introduced into schools instruction in elementary drawing.[56] At the request of Wilhelm von

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[52] Dupin, *Mathematics practically applied to the useful and fine arts*.

[53] Library of Foreign Literature and Science, Catalogue of foreign literature (Philadelphia, 1835), LCP.

[54] Eugene Ferguson, *Engineering and the Mind's Eye* (Cambridge, MA: MIT Press, 1992), 83.

[55] Booker, *History of Engineering Drawing*; Ferguson, *Engineering and the Mind's Eye*, 83.

[56] On the wide ramifications of the Napoleonic conquest in Germany in general, see Timothy Blanning, *The French Revolution in Germany: Occupation and Resistance in the Rhineland, 1792-1892* (Oxford: Oxford University Press,

Humboldt, Alois Hirt drew on Johann Pestalozzi's visual "alphabet" and theories of developing sense perception to construct a liberal drafting program based on geometric forms for the school system in its entirety. This system would be discarded following the failures of the 1848 revolutions, when conservative educators reinstituted drawing as rendering according to prints and casts. [57]

From the 1810s to the *Vormärz*, Gottlob Kunth, a high official in the Prussian department of trade, pursued a combination of neomercantilist and liberal economic policies aimed at industrialization.[58] When Wilhelm Beuth, an expert in financial and fiscal concerns, became head of Prussia's office for economic development and technical education in 1820, he founded the Technical Institute in Berlin as well as provincial trade schools.[59] However, Beuth's program of industrial reform proved disconcerting among Prussia's conservative elite, who thought that engineering education would inspire workers to pursue social mobility and stir discontent. In 1830, a bureaucrat in Hanover argued that such education would only "make obvious the oppression of misery, show more clearly the gap between dignity and indigence, to alienate the tradesman from his occupation in which he is happy because of his limited horizons, and, through various measures of enlightenment, to let him wake up out of the unconsciousness of a pleasant dram to calamitous reality."[60] In the face of such suspicion, Beuth aimed to keep technical education purely practical. To this end, he advocated emphasis on drafting courses in

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1983); Thomas Nipperdey, *Deutsche Geschichte, 1800-1866* (Munich: C.H. Beck, 1983); Mack Walker, *German Home Towns: Community, State, and General Estate, 1648-1871* (Ithaca: Cornell University Press, 1998 [1971]).

[57] Brett, "Drawing and the Ideology of Industrialization."

[58] Kees Gispen, *New Profession, Old Order: Engineers in German Society, 1815-1914* (Cambridge: Cambridge University Press, 1990), 21.

[59] Ibid., 27.

[60] Ibid., 28.

curricula and a prominent place for models and visual aids in pedagogy. Additionally, Beuth's Industrial Institute housed workshops and a laboratory directed toward the purposes of industry.[61]

In May 1823, mechanical engineer Georg Reichenbach received his diploma in *Kameralwissenschaft*, which included courses in theoretical and practical philosophy, elementary mathematics (arithmetic, geometry, and trigonometry), philology, general world history, physics, natural history, psychology, ancient history, classical literature, combinatoric analysis, forestry, mining arts, technology, civil engineering, public finance, philosophy of right or natural rights, institutions of legal science, German private law including exchange, trade, private cameral and private police law, statistics, chemistry and general technical chemistry, mineralogy, botany, zoology, Bavarian mining law, mechanics, higher analysis and higher geometry, encyclopedia and methodology of cameralist studies, civil law of Bavaria, agriculture, police science, practical science, political arithmetic, cameralist practice in terms of state budgeting and accounting, mine surveying, and hydraulic engineering.[62]

Isometric drawing presents a view between the picture and the plan, which contemporary drafting guides cast as useful for mining, when a surface juts out irregularly on a plane. Isometric views were also more comprehensible to non-engineers, offering a form of structural and machinery portraiture useful as a model in presentations in civil engineering to statesmen and patrons. Nineteenth-century British visual imaginations were structured by mining surveys, a semi-artisanal approach to machine-building, and the cultural significance of picturesque drawing among the bourgeois classes. British engineers were familiar with planes, sections, and

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[61] Ibid., 32.

[62] Georg Wilhelm Reichenbach, Immatrikulirungs-Bescheinigung für die Vorlesungen am k.k. polytechnischen Institute Wien (9 April 1822) and Akademisches Semeltratzenamt (15 January 1822), Deutsches Museum, NL 033.

elevations in architectural drawing, but oftentimes chose the isometric view for "combination" or synthesis—this meant an incomplete effort to specify dimensions in a way immediately translatable to machine forms and an inhibiting of manipulation on paper, that is, the series of analytical moves performed upon a plane via descriptive geometry.[63]

In Albany, the *New York State Mechanic* described in its "invention and discoveries" section the announcement of an "Electro Magnetic Locomotive" as a "vast improvement by a new modification of mechanical power" in a Parisian scientific paper based on a July 1840 letter from Leipzig. The *Mechanic* shared the contents of the letter with its readers in upstate New York: "Mr. Lewis Gabriel Stochrer, a mechanic of that city, has just finished an electro magnetic locomotive, the greatest part of which is constructed after Mr. Wagner's plan." The locomotive, the journal continued, offered seven horse power, could draw three passenger cars, cost approximately one thousand dollars rather than over seven thousand for a steam locomotive, could be supplied for no more than 60 cents per day, and had apparently been purchased by the German Diet.[64] That an enthusiastic account of the "Electro Magnetique Locomotive" taking an experimental journey on the railroad between Leipzig and Dresden would be circulated in the *Echo du Monde*, *La Phalange*, and the *Mémorial Encyclopédique et Progressif Des Connaissances Humaine*s, and then translated and reprinted in the *American Railroad Journal* and the *American Railroad Journal and Mechanics' Magazine*, suggests the extensive reach of the "romantic machine" in the Atlantic age of revolutions.[65]

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[63] Thomas Sopwith, *Treatise on isometrical drawing* (London, 1838), Library Company of Philadelphia, Rare Is Sopw 16751.O.

[64] New York State Mechanic: A Journal of the Manual Arts, Trades, and Manufactures (Albany, 1841).

[65] "Electro Magnetique Locomotive," *American Railroad Journal* 13 (1841): 320; *La Phalange* (1841): 686; "Locomotive électro-magnétique," *Mémorial encyclopédique et progressif des connaissances humaines* 11 (1841): 476.

Francophilia among American politicians and military leaders of the early republic meant that the *Ecole Polytechnique* served as the model for training at West Point.[66] Sylvanus Thayer, superintendent of the U.S. Military Academy, toured Europe in 1815-1816, where he became convinced to implement French technical and scientific education and hire French or French-trained instructors in engineering and mathematics.[67] From 1816 to 1823, Claudius Crozet, a Napoleonic engineering officer trained at the *Ecole Polytechnique*, introduced descriptive geometry to cadets at West Point by offering courses and publishing an English translation of Monge's textbook in 1821.[68] Crozet established descriptive at the center of West Point's curriculum: taking the course in their second year, cadets transitioned from elementary training in mathematics to tactics and engineering. Crozet's legacy of emphasizing descriptive geometry continued in consistent form via Dennis Hart Mahan, who taught at West Point from the 1820s to 1870s, as well as via Charles Davies, who authored mathematics textbooks used within the military academy and without for decades.[69] Like graduates of the *Ecole Polytechnique*, West Point's students often went onto careers in civil engineering within the military or in private practice—utilizing the mathematical and depictive skills gained on the French model for drafting and surveying for continental conquest. [70]

Training in drafting according to descriptive geometry was meant to hone discipline of head and hand. During recitations in descriptive geometry, instructors at West Point depended on

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[66] Gray, "Mathematics in the French Revolution."

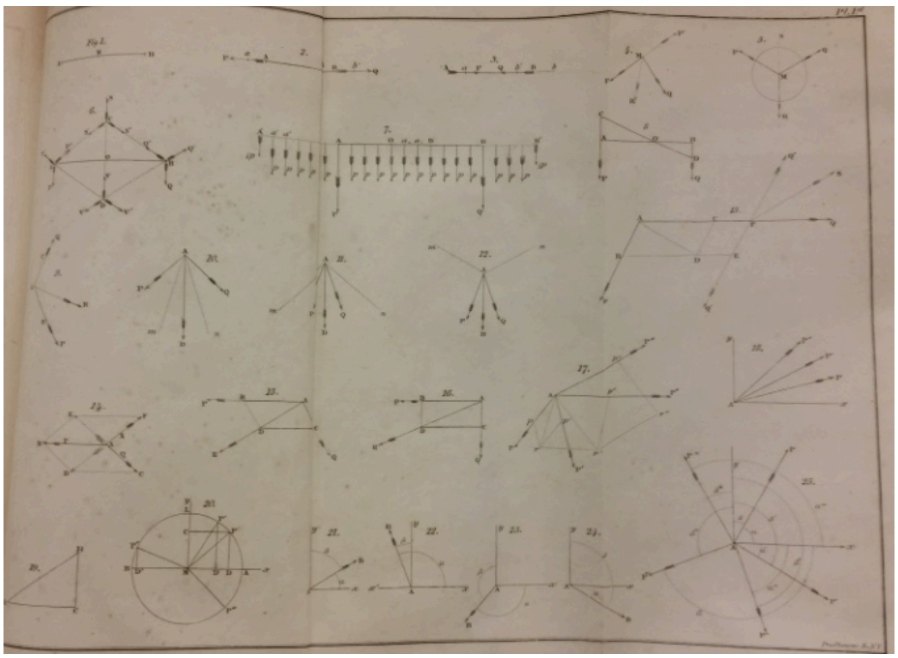
[67] Stapleton, *Transfer of Early Industrial Technologies*, 126-127.

[68] Phillips, "An Officer and a Scholar."

[69] Ibid.

[70] Ibid.

blackboard inscriptions to reveal mental strategies and habits.[71] At the board, West Point students did not recite in rote, but rather were expecting to explain and defend to an examiner each claim made.[72] Instructors intended this process to cultivate mental discipline, depriving students of access to West Point's collection of geometric models until after they had completed examinations on the board.[73]



[71] Ibid.

[72] Ibid.

[73] Ibid.

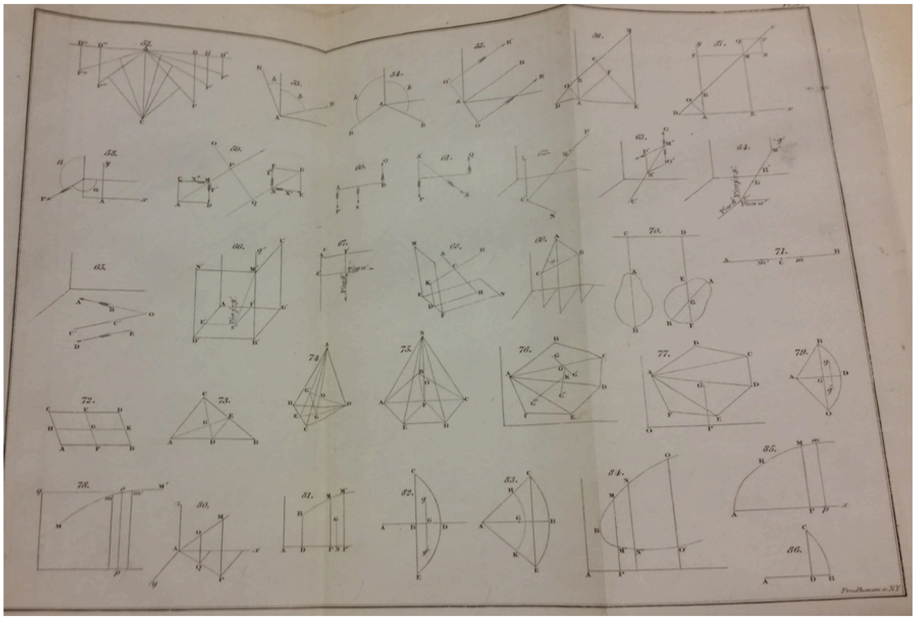


Figure 4: Composition of Force Diagrams in Edward H. Courtenay, *An Elementary Treatise on Mechanics, Translated from the French of M. Boucharlat* (New York: J. & J. Harper, 1833), Library Company of Philadelphia.

In 1833 Edward H. Courtenay, professor of natural and experimental philosophy at the U.S. Military Academy, published an English translation of Boucharlat's treatise on mechanics.[74] In 1852, Dennis Hart Mahan, military theorist and civil engineering professor at West Point, published a guide to "industrial drawing" for non-cadets. He explained that the manual had emerged out of having to "direct workmen in constructing models, &c., from drawings" and discovering that, "though in other respects very intelligent and conversant with the resources of their art, they were, with but rare exception, almost entirely ignorant of the art of rendering their ideas by a drawing, and equally so in comprehending the ideas of others, however clearly expressed, when laid before them in this way."[75] Mahan attributed lost time and frequent errors

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[74] Jean-Louis Boucharlat, *An elementary treatise on mechanics. / Translated from the French With additions and emendations, designed to adapt it to the use of the cadets of the U.S. Military Academy. By Edward H. Courtenay, professor of natural and experimental philosophy in the Academy* (New York, 1833), LCP, Rare Am 1833 Bouc 78757.O.

[75] D. H. Mahan, *Industrial Drawing* (New York: J. Wiley, 1852), ix-x.

to visual illiteracy, deploring that he was “obliged literally to stand at the workman’s side and say ‘cut here,’ ‘saw there,’ &c. in any portion of the work of only ordinary complexity of design.” Consequently, Mahan undertook to introduce drafting into schools among the “intelligent and more advanced boys who would soon begin their apprenticeship to some trade.”

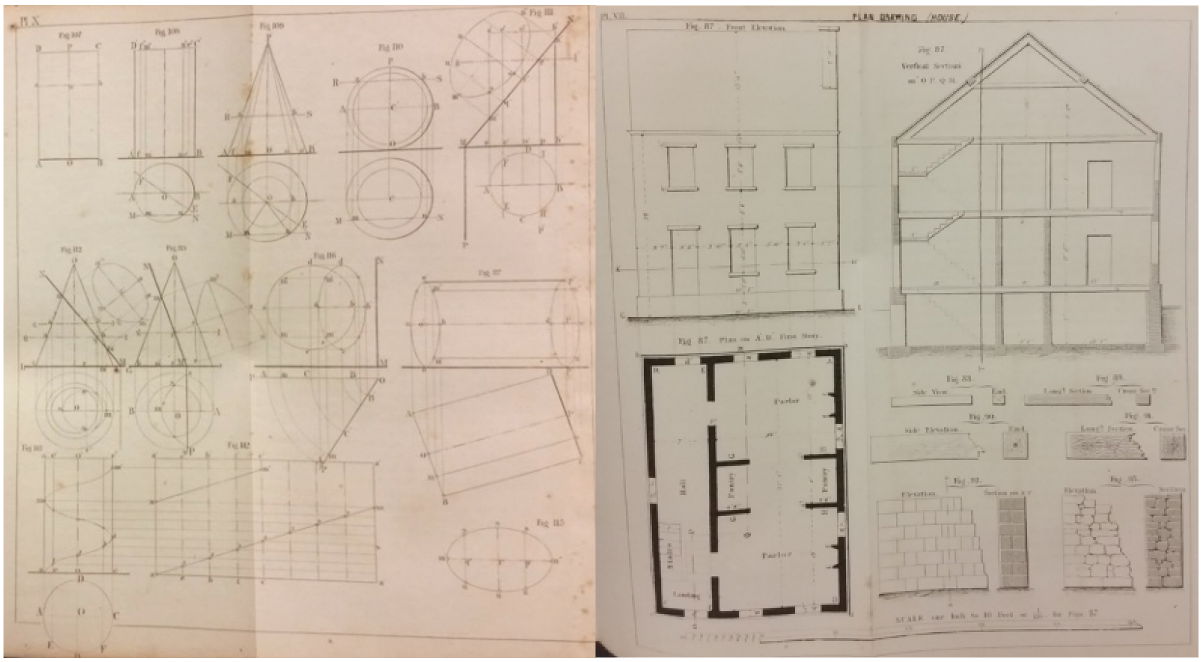

Figure 5: Dennis Hart Mahan, *Industrial Drawing* (New York: J. Wiley, 1852), Library Company of Philadelphia.

He began with the school attached to the West Point Foundry Company, whose president provided for models and implements for workers’ sons to learn to draw. Mahan followed the methods proposed by graduates of the *Ecole Polytechnique*, such as Dupin’s *De la Géométrie et de la Mécanique appliqués aux Arts et Metiers en Faveur de la Classe Industrielle.* He praised the elite polytechniciens for having “brought their knowledge down to the level of the working classes, and those who had time only for elementary acquirements…which have served to form most of the very intelligent body of operatives to be met with in every town of France any way engaged in manufactures."[76]

Both the original French polytechnicians and their American followers at West Point engaged in a seeming conflation of descriptive geometry's social potential and significance. They conceptualized learning to draft as republican *and* technocratic, popular *and* stratified. Monge had counterpoised descriptive geometry's uses—mechanics and engineering for military applications—against the focus of analytical mathemataics on optics, heat, electricity, and the movement of the planets. He had also envisioned training students at the *Ecole Polytechnique* to apply mathematics to social problems in public-minded careers.[77] Was descriptive geometry to be *by* engineers, *for* the public, or in the service of creating an engineering republic?

In his guide to industrial drawing, West Point's Dennis Hart Mahan asserted that "there is no person, whatever his profession, but at times has need of drawing…to render his ideas perfectly intelligible to others." [78] Beyond the examples he deemed obvious, such as engineers, carpenters, masons, and mechanicians, Mahan claimed that industrial drawing "to the artisan of every class," what "writing is to all."[79] Industrial drawing mattered for both design and fabrication, for "without its aid, they would be entirely unable to conceive understandingly any plan of a structure in any degree of a complex character, and still less to carry it satisfactorily into execution." [80]

[76] Ibid., xi.

[77] Phillips, "An Officer and a Scholar,"

[78] Ibid.

[79] Ibid.

[80] Ibid.

Mahan did not seek to "deal with abstract reasoning on which it is based," but rather planned to "furnish the most simple means of mastering its difficulties and applying it to the many practical purposes of which it is susceptible." He taught industrial drawing with an apparatus to simulate the perpendicular planes of Monge's descriptive geometry, to be built "by an ordinary carpenter and turner" (evidently their mind's eyes were up to the task). This apparatus included:

> 1st, of a large pair of dividers, the legs about twelve inches long, one leg with a sharp point, the other having a port-crayon for holding a bit of chalk or white crayon, attached to it; this instrument serves for describing arcs, setting off distances;
>
> 2d, a wooden scale or ruler, three feet long, and of sufficient breadth and thickness to render it stiff; this is divided off into inches and any desired subdivisions of this unit; this instrument is used, either alone or with the port-crayon dividers, for setting off distances and drawing right lines;
>
> 3d, a plumb-line of silk thread, having a small flat leaden bob, with the lower end sharpened or having a needle-point; this is used for marking on paper or a smooth board the point where a perpendicular, let fall from any point of an object to be represented, would meet the board;
>
> 4th, wooden models of several simple bodies, as the prism, hollow pyramid, cone, &c. divided into sections by being cut through obliquely to their axes, and vertically; these may have bases of from six to eight inches in diameter, and heights of from ten to twelve inches, or less;
>
> 5th, drawings on the same scale as the models, showing their projections and sections made according to the methods shown in the text-book;
>
> 6th, a small table made with a leaf to fold over on the top of the table, like the ordinary card tables, or else two boards united by hinges so as to fold on each other like the table; either of these must be so arranged that the leaves can be fixed at right angles to each other when they are required for use; the interior faces of the boards should be painted a dead black, or slate color, to receive chalk marks readily…
>
> 7th, several rectangular pieces of stiff block tin, copper, or thin board, so arranged, by a wire attached along one of the edges and projecting a little each way beyond the two edges adjacent, that they can be readily places, by means of small wire staples attached to the surfaces of the leaves of the table, either perpendicular or inclined under a given angle

> to either of the leaves; the positions to be given to these pieces to be so chosen as to correspond to the planes of section of the models.[81]

With this folding apparatus and textbook, Mahan proceeded to perform each operation of projection himself and then required students to repeat the method and then explain the connection between the drawing and the model. Mahan reported to readers of his manual that the "boys readily acquired an easy use of the instruments, both at the black-board and on paper."[82] He asked students to "construct, by eye alone, some of the more simple problems in perpendicular and parallel lines, the laying out and bisecting the more usual angles, and the construction of the more simple rectilinear figures," which he found "very good in tutoring the eye and giving steadiness to the hand." Mahan's exercises prioritized corporeal discipline and a notion of visual literacy over the cultivation of the designing mind's eye. Like Dupin, Mahan posited class-specific versions of industrial drawing and engineering sight, with a place accorded to natural talent. Mahan observed that "as in other handicraft operations, whatever could be gathered by the eye the hand was found apt at once to execute, with more or less of skill according to the aptitude of the pupil." [83] Following the projection work at the board, the students moved to exercises on paper following "carefully drawn diagrams," and eventually to making "pen and ink sketches of large objects from measurements made on the object."[84] Without learning the theoretical foundations of descriptive geometry, the students had followed from objects to fold-points and traces on the apparatus, toward internalizing the apparatus to measure dimensions, execute rule-bound routines, and perhaps understand the surfaces of objects in a new

[81] Ibid., xiii-xiv.

[82] Ibid., ix-x.

[83] Ibid., xv-xvi.

[84] Ibid., xv-xvi.

way. Whether or not the origins of Monge's method lay in the ateliers, it is striking that Mahan referred to drafting practices based on descriptive geometry as a handicraft operation. But he had attempted to make "industrial drawing" just that.

Mahan also attempted to bridge elite engineering and popular practice by authoring military guides such as *An Elementary Treatise on Advanced-Guard, Out-post, and Detachment Service of Troops, And the Manner of Posting and Handling them in the presence of an Enemy*, intended as a "Supplement to the System of Tactics adopted for the Military Service of the United States, and especially for the use of officers of Militia and Volunteers" in the "daily services of a campaign." The work cost 75 cents.[85] Reflecting the origins of Monge's practice in fortification design and stone-cutting, Dennis Hart Mahan also published a treatise on field fortification, which instructed readers in "Methods of Laying Out, Constructing, Defending, and Attacking Intrenchments." For a dollar, readers could access a version of West Point's textbook for the "Arrangement, the Attack and Defense of Permanent Fortifications," "to be used in the field in planning and throwing up entrenchments." Depiction formed an important component of Mahan's more popular curriculum; as he explained to lay readers, for instance, "a special reconnaissance consists for the most part of a sketch in pencil made with all the accuracy that the means at the disposal of the officer admit of and a memoir."[86]

Although he only mentioned Native Americans once in this field manual (as potential guides, alongside "carriers, wood-cutters, hunters, trappers," in reconnaissance missions), Mahan explicitly tied the "intrenchment" of militias to the defense of the American republic and its continental expansion. According to Mahan, proper trenching could enable militias to defeat

[85] Ibid.

[86] Dennis Hart Mahan, *A Treatise on Field Fortification* (New York: Wiley, 1852).

standing armies with greater training by adding “strength and confidence to irregular forces when brought for the first time before an enemy.” [87] “Place the militia soldier on his natural field of battle behind a breastwork,” Mahan asserted, “and an equilibrium between him and his more disciplined enemy is immediately established.” With “a feeling of security in his position, he continued, “his confidence in his own exertions is restored; with a full certainty that his enemy cannot close upon him before he can retire beyond his reach, he does his duty coolly and with an execution so terrible as to have placed the achievements of our militia, from the day of Bunker Hill to the closing scene of our last war at New Orleans, on a line with the most brilliant military exploits of the best disciplined troops in the world.” [88]

Despite his post at the nation’s military academy, Mahan echoed Harrington and the “country” versus “court” politics of the early modern British Atlantic and U.S. revolutionary era, arguing that “an efficiently organized Militia is the firmest and only safe bulwark of the State is a political axiom admitted by all who understand the nature of our free Institutions.”[89] Mahan claimed that the “ranks” of the militia were “filled with all that is most valuable in society.” Akin to the avatars of contemporary economist Henry Carey’s *Harmony of Interests*, he invoked “the farmer, the mechanic, the merchant, the members of the learned professions,” all of whom “must…quit their peaceful avocations to meet the foe.”[90] Writing in the 1840s and 1850s, Mahan elaborated a social politics and defined the strategic tools that confirmed continentalist political

[87] Ibid., vi.

[88] Ibid., vii.

[89] Ibid.; on court and country politics, see James Harrington, *The Commonwealth of Oceana* (1656); on militia service in eighteenth-century North America, see Fred Anderson, *A People’s Army: Massachusetts Soldiers and Society in the Seven Years’ War* (Chapel Hill: University of North Carolina Press, 1984); on “country” versus “court” politics, see Bernard Bailyn, *The Ideological Origins of the American Revolution* (Cambridge, MA: Harvard University Press, 1967) and Jack P. Greene, “Bridge to Revolution: The Wilkes Fund Controversy in South Carolina,” *Journal of Southern History* 29, no. 1 (1963): 19-52.

[90] Mahan, *A Treatise on Field Fortification*, vii.

economy, without explicitly mentioning the wars against the Seminoles or the Black Hawk War. Like Mahan's approach to "industrial drawing," his militia guides aimed in practice to unite republicanism and technocratic uplift while eliding concentrations of power and new hierarchies, displacements and expulsions.

The Revolutionary Atlantic of the Romantic Machine

West Point's engagement with French engineering was not the sole avenue of exchange between artisans, manufactures, and the Francophone Atlantic. Between 1815 and 1848, Paris served as capital of the "romantic machine," where a "second scientific revolution" in the precise experimentation with heat, light, electricity, and magnetism met rapid steam industrialization and its coal-fired consequences.[91] In the wake of the French Revolution and Restoration, debates over experimentation and practice in the arts and sciences were embedded within contests over the fate of republicanism, liberalism, and monarchy.[92] Counterpoised against the "classical machine" defined by mass, position, and velocity and positing a "stable determinist nature" as an "unchanging agglomeration of points and forces," the "romantic machine" and its partisans celebrated holism and spontaneity.[93]

Thermodynamics cut across the domains of the classical and romantic machine as well as formal science and engineering practice. In the 1840s, Sadi Carnot's theories of heat spread to the United Kingdom and the German lands, informing debate over and experimental research

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[91] Tresch, *Romantic Machine*.

[92] Ibid.

[93] Ibid.

into heat's relation with motive force.[94] Emile Clapeyron conveyed Carnot's ideas in a new visual language accessible to engineers. A mining and railway engineer, Clapeyron published a mathematical and graphic analysis of Carnot's ideas in 1834, which included a diagram depicting volume and pressure coordinates based on a secret drawing by James Watt.[95] Clapeyron spread English techniques for fabricating steam locomotives in France, teaching a course on steam engines at the *Ecole des Ponts et Chaussées* in the 1840s and 1850s. Clapeyron's revival of Carnot's ideas initiated controversies among physicists, natural philosophers, and mechanics not only in France but also in England and the German lands. Over the 1840s, experimental results by James Prescott Joule and Henri Victor Regnault responded to Carnot's paradigm. Having come across Carnot's ideas in 1844, the brothers William and James Thomson developed a "dynamic theory of heat" in the early 1850s; simultaneously, Clapeyron's formulas, which rendered Carnot's theory of heat more comprehensible to engineers, were taken up by Rudolf Clausius and the Berlin Academy in the thesis "*Ueber die bewegende Kraft der Wärme.*"[96] This exchange culminated in the establishment of thermodynamics based on the conservation of energy.[97]

As political theorist Susan Buck-Morss has argued, Freemasonry connected the "slave-trading ports of Bordeaux, plantations of Saint-Domingue, English antislavery authors, journalists reporting for *Minerva* from Paris, book publishers in Germany." Readers of and correspondents for the German journal *Minerva*, founded in 1792 by freemason Archenholz and

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[94] François Caron, *Dynamics of Innovation: The Expansion of Technology in Modern Times* (New York: Berghahn Books, 2013), 93.

[95] Ibid., 92.

[96] Ibid., 92.

[97] Ibid., 91.

with a circulation of approximately six thousand by 1809, included Hegel, Goethe, Schiller, Schelling, Lafayette, the publisher Cotta, the English author Marcus Rainsford, and Friedrich Wilhelm III of Prussia.[98] In its pages, Rainsford contrasted the "assassins and executioners" of the French Revolutionary Terror, whom he saw as transforming "a great and polished nation" into "the barbarism of the earliest periods," with the Black Jacobins' "Black Republic," in which "negroes emancipating themselves from the vilest slavery, and at once…enacting laws, and commanding armies, leaving slavery's barbarism behind."[99]

Buck-Morss traces the transatlantic routes of Freemasonry within the slave revolts in Saint-Domingue, beginning in the lodges of radical French Freemasons, which admitted members irrespective of religion, race, or sex. A mason in Bordeaux in the 1770s, Etienne Polverel served as commissioner to Saint-Domingue in 1793 and declared the abolition of slavery in the colony. French-educated Vincent Ogé gained support from the *Amis des Noirs*, with networks in Philadelphia and London, to spearhead a revolt among free mulattoes for citizen rights in 1790. A colonial court tortured and executed him the next year, year two of the French Revolution. In year seven of the French Revolution, 1796, Julien Raimond, another lawyer who campaigned for mulatto rights, served as Haiti's colonial commissioner and participated in the drafting of the 1801 Constitution. In the U.S. Revolutionary War, André Rigaud, a mulatto from Bordelais, had fought with the French army and went onto lead resistance to the British in Saint-Domingue in the 1790s.[100]

The legacy of the Haitian Revolution and Freemasonry was commemorated in 1841, when the *New York State Mechanic* argued that "Toussaint L'Ouverture, the black chieftain of

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[98] Susan Buck-Morss, *Hegel, Haiti, and Universal History* (Pittsburgh: University of Pittsburgh Press, 2009).

[99] Ibid.

[100] Ibid.

Hayti," was "entitled to a high rank in rolls of history, and, though it is scarcely known at present day, the time is not far distant when it will be as familiar as the names of Bolivar and Washington." The journal proclaimed that it was "by the force of that uncontrollable spirit of freedom which glows alike in every human breast, dared all for liberty, and broke from the heavy bonds of slavery and degradation, that Toussaint L'Ouverture will claim the admiration, and his name the respect of the world."[101]

The *New York State Mechanic* kept readers apprised of political events and engineering opportunities in the American South, Cuba, and Brazil. In 1841, for instance, the journal reported that,

> David Bradford, Esq, proposed a scheme for draining the whole delta of the Mississippi, by which the city of New Orleans will be kept high and dry above the reach of the annual freshets of the river. To effect this he proposes to construct two parallel levees in the west bank of the over, extending from Baton Rogue [sic] to the gulf, in a direct line, and throw an immense dam across the stream, to turn the current between these levees…reclaiming valueless, which, at $50 per acre, will, after deducting one-fifth for the small portion that is now partially first for cultivation and for the space to be occupied by the proposed works, amount to $356,000,000.[102]

Mechanics North and South were intimately connected to the slavery economy expanding into the "New Southwest." Having begun with the importation of an English engine in 1822, sugar mills used the greatest amount of steam power compared to those for other crops in 1838. By the mid-1830s, an estimated three quarters of Louisiana sugarcane was ground by steam, with engines manufactured in Ohio and Tennessee costing half what British imports did.[103]

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[101] "Toussaint L'Ouverture," *New York State Mechanic: A Journal of the Manual Arts, Trades, and Manufactures* (Albany, 1841), Rare | *Per N 83.5 10142.Q (McAllister), LCP.

[102] *New York State Mechanic: A Journal of the Manual Arts, Trades, and Manufactures (*Albany, 1841), Rare | *Per N 83.5 10142.Q (McAllister), LCP.

[103] Peter Temin, "Steam and Waterpower in the Early Nineteenth Century," *Journal of Economic History* 26 (1966): 187-205; on sugar and mechanization in the early modern Atlantic, see John E. Crowley, "Sugar Machines: Picturing Industrialized Slavery," *American Historical Review* 121, no. 2 (April 2016): 403-436.

Planting a Prison in the Wilderness

In the 1830s and 1840s, the American mechanics' press imbued its labor republicanism with a defense of citizenship against slavery and mechanics' craft labor contra prison labor. Protest ensued when a convict named Plomb at Auburn prison in New York died after having been "whipped severely…on two successive days" in which he "received 428 lashes" from keeper Melancthon Cary, who used a "cat-'o-nine tails."[104] The event was reported in *The Liberator*.

Beyond the corporal punishment pursued there, the prison at Auburn constituted a "plan," a development in early nineteenth-century penology whereby prisoners would labor in workshops during the day and find themselves confined in cells at night. Both day and night were to be passed in total silence. So-called keepers were instructed that they "shall not permit them [prisoners] to hold any conversation with each other, or with any person whatever; nor to communicate with each by signs and signals" and to make "utmost endeavors to enforce perfect non-intercourse."[105] Elaborated in the 1820s by New York legislators, jurists, experts, and prison overseers, the Auburn plan would spread to nearly all Northern and several Southern states by the 1830s.[106] Under the Auburn plan, keepers hoped to make imprisoned men "silent and insulated working machines."

[104] "Death in Auburn Prison," *Liberator* (Feb 20, 1846): 31.

[105] Rules and Regulations for the Government and Discipline of the State Prison at Auburn, Adopted August 6, 1834.

[106] Rebecca McLennan, *The Crisis of Imprisonment: Protest, Politics, and the Making of the American Penal State, 1776-1941* (Cambridge: Cambridge University Press, 2008).

The focus on remaking the individual through social isolation within workshop labor quickly drew the attention of private manufacturers. [107] In 1827, over fifty prisoners labored as shoemakers and tailors, over twenty-five as blacksmiths and tool-makers at Auburn. One hundred prisoners labored as weavers and coopers.[108] The next year, 411 prisoners labored under contract work, and "earnings of all shops during year without making deductions for shop expenses" amounted to $28,234.04.[109]

Manufacturers introduced machinery into the prison, where they paid daily or piece wages for prisoners work as "Cotton weavers, Shoemakers, Coopers, Hame and saddletree makers and platers, Satinett weavers, Tailors, Cabinet-makers, Tool-makers, Machinists, Comb-makers, Clock-makers, Coverlet weavers, Stone-cutters, [and] Blacksmiths."[110] With the introduction of water, and eventually steam, power and the expansion of the prison to encompass a "new shop built…occupied by barrel coopers," a "shop occupied by the fine coopers," a "shop occupied by manufacturers of joiner's tools," a shoe shop, a tailor's shop, a weaver's shop, a dye house, a blacksmith's and machine shop, and a turner's and chairmaker's shop," the number of convict workers soared. [111] In 1843, forty prisoners at Auburn worked at the newly-introduced manufacture of silk alone, using machinery and utensils costing $2115. The "aggregate value of the silk manufactured, sewing silks, twist and fabric, with materials and products on hand, at low

[107] Ibid., 60.

[108] Joshua R. Greenberg, *Advocating the Man: Masculinity, Organized Labor, and the Household in New York, 1800-1840* (New York: Columbia University Press, 2007).

[109] Report of Gershom Powers, Agent and Keeper of the State Prison, at Auburn.

[110] Annual report of the inspectors. 1834; McLennan, 60.

[111] Report of Gershom Powers, Agent and Keeper of the State Prison, at Auburn.

rate, market prices" reached $12,762.26.[112] The profits from these contracts came to constitute the fiscal basis for the prison system.

To ensure silence and labor discipline among the prisoners, agents at Auburn and Sing Sing relied on novel architectural features, precise accounting techniques, and the policing of tools for communication. At Sing Sing, Robert Wiltse arrayed the workshops, where prisoners labored for contractors making barrels, shoes, locks, carpets, and saddles, in a geometric design mirroring those emerging in textile centers of the Northeast.[113] At Auburn, keepers used passageways lit by "numerous small orifices cut in the partition and designed to enable the keepers to inspect the convicts in the shops without their knowledge."[114] In this panopticon-like structure, the prison's agent, Gershom Powers, asserted that "Every thing in the shops can be distinctly seen through the orifices, which are mostly covered with glass while the convicts are not aware that any one is looking at them and of course have not their attention called off from their work."[115] However, Powers also emphasized that the "inspection avenues" render "it unsafe for a convict while in the shops ever to transgress the rules" and that the prisoners "know officers are constantly patroling these avenues unseen and unheard by them and that these officers can have a perfect view of all their motions."[116]

While overseers and slaveholders developed accounting practices on plantations, the assistant keeper at Auburn kept a "book containing names of the men under his charge" with a "table of their labor," in which he entered "daily the labor performed, with the prices

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[112] "Silk Business in the Auburn Prison," *The New York State Mechanic* (Feb 18, 1843): 100.

[113] McLennan, *Crisis of Imprisonment*, 65.

[114] Report of Gershom Powers, Agent and Keeper of the State Prison, at Auburn.

[115] Report of Gershom Powers, Agent and Keeper of the State Prison, at Auburn.

[116] Report of Gershom Powers, Agent and Keeper of the State Prison, at Auburn.

therefor."[117] At the end of each month, he would report the "amount earned, and chargeable to contractors for labor of convicts" to the clerk.[118] The assistant keeper would also instruct new convicts and see "that the old make first rate work," or place "a faithful and experienced convict by the side of a raw hand to show him." Through these methods, the assistant keeper aimed to "discover what the convict ought to perform" such that he could "compel him to do it, and when well he is not suffered to be idle a single moment or have any particular favor or allowance for any thing that might be called over work." Consequently, he could class "different descriptions of men" and "put at different kinds of business at different prices." Machinists were contracted at 50 cents per day, while "about 30 invalid old and broken down convicts" were "employed as spoolers on the weaving contract at 15 cents per day.[119] The role extended from inspecting and tracking raw materials to avoid waste to "critically" assessing "all work" bound "for the contractors every day."[120] After a decade in Auburn plan prisons from 1821 to 1831, John Maroney recounted, "I often thought that we were in worse bondage than the children of Israel, when under their Egyptian task-master."[121]

In a developmental republic, the *New York State Mechanic* argued, convicts should not be employed to manufacture goods entailing competition with free mechanics. While their critique initially focused on political economy and displayed some empathy toward convicts, mechanics'

[117] Rules and Regulations for the Government and Discipline of the State Prison at Auburn, Adopted August 6, 1834; Caitlin Rosenthal, *Accounting for Slavery: Masters and Management* (Cambridge, MA: Harvard University Press, 2018).

[118] Rules and Regulations for the Government and Discipline of the State Prison at Auburn, Adopted August 6, 1834.

[119] Report of Gershom Powers, Agent and Keeper of the State Prison, at Auburn.

[120] Report of Gershom Powers, Agent and Keeper of the State Prison, at Auburn.

[121] John Maroney, *Narrative of the Imprisonment of John Maroney, in the prisons of New-York and Auburn, from 1821 until 1831, or Maroney's Meditation while in the school of wisdom written by himself* (Newburgh: Charles U. Cushman, 1832), 16-17.

remonstrations after 1834 increasingly posited a stark moral superiority over the imprisoned.[122] The *New York State Mechanic* envisioned tasking convicts with the dredging of canals, the mining of ores, the felling of forests. They asserted their rights as a special and protected class whose skill and labor deserved protection against competition and undercutting. Instead, they proposed employing prisoners in the punishing tasks on infrastructure works and natural resource extraction, the bases for mechanics to pursue fabrication:

> They may be employed upon the public works; let them dig the tunnels, and excavate the rocks, upon our public improvements. Lockport, Little Falls, and aqueduct sections upon the canals, would afford '*hard work*' for numbers that might be employed there. They might be so arranged and economized as to break stone for McAdamizing the roads, and thus serve and benefit the whole people, to the injury of no one.

This would serve, they argued, as "more profitable employment of those condemned to work—aye, *to work—to be punished for crime by being sentenced to work for the state,*" by "developing the resources and hidden wealth of the state." Calling on prisoners to "bring forth materials and employment to the artificer," they relied on a stark division between the culling of raw materials and their later fabrication.

They also inscribed a line setting convicts apart from settlers yet placing them in a relation of economic symbiosis. States would use prisoners to graft a transportation network onto the landscape by mining ore for iron rails, not as yet produced domestically in the United States, and digging canals. Moreover, the *Mechanic* argued, by "planting a prison in the wilderness of the north, the country about it would soon become settled, by those disposed to supply the wants of the prison."[123]

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[122] McLennan, *Crisis of Imprisonment*, 81.

[123] "Substitute for Mechanical Labor in State Prisons," *New York State Mechanic: A Journal of the Manual Arts, Trades, and Manufactures* (Albany, 1841), Rare | *Per N 83.5 10142.Q (McAllister), LCP.

This development would, in turn, increase the value of state lands, "*some three hundred and thirty thousand acres belonging to the literature and school funds,* now utterly unproductive and worthless for all the purposes to which they are assigned, for want of improvement." [124] Convict labor would connect and incorporate frontiers into New York, bolster fiscal resources, and plant a seed in lands assessed by "the geologists, engineers and surveyors who have examined them, as among the best…for grazing and dairy purposes, and…excellent for tillage in all the varieties of grains and vegetables" for free citizens to undertake. Simultaneously protecting mechanics in growing cities and enabling the "improvement" of hinterlands, the *Mechanic*'s plan concluded: "new employments, new resources, and new dominions would be added to the *empire* state."[125]

Discussing the Haitian Revolution and prison labor on the same pages, the *New York State Mechanic* fashioned a moral economy of skilled and unskilled, fabrication and extraction, deserving and undeserving, man and resource—or man and means of development. Mechanics conceived of artisan republicanism both in opposition to and in contradistinction to slavery, to bondage as a "hand" for life.[126]

Prisoner-made articles sold in Buffalo included "joiners' tools, saddlery, both brass and plated, hames, saddle trees; copper ware, furniture for cook stoves; blacksmith work, such as iron doors, grates, bars, bolts, locks, chains, and hinges; wooden ware, tubs, pails, churns; ready made clothing, boots and shoes" as well as "combs, some of which purchased in New-York, at second

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[124] Ibid.

[125] Ibid.

[126] David Roediger, *The Wages of Whiteness: Race and the Making of the American Working Class* (London: Verso, 2007); E.P. Thompson, "The Moral Economy of the English Crowd in the Eighteenth Century," *Past and Present* 50 (Feb. 1971): 76-136.

hand, without purchaser's being aware of articles being manufactured in prisons."[127] *Mechanics Magazine* reported that Buffalo establishments working copper, tin, and sheet iron ware claimed it was "impossible for them to compete with prison prices," and that "iron work for the new county prison, erected 1832 and 3," had been "wrought at Auburn, consisting of doors, grates, locks, amounting to more than two thousand dollars."[128] William Leggett decried the prisoners' unpaid labor as driving free mechanics out the market, for the prison contractors could "sell articles of prison manufacture at a price which would not supply the free mechanic with bread."[129]

After a decade of complaints about the effects of prison labor, mechanics sought state legislation in their defense in 1833-1834, submitting petitions containing over 20,000 signatures from Albany, Auburn, Brooklyn, Buffalo, Cayuga, Elmira, Erie, New York City, Onondaga, Palmyra, Rochester, Skaneatelas, Tompkins, Troy, Utica, Wayne, and Yates. The number of petitions the New York legislature received in 1833-1834 for the amendment or abolition of prison labor exceeded that of any topic yet addressed.[130] Periodically over two decades, New York mechanics struck in an attempt to compel the abolition of prison labor in the skilled trades.[131]

A special committee, comprised of J.F. Van Duzen, R.D. Dodge, and William Seymour, compiled a report on the "state of the prisons at Auburn and Sing Sing." The committee's conclusions confirmed,

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[127] "State Prison Labor [From the Buffalo Whig]," *Mechanics' Magazine* (Nov 15, 1834): 289.

[128] "State Prison Labor [From the Buffalo Whig]," *Mechanics' Magazine* (Nov 15, 1834): 289.

[129] Joshua R. Greenberg, *Advocating the Man: Masculinity, Organized Labor, and the Household in New York, 1800-1840* (New York: Columbia University Press, 2007).

[130] McLennan, *Crisis of Imprisonment*, 77.

[131] Ibid., 72.

> what has often been asserted by the mechanics and denied by their opponents, that the main object of the present system is, to realize large profits from the labor of convicts, and thus virtually build up a large government monopoly, at the expense of the interests of the mechanics, or else establish individual monopolies, at the same cost, by letting contracts to favorites, enabling them successfully and ruinously to compete with mechanical labor.[132]

In response to this assessment, the committee on state prisons determined to "inquire into the expediency of regulating the character and prices of the labor of the convicts, so that the same may not interfere with the free labor of mechanics and citizens." As a means of resource extraction, infrastructure building, and public fiscal accumulation through land values, prison labor was meant to occupy a territorial frontier for the preservation and eventual extension of free labor in the mechanics' moral economy. New York mechanics paired the maintenance of their individual independence with efforts to elevate their state from dependency via confinement to a single branch of industry.

Before the politicking of the late 1840s and 1850s, the synthesis of Whig developmentalism and artisan republicanism—"Free Soil, Free Labor, Free Men"—was pioneered in plans for the prison in the wilderness.[133] Indeed, in October 1834, a young William H. Seward sent a public letter to Rudolph Snyder, chairman of the Corresponding Committee of the Mechanics' State Convention, commending the "physical force of the convicts at Auburn, averaging at least six hundred for a number of years past, controlled and directed by the admirable police which prevails there, and aided by both steam and water power, has converted that prison into an immense manufacturing establishment, which might be expected to yield a revenue greater than all the manufactories in any town in the state." However, noting the fact that

[132] New York State Mechanic: A Journal of the Manual Arts, Trades, and Manufactures (Albany, 1841).

[133] Eric Foner, *Free Soil, Free Labor, Free Men: The Ideology of the Republican Party before the Civil War* (New York: Oxford University Press, 1995).

the prison "yields a surplus revenue of only some $3000 or $4000 annually," Seward ultimately argued that the "advantage to the state, even in a pecuniary point of view, bears no comparison to the enormous extent of the injury inflicted upon the interests of citizens engaged in manufacturing pursuits."[134]

The editor of *The Man* argued that the "most proper way to get rid of the evil of convict labor in competition with that of honest mechanics would be to remove the causes which produce convicts; to prevent poverty and ignorance" by government introduction of a "just and practicable measure of allowing every necessitous individual to cultivate (without charge) a portion of uncultivated land, under such restrictions as would prevent any further monopoly of it.'"[135]

Under the heading of "Automata," the *New York State Mechanic* classed machines, "which, although they do not take the form of any living creature, yet perform many of the movements and labors of even the highest of order of intelligent beings, in a manner far surpassing the utmost power of animation." [136] They included foremost the steam engine alongside the "calculating machine of Mr. Babbage" computing "mathematical and astronomical tables with an accuracy and despatch almost incredible." [137] The *Mechanic* found the human brain "a clumsy instrument beside these machines in their proper avocations." [138] However, unlike contemporary British critics of capitalist mechanization (whether Luddite, Tory Radical, or utopian socialist, as the apprentice mathematical instrument-maker in chapter one), the *New*

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[134] "State Prison Labor [From the Buffalo Whig]," *Mechanics' Magazine* (Nov 15, 1834): 289.

[135] McLennan, *Crisis of Imprisonment*, 75.

[136] "Automata," *New York State Mechanic: A Journal of the Manual Arts, Trades, and Manufactures* (Albany, 1841), Rare | *Per N 83.5 10142.Q (McAllister), LCP.

[137] Ibid.

[138] Ibid.

York State Mechanic concluded with assurance that such machines "are the offspring and require the direction of the human mind."[139] The relative lack of antipathy toward mechanization amazed British and European visitors such as Joseph Whitworth, who observed that the "workmen hail with satisfaction all mechanical improvements, the importance of which…they are enabled by education to understand and appreciate."[140]

The *New York State Mechanic* recognized that "mechanics have long opposed" labor-saving machinery "with the most determined resolution," but ultimately editorialized that the paper aimed to "record the progress of invention—that great department of the mechanic's profession—the sphere in which he rises above the common level of his fellow beings."[141] Instead of trying to check the "march of improvement" when "nothing can arrest it," the paper recommended devising "some way to mitigate the evil consequences which fall upon the laborer."[142] For Americans disposed to agree with *The New York State Mechanic*, that conclusion would mean learning to draw.

Cultures of Engineering Drawing

Over the nineteenth century, the advent of engineering drawing across industries increasingly drew decision-making away from the shop floor and toward the drafting room.[143] Yet standardized-model industries associated with the "American System" of manufactures—guns, sewing machines, and eventually bicycles—relied more on locks, jigs, and templates than

[139] Ibid.

[140] Merritt Roe Smith, *Harpers Ferry Armory and the New Technology: The Challenge of Change* (Ithaca: Cornell University Press, 2015), 17.

[141] "Labor Saving Machinery," *New York State Mechanic: A Journal of the Manual Arts, Trades, and Manufactures* (Albany, 1841), Rare | *Per N 83.5 10142.Q (McAllister), LCP.

[142] Ibid.

[143] Ferguson, *Engineering and the Mind's Eye*, 99.

design and shop drawings until the 1880s.[144] Drawing proved much more transformative among machinery builders, particularly machine tools workshops. Although detailed drafting for design and construction purposes had been previously restricted to large-scale civil engineering projects, nineteenth-century machinery makers forged an intimate connection between mechanical engineering and drafting.[145] Mechanical drawing enabled engineers to pursue a systematic approach to design based on break machines down into elements, determine the specification of each one, and reconstitute the general assembly, all on paper.[146]

In 1821, the Rhenish mining and metalworking firm Jacobi, Haniel, and Huyssen (a forerunner to Gutehoffnungshütte) sent a specification of an oven to a client, a Johann Christian Renken, in Oldenburg.[147] The specification was on paper, but it was not exactly a drawing. Rather, it was carefully folded and inserted in the letter's envelope. Unfolding the tight creases two centuries later, I watched—as had Renken—the oven pop up into form, a hand-sized rectangular prism with cutouts to indicate the hearth and piping. Rendering an elevation or section of such an object would have been simple. In its unfolded state, it *was* more or less a dimensioned plan projected according to the perpendicular planes of descriptive geometry. But would such a plan have been understood alone?

[144] Brown, "Design Plans, Working Drawings."

[145] Ibid.

[146] Ibid.

[147] Originalschreiben betreffend Angebot der J.H.H. mit Skizze auf Lieferung einer Kochmaschine (Küchenherd) an Chr. Renken, Oldenburg (August 8, 1821), Rhenisch-Westfälisches Wirtschafsarchiv (RWWA), 130-2034/5.

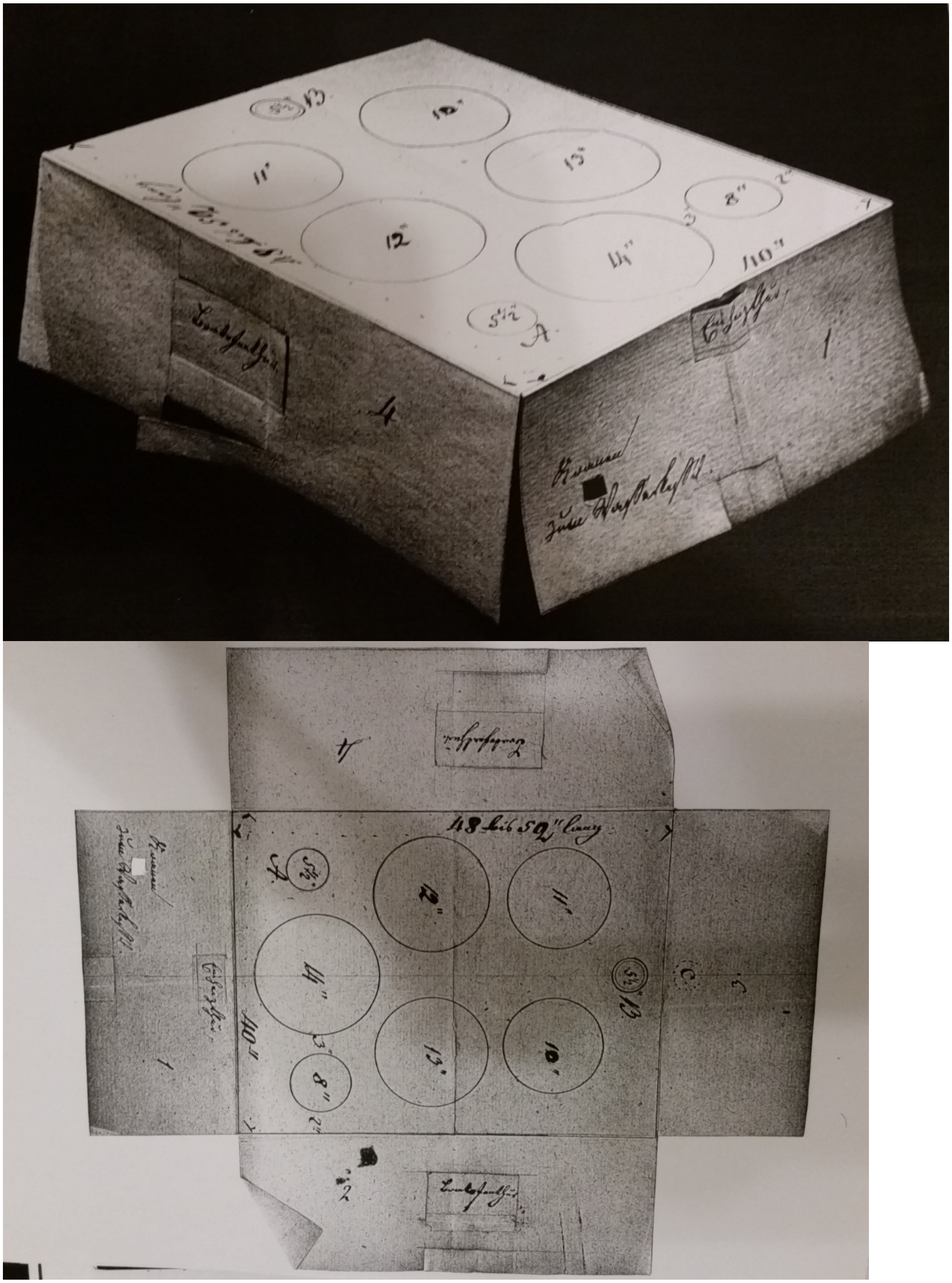

Figure 6: Specification of an oven, 1821, Rheinisch-Westfälisches Wirtschaftsarchiv, 130-2034/5

The practice of descriptive geometry entered neither a depictive vacuum nor a tabula rasa of mechanic practice. Drawing constituted a fundamental part of eighteenth- and nineteenth-century bourgeois cultures on both sides of the Atlantic.[148] Drawing was part of a larger movement of industrial promotion and social reform in cities such as Philadelphia in the 1830s and 1840s. Philadelphia lay at the interstices of Atlantic movements for scientific, moral and mechanic reform, but artisan machinery builders in a wider hinterland engaged in all of the questions at hand. In 1838 William Carey, from the prominent family of printer-publishers devoted to national political economy, addressed a pamphlet to the Artists' Fund Society, which aspired to "impress upon the people of the United States, 'the utility, the profit, the necessity, the wisdom, and the moral glory of cherishing a national spirit in the patronage of the Arts of Design."[149] Philadelphia's Carey family had begun with Irish-American Revolutionary printer Mathew Carey and would extend to nineteenth-century economist Henry Carey, promoter of tariffs and theorist of the "harmony of interests," and self-styled "industrial publisher" Henry Carey Baird, a close associate of the "Philadelphia interests," Union League, and Iron and Steel Association from the Civil War through the 1890s.

Although early historians of technology posited a particularly American approach to mechanization due to chronic shortages of skilled labor in the colonies and early republic, millwrights and mechanics also participated in a thoroughly Atlantic space of exchange of invention and technique.[150] American, British, French, and German engineers communicated

[148] Ann Bermingham, *Learning to Draw: Studies in the Cultural History of a Polite and Useful Art* (New Haven: Yale University Press, 2000).

[149] William Carey, *To the president and members of the Artists' fund society of Philadelphia* (Philadelphia, 1838), 2, LCP.

[150] H.J. Habukkuk, *American and British Technology in the Nineteenth Century: The Search for Labour-Saving Inventions* (Cambridge: Cambridge University Press, 1962).

through personal travel and the testimony of eye-witnesses, exchanges of letters and the profusion of technical print culture.[151] In 1817 E. Hoesch wrote to G. Jacobi, the founder of Gutehoffnungshütte, that he would rather travel to England than Berlin to learn iron puddling processes.[152] Emerging Rhineland industrialists employed foreign workers; beyond the crossroads of the Low Countries, in the German interior, mechanics such as the Quaker William Richard worked for C.R. Bückling. Friedrich Harkort traveled to England in 1819 to hire workers for his mechanical workshops via the enticement of higher wages.[153] In 1847, A. Seydell published his work on a technological journey through England and Scotland.[154]

In the United States, immigrant mechanics such as English millwright Thomas Oakes, known as a former worker in John Smeaton's engineering workshop, frequently circulated among projects in the opening decades of the nineteenth century.[155] Another English mechanic, John Hall, contributed to designing and fabricating Thomas Paine's iron bridge as well as John Fitch's steamboat.[156] After working on projects in New York for John Stevens, Marc Isambard Brunel brought his experience back across the Atlantic to become a prominent engineer in England. In establishing his Mars Works in Philaldephia, Oliver Evans relied on the skills and knowledge of English steam engineer Charles Taylor.[157] By the 1820s, American artisans and engineers were constructing textile machinery sufficiently different from British models. By the 1820s, a textile mechanic from Rhode Island, J.C. Dyer, established a textile factory on the basis

[151] Stapleton, *Transfer of Early Industrial Technologies*, 17.

[152] Schumacher, *Auslandsreisen deutscher Unternehmer*, 227.

[153] Ibid., 229.

[154] Ibid., 210.

[155] Stapleton, *Transfer of Early Industrial Technologies*, 6.

[156] Brooke Hindle, *Emulation and Invention* (New York: New York University Press, 1981).

[157] Ibid.

of American machinery.[158] American manufacturers prized English mechanics with strong "fingertip knowledge" and valued their existing stock of machine designs, but often found them too inflexible to invent new ones.[159]

In the 1830s, William Carey argued that a "very valuable lesson, well worthy of serious consideration in the United States, is to be derived from a glance at the vast wealth, superior excellence in manufactures, and increase of commerce obtained in many parts of Europe, within the last forty years, by a judicious application of the arts of design to the embellishment of social life." [160] William Carey instantiated the support of the arts within the "lucrative question of GAIN," the "profit of the *one* and the *whole* being intimately connected."[161]

Carey offered the example of the British Institution in London, pointing out that it included "nobility, gentry, great commoners, and most eminent members of the learned professions…the wealthiest capitalists, bankers, merchants and manufacturers." [162] Carey commended the inclusion of a broad array of "art, science, or speculation" intended to enable the United Kingdom to compete with the efforts in continental Europe to promote the "ARTS OF PAINTING, SCULPTURE AND DESIGN, BY GREAT NATIONAL ESTABLISHMENTS AND THEREBY TO WREST FROM USE THOSE ADVANTAGES WHICH CAN ONLY BE RETAINED BY A PRE-EMINENCE IN THE FINE ARTS."[163]

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[158] Stapleton, *Transfer of Early Industrial Technologies*, 17.

[159] Hindle, *Emulation and Invention*.

[160] Carey, *To the president and members*, 3.

[161] Ibid., 3.

[162] Ibid., 5.

[163] Ibid.

Carey argued that the "era of mere *utility* has passed away."[164] Although there was feverish debate over the meaning—and risks of luxury—in the early American republic, the Philadelphia printer emphasized the inexorable march of wealth accumulation.[165] The "wardrobe and household furniture of the most expensive nobleman, even so late as the reign of George III," he observed, "would now be consigned as cast clothes to Monmouth street and the stalls of brokers."[166] Beyond the centripetal force of sartorial trends across classes and oceans, homes were being designed and decorated with intensifying intricacy.[167] Every "dwelling of the respectable classes, from the carpet on the floor to the cornice on the ceiling—from the service of plate on the sideboard to the brazen knocker on the door or iron scraper and rails at the entrance; every piece of furniture," Carey pointed out, "*now* receives its estimation and salable value from the impress of the Fine Arts."[168] In Carey's account, the prominence of design in economic concerns stemmed from "craving pride of birth, rent-roll, and rank," which "creates a constant demand for novel attraction, with a necessity for new decorative furniture."[169] His conclusion was clear: "Durability is less prized than embellishment and beauty."[170]

On both sides of the Atlantic, promoters of manufactures such as Carey understood the productive foundation of this expansionary cycle of fashion and trade supremacy to be drafting.

[164] Ibid., 6.

[165] Drew McCoy, *The Elusive Republic: Political Economy in Jeffersonian America* (Chapel Hill: University of North Carolina Press, 1980).

[166] Carey, *To the president and members*, 6.

[167] William H. Sewell, Jr. "The Empire of Fashion and the Rise of Capitalism in Eighteenth-Century France," *Past & Present 2*06, no. 1 (February 2010): 81–120; see also, Leora Auslander, *Taste and Power: Furnishing Modern France* (Berkeley: University of California Press, 1996).

[168] Carey, *To the president and members*, 6.

[169] Ibid., 11.

[170] Ibid., 6.

“Each piece of work must be executed from a *pencilled drawing*,” he argued. Furthermore, Carey asserted that

> according to the taste, fancy and elegance of the pattern, the article, however cheap its materials, doubles or trebles its price and vendible attractions, multiplies its purchasers, and becomes a greater source of profit to the manufacturers, and of more wealth to the nation, by preventing the influx of foreign manufactures at home, and by opening markets in other countries for those productions.[171]

Carey and his colleagues, who would come to be known as the “Philadelphia interests,” viewed both aesthetic design and mechanical drawing as conducive to national economic progress in the antebellum period. Cognizant of Americans’ revolutionary antipathy toward aristocratic finery or the dead weight of wasteful consumption, Carey emphasized, “with all my enthusiasm for the fine arts, I am a staunch UTILITARIAN, and prize the mechanic arts and inventions as much as any of those gentlemen.”[172] The sartorial politics of “homespun” had enabled Americans of the revolutionary era and early Republic to express and pursue republican simplicity, trade independence from the “baubles of Britain,” and civic activism in a culture of spinning, weaving, and quilting bees.[173] The blockades of the Napoleonic conflicts, including the War of 1812, had enabled mechanized textile manufactures to take off in the United States with an enclosed domestic market.

Historians such as Jan de Vries have argued that “the key to understanding the growing power of capital in the European economy is not to be found by searching for esoteric sources of capital; rather, it rests with the solution to the problem of preserving and keeping productive the

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[171] Ibid., 6.

[172] Ibid., 7.

[173] Michael Zakim, *Ready-Made Democracy: A History of Men’s Dress in the American Republic, 1760-1860* (Chicago: University of Chicago Press, 2006); T.H. Breen, “‘Baubles of Britain’: the American and Consumer Revolutions of the Eighteenth Century,” *Past and Present* (1988): 73-104; Leora Auslander, *Cultural Revolutions: Everyday Life and Politics in Britain, North America, and France* (Berkeley: University of California Press, 2009).

capital stock already in existence."[174] In de Vries' account, bourgeoisies in the Dutch Republic and England managed to overcome or avoid the dissipation and misinvestment of capital, which France and Spain had pursued in titles, military, administrative, and judicial offices or luxury goods. Consequently, de Vries concludes, "as long as the reference group of the bourgeoisie was the aristocracy, the economy suffered an ongoing hemorrhaging of capital from trade to industry."[175] Yet William Sewell has argued that this very referential relationship, an "empire of fashion" from higher to lower classes and from metropole to province, stirred and accelerated investment in design-intensive textiles as well as the machines to make them *en masse*.[176]

Informed by the historical accounts produced by the French and Scottish Enlightenments, Americans of the early Republic had developed a similar critique of luxury, ornately designed consumer goods as the path to moral decline and economic stagnation. An avid consumer of European luxuries, Thomas Jefferson argued against the promotion of domestic manufactures in *Notes on the State of Virginia* as breeding the dependency of wage-labor, an element corrosive to a republican citizenry.[177]

Members of Philadelphia's Franklin Institute and emergent manufacturing classes attempted to unravel the threat of venality in this ideological matrix in multiple ways and recast republicanism. Carey sought to upend this associative framework by stressing that consumer and capital goods production complemented and furthered one another. He offered the example of Josiah Wedgwood, who had "engaged good artists to draw designs and select antique models for

[174] Jan de Vries, *The Economy of Europe in an Age of Crisis, 1600-1750* (Cambridge: Cambridge University Press, 1976), 213.

[175] Ibid., 214.

[176] Sewell, "Empire of Fashion."

[177] Thomas Jefferson, *Notes on the State of Virginia* (Chapel Hill: University of North Carolina Press, 1982).

their workmen, and reaped the advantage by a corresponding rise in price and an increase of sales in every market."[178] More directly, Frederick Fraley asked at the Exhibition of American Manufactures held at the Franklin Institute, "Who would be willing to exchange the comforts, nay luxuries which surround us, attended as they necessarily are by some restraints of personal independence, for the uncontrolled freedom enjoyed by man in his normal condition?"[179]

As historian Maxine Berg has shown, imports of Asian luxuries spurred eighteenth-century British manufacturers to pursue imitation strategies.[180] Sometimes ignorance of the actual methods to produce Asian luxuries could generate new modes of manufacture. The East India Company sponsored "industrial travellers" to survey, record, translate, and codify both work processes and designs in crafts and manufactures. Commerce in and manufacture of consumer goods cut paths toward the accumulation of capital and the development of machinery-building in the capital goods industries. European merchants and consumers valued both the scale and design variation of imports from South and East Asia, which relied on technologies capable of reconciling the production of quality workmanship with concepts and methods of "modularity, standardization,…and mechanical replication."[181]

Scholars have argued that "technologies associated with immigrant skills and state promotion," especially for the fabrication of luxuries and military arms, "tended to become

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[178] Carey, *To the president and members*, 9.

[179] Frederick Fraley, Address delivered by Frederick Fraley, Esq., at the close of the fourteenth Exhibition of American Manufactures, held by the Franklin Institute of the state of Pennsylvania, for the Promotion of the Mechanic Arts. October, 1844.

[180] Maxine Berg, "In Pursuit of Luxury: Global History and British Consumer Goods in the Eighteenth Century," *Past & Present*, No. 182 (Feb., 2004): 85-142.

[181] Maxine Berg, "Useful knowledge, 'industrial enlightenment', and the place of India," *Journal of Global History* 8 (2013): 117-141.

locked from rest of economy in enclaves of high cost."[182] However, the political economies of consumer and capital goods were intertwined in the late eighteenth and early nineteenth centuries. In the Birmingham hardware industry, Matthew Boulton of Boulton & Watt drew on continental European craftsmen for inventions to manufacture luxury wares. In 1790, for instance, Boulton purchased a lathe from French engraver and tool-maker J.B. Dupeyrat.[183] Boulton and Fothergill employed a precious metalworker from Saxony, and attempted to monopolize his designs and processes by preventing him from contact with all London jewelers. As early as 1759, testimony before a Select Committee of the Commons reported "30 or 40 Frenchmen and Germans constantly employed in Drawing and Designing" in Birmingham.[184]

Although the name Krupp would eventually become synonymous with cannons, the metalworking business began with consumer goods for the emerging middle classes and their "empire of fashion" as much as capital goods. In 1843, Krupp worked with Alexander Schoeller, an investor from a Düren textile manufacturing family, to plan a silverware factory in Austria. The silverware factory at Berndorf near Vienna initially incurred heavy losses, but provided Krupp with crucial experience.[185] Three years later Krupp acquired a British patent for the spoon-rolling process, and then attempted to form an international patent monopoly with applications to the Prussian, French, Belgian, and Russian governments.

Krupp integrated backward toward the machinery and equipment for a silverware factory and then developed a strategy whereby the firm would sell the tools a sole customer per country, such that Krupp's customers, the individual silverware factories, would acquire a national

[182] Mathias, "Skills and the Diffusion of Innovations."

[183] Robinson, "International Exchange of Men and Machines."

[184] Ibid.

[185] Harold James, *Krupp: A History of the Legendary German Firm* (Princeton: Princeton University Press, 2017).

monopoly (and thus be willing to pay steep prices for Krupp's capital goods).[186] Experimentation with materials in fine steel products also lent itself to subsequent military uses at Krupp.[187]

Figure 7: An advertisement of the Reichenbach'sche Maschinen-fabrik, forerunner to the merged Maschinenfabrik Augsburg-Nürnberg, from the 1840's. M.A.N. Museum, Augsburg. Note the significance of the male figure drawing as well as the ornate frame.

[186] Ibid.

[187] Ibid.

Figure 8: Illustration of the Reichenbach'sche Maschinenfabrik. M.A.N. Museum, Augsburg.

The directorship of Philadelphia's School of Design counted as members the early locomotive manufacturer, Samuel V. Merrick and his wife, as well as D.S. Brown and Frederick Fraley. The School of Design's visiting committee included several facets of early industrial Philadelphia: Mrs. B. Wilcocks, wife of a machinery manufacturer; Mrs. Mutter, wife of doctor Mutter, Mrs. F.C. Lea, a member of the Lea publishing family, and J.B. Ingersoll.

The April 1850 meeting of Philadelphia's Franklin Institute, then under the presidency of Merrick, received a letter from Mrs. Sarah Peter regarding the establishment of a school of design for women. Peter proposed combating the "deprivation and suffering to which a large and increasing number of deserving women are exposed in this city and elsewhere" by providing for "a wider scope in which to exercise their abilities for the maintenance of themselves and their children." [188] The wider scope of activity Peter envisioned would be premised on "instruction of a class of young girls in the practice of such of the arts of design."[189] She stressed that this

[188] Franklin Institute, *Proceedings of the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanical Arts* (Philadelphia: King & Baird, 1851), 3-4.

[189] Ibid.

"department of industry" was "as yet unoccupied by our countrymen," posing no threat to existing industries or tradesmen. Nor would these design arts be practiced in the workplaces of craftsmen. She advocated them with the argument that such "arts can be practiced *at home*, without materially interfering with the routine of domestic duty, which is the peculiar province of women."[190]

Advocates of drawing instruction posited gendered abilities in visualization and taste. Peters' recommendations to Philadelphia's Franklin Institute referred to "peculiarities of the female sex," including "the very general possession by them of a more refined and correct taste, and a power of delicate discrimination, especially in regard to the effects of form and color—effects which strike almost every one among us, but which few, except women, are able to analyze and produce at will."[191] She did not speculate whether this was "an intrinsic difference in their intellectual nature from that of man, or only the result of a difference of education." [192]

Deploring rising applications for public and private charities in Philadelphia, Peters viewed instruction in drawing as a way to offer widows, abandoned wives, and "young women….chiefly or entirely dependent upon their own resources"—a consequences of "the unceasing drain, by emigration to the West and elsewhere"—a means to economic independence.[193] She counterpoised their situation against that of the city's men for whom "there are now, and there must long continue to exist, so many more direct and more easily to be attend

[190] Ibid.

[191] Ibid., 8.

[192] Ibid., 8.

[193] Ibid., 7.

avenues to fortune, that high excellence in the industrial arts of design can rarely be expected from them."[194]

She hoped drawing schools could conform to gendered talents, fitting women for "employment in many arts, such as woodcutting and engraving, for which their quick perceptions of form and their delicacy of hand very especially." Anticipating concerns of male artisans about female competition and proletarianization, she interjected, "even should they, in these and similar branches of labor, supplant men entirely, no evil could occur, especially in a country like ours, where broad fields for male labor lie entirely unoccupied."[195] Ultimately, Peters believed the arts of design might prove a bulwark against prostitution.[196]

By 1853, Baltimore professor of drawing William Minifie would argue that, though conditions were worse in old Europe, "we have more laborers in many departments of industry than employment for them" and "consequent competition has reduced the remuneration to a miserable pittance they can hardly afford subsistence." Minifie chastised interlocutors who claimed

> that our country is too young for the study of the Fine Arts, even in connection with manufactures; that we have full scope for more vigorous pursuits; that we have no time to sit down and learn Drawing; that we must leave all those trifling matters to the over-populated countries of the old world.[197]

Instead, like Peters, Minifie viewed learning to draw as an avenue to industry and a remedy to a situation where "in departments of female industry, this fact is so notorious as to be generally

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[194] Ibid., 6.

[195] Ibid., 9.

[196] Christine Stansell, *City of Women: Sex and Class in New York, 1789-1860* (New York: Knopf, 1986).

[197] William Minifie, *Popular lectures on drawing and design* (Baltimore, 1854), 5.

admitted, and it is no doubt a prominent cause of immorality."[198] He decoupled the association between the arts of design and venality; manufactures and morality were of a piece.

Such a claim complemented Carey's advocacy of national political economy. Giving the examples of designs of furniture and patterns of dresses, which he called mere "servile imitations of those imported from France and England," Carey argued that design dependency rendered the United States "tributary, and in so far inferior, to foreign nations."[199] Design dependency meant that despite

> rapid advances which we have made in manufacturing, it must be admitted, our improvement in the arts of design has been by no means commensurate with our other successes; while the quality of our materials and the cheapness of their production are enabling us gradually to exclude foreign productions from our markets, we are still compelled to depend almost entirely upon foreigners for our designs and patterns.[200]

Carey integrated this notion into a wider promotion of American manufactures, continuing, "if, by any means, we shall succeed in freeing our manufacturing industry from this slavery, which is a defect and reproach upon it, we shall certainly have made another important step forward in our career as a producing nation."[201]

The Shuttle and the Cross, and the Pencil

Although far from new to artisan milieu, the focus on education and temperance in the moral differentiation of Philadelphia workers in the 1830s and 1840s increasingly fed into anti-Catholic and nativist sentiment.[202] Moreover, with the degradation of the apprenticeship system

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[198] Ibid.

[199] Franklin Institute, *Proceedings of the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanical Arts*, 9.

[200] Ibid., 8-9.

[201] Ibid., 9.

[202] David Montgomery, "The Shuttle and the Cross: Weavers and Artisans in the Kensington Riots of 1844," *Journal of Social History* 5, no. 4 (Summer 1972): 411-446.

and in the wake of the Panic of 1837, artisan politics between masters and workingmen fractured into Protestant versus Freethinking or Masonic wings.

In 1841, the *New York State Mechanic* reported that riots had broken out in Philadelphia--"one of those outbreaks, so common amongst the mechanics of England on the introduction of labor-saving machinery, but less frequent among us." Taking the opportunity to extol the virtue of invention and the futility of resistance, the Mechanic explained,

> The sheriff had received in the morning of that day an intimation that attempt would be made to burn the factory of Mr. Kempton, at Manayunk, by a party of hand-loom weavers from the city and district…About 2 o'clock in the morning some two or three hundred of the mob made an assault upon outposts with various kinds of weapons, and wounded two or three severely with fire arms. origin of this mischievous affair, machine introduced by Mr. Kempton, by which one woman is enabled to work of eight men at their hand looms…no doubt the weavers are or will be sensibly affected by a machine which makes so great a reduction of hand labor; but it is the most absurd thing in the world to resort to violence for relief. progress of invention cannot be checked by any such means. Nearly all machinery we now haven the various departments of labor has been obnoxious to the same objections, yet who can calculate how much greater would be the calamity should it be demolished.[203]

In response to the Kensington Riots in Philadelphia in 1844, Ann Sellers, from the family of mechanicians (soon-to-be machine-tools manufacturers) including William Sellers and Coleman Sellers, wrote to Hannah Sellers Hill:

> What an awful state the City is in just now, and I see no way to resist the mob. It appears the Catholics had no part in this out break, and yet it is asserted they are the ostensible cause of all the late disturbances. Satan certainly is let loose, and what can stay his course, nothing but the strong arm of the Almighty. O, may we deserve his protecting power.[204]

Class and confessional divisions increasingly separated the erstwhile "mechanic" as both a user and maker of tools. The Sellerses viewed themselves as on the right side of morality and progress alike.

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[203] New York State Mechanic: A Journal of the Manual Arts, Trades, and Manufactures (Albany, 1841).

[204] Sellers, Ann, b. 1785. Letter to [Mrs.] Hannah S[ellers] Hill (July 2, 1844), APS.

For a fee of four dollars per quarter, students of the design school would have access to the Franklin Institute's library, cabinets of models, minerals, and specimens of the arts and manufactures, and lectures and exhibitions.[205] Students would receive "gratuitous instruction" when "required by circumstances" upon an entrance fee of two dollars.[206] Solomon Roberts exhorted mechanics to "practise self-culture, not only as a man, but as a mechanic, in order to acquire a knowledge of the principles upon which his labors depend for success."[207]

Frederick Fraley commended mechanics' institutions and apprentices' libraries for taking the "various industrial arts out of the routine of the mere workshop," and giving "the artisan the possession of a new and almost infinite power; the power of useful knowledge." Like the French philosophes, Fraley advocated the systematization of knowledge and the establishment of the workmanship of certainty over that of risk:

> traditions of the shop may, up to a certain point, make a good workman, but how vastly superior is the mechanician whose art is the combined production of well trained practice, and well directed knowledge of the properties and affinities of the substances on which he manipulates...
>
> Compare the beautiful designs and perfection of colors with which our fine woolen and cotton fabrics are covered by the use of the modern printing machine, with whose elaborate but grotesque and heavy productions of the old methods of block printing, and you will acknowledge another important benefit conferred by the scientific skill that has the faculty of readily and simply impressing by unerring machinery the types of so much beauty on the copper roller.[208]

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[205] Franklin Institute, *Proceedings of the Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanical Arts*, 13.

[206] Ibid., 27.

[207] Solomon W. Roberts, *The promotion of the mechanic arts in America* (Philadelphia, 1846), 20.

[208] Frederick Fraley, *Address at the close of the fourteenth Exhibition of American Manufactures* (Philadelphia, 1844), 6.

In his address, Fraley reminded listeners that students attending the drawing school could "without expense, attend courses of general chemistry, natural philosophy and mechanics."[209]

As a teenager, Coleman Sellers, later president of the American Society of Mechanical Engineers (ASME) and chief draftsman of William Sellers & Co., attended Bolmar's school in Philadelphia. In early November 1842, Sellers began to make a hygrometer out of cat gut

> on which the atmosphere acts expanding and contracting it thus moving an index which shows the degrees on a plate. I have been thinking of making one of a piece of ash which by expanding and contracting works compound leavers, which are joined to the index, thus by a slight difference in the wood a great difference will be perceived in the position of the index; it is to be made pretty much on the same principal as those instruments made which show the expansive power of metals only instead of metal a piece of ash is used as the body to be expanded, and instead of being acted upon by the heat it is to be acted upon by the atmosphere.
>
> At work at my hygrometer but could not complete it for want of tools. Made an improvement in the instrument instead of having a weight fastened to the cat gut I intend to put a spring in this manner AB is the spring fastened to the farm at A and moving with the index at B the benefit of which is that the instrument will work in any position when if there was a weight fastened to the string it could only work when in a perpendicular position.[210]

At Bolmar's school in the 1840s, Coleman Sellers attended lectures relevant to such experiments, including lectures on pneumatics, hydraulics, hydrostatics, and mechanical power. Sellers also received the *Dictionary of Arts and Sciences* and the *Emporium of Arts and Sciences* as a Christmas present.[211] Sellers used his pocket money to buy volumes of the "economical library." He noted geometric rules from the *Dictionary of Arts and Sciences*. In the winter and spring of 1843, Sellers's studies included attending lectures on optics, electricity, galvanism, chemical affinity, hydrogen, and nitrogen gas, all the while studying bookkeeping.

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[209] Ibid., 7.

[210] Coleman Sellers, Diary, APS.

[211] Coleman Sellers, Diary [while at Bolmar's school] (Nov.-March 24, 1842-1843), APS.

Protestantism inflected Coleman Sellers' interpretation of his elite mechanics education to a very real extent. Whereas his relative and business partner William Sellers would employ Frederick W. Taylor to investigate the properties of metal a mere few decades later, for teenage Coleman Sellers, discussing the properties of matter evoked most immediately the Day of Judgment. In 1842, he wrote in his diary:

> Dr. Washington delivered his first lecture; on some of the general properties of matter. An idea struck me while listening to the lecture that I can not refrain of committing to paper. It is found to be a fact that that the same particles of matter that exist at the present day existed at the creation of the world, only under different forms; and it is also known that when a person dies putrefaction takes place and his body returns to the dust from which it came, and that the same particles of matter that composed the body may remain for centuries hid until at last they are taken up by some plant and that plant is eaten by some animal and thus it forms part of the animal body, and the animal is eaten by man and thus those very same particles form a part of that man, who in his turn dies and forms part of other men who in their turn die. Now it is believed that at the day of judgement every person will appear with the same body that he tenanted during his life time, and since we are certain that the same particles that composed the body of one man composed the bodies of hundreds of men after then, so how is it possible that every man can have the body that he had during his life since the particles of matter in his body belonged to the bodies of thousands of men before him.

In 1841, a year before Coleman Sellers began attending Bolmar's school, New England author and abolitionist Frances Harriet Whipple published a novel entitled *The Mechanic*. Predictably in such a "conduct of life" novel, Whipple used the tract to condemn the foppery of antebellum America's nouveau riche and the drinking culture of the growing class of urban workers alike. More interestingly, the novel's hero, an upright and intelligent apprentice from the country named Victor Hyde, and the villain, dissolute journeyman George Rankin, both advocate tenets of labor republicanism. While praising the combination of head and hand and the dignity of skilled, independent work, Whipple meant the book to inoculate youth against collective, masonic, and deist-atheist labor politics in such associations as the Workingmen's Party. Accordingly, she prefaced the novel with the statement:

> …if those who are called levelers, would stop leveling down and begin to LEVEL UP!—if, instead of attempting to bring down the higher orders of society, they would aim at elevating the low, if they would preach at the corner of the streets, and by the fire-side—through all our high-ways, and through all our bye-ways, the great doctrine of the dignity—the divinity of human nature—a dignity, a divinity, which the contact of no outward circumstance could, possibly, either degrade, or exalt, a great change would begin to be wrought,—and this, undoubtedly, would lead to a clearer perception of the spirit, and a carrying out of the principle, which was in the mind of Jesus…When these doctrines are generally preached, and embodied in practice, every man will begin to feel himself, and TO BE—A MAN; and feeling, and being this, however high, or however low he may be in a worldly point of view, he will regard his fellow men as equals, and brethren, all walking in different paths, it may be—all pursuing different avocations; yet each bearing on his brow the visible signet of Jehovah, which confirms THE NOBILITY OF A GODLIKE NATURE—each invested with a mission to his race, for the faithful discharge of which he is accountable to all future generations. When this spirit comes to be diffused, the rich man will cease to be arrogant, and the poor man will forget to be servile; for will not each feel himself equally a MAN?[212]

In Whipple's narrative, Mr. Gray, a responsible master craftsman, presents Victor with a "season ticket to a course of scientific lectures" and his membership in the Mechanics Library enables Victor in winter to pass "many leisure hours" with resources obtained there.[213] Importantly, Victor's self-improvement efforts center around drawing, which he learns from Gray's unimpeachably bourgeois and republican daughter.

In a letter to his mother, Victor confesses to having unwittingly attended a lecture by a "celebrated atheist" on a Sabbath afternoon, having been invited by the villainous journeyman George Rankin.[214] Victor estimates that two thousand people attended, primarily "dashing young men of the city" as well as "many Mechanics and decent respectable looking people, with their families," then describes the services commencing "by reading a hymn in praise of Wisdom,"

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[212] Frances Harriet Whipple, *The Mechanic* (Providence: Burnett & King, 1841), IX-X.

[213] Ibid., 41-42.

[214] Ibid., 55-57.

followed by a reading of a chapter "from one of the French philosophers on the organization of Matter."[215]

When Victor refuses to disavow the term "master" for a "man who teaches any art…as well as he that teaches any science," Rankin retorts, "servile in every thing! I tell you he is incapable of taking in a noble thought. Go to the South! the whip of the negro-driver might make you feel! Go to the South; and there you might really have a master!'" Whipple would become a prominent abolitionist; in 1841, she concerned herself as a writer with patching over nascent class divisions among mechanics and critiquing the wanton godlessness as well as the implied sodomy of political journeymen.

Similarly didactic conduct of life literature such as John Frost's *The Young Mechanic* and James W. Alexander's *The American Mechanic* hoped to find an audience in "the shop and the manufactory," to be "read aloud from the workman's bench."[216] Echoing Whipple's fears, Alexander extolled,

> Ours is not the country where one may sneer at the "mechanic." Demagogues know this; agitators who would spurn the "unwashed artificer," if met in some old despotic realm, find it to be their true policy to flatter and cajole him here. I respect honest labour, though it be in the black man who saws my wood. Wherever the demeanor and life of a man are good, let me get as near to him as he will allow, that I may take his hand, though it be as black and hardened as his anvil.[217]

Alexander hoped "to see American mechanics elevated in their own esteem," which he considered the "surest means towards their elevation in the esteem of others."[218] Frost also emphasized the "respectability of mechanical trades" alongside the "evils of ignorance,"

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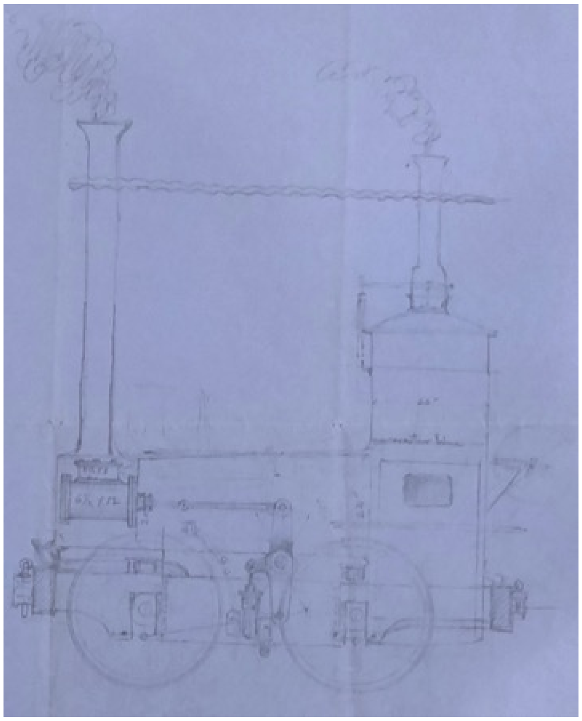
[215] Ibid., 58.

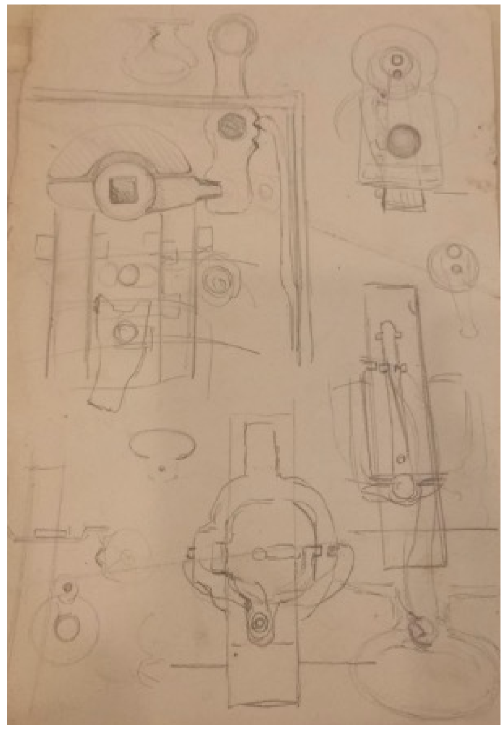
[216] James W. Alexander, *The American mechanic* (Philadelphia: H. Perkins, 1838), 3.

[217] Alexander, *The American mechanic*, 7-8.

[218] Alexander, *The American mechanic*, 4.

"application of science to art," and the "triumph of American ingenuity." Above all, the authors of Conduct of Life guides promoted drawing.[219] Learning to draw became a capital virtue; claims to virtue would underwrite drawing capital.





[219] John Frost, *The young mechanic* (1848), LCP.

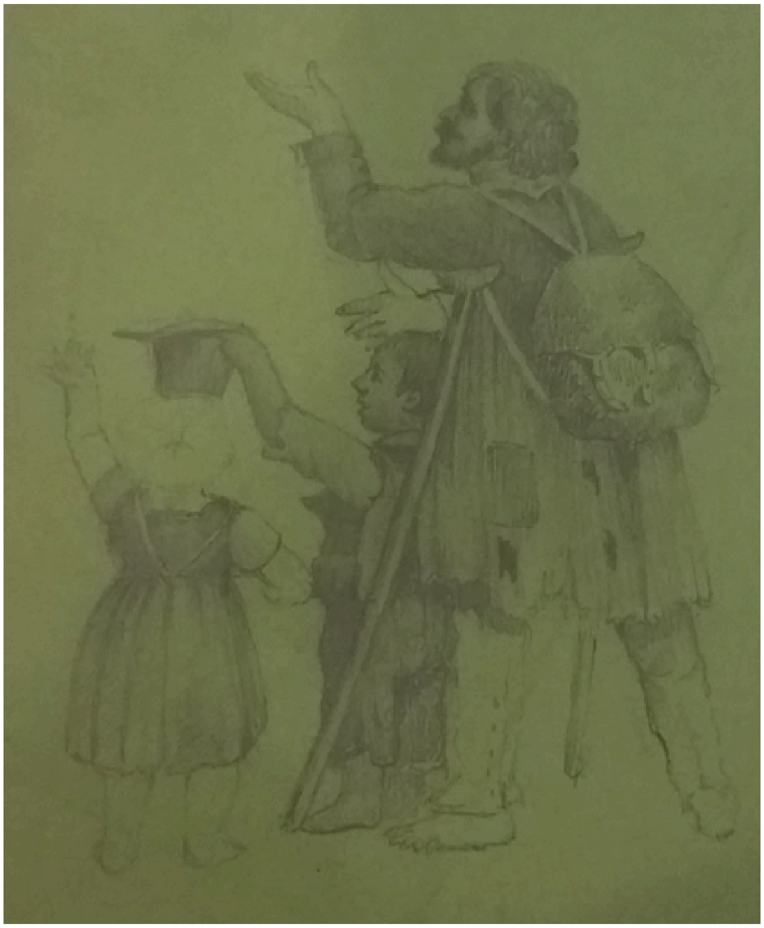


Figure 9: George Escol Sellers (1808-1899) Drawings, American Philosophical Society.

Chapter Three: The Lathe of Heaven

Drawing Machines in the U.S. Civil War

War suited William Sellers. In 1861, his Philadelphia machine-tools works played host to William Wood and Edward Latch of the U.S. Navy and Col. Eardley of Britain's Royal Artillery. Captain Dyer, Major Saidly, and Captain Rodman visited from the Frankford Arsenal in late August 1861 to view the turning and boring of guns, engaging in discussion with Coleman Sellers about undertaking experiments in using "cyanide of pottarie as a flue in unity lead to cast iron" for shells.[1] Luminaries Lucian Sharpe, Louis d'Orleans, comte de Paris, Charles Minot, and Benjamin Latrobe followed the next year. In 1863 and 1864, Sellers met with a succession of standardizers: G.J. Prescott of the U.S. Navy Yard in Portsmouth, New York; Joseph P. Haigh of the West Point Forge; George Rose Mackenzie of the Singer Manufacturing Co., New York; and William L. Stor of Philadelphia's massive publisher J.B. Lippincott and Co. As destruction of rolling stock grew and Southern debts mounted, D.A. Keith and E. Thurston of the Kentucky Central Railroad visited William Sellers in 1864, as did James Guthrie Pursall of the Louisville and Nashville Railroad the same year.

All the while, representatives of railroads penetrating the North American continent and hinting toward American empire flocked to Sellers' shop made by and for the lathe. They came from the Ohio & Mississippi Railway (St. Louis), the Indiana Car Works, and the RPM Estrada (Havana, Cuba). Y.M. Montero visited from Peru as did representatives of the Havana Railroad, administrator J.A. Echeverria and master mechanic A. Gonsales, followed by Arthur M. Cazinajon, a civil engineer and draftsman at the Spanish Consulate.[2] They were followed by Carlos V. Duque of Bejucal, Cuba, P.Y.F. de Alfara of Havana, and an engineer for the Western

[1] Sellers, Coleman, b. 1827. Memorandum concerning his invention of projectiles; [1861], APS.

[2] William Sellers Visitor Book, Hagley Museum.

Railroad of Havana, who sought to discuss plans of turntables and estimate the cost of machinery for repair shops. Above all, they came to witness drawing capital.

The Sellerses had long invoked the "mind's eye" in engineering, turning to landscape drawing in addition sketching machinery.[3] Their cousins, the Peales, painted and curated the apex of portraiture in Philadelphia. But during the Civil War, the Sellerses manifested their visuality in altogether new ways. In 1858, Coleman Sellers had assembled notes from the *National Review* and *Litell's Living Age* on cognition and inspiration, as well as writing and drawing mediums (of psychic sort):

> Every artist must be aware that he owes a great deal to the unconscious workings of his mind or hand; hints seem to arise spontaneously, and much of his art consists in his availing himself of them and giving them shape and consistency. A metaphor flashes across the mind, an imperceptible turn of the wrist adds an unpremeditated grace; which enchants with delightful surprise him from whose hand it flowed; and so little are we able to trace the fine clues of suggestion from which these things (often the best we are capable of) arise, that we are as a metaphor to describe their origins the inspiration of genius. No one has solved the problem of the mode in which thoughts spring up in the mind. [4]

His reflections on such articles contained discussions of: nervous phenomena, jerking, inducement of nervous states, monomania; training of the mind to resist such responses to sensory phenomena, selection of ideas; recollection, and the power of concentration to increase the intensity of impressions.[5]

The Sellerses simultaneously experimented with the instrumentation of microscopy and the chemistry of photography. In February 1861, Coleman Sellers wrote to Titian Ramsay Peale about a process for copying drawings, clearing with cyanide and strengthening "by immersing in a vat solution of chloride of mercury until it looks like porcelain." At the same time, Sellers

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[3] Eugene S. Ferguson, *Engineering and the Mind's Eye* (Cambridge, MA: MIT Press, 1999).

[4] Sellers, Coleman, b. 1827. Mental philosophy (1858), APS.

[5] Sellers, Coleman, b. 1827. Mental philosophy (1858), APS.

experimented with coloring albumin prints and invented "a new mode of varying the velocity of revolving machinery that is particularly adapted to the varying feed of lathes and drill presses." Hoping to quickly patent the invention, Sellers viewed it as a "stepping stone towards motive power on common roads our principal locomotive builders think it is all that is wanted to accomplish the varying speed required from a constant velocity in the prime mover."[6]

The Sellerses' depictive, mechanical, motive, and industrial pursuits complemented one another. Coleman Sellers, for instance, developed a wet process and dark box for photography that "should prove good for the field and not weigh too much."[7] Engineers sought to break photography out of its confines and find for it new applications, from naturalist research to advertising their machinery.

In March 1861, Sellers asked Peale for photographic "proofs of your courage in taking soldiers and their war like firings—did not Walker or Wood take any views of the draught[?]"[8] In March 1864, Coleman Sellers wrote to his brother George Escol Sellers to request he collect diatoms: "please turn your attention to the scum on the Saline River and on your ponds and see if you can not find some splendid specimens of Diatoms."[9] Coleman felt "quite anxious about you with the rebels operating in your neighborhood"—western Tennessee, two weeks before the capture of and massacre at Fort Pillow. But he had been "preparing specimens for the microscope" and "made some progress using an instrument loaned to me," and was eager to tell his brother about a large microscrope he had commissioned, which was to cost about $260.[10]

[6] Sellers, Coleman, b. 1827. Letter to Titian R[amsay] Peale (February 3, 1861), APS.

[7] Sellers, Coleman, b. 1827. Letter to [Titian Ramsay Peale] (February 17, 1861), APS

[8] Sellers, Coleman, b. 1827. Letter to [Titian Ramsay Peale] (March 10, 1861), APS.

[9] Sellers, Coleman, b. 1827. Letter to [George Escol Sellers] (March 29, 1864), APS.

[10] Sellers, Coleman, b. 1827. Letter to [George Escol Sellers] (March 29, 1864), APS.

The focus on depiction, the world in section, did not stop at diatoms. Starting in the late 1850s and accelerating through the U.S. Civil War and German "wars of unification," machine tools and locomotive works centered the drafting room as the locus of managerial reform and control.[11] Before the advent of Frederick W. Taylor's scientific management, works such as Baldwin Locomotive turned to piece drawings to manage cost-accounting and inside contracting systems for erecting steam engines.

A dozen years prior to the U.S. Civil War, Sophonisba Peale Sellers wrote to her sister, Ann Sellers, "far from feeling lonely as I expected I should, I find all is life around us." Sophonisba, widow of engineer Coleman Sellers, had moved south to Palmyra, Tennessee from Philadelphia, home to her family of artists and naturalists Charles Wilson Peale, Rembrandt Peale, Titian Ramsay Peale, and Franklin Peale. From the "middle ground" of the upper South, she recounted hearing the "constant working of the Furnace night and day with the merry singing of the negroes at their work frequently in chorus which is reverberated from hill to hill and the merry sound of the bugle which they pride themselves in blowing when about to let out the Iron." This "with the merry voices of the mule drivers cheering on their mules as they pass and repass with their teams," she added, "enlivens the scene very much."

Working the furnace, likely a charcoal furnace for refining iron ore, enslaved people took shifts from "twelve o'clock at night until 12 at noon when another sett take their place."[12] While the young Philadelphia machinery works of William Sellers remained a general jobbing shop, the

[11] John K. Brown, "When Machines Became Gray and Drawings Black and White: William Sellars and the Rationalization of Mechanical Engineering," *IA: The Journal of the Society for Industrial Archaeology* 25 (1999): 29-54; Jürgen Kocka, "From Manufactory to Factory: Technology and Workplace Relations at Siemens, 1847-1873," *Industrial Culture and Bourgeois Society: Business, Labor, and Bureaucracy in Modern Germany* (New York: Berghahn Books, 1999).

[12] J. Peter Lesley, "Charcoal Furnaces in Western Tennessee," *The Iron Manufacturer's Guide to Furnaces, Forges and Rolling Mills of the United States* (New York: John Wiley, 1859), 133; on industrial slavery, see Jeremy Zallen, "American Lucifers: Makers and Masters of the Means of Light, 1750-1900" (PhD Dissertation, Harvard University, 2015) and Alicia Maggard, "One Nation, Under Steam" (PhD Dissertation, Brown University, 2018).

Tennessee Sellerses experimented with incentive schemes: “Many work over work which they are paid for as the furnace must be worked on Sunday they are paid for that also—as a stimulus for good behavior allows those that wish it a pint of roasted coffee a week—he having abolished whipping—should they misbehave they are deprived of their coffee.”

This branch of the Sellerses settled into a truce with the slave system in western Tennessee (in Sophonisba’s words, “they appear to be very happy—say they love him more than any master they ever had—still to me it is a sad feeling to think they are in bondage”). They simultaneously applied the wage system to family labor:

> Sophy has been making good stout chemises for the women putting much better work on than customary her father pays her the usual price 10 cents a piece for them,..Charles has pockets put in their pantaloons which has pleased them very much this being a luxury they never had.[13]

Before the transformations of the 1860s, offshoots of the Philadelphia machine-building milieu had conceived ways to honor contract and commend paternalism.

Alongside locomotive manufacturer Matthias Baldwin, the Sellerses—William, George Eschol, and Coleman—have been taken to epitomize Philadelphia’s Republican establishment of engineers. Historians have attributed to them a distinctly national political economy, the Pennsylvania School of economist Henry Carey, descendant of Irish-American revolutionary printer Matthew Carey, who worked in the Whig tradition, of Tench Coxe, Alexander Hamilton, and Friedrich List.[14]

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[13] Peale, Sophonisba Angusciola, 1786-1859. Letter to Ann Sellers, Mill Bank (July 14, 1848), American Philosophical Society.

[14] Henry C. Carey, *The Harmony of the Interests* (Philadelphia, 1851); Jeffrey Sklansky, *The Soul’s Economy: Market Society and Selfhood in American Thought, 1820-1920* (Chapel Hill: University of North Carolina Press, 2003); Friedrich List, *The National System of Political Economy*, trans. Sampson S. Lloyd (London: Longmans, Green and Co., 1916).

Historians have recently highlighted the imperial ambitions of the antebellum South, the desire to resolve internal tensions in the region through projection of conquest and visions of re-opening of the slave trade. These found expression in popular filibustering efforts such as William Walker's military ventures in Nicaragua in 1856.[15] But Philadelphia machinery makers also harbored ambitions surrounding Latin America. Philadelphia machinery works sought world markets, aiming to successfully vie with and displace British machinery makers' monopoly on South American capital goods customers (on the turn toward exporting machines in Britain, see chapter one). The horizons of Philadelphia capital goods industrialists were distinctly international in the 1850s and 1860s. Firms engaged with new materials during the 1860s; with the help of New York merchants Gilead Smith and T.M. Tyng and Krupp representative Thomas Prosser, Baldwin began importing Krupp steel for railroads traversing the American continent.[16]

Baldwin Locomotive exported engines to Cuba and Brazil before and during the Civil War.[17] As early as January 1854, for instance, Baldwin Locomotive sent brass flanges, grates, and a hose to the Havana Railroad; the next month, the works shipped boilers to the Cardenas Railroad. In May 1855, Baldwin shipped bolts, springs, frogs, and shafts to the Havana Railroad, wheels and axles to the Cardenas Railroad, and axles, springs, and pedestals to the Matanzas Railroad.[18] In August 1863, Baldwin exported a copper firebox and combustion chamber crowns to the Havana Railroad; a year later, while provisioning the U.S. Military Railroads in Nashville

[15] Matthew Karp, *This Vast Southern Empire* (Cambridge, MA: Harvard University Press, 2016); Walter Johnson, *River of Dark Dreams: Slavery and Empire in the Cotton Kingdom* (Cambridge, MA: Harvard University Press, 2017), 374-417.

[16] T.M. Tyng to M.W. Baldwin & Co (July 23, 1866); Thomas Prosser to M.W. Baldwin (Dec 28, 1866); Incoming correspondence (New York City Office) Jan. 2, 1861-Feb. 13, 1861 57 1, HSP.

[17] Baldwin Order Books (1854-1865), HSP

[18] Baldwin Order Books (1854-1865), HSP.

with items such as a spring balance, the works shipped driving wheels, tires, and a hydraulic jack to the Trinidad Railroad. In February 1861, Gilead Smith wrote to Baldwin,

> I have red [sic] the enclosed letter from Havana to day and the $5,500 draft at 60 days…duly presented for acpt. Shall I try it for discount a send it to you?
> Have you received the money yet from Cash? The delay is inexcusable I think what luck about the $5000 Louisville note received further [sic] Pacific engine. Is it paid?[19]

Both the scarce banking facilities of the South and the complications of transnational financial dealings already frustrated Philadelphia machinery works such as Baldwin Locomotive.

After the Civil War, the sons of ex-planters often became engineers and were drawn to mining and civil engineering projects in the American West and abroad.[20] In November 1865, Baldwin Locomotive sent driving wheel centers, tender wheels, axles, sheet boiler iron, spring steel, bars of cast steel, and one hundred pounds of Babbitt metal to the Cienfuegos & Villa Clara Railroad. In the 1880s, American newspapers invoked of the term "Zollverein" to envision a pan-American customs union.[21] The nucleus of these ideas emerged in the Civil War when Copperhead factions used the term "Zollverein" to denote a peaceable commercial reunion with the South.[22]

Historians have demarcated merchants and financiers on one hand and mechanics and manufacturers on the other, only consolidating into a single bourgeoisie over the course of the Civil War.[23] Historians of the Philadelphia capital goods industries specifically have posited a

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[19] Gilead Smith to M.W. Baldwin (Feb 23, 1861), HSP.

[20] Ruth Oldenziel, *Making Technology Masculine: Men, Women, and Modern Machines in America, 1870-1945* (Amsterdam: Amsterdam University Press, 1999).

[21] "Wants Closer Relations BETWEEN THE UNITED STATES AND SOUTH AMERICAN NATIONS," *The Rock Island Argus* (February 23, 1886); "David Wells calls for an American Zollverein," *The True Northerner* (June 8, 1883); "The American Zollverein," *The Washington Post* (Aug 25, 1889),

[22] "Extracts from Mr. Vallandigham's Speech in Congress, 1863," *The Polynesian* (March 14, 1863).

[23] Sven Beckert, *The Monied Metropolis: New York City and the Consolidation of the American Bourgeoisie, 1850-1896* (Cambridge: Cambridge University Press, 2003).

political distinction likewise between merchant-mechanics and artisan-mechanics. Free Labor ideology narrowed in the wake of emancipation to a punitive liberalism focused solely on securing the freedom of contract in the market.[24] For the Philadelphia capital goods industries, however, the story may be of continuous internal tensions rather than unidirectional change. Indeed, relying on the political economy of Henry Carey, they would never fully endorse the liberalism of William Graham Sumner.

On one hand, the Philadelphia machinery industrialists expressed opposition to slavery and support for Free Labor politics.[25] Invoking a broad producerism, they contrasted themselves with the commercial and financial interests of New York, and the established mercantile elite of Philadelphia itself. Locomotive manufacturer Matthias Baldwin took a known antislavery position. When machinist James Gay, who had emancipated himself from slavery, anticipated an invention of his would by stolen by the New York Mechanics Institute, his advocates addressed those concerns to Baldwin.[26]

In April 1861, Franklin Peale wrote to Titian Ramsay Peale, "but of this fact you may feel assured that there is but one feeling in Philad. and the state, and, that is union and patriotism. I have never seen such excitement all one way—our streets are festooned with the Stars & Stripes and the Ladies are displaying union badges and colors, in every variety of decoration."[27] "The patient endurance and conciliation spirit so remarkable hitherto," Peale continued, "is rapidly changing with a strong military spirit, that we know not what may be its end unless

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[24] Amy Dru Stanley, *From Bondage to Contract: Wage Labor, Marriage, and the Market in the Age of Slave Emancipation* (Cambridge: Cambridge University Press, 1998).

[25] Foner, *Free Soil, Free Labor*.

[26] Dawson, *Philadelphia Engineers*, 124.

[27] Peale, Franklin, 1795-1870. Letter to Titian R. Peale (April 20, 1861), APS.

treason, piracy, privateering and slave trade aspirations an as rapidly, and entirely abandoned as they have heretofore been promulgated."[28] In addition to building war materiel, engineering employers such as Matthias Baldwin and William Sellers established the first Union League in December 1862 to raise funds for the war effort.[29] They fed troops passing through the city and established charities for widows and orphans. Baldwin and Sellers, along with machine-tools works Merrick, Bement, & Dougherty and the shipbuilding works William Cramp organized factory militia to defend the city, with ranks according to shop hierarchies and activity peaking immediately before Antietam in September 1862.[30]

Yet, despite their commitment to identity as producers, seemingly consonant with labor republicanism, the Philadelphia machine tools manufacturers resisted the unionization of their shops before and after the Civil War. Facing the shift away from jobbing shops and toward an increased division of labor, mechanics in Philadelphia engineering works formed a machinists and blacksmiths union in 1858. This organization grew into the national Machinists and Blacksmiths Union (MBU) with a membership of well over four thousand at its zenith in April 1861. When mechanics addressed Matthias Baldwin with a request to end compulsory overtime and restore the prior wage rate in March 1860, Baldwin announced, "Now before I pay time-and-a-half for all overtime, I'll see this shop burn to the ground." In response, over a third of Baldwin's workers, one hundred and seventy blacksmiths and machinists, struck. Baldwin tried to enlist Philadelphia's police force, which he had developed (foreshadowing the New York

[28] Peale, Franklin, 1795-1870. Letter to Titian R. Peale (April 20, 1861), APS.

[29] "William Sellers, 1824-1905," 4.

[30] Dawson, *Philadelphia Engineers*, 142.

bourgeoisie's construction of city arsenals), to work in the firm's interest in the dispute. They stymied picketing during the four-month contest, and Baldwin ultimately prevailed.[31]

Moreover, despite the antislavery politics of the Philadelphia engineering employers, firms such as William Sellers & Co. and Baldwin Locomotive Works forged commercial ties wide and deep with the South in the 1850s. In addition to shipping steam engines and locomotives south, Baldwin supplied and traded in tools, replacement parts, hardware, castings, metal, and fuel to railroads in the region. In January 1854, for instance, Baldwin Locomotive Works shipped a guide to a crosshead and sand pipes to the Georges Creek Railroad in Maryland; an anvil, perforated head, and wheels to the Montgomery & West Point Railroad; and coal to the Vicksburg & Jackson Railroad as well as Vanloan, Paster & Co., both via New Orleans. Orders fulfilled in February included spring steel for the Montgomery & West Point; wheels for the Virginia Central Railroad; wheels and tires for the Pontchartrain Railroad; and pumps for the Western & Atlantic Railroad. In May 1855, Baldwin sent flues to the Pontchartrain Railroad, tires and tubes to the South Carolina Railroad, tires to the Charlotte & Columbia Railroad, an eccentric to the Georges Creek Railroad, bar iron and iron sparkers to the Western & Atlantic Railroad, and tender boxes, brakes, Babbitt metal, perforated iron, pedestals, and flue sheet metal to the Virginia Central Railroad. Baldwin also provided temporary installations engineers as well as permanent personnel to run the engines. Matthias Baldwin received more than bills of exchange in return. In settling a debt owed by the Commercial Railroad & Banking Company of Vicksburg in 1842, he was paid in the form of eight slaves, whom he subsequently resold.[32]

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[31] Ibid., 70.

[32] Ibid., 124.

Baldwin also exchanged patterns and drawings, while acquiring detailed data on the performance of and repairs to his locomotives. In March 1854, Baldwin fabricated cranks and axles according to a sketch from the Clinton & Port Hudson Railroad in addition to valves according to a sketch sent by the Central Railroad from Savannah. Drawings circulated among machine tools works and end-users such as railroads. Internal rationalization of work processes through piece drawings and uniform parts complemented the geographic expansion of Baldwin Locomotive's trade in parts and machinery with railroads looking to reduce maintenance costs: "if an engineer in Oregon should telegraph to the Baldwin Locomotive Works that the piston-rod or the cross-head of locomotive No. 2,300 is broken, a duplicate, certain to fit with absolute exactness could be forwarded at one."[33] While early railroads had had to outfit costly repair shops, even resorting to locomotive manufacture when these capital goods lay idle, they economized by abandoning such activity after the Civil War.[34]

The capital goods industries constituted a sort of "platform capitalism," accumulating recursive data flows and structuring markets via their uniform standards.[35] William Sellers, for instance, standardized nuts and bolts previously made by hand in pairs. In 1857, he invented a bolt machine to automatically cut uniform threads; in 1864, he proposed to the Franklin Institute a standard thread for the American continent, to displace the British design by Joseph Whitworth (which, in his view, required too numerous and complex machining operations).[36]

Baldwin Locomotive Works struggled to retain apprentices in the late 1850s and early 1860s. In this period, most apprentices at Baldwin Locomotive Works came from families

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[33] Dawson, *Philadelphia Engineers*, 61.

[34] Ibid.

[35] Nick Srnicek, *Platform Capitalism* (Cambridge: Polity, 2017).

[36] Dawson, *Philadelphia Engineers*, 61-62.

engaged in skilled labor (46.3%) in addition to small producers and retailers (26.8%). Only 8.6% of apprentices' parents worked as common laborers; only 4.9% and 2.4% were members of the professions and upper class, respectively. Baldwin drew apprentices born not only in Philadelphia and its environs, but also in Ireland and Cuba.

But increasingly, they did not serve complete, five-year terms. They ran away, left, and eventually enlisted in the Union Army. Some contracts were dissolved by mutual consent, but most were unilaterally broken.[37] Apprentices from farmer-mechanic backgrounds in Philadelphia's hinterland chafed at the heightened division of labor, monotonous work, minutiae of shop rules, and barrenness of weeks spent sweeping and shoveling.[38] Youths training as machinists were the most frequent offenders in absconding, followed by blacksmiths and moulders.[39] Those learning ornamental painting were the least likely to abscond. Leaving in their third year of service, apprentices with an adequate knowledge of the mechanics of steam engines heeded Horace Greeley's "Go West."

Seeking to reclaim apprentices, masters advertised rewards in the Philadelphia *Public Ledger* for one cent to five dollars.[40] The laws of individual states covered the capture of runaway apprentices; however, no law ensured the recovery of apprentices across state lines (unlike the contemporaneous Fugitive Slave Act). Economic historian Ross Thomson has attributed the industrialization and subsequent patenting patterns of the Midwest to this migratory leakiness.[41] Instead of going to court, engineering employers ostensibly in competition

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[37] Baldwin Locomotive, HSP.

[38] Dawson, *Philadelphia Engineers*, 203.

[39] Baldwin Locomotive, HSP

[40] Dawson, *Philadelphia Engineers*, 203.

[41] Ross Thomson, "Machine Tools."

colluded, writing letters to one another alerting them to runaways who failed to complete apprenticeships and demanding letters testifying to the completion of contracts and containing endorsements of good character.[42]

The outflow of apprentices presented immediate and long-term problems for Baldwin Locomotive. The Civil War rapidly increased demand for capital goods while creating a major shortage in the supply of labor by 1863. On April 20, 1861, Franklin Peale wrote to Titian Ramsay Peale, "The young men are all enlisting and the old men forming home guards by the thousand; and the Southern fools may feel assured that if they make any attempt to move north, extermination is the only word suited to the consequences of such madness."[43] By 1863, the *New York Tribune* reported, "manufacturers are crowded with work—have orders ahead for weeks and cannot get enough hands or increase their facilities to keep pace with the increasing demand. . . . Mechanics too, of every trade, are busy as bees."

Engineering firms suffered from instability, in the sense of a rupture in the transmission of readily accessible fingertip knowledge. Simultaneously, however, Philadelphia works such as Baldwin Locomotive and William Sellers & Co. grew enormously during the 1860s. The New England machine-tools shop of Pratt & Whitney similarly experienced a surge in demand, which, despite their expertise in gun manufacturing from time served at Colt's Armory, they struggled to meet.[44] By 1865, wartime orders enabled the pair to quit posts at Phoenix Iron Works to erect a plant, which Francis A. Pratt and Amos Whitney then made their sole enterprise.[45] A later company history would remark,

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[42] Dawson, *Philadelphia Engineers*, 203.

[43] Peale, Franklin, 1795-1870. Letter to Titian R. Peale (April 20, 1861), APS.

[44] *Accuracy for Seventy Years, 1860-1930* (Hartford: Pratt & Whitney, 1930), 23-24, UConn Special Collections.

[45] Ibid., 27.

> There is a strange irony in the fact that their first chance to create should be in the making of firearms for the killing of people—they who later were to ease the tired fingers of seamstresses, help to change the pen to the typewriter, make many machines that took the burden from the eyes, the souls and the bodies of so many people throughout the world.[46]

The political hand of capital goods industrialists in workshop struggles grew in strength as well. With little initial resistance from workers in a time of high employment, low union membership, and fervent nationalism, engineering employers turned increasingly to strategies of depiction for rationalization and control of work processes.[47]

In October 1865, Matthew Baird of Baldwin Locomotive purchased “one t square,” “one cake india ink,” “one ink saucer,” and “one triangle.”[48] Baldwin had begun experimenting with interchangeable parts production in the 1850s, when rising demand had convinced the firm to implement a night shift, offer piece-work, and build a new erecting shop capable of handling multiple locomotives at once. In this context, Baldwin realized that cost savings could be achieved by working parts to precise tolerances and uniform dimensions to reduce the filing and chipping of fitters on the floor of the erecting shop.

Unlike in the light manufacturing and small arms workshops of New England, heavy industrial works like Baldwin relied more on new genres of drawing rather than locks, gauges, and jigs to rationalize production. Emerging in the 1850s in the capital goods industries, drafting offices staffed by architectural draftsmen and artists initially focused on recording the dimensions of single machines built for customers, preparing marketing drawings, and making complete design drawings. The latter two genres were often water-colored. Only in the 1860s did marketing, design, and production drawings develop into truly distinct genres of dimensioned

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[46] Ibid., 7-8.

[47] Heather Cox Richardson, *The Greatest Nation of the Earth: Republican Economic Policies During the Civil War* (Harvard University Press, 2009), 26.

[48] Baldwin Order Books (1854-1865), HSP.

plans. At the same time, mechanical draftsman became its own occupational path, no longer premised on shop-floor experience.[49]

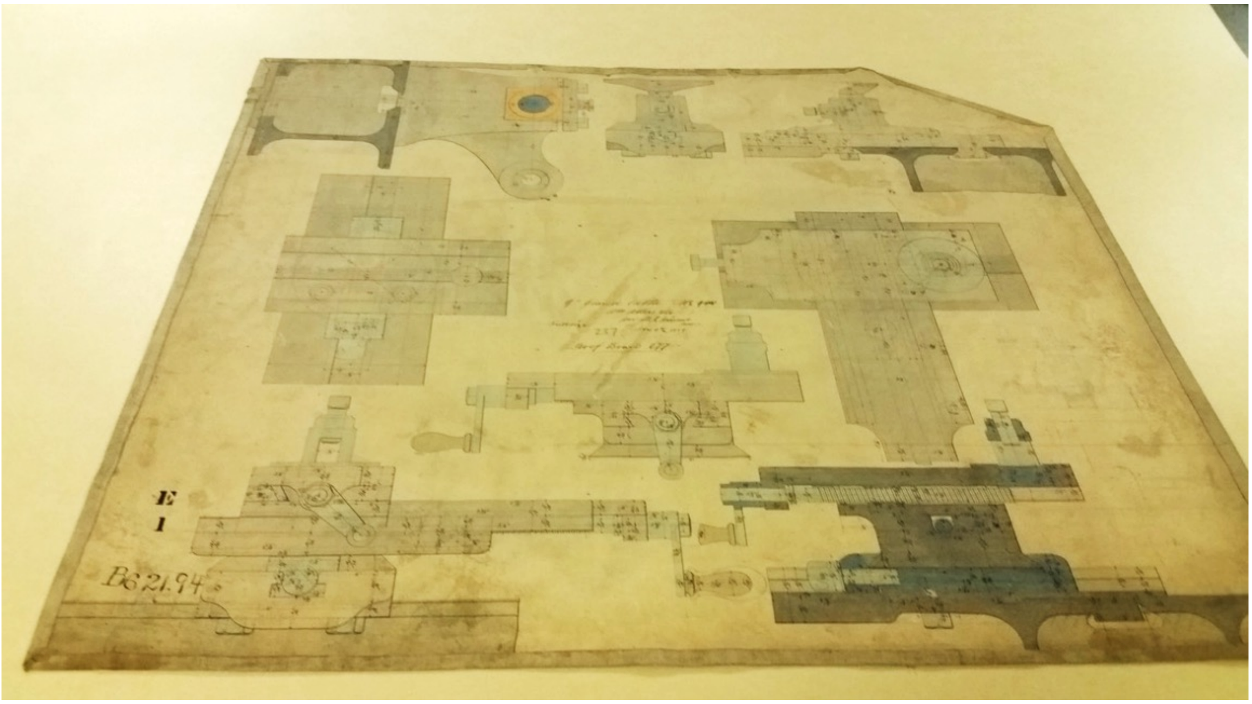

Figure 10: William Sellers & Co. Geared Lathe (1858). Franklin Institute, Philadelphia.

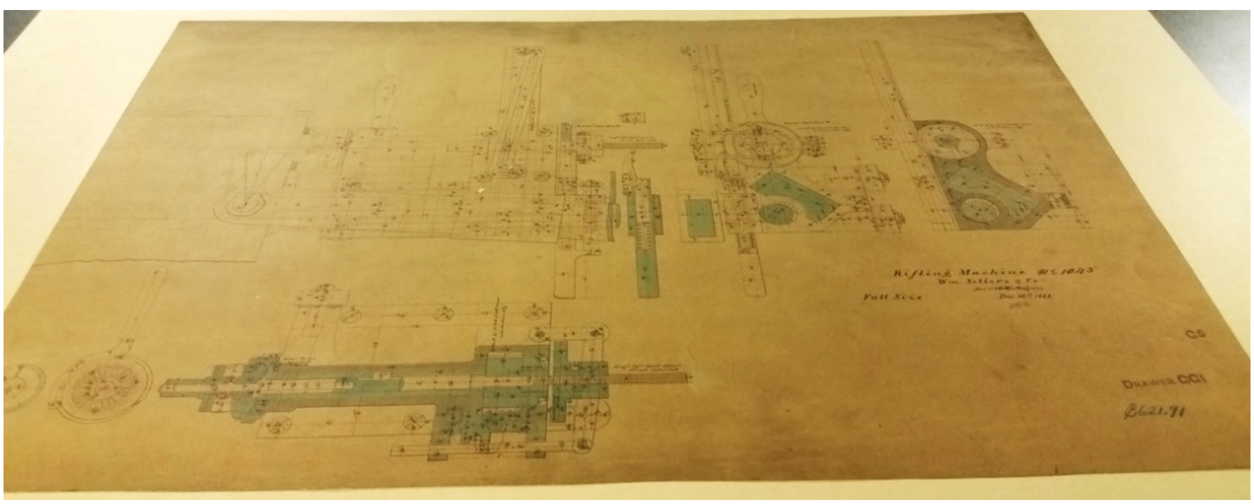

Figure 11: William Sellers & Co. Rifling Machine (1862). Franklin Institute, Philadelphia.

[49] Brown, "When Machines Became Gray."

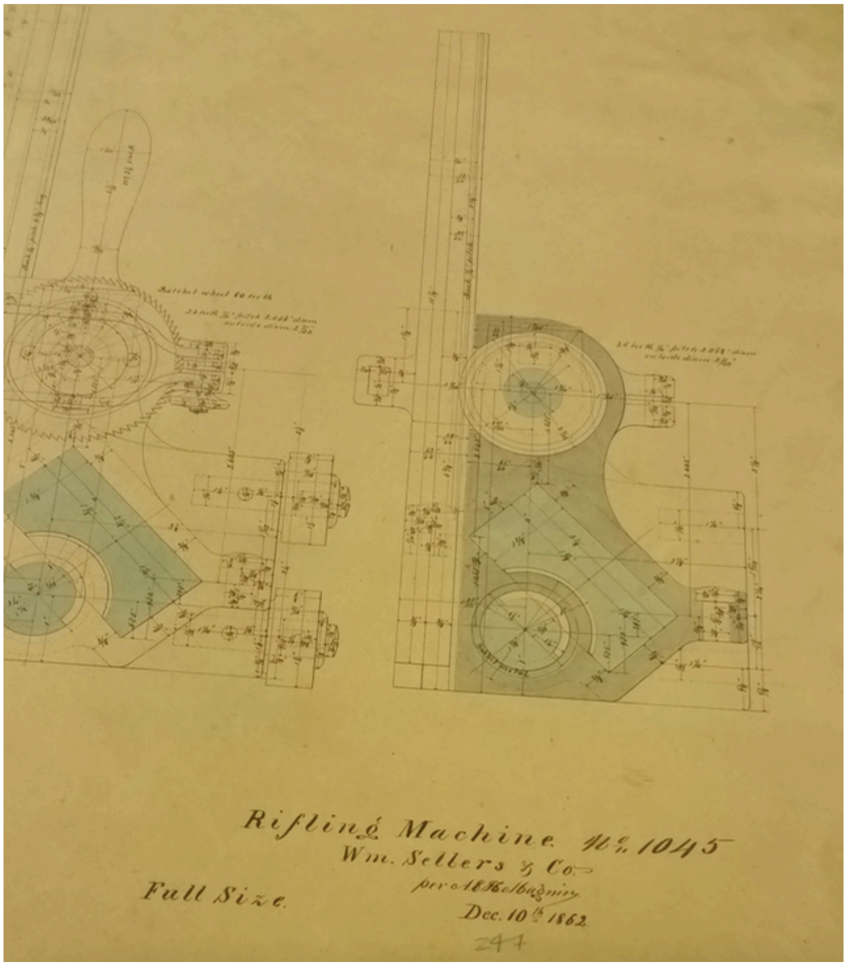

Figure 12: Detail of a rifling machine built by William Sellers & Co. Franklin Institute, Philadelphia.

Using personal pocket books in which they inscribed useful formulae and equations, draftsmen at William Sellers employed knowledge of algebra and trigonometry to design such items as gear trains powering the cutting tools on lathes. [50] Moreover, thanks to Philadelphia "industrial publisher" Henry Carey Baird, a vibrant trade in technical literature had developed for works such as that of John W. Nystrom, a protégé of William Sellers. [51] These works contained tables on sines, cosines, and tangents and information on the strength of materials.

[50] Ibid.

[51] Ibid.

In the 1850s, foremen and mechanics read these drawings with relative autonomy and participated in design work. During the Civil War, however, mounting demand combined with labor shortages only increased Baldwin's desire to subdivide work. Baldwin orchestrated this subdivided work via the drafting room, accounting for time based on the flow of drawings. Similarly, machine-tools manufacturer William Sellers standardized and simplified components in the 1860s.[52] The Baldwin drafting room prepared full sets of drawings for every machine, and carefully filed them. The office transcribed an account of casting, patternmaking and machining linked to each part drawn.[53] Together, these techniques constituted the "shop order" system, whose departmental integration and cost-allocation procedures had begun with Captain Henry Metcalfe of the Frankford Arsenal, Philadelphia.[54] These depictive efforts would influence subsequent efforts at scientific management.

The system implemented at Baldwin Locomotive by 1872 would continue into the twentieth century. With a stock of detailed component drawings for every class of locomotive, the Baldwin drafting room would send them as detailed instruction cards with lists of tasks, tools, and materials to mechanics, who would then employ jigs, gauges, and templates to cut metal.[55] Tracking a historical record, these cards would then document materials consumed and completion times. At William Sellers, however, historian John K. Brown notes that drawings from this period contained no legends for parts or sub-assemblies; instead, Sellers "evidently

[52] Dawson, *Philadelphia Engineers*, 237.

[53] Ibid., 64-65.

[54] Ibid., 233.

[55] Ibid., 61.

believed workers who could not name the parts on a plan likely lacked skills required to make those components."[56]

In the 1860s, Philadelphia machinery firms typically employed mechanics on a combination of day wages and individual or gang piece-work, with piece-work coming to dominate during the deflationary depression of the 1870s.[57] Workers resented the introduction of piecework, wherein employers set rates seeking the greatest output and varied them according to the trade cycle. In response to workers' critiques of the variability of piece rates, engineering employers such as Baldwin Locomotive and William Sellers turned the language of the market to rebrand the piecework system as "contract."[58] Whereas workers believed in a fixed rate per work performed and referenced published price lists of firms, engineering employers hoped to inure them to the concept of contract as an agreement for the exchange of product for pay with no bearing on future wages.[59]

Baldwin Locomotive developed a sophisticated system of gang piecework. As Baldwin began to standardize work via drafting and the shop-order system, gangs might bore cylinders, plane surfaces, or assemble a locomotive. With the expansion of the piece contracting system, however, gangs completed specialized tasks such as attaching cab fittings.[60] Bidding for jobs on specific tasks from foremen, contractors would put together teams to, for instance, machine one hundred connecting rods. In the process, the contractor would be responsible for the order and

[56] Brown, "When Machines Became Gray."

[57] Dawson, *Philadelphia Engineers*, 65.

[58] On contract in this era, see Amy Dru Stanley, *From Bondage to Contract*.

[59] Dawson, *Philadelphia Engineers*, 67; on ideas of labor as time versus motion versus material item produced, see Richard Biernacki, *The Fabrication of Labor: Britain and Germany, 1640-1914* (Berkeley: University of California Press, 1995).

[60] Dawson, *Philadelphia Engineers*, 61.

delivery of materials, inspection for quality, and delivery of the work completed to the fitting department. Contractors worked as part of smaller gangs; in larger gangs, however, they occupied a solely managerial position.[61] In this way, Baldwin's system differed from a Fordist assembly line. In certain respects, the system accorded more with the forms of sub-contracting long associated with the building trades, or the "gig" economy within the context of platform capitalism today.[62]

The Philadelphia machinery industries present questions in the history of skill and the workmanship of risk versus the workmanship of certainty.[63] Rather than pure deskilling, they engaged in a socially contested process of displacing skill and reskilling. Economic historians as well as historians of labor and technology have contrasted a capital-intensive development path for the United States based on labor-saving machinery with labor-intensive routes, often involving skill—in different contexts, in the United Kingdom, continental Europe, and East Asia.[64]

Historian Philip Scranton has questioned the inexorable march toward Fordism in U.S. industry by pointing to the prevalence of custom and batch production in Philadelphia industries.[65] However, historian of technology John K. Brown argues that in the Philadelphia

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[61] Ibid., 67-68.

[62] Michael Kazin, *Barons of Labor: The San Francisco Building Trades and Union Power in the Progressive Era* (Urbana-Champaign: University of Illinois Press, 1988).

[63] David Pye, *The Nature and Art of Workmanship* (Cambridge: Cambridge University Press, 1968).

[64] H.J. Habakkuk, *American and British Technology in the Nineteenth Century: The Search for Labour Saving Inventions* (Cambridge: Cambridge University Press, 1962); Michael Piore and Charles Sabel, *The Second Industrial Divide: Possibilities for Prosperity* (New York: Basic Books, 1986); Kathleen Thelen, *How Institutions Evolve: The Political Economy of Skills in Germany, Britain, the United States, and Japan* (Cambridge: Cambridge University Press, 2004); Gareth Austin and Kaoru Sugihara, *Labour-Intensive Industrialization in Global History* (London: Routledge, 2013).

[65] Philip Scranton, *Endless Novelty: Specialty Production and American Industrialization, 1865-1925* (Princeton: Princeton University Press, 2000).

capital goods sector "methods of standardizing parts and subdividing tasks through production-control drafting occupied a middle ground between capital- or labor-intensive alternatives, representing (literally) "investments (of money and personnel) in new forms of technical knowledge that enhanced managerial capacity."[66] Learning the syntax of the dimensioned plan involved social institutions and struggles. This "subordination of knowledge and efforts of production workers to the profit-seeking goals of the firm" suggests a deeper restructuring or appropriation, applicable to the shop floor and drafting room, no less revolutionary than Fordism.[67] On the death of William Sellers in 1905, S.M. Vauclain, superintendent of Baldwin Locomotive Works, reflected, "surely no man has as yet done so much to promote the art, or establish fixed principles therein from which it would be suicidal to depart."[68]

Such rationalization methods in machinery firms crossed borders. More devoted to standardization of parts, volume production, and labor subdivision and deskilling than works building custom machinery, Baldwin Locomotive grew increasingly able to compete in world markets following the Civil War. [69] Similarly, in 1870, the barely five-year-old Pratt & Whitney began receiving machinery and tools orders from the gun factories of Imperial Germany, culminating in an order of $1,250,000.[70] Upon receiving the machinery at Hamburg and having it erected, installed, and tested by Pratt & Whitney technicians, the German government congratulated the firm: "Pratt & Whitney Company has furnished Royal Armories of Spandau, Erfurt and Donitz with plants of machinery which execute the work with such precision as to

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[66] John K. Brown, "Design Plans, Working Drawings, National Styles: Engineering Practice in Great Britain and the United States, 1775-1945," *Technology and Culture* 41, no. 2 (Apr. 2000): 195-238.

[67] Ibid.

[68] "William Sellers, 1824-1905," *Journal of the Franklin Institute* (May 1905): 9.

[69] Dawson, *Philadelphia Engineers*, 251.

[70] Ibid., 29-30.

save half the wages, and render the Government in no small degree independent of the power and skill of the workmen."[71]

The Currency of Expansion

Within the wartime boom, inflation left workers highly attuned to the whims of the market and permanent wage labor, heightening their consciousness as a class.[72] But, fueled by greenbacks and backed by bonds, Philadelphia machinery manufacturers saw little reason to regard inflation as an evil. In the Sellers circle, only cousin Titian Ramsay Peale voiced a complaint regarding inflation. Working at the Patent Office "on a fixed salary paid in a depreciated currency" while trying to start a photography enterprise, Peale wrote,

> Photographic materials have not advanced in price, equal to bread and beef; and a little of the two latter would do, if I could command the sun to stand still; but a doubled rent, and the inability to command the sun, throws a veil over my photographic's for the present.[73]

Philadelphia machinery manufacturers possessed an expansionary interest and different constraints. They yearned for an abundant money supply, cheap credit, and sufficient banking facilities for commerce west of the Hudson.

Following the political economy of Pennsylvania's Henry C. Carey, they considered themselves producers, along with craftsmen and farmers, partaking in a salutary "harmony of interests." A descendant of Irish Revolutionary printer Matthew Carey, Henry Carey inherited a passion for the national political economy of Alexander Hamilton and Tench Coxe, an antipathy toward the British empire, and one of the largest publishing houses in the United States. Retiring at the age of 42 on investments in iron and paper manufacturing, coal mining, and real estate,

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[71] Ibid., 31.

[72] John Jentz and Richard Schneirov, *Chicago in the Age of Capital* (Urbana: University of Illinois Press, 2012),

[73] Peale, Titian Ramsay, 1799-1885. Letter to Coleman Sellers, Philadelphia (May 28, 1864), APS.

Henry Carey began a career as a political economist. In his many books and pamphlets published over a span of four decades, he aimed to develop a political economy capable enabling the coming of industrial capitalism without the cost of permanent inequality and class strife. [74]

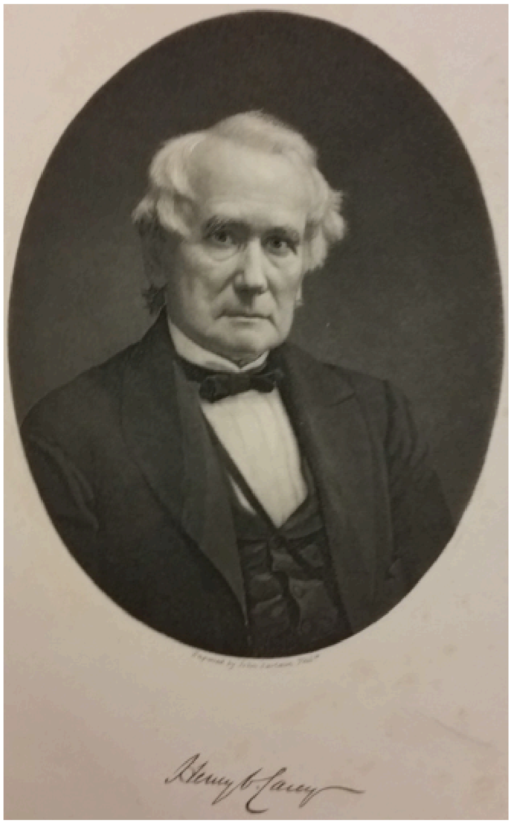

Figure 13: Portrait of Henry C. Carey in Hermann Grothe, *Die Industrie Amerika's* (Berlin, 1877)

Through the expansion of circulation in a diversified and sectionally balanced economy of small- and medium-sized producers, Carey purported to have solved the problem of establishing a "harmony of interests" between industry and agriculture, workers and capital owners. Prior to the Civil War, he had argued against a political abolition of slavery, claiming that economic development would end slavery on its own. Carey considered it a fundamental law that "whatever has a tendency to prevent the growth of capital is injurious," and sanctified the

[74] Sklansky, *Soul's Economy*, 80-81.

Republican Party's conviction that the growth of individual wealth on the basis of private property and the right of all men to accumulate would imply national prosperity and independence.[75] Assessing Carey's doctrine, fellow contributor to the New York *Tribune* Karl Marx wrote to Engels that Carey's expression of the industrial interest explained, "why the *Tribune*, despite all its 'isms' and socialist flourishes, is 'leading journal' in the United States."[76]

Henry C. Carey deeply influenced the economic thought of the Republican Party. To Ralph Waldo Emerson, Henry C. Carey was America's greatest political economist.[77] Secretary of the Treasury Salmon P. Chase consulted Henry Carey regularly for advice.[78] At the "Carey Vespers," weekly gatherings held at his home, Henry Carey discussed political economy with pro-tariff congressman William D. Kelly; economists Stephen Colwell, William Elder and E. Peshine Smith; iron master Joseph Wharton; machine-tools manufacturer William Sellers; railroad promoter Thomas A. Scott; and publishers Henry Lea and Henry Carey Baird.[79] Diplomats, members of Congress, and Secretaries of State and Treasury frequently visited the "vespers" during the half-century it took place.[80]

Joseph Wharton shared Carey's gospel of high tariffs, low interest, and fiat currency with western iron masters such as Daniel Morrell of the Cambria Iron Works and Eber B. Ward of the

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[75] Richardson, *Greatest Nation*, 24.

[76] Andrew Zimmerman, "From the Rhine to the Mississippi Property: Democracy, and Socialism in the American Civil War," *Journal of the Civil War Era* 5, no. 1 (March 2015): 3-37.

[77] Richardson, *Greatest Nation of the Earth*, 19.

[78] Ibid., 20.

[79] Irwin Unger, *The Greenbacks Era: A Social and Political History of American Finance, 1865-79* (Princeton: Princeton University Press, 1964), 54.

[80] Charles H. Cramp, "Carey's 'Vespers'" (1908), HSP.

Johnstown works. In one tract published by Henry Carey Baird, follower of Henry Carey iron master Joseph Wharton expressed his belief in the "essentially antagonistic nature of trade" and his commitment to tariffs for national "independence" via the words of Goethe's Mephistopheles:

> Having the power, yon have the right
> One asks but what you've got, not how
> Talk not to me of navigation:
> For war. and trade, and piracy
> These are a trinity inseparable.[81]

Carey's disciples engaged directly in Civil War and Reconstruction financial politics. Daniel Morrell served in Congress from 1867 to 1871. Ward headed the Iron and Steel Association in the late 1860s. [82] In 1872, the Iron and Steel Association sent copies of Henry Carey's *Unity of Law* to dozens of members of the Senate and House of Representatives gratis. The association spread their lobbying efforts across geographic sections, addressing not only representatives like Pennsylvania Senator Simon Cameron and Ohio Representative Aaron F. Perry but also Western legislators like Senator Alexander Ramsey of Minnesota, Senator P.W. Hitchcock of Nebraska and H.W. Corbett of Oregon, New England legislators like Connecticut Senator William A. Buckingham, and Southern Republicans like George C. McKee of Mississippi and John S. Bigby of Georgia.[83]

Heavy industry had long embraced Carey's tariff protectionism. In the wake of the fiscal and financial transformations wrought by the Civil War, however, they manifested an increasing

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[81] Joseph Wharton, *International Industrial Competition* (Philadelphia, 1870), LCP.

[82] Unger, *Greenbacks Era*, 54.

[83] Simon Cameron, Harrisburg, PA to Henry C. Baird (Nov 27, 1872); Aaron F. Perry, Cincinnati to Henry Carey Baird (Nov 29, 1872); Alx. Ramsey to Henry C. Baird (Dec 14, 1872); P.W. Hitchcock, Washington, D.C. to Henry C. Baird (Dec 19, 1872); H.W. Corbett, Washington, D.C. to H.C. Baird (Nov 5, 1872); W.A. Buckingham, Norwich, CT to Henry C. Baird (Nov 26, 1872); Henry Carey Baird to Geo. C. McKee M.C., Washington, D.C. (Nov 28, 1872); John S. Bigby, Washington, D.C. to Baird (Dec 9, 1872), HSP.

interest in his monetary ideas. Prior to the Civil War, the U.S. government raised funds during exigencies by issuing bonds, collecting tariff revenues, and selling public land. There was no national system of taxation, banking, or currency.[84] In order to pay troops and purchase supplies during the Civil War, the government issued greenbacks, or paper IOUs not redeemable in silver or gold. At the cessation of hostilities, almost half a billion dollars' worth of them were in circulation, fluctuating in value against more valuable U.S. gold coins.[85] Henry Carey called greenbacks the "machinery of circulation."

During Reconstruction, when three forms of money (greenbacks, national bank notes, and specie) circulated concurrently, debate quickly swelled over whether to contract the circulation of greenbacks and convert the economy onto the gold standard. This discussion fractured both parties. If the government could no longer issue greenbacks beyond what it could redeem in gold, the money supply would contract and deflation would ensue. As debtors in regions with limited banking facilities, manufacturers, craftsmen, and farmers in the South and West would suffer the consequences of wealth transfer to creditors.[86]

As "producers" in ideology and on their balance sheets, the Philadelphia heavy industrialists surrounding Carey were frequently borrowers. Industrialists often favored banknotes over greenbacks, but they shared a belief in an abundant money supply and access to cheap credit that would be impossible with gold as the sole currency.[87] Moreover, they were committed to expansion, doing business with debtors. By October 1865, Baldwin Locomotive's

[84] Richardson, *The Greatest Nation of the Earth*, 27.

[85] Richard White, *The Republic for which It Stands: The United States During Reconstruction and the Gilded Age, 1865-1896* (Oxford: Oxford University Press, 20), 181; on the history of fiat currency, see Christine Desan, *Making Money: Coin, Currency, and the Coming of Capitalism* (Oxford: Oxford University Press, 2014).

[86] White, *The Republic for which It Stands*, 371.

[87] Nicolas Barreyre, *Gold and Freedom: The Political Economy of Reconstruction*, trans. Arthur Goldhammer (Charlottesville: University of Virginia Press, 2016).

commerce with the South had recommenced. They sent car springs and 200 tons rails, 100 reg spikes, 750 chains to the Pontchartrain Railroad.

With extensive trade with the West and South, Pennsylvania machinery firms deplored the concentration of banking in the Northeast and endorsed free banking. Representing Carey's following beyond Pennsylvania, Eber Ward attributed the high interest rates (twelve percent) paid by western iron masters to the "steady increase of business of various kinds" outgrowing "the amount of currency that the government has furnished us." In Congress, Daniel Morrell twice introduced a free banking bill in 1869 and 1870 in order to make "money cheap and plentiful." [88] Industrial publications such as *Iron Age* and *American Manufacturer* celebrated banking expansion as a means to foster increased commerce and manufacturing.[89]

In *The Resources of the Union* (1866), Henry Carey applauded the Morrill Tariff and the issuance of greenbacks as the foundation for expanded commerce and increased manufacture. Displaying his Pennsylvania interests, he celebrated

> rolling mills…capable of furnishing annually 750,000 tons of bars, while the power by means of which those bars are to be converted into ships engines, and other machinery of transportation and production has more than doubled and has probably even trebled.

Looking beyond Philadelphia heavy industry and the surrounding coal fields, he commended the creation of "factories…capable of supplying almost the world's demand for various instruments production or defence, sewing machines on the one hand pistols rifles and Parrott guns on the other." [90] Connecting the Philadelphia interests to those of producers in Western states, Carey wrote, "Throughout the vast fields of the west machines are everywhere doing the work that five

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[88] Unger, *Greenbacks Era*, 62.

[89] Ibid.

[90] Henry Carey, *The Resources of the Union* (Philadelphia: Baird, 1866).

years since was done by human hands," noting that "St. Louis presents to day as we are told an amount of steam tonnage two fifths greater than there existed before the war."[91]

On the other side, most merchants and bankers favored liberal political economy, including "hard money" in the form of the gold standard and free trade. Wealthy liberals such as Isaac Sherman, a free-soil Republican, abolitionist, and creditor, had opposed the adoption of greenbacks during the Civil War, realizing that they would cause inflation and deplete the yields of his existing loans.[92] After the Civil War, Sherman campaigned again for the gold standard; the government bonds he had purchased with cheap greenbacks were guaranteed to pay interest in gold—if the principal would be repaid in gold as well, he would stand to profit. Consequently, Sherman funded the efforts of gold advocates like Edward Atkinson, who in moralizing tones cast greenbacks as theft.[93]

Railroads, however, brought a sect of bankers and financiers such as Jay Cooke into communion with the expansionary political economy of Carey and his industrial interests. Cooke had routed his profits from selling war bonds into investments in industry and railroads. Echoing Carey's circulatory language, he wrote,

> Why should this Grand and Glorious Country be stunted and dwarfed—its activities chilled and its very life blood curdled by these miserable 'hard coin' theories—the musty theories of a bygone age—These men who are urging on premature resumption know nothing of the great & growing west which would grow twice as fast if it was not cramped for the means necessary to build Rail Roads and improve farms and convey the produce to market.

[91] Ibid.

[92] White, *Republic for which It Stands*, 183.

[93] Ibid.

Based on these investments, he opposed forced contraction and endorsed a large money supply via banknotes rather than greenbacks.[94]

Interestingly, George F. Baker, a leading banker at First National City Bank and a close colleague of J.P. Morgan, was also a consistent attendee of Carey's "vespers."[95] At the turn of the twentieth century, the National City Bank would seek to undertake branch banking and finance infrastructure-building in the Caribbean.[96]

Circulation and Accumulation among Printer-Publishers

It is tempting to analyze the views of Henry Carey and Henry Carey Baird—on labor, capital, transport and commercial circulation—through the prism of their business and trade: they were printer-publishers, or in Baird's case, a self-described "industrial publisher." Most directly, on the back of pamphlets on political economy, Henry Carey Baird advertised works such as Joshua Rose's *Complete Practical Machinist*, "embracing lathe work, vise work, drills and drilling, taps and dies, hardening and tempering, the making and use of tools."[97]

At a deeper level, Henry C. Carey a attempted to revamp classical theories of value as the cost of reproduction. Casting aside the value doctrines of Adam Smith and David Ricardo, Carey argued that the exchange value of a commodity was not the cost of the labor to produce it, but rather the labor the purchaser saved instead of undertaking the labor to reproduce the

[94] Barreyre, *Gold and Freedom*.

[95] Charles H. Cramp, "Carey's 'Vespers'" (1908), HSP.

[96] Peter James Hudson, *Bankers and Empire: How Wall Street Colonized the Caribbean* (Chicago: University of Chicago Press, 2018).

[97] Henry Carey Baird, *The Lesson of German and French Finance* (Philadelphia: Baird, 1876),

commodity. This theory provided Carey the essential analytical tool to bind together class incomes and ensure the "harmony of interests."[98]

Carey and Baird frequently used the metaphor of machinery to refocus political economy on the flow and circulation of currency. In this way, they sought to overcome the zero-sum game of industrial capitalism and substitute an understanding of the "harmony of interests." This view accorded with printers, publishers, and book importers accustomed to thinking in terms of the diffusion of knowledge. In principle, information is, to use an anachronistic economic locution, "non-rival" but "excludable." My consuming it does not preclude you from doing so as well; however, it is possible to exclude those who have not paid for it from consuming it. Treating capital somewhat analogously enabled Carey and Baird to overturn the distributional struggle implied by the classical economists' account of capital accumulation.

Historian Jeffrey Sklansky has noted that, "Whereas classical economists considered the fundamental distinctions between class incomes axiomatic, he [Carey] conflated rent with profit, and profit with wages." Considering land a form of capital, he called it a "great machine"—with yields based on the human labor instead of natural resources. According to Sklansky, Carey treated labor as a "fund of prior investments in education, skills, and training" and wages as "the price of human capital."[99] Collectively, Carey called the "instrument of association" the greatest "labor-saving machinery in use among men."[100]

According with their opinions on soft money, Henry Carey Baird endorsed weak (authorial and international) copyright and strong patent laws—in the sense of wide affordability

[98] Sklansky, *Soul's Economy*, 84.

[99] Ibid., 86; on the history of capitalization, see Eli Cook, *The Pricing of Progress: Economic Indicators and the Capitalization of American Life* (Cambridge, MA: Harvard University Press, 2017).

[100] Sklansky, *Soul's Economy*, 92.

and stable protection for inventors. Baird regularly reprinted technical works from the publishing houses of Fleet Street, including Sampson, Longman, and Trübner. In 1855, for instance, Trübner wrote to Baird assenting to procure the new edition of the *Miller's Guide* and requesting American military books; the next year, Trübner notified Baird of books advertised in London newspapers and the Berlin *National-Zeitung*, offered a translation of Karsten's *Metallurgy of Iron*, and asked for up to fifty copies of Dahlgren's works on boat armament and gun shells and Nystrom's work on the screw propeller.[101] Economic historian Zorina Khan has argued that the combination of weak copyright and strong patent fostered a "democratization of invention" in the nineteenth-century United States.[102]

As a printer-publisher, Henry Carey Baird gathered, synthesized, and distributed crafts and engineering knowledge from mechanics, inventors, surveyors, and journal editors from nearby and far-flung regions of the United States. In 1851 locomotive builder Septimus Norris, then engaged in publishing a work on locomotive construction, reminded Baird that since the book gave "all the proportions etc. of Engines which some Builders think secrets," he could not "consent to the price being $1." After all, he had already "received over 500 subscribers at $1 50/100 each copy."[103] Again in 1853, Norris wrote to Baird that his new work, a handbook for locomotive engineers, "containing all the proportions & rules of construction for Locomotives & Tables," mean disclosing "all the secrets of the business considered so by men of illiberal mind."

Although the United States possessed no real guild tradition, a consistent dearth of skilled labor, and an attenuated (and, as seen above, crumbling) apprenticeship system, some locomotive

[101] Trübner to Henry Carey Baird (16 Nov 1855), (18 Jan 1856), correspondence, HSP.

[102] B. Zorina Khan, *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790-1920* (Cambridge: Cambridge University Press, 2005).

[103] Septimus Norris to Henry C. Baird (Sep 12, 1851), HSP.

builders were keen to preserve a monopoly in a new object of manufacture. Norris, however, cast himself as an enlightened employer: "I go in for letting every workman know as much as I do, if he can learn I am willing to teach." Asking for a percentage of the sales, Norris then offered to procure for Baird five thousand subscribers.[104] Like Norris, Baird objected to monopolies; also like Norris, Baird assessed a world of opportunities by tabulating future returns on capital—given sufficient distribution and circulation.

In 1855, an H. Bent wrote to Baird from Texas requesting information on obtaining "a recent work on Military Engineering on which I would prefer one which treats exclusively on Ordnance with the recent improvements in…projectiles."[105] In 1856, Randall Aston from Columbus, Ohio wrote to Baird requesting a copy of Charles Holtzappfel's *Practical Metal Worker's Assistant*.[106] Consulting a catalogue of Baird's publications, N.H. Blackwood in Rockford, North Carolina inquired about the price to ordered Frederick Overman's 500-page octavo volume on *The Manufacture of Iron in all its various branches* and Thomas U. Walter's *A Guide to Workers in Metal and Stone*. He added,

> I have most of your valuable publications already in my library, and must be permitted to express my high approbation of the course you pursue in publishing practical works which when read by practical men, can be understood and result in some practical good.[107]

Authors and editors regularly reached out to Henry Carey Baird unsolicited. William Stevens, editor of the *Virginia Farmer*, requested books on agricultural improvement and proposed to advertise Baird's publications at the rate of five dollars for six months in a new journal with a

[104] Septimus Norris to Henry C. Baird (Aug 2, 1853), HSP.

[105] H. Bent, Texas to Henry Carey Baird (March 3, 1855), HSP.

[106] Randall Aston to Henry Carey Baird (Nov 21, 1856), HSP.

[107] N.H. Blackwood, Rockford, N.C. to Henry Carey Baird (Jan. 17, 1852), HSP.

circulation of two thousand. In 1853, William Strickland wrote from Mobile to offer his almanac as an advertising medium for Baird's publications in Alabama and Mississippi, where twenty thousand copies were to be "judiciously distributed" at $10 per page.

From across the South, Francis Lieber (jurist and author of the Lieber Code laws of war) and his son, military engineer, surveyor, and geologist Oscar Lieber, engaged in a years-long correspondence with Henry Carey Baird. In 1854, Oscar Lieber wrote to Baird that he had been "solicited to join in a survey of some mineral lands on the island of Jamaica" and, if he were to take up the offer, had "thought that the general interest which Jamaica at present excites might be an inducement to write something upon the subject." He added, "I do not mean to write a political book on the effects of emancipation there,—for that I would prefer to have the wiser head."[108] Instead, Oscar Lieber translated German chemical treatises for Baird and published with Baird *The Assayers' Guide: or, Practical directions to assayers, miners and smelters, for the tests and assays, by heat and wet processes, of the ores of all principal metals, of gold and silver coins and alloys, and of coal* (1856).

In 1855, Sigismund Löw wrote to notify Baird that he had nearly finished the manuscript of a treatise on "plane and spherical Trigonometrie &c you must have remarked that that most important branch of mathematics has been very much neglected, and it is remarkable that such an useful science has been left in the shade." Löw explained that he had treated the subjects

> with a view to have the practical man who has none or little knowledge, able to understand it thoroughly and I have accumulated different formula to suit architects, Engineers and navigators in the different practical applications which they meet at every step of their professions.[109]

[108] Oscar Lieber to Henry Carey Baird (Jan 18, 1854), HSP.

[109] Sigismund Löw, to Henry Carey Baird (March 20, 1855), HSP.

In an era when works like Baldwin Locomotive were implementing heightened divisions of labor and transporting control over work processes from the shop-floor to the drafting room, Henry Carey Baird developed a mass market for technical literature aiming to (re)connect theory and practice in the mechanic trades.

Francis Campin, author of *A Practical Treatise on Mechanical Engineering* (1864), commented on a "very obvious chasm" in published works on mechanical engineering between, on one hand, "elementary works, describing the general principles and forms of steam-engines" and "complete treatises, including detailed descriptions, scientific disquisitions, and rules for calculating the proportions of various machines" on the other.[110] As the apprenticeship system deteriorated (Baldwin discarded its program altogether in the 1860s), authors of mechanics manuals published by Henry Carey Baird prefaced their works with such observations as:

> Being dependent upon the information which he may be able to gather from the particular pieces of work which chance to fall to his lot, and to such scraps of disjointed instruction as a fellow-workman may feel disposed to impart, it often occurs that, when he encounters a difficulty, the more experienced hand who helps him out of it neglects to explain the principles governing the means by which the difficulty was overcome.[111]

Henry Carey Baird and authors such as Francis Campin and Joshua Rose sought to include workers in the systematization of knowledge; as uplifted participants, mechanics as readers would accompany the author in his "aim…to develop from the promiscuous practice of the workshop its inherent science."[112] Rose deplored the fact that the machinist's "art" had "not received its proper share of attention at the hands of those authors who have written books upon mechanical subjects," reserving special ire for the fact that the "artisan is, in consequence,

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[110] Francis Campin, *A practical treatise on mechanical engineering* (Philadelphia: Henry Carey Baird, 1864), 5, LCP.

[111] Joshua Rose, *The Complete Practical Machinist* (Philadelphia: Henry Carey Baird & Co., 1876), 6-7, LCP.

[112] Ibid., 8.

deprived of the aid derivable from the experience of the thousands who have trodden the same path before him." He concluded that it "takes years of practice and observation to acquire knowledge which could be gained in a comparatively short space of time by the aid of a little book-learning."[113] A statement more in harmony with Henry C. Carey's cost-of-reproduction theory of value could not have been made.

As historian Jeffrey Sklansky has observed, the political economy of Henry C. Carey and Henry Carey Baird was rife with unintended consequences. While trying to foster a decentralized political economy of producers, the success of Carey's policy recommendations—permanent tariffs, intensified industrialization greenbacks as fiat currency—helped usher in the Gilded Age of large-scale industry riven with class conflict.[114] On the principle of associationalism, it sanctified the modern corporation. A critic of monopolies, Carey had not anticipated that circulation could facilitate the entrenchment of first movers.

There is a certain parallel in the faith, or figment, in circulation itself as ensuring democracy. While engineers often discussed drafting as a "universal language," production drawings and piecework had become conjoint tools of hierarchy and control in Philadelphia machinery shops. Breaking open and glimpsing into "association" in industrial capitalism, Marx wrote in the era of the Civil War,

> The implements of labour, in the form of machinery, necessitate the substitution of natural forces for human force, and the conscious application of science, instead of rule of thumb. In Manufacture, the organisation of the social labour-process is purely subjective; it is a combination of detail labourers; in its machinery system, modern industry has a productive organism that is purely objective, in which the labourer becomes a mere appendage to an already existing material condition of production. In simple co-operation, and even in that founded on division of labour, the suppression of the isolated, by the collective, workman still appears to be more or less accidental.

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[113] Ibid., 5.

[114] Sklansky, *Soul's Economy*, 92-93.

> Machinery, with a few exceptions to be mentioned later, operates only by means of associated labour, or labour in common. Hence the co-operative character of the labour-process is, in the latter case, a technical necessity dictated by the instrument of labour itself.[115]

The circulation of piece drawings and eventually blueprints around the shop of works like Baldwin Locomotive may have represented a joint stock of technical knowledge; they did not, however, secure an equitable distribution of returns on capital—in the form of wages, or universal individual knowledge.

[115] Karl Marx, "The Development of Machinery," *Capital, Vol. I.*

Chapter Four: The Caged Simulacrum

Industrial Education and the Manual Training Movement

Having embraced the shop-order system and piecework, machinery firms such as Baldwin Locomotive disbanded their apprenticeship programs around 1870. Craft unionists in Philadelphia pushed back—the Patternmakers Association would not admit men from Baldwin unless they proved themselves "all-round mechanics." But to little avail.[1] Instead, George Burnham, a partner in Baldwin Locomotive, worked with education reformer Addison B. Burk of the Philadelphia *Public Ledger* to develop industrial education at the Spring Garden Institute with the mantra "instruction not construction."[2] By the 1880s, the endowment of Burk's school specifically for mechanical training received funds from Baldwin Locomotive Works, its individual partners, and the machine-tools manufacturers William Sellers and William Bement.

Throughout the projects associated with the Spring Garden Institute, Burk, Burnham, and Baldwin emphasized training in drawing—freehand, mechanical, and architectural. Their courses in drafting prioritized the ability to make and comprehend drawings over understanding the theory behind descriptive geometry or higher-level engineering. Burk and Burnham had also been inspired by the display of the manual training movement at the 1876 Centennial Exhibition in Philadelphia. The manual training movement focused on elementary tool usage and handicraft techniques across trades. Consequently, the Institute offered instruction in modeling and woodcarving, painting, and mechanical handiwork alongside the basics of geometry, physics, metallurgy, and chemistry. Taken together, drawing and elementary tool training would provide a new class of semiskilled workers.

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[1] Dawson, *Lives of the Philadelphia Engineers*, 61.

[2] Ibid., 213.

Working under a "foreman teacher," courses also introduced students to the regimes and hierarchies of manufacturing. The actual foremen at Baldwin Locomotive noticed the ability of graduates of the Institute to work with dimensioned plans and designated them as gang bosses. For students at the Spring Garden Institute, however, the real prize was a position in the drafting bureau of a major machinery works, not the shop floor.[3]

The increasingly frayed relationship between head and hand in an industrializing republic occupied many beyond the postbellum Philadelphia machinery industrialists and stimulated widespread debate throughout the Long Gilded Age. At its 1907 meeting the National Society for the Promotion of Industrial Education (NSPIE) resolved to combat proletarianization and German commercial competition simultaneously by adopting elements of the "German" education system. The NSPIE meeting brought vocal proponents of increasing American exports such as Frank Vanderlip, vice president of the National City Bank, together with figures such as Chicago settlement house reformer Jane Addams and Samuel B. Donnelly, Secretary General of the Arbitration Board of the New York Building Trades.

Donnelly used the occasion to remind listeners that even John Mitchell had "endorsed…industrial education and…testified…that a great number of miners have been enabled to increase their earnings and advance to high positions in the employ of the mining companies as a result of the opportunities afforded them."[4] Such an argument relied upon the premise that skill somehow constituted a share, substitute, or synecdoche for ownership of the means of production.

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[3] Ibid., 214.

[4] Samuel B. Donnelly, "Address," *Proceedings of the Organization Meetings of the National Society for the Promotion of Industrial Education* (New York: C.S. Nathan, 1907), 33.

At the same NSPIE meeting, Frank Vanderlip of the National City Bank concurred that the solution to stagnation and strife lay in industrial education, German-style. He noted that despite sending "into the markets of the world products valued at $1,800,000,000" in the last year, the United States had failed to convince any purchaser to buy our goods "for the reason that there had been wrought into them superior handicraft…manual skill controlled for us no market."[5] Access to cheap natural resources and ingenious labor-saving machinery would not be enough to compete, argued Vanderlip, when the former became depleted and the latter copied around the world. By contrast, the success of Germany, "the one competitor that we fear," rested, as "every manufacturer in this nation [knew]" on its "superior school system."[6] Vanderlip stressed that this system sought to give the worker "opportunity to train his mind in harmony with the developing skill of his hand."[7] Tying social peace and international competitiveness together, Vanderlip predicted that such education would "do much for our commercial future, much for our social welfare, and much for the permanent establishment of contented prosperity."[8] Vanderlip viewed individual skill as a capital stock, which would yield a surplus visible in heightened export figures and diminished class conflict.

Jane Addams agreed with the views expressed at the NSPIE meeting, but urged her colleagues to consider emulating the role of the state in Germany and embrace the salutary phenomenology of skilled work in itself. She asserted that, while "much has been said this evening concerning German education," the real root of "those fine technological schools in

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[5] Frank Vanderlip, "Address," *Proceedings of the Organization Meetings of the National Society for the Promotion of Industrial Education* (New York, 1907).

[6] Ibid., 30.

[7] Ibid., 30.

[8] Ibid., 31.

Germany" was in "the same spirit as they have developed legislative protection for the working man."[9] She argued that America's "achievement in mechanical invention" needed to be complemented by the German understanding that it was the state's "business to uncover and develop…that source of cultivation which lies in the people themselves."[10] The worker's "power of variation," "art instinct," and "intelligent skill," she concluded, would "ultimately be reflected in the industrial product."[11] For Addams, only state guardianship could ensure for workers the opportunity for individual self-development—consciously knowing and shaping the objects of their toil—in the face of the depredations of industrial capitalism.

As historian T.J. Jackson Lears has argued, Jane Addams vacillated between protest and accommodation, transitioning from an advocate for combined mental-manual education as a tool to alter industrialism itself to an apologist who cast inner uplift, the worker's subjective state or orientation toward whatever type of work, as a sufficient palliative to the harms perpetrated by the factory system. In *Twenty Years at Hull House* (1910), her reflections on the role of repetitive, mind-deadening labor in driving workers to alcoholism and suicide echoed her engagement with William Morris and John Ruskin; however, in *The Spirit of Youth and the City Streets* (1909), Addams called their critique obsolete, the manifestation of an impractical idealism.[12] She ultimately accepted the irrevocable nature of industrial capitalism, writing:

> If a child goes into a sewing factory with a knowledge of the work she is doing in relation to the finished product, if she is informed concerning the material she is manipulating and the processes to which it is subjected; if she understands the design she is elaborating in

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[9] Jane Addams, "Address," *Proceedings of the Organization Meetings of the National Society for the Promotion of Industrial Education* (New York, 1907), 26.

[10] Ibid. 26.

[11] Ibid., 26.

[12] T.J. Jackson Lears, *No Place of Grace: Antimodernism and the Transformation of American Culture, 1880-1920* (Chicago: University of Chicago Press, 1981), 79-80.

> its historic relation to art and decoration, her daily life is lifted from the drudgery to one of self-conscious activity, and her pleasure and intelligence is registered in her product.[13]

Addams's formulation paired quality production and inner quiescence, attempting to imbue the most routine or dangerous of work with an aura of craftsmanship and control.

This variant of politics inverted the cause and consequence of earlier labor republicanism, while expanding its scope to include women and children. She discarded the expectation of a trajectory toward independence in economy and polity. The logics of Addams's industrial education politics heavily distorted yet nevertheless remained in the shadow of one key element of "Free Labor" ideology: autonomous creation using head and hand. Rejecting the "mud-sill theory" of southerners such as George Fitzhugh, which held that some must always occupy the bottom of the social hierarchy, Abraham Lincoln had claimed that no one must remain a wage-laborer or hired hand for life.[14] His speeches of the 1850s twinned the concepts of the individual's opportunity for capital accumulation and his opportunity to progressively come into self-direction in work. Lincoln had asserted:

> Free Labor argues that, as the Author of man makes every individual with one head and one pair of hands, it was probably intended that heads and hands should cooperate as friends; and that that particular head, should direct and control that particular pair of hands…that each head is the natural guardian, director, and protector of the hands and mouth inseparably connected with it; and that being so, every head should be cultivated, and improved, by whatever will add to its capacity for performing its charge. In one word Free Labor insists on universal education.[15]

To possess skills and to practice them offered partial ownership of the means of production, a degree of the economic autonomy necessary to sustain a democracy.[16] Proponents of this nexus

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[13] Quoted in Lears, *No Place of Grace*, 80.

[14] George Fitzhugh, "Cannibals All! Or Slaves without Masters" (Richmond, 1857).

[15] Abraham Lincoln, "Address to the Wisconsin State Agricultural Society," September 30, 1859.

[16] On antebellum Free Labor politics, Eric Foner, *Free Soil, Free Labor*; Jonathan A. Glickstein, *Concepts of Free Labor in Antebellum America* (New Haven: Yale University Press, 1991); on labor republicanism among the

of ideas often endowed work with Transcendental or Romantic significance. That Addams, invoking the example of a girl consciously creating in a factory context, broke the link between the political economy and the moral economy of (a historically masculine) labor republicanism does not mean that her thought was not indebted to it.[17] Her sublimation of concepts previously associated with "Free Labor" suggests the continued salience of producerist idioms in the long Gilded Age, albeit in strange and problematic ways.

German Immigration, Mental-Manual Education, and Labor Republicanism

The social politics revolving around industrial education were entangled with notions of a "German" model rooted in at least two distinct experiences. From the 1850s to 1870s, German immigrants, including revolutionaries of 1848, had contributed to the elaboration of "Free Labor" politics in the Republican Party.[18] Steeped in liberal nationalism or socialism, they paired the Romantic notion of *Bildung* and a Hegelian concept of coming into subjecthood with labor republicanism. German immigrants founded kindergartens, introduced concepts of child-centric learning developed by Friedrich Froebel, Johann Pestalozzi, and Johann Friedrich Herbart, and advocated curricular expansion within public schools to include German language, drawing, singing, gymnastics, natural sciences, and other manual activities. They centralized their activities in publications circulated nationally, such as Swiss-born editor William N. Hailmann's

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Knights of Labor, see Alex Gourevitch, *From Slavery to the Cooperative Commonwealth: Labor and Republican Liberty in the Nineteenth Century* (Cambridge: Cambridge University Press, 2014).

[17] E.P. Thompson, "The Moral Economy of the English Crowd in the Eighteenth Century," *Past and Present* 50 (Feb. 1971): 76-136.

[18] Bruce Levine, *The Spirit of 1848: German Immigrants, Labor Conflict, and the Coming of the Civil War* (Urbana-Champaign: University of Illinois Press, 1992); Alison Clark Efford, *German Immigrants, Race, and Citizenship in the Civil War Era* (Cambridge: Cambridge University Press, 2013); Carl Wittke, *Refugees of Revolution: The German Forty-Eighters in America* (Philadelphia: University of Pennsylvania Press, 1952).

Amerikanische Schulzeitung and the *Pädagogische Monatshefte*, as well as in nationally-networked organizations such as the *Deutschamerikanischer Lehrerbund*.

In Missouri, a circle of "St. Louis Hegelians" comprised of William Torrey Harris, Henry Brokmeyer, and Susan Blow promoted a world-historical view of the U.S. Civil War and imperial Manifest Destiny along with the kindergarten--all through a lens of individuals coming into "self-activity" and nations developing immanently as evinced by their art, science, and industry. The Blow family had participated intimately in the Dred Scott case, with Susan Blow's grandfather having once held legal rights over Scott and her father, Henry T. Blow, having aided Scott in filing his case before the Supreme Court. Following the infamous ruling, Henry T. Blow, a prominent businessman and later Unionist politician and Republican-nominated diplomat, repurchased Scott and proceeded to manumit him.[19]

Susan Blow interpreted Froebel's method as developing human "self-activity." Mothers and teachers would introduce children to perceptual and sensory objects in a systematic way such that their awareness would internalize the impression.[20] Blow promoted this form of kindergarten practice on the lecture circuit, addressing the Normal School Association in 1875 and showcasing displays at the 1876 Philadelphia World's Fair and the 1878 Paris Exposition.[21] She also published a series of books exposing American educators to the kindergarten, Froebel, and Hegelian thought simultaneously: *Symbolic Education* (1894), *Kindergarten Education* (1904), and *Educational Issues in the Kindergarten* (1908). The St. Louis Hegelians advocated educational institutions and pedagogical techniques that would enable children to repeat the

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[19] Dorothy G. Rogers, *America's First Women Philosophers: Transplanting Hegel, 1860-1925* (New York: Continuum, 2005), 48.

[20] Ibid., 65.

[21] Ibid., 54-55.

course of civilizational development and acculturate themselves to their surrounding societies.[22] In the 1870s and 1880s, networks such as the National Education Association (NEA) frequently brought together St. Louis Hegelians such as William Torrey Harris with German-speaking immigrants from beyond St. Louis such as William Hailmann, who would later promote Froebelian methods as Commissioner of Indian Schools (1894-1898).[23]

In the 1890s the broad stream of influence situated among German-Americans in the Ohio River Valley and Midwest and the narrower channel of American Hegelians who had returned eastward from St. Louis to elite milieux of arts and letters in Concord, Massachusetts and New York were joined by organizations such as the National Association of Manufacturers and the National Civic Federation interested in in technical education and manual training as the basis of Imperial Germany's rapid economic development and impressive export record. These industrialists admired Germany's "dual" system of public-private *Fachschulen*, instituted nationwide in the 1897 Industrial Code and offering teenagers technical training for specific trades with curricula determined by local *Handwerkskammern* comprised of local workshops and private industry.[24]

The subsequent push for industrial education in the United States cannot be explained solely through the Atlantic crossings taken by Anglo-American elites. Instead, it depended on the

[22] Kathleen Neils Conzen, *Immigrant Milwaukee, 1836-1860* (Cambridge, MA: Harvard University Press, 1976).

[23] "Educators in Council," *New York Times* (15 July 1885): 2.

[24] On technical education in Imperial Germany, see Kathleen Thelen, *How Institutions Evolve: The Political Economy of Skills in Germany, Britain, the United States, and Japan* (Cambridge: Cambridge University Press, 2004), ch. 2; Kees Gispen, *New Profession, Old Order: Engineers and German Society, 1815-1914* (Cambridge: Cambridge University Press, 2002), especially chs. 4 and 7; James C. Albisetti, *Secondary School Reform in Imperial Germany* (Princeton: Princeton University Press, 2014); Hal E. Hansen, "Caps and Gowns: Historical Reflections on the Institutions that Shaped Learning for and at Work in Germany and the United States, 1800-1945" (PhD Dissertation, University of Wisconsin-Madison, 1997); Hal Hansen, "The Dual Training System: The Southwest's Contributions to German Economic Development," in Konrad H. Jarausch, Harald Wenzel, Karin Goihl, eds. *Different Germans, Many Germanies: New Transatlantic Perspectives* (New York: Berghahn Books, 2017).

longer-term layering of constituencies and competing conceptions of "German" education within the United States—and their conflation. Crossing class and ethnic communities and institutional levels from kindergartens to universities, *fin-de-siècle* debates over curricular expansion, manual training, and industrial education revealed pressing questions about the nature of freedom in industrial society—and then often submerged them in notions indebted to the German-American encounter, such as "self-activity."

Would conjoined mental-manual education upend a hierarchical social order or reinforce it through a mere "enrichment" of factory work, as Jane Addams envisioned, via the individual worker's subjective orientation toward his or her work? Did emancipatory pedagogical efforts depend on a revolution within work processes and workplace governance in the world outside the classroom? What constituted the way to democratize industrial capitalism: to institute mental-manual education in classroom workshops best approximating the the most modern technological facilities of industry or to prioritize more open-ended development via crafts and object lessons associated with the pedagogy of Pestalozzi and Froebel? Did one need to fashion an industrial simulacrum to prepare students for the most advanced technical society awaiting them in order for them to stand a chance in climbing its ranks, or altering it altogether?

Amidst Reconstruction, the weighing of disenfranchisement policies North and South, the rapid rise of industrial concerns and onset of deflationary depression, and the resurgence of nativism, an 1874 letter to the editor of Chicago's socialist *Vorbote* asked simply: "Through education and self-development [*Bildung*] to freedom [*Freiheit*] or through freedom [*Freiheit*] to education and self-development [*Bildung*]?"[25]

[25] "(Eingesandt.) Durch Bildung zur Freiheit oder durch Freiheit zur Bildung?," *Vorbote* (1874):; on disfranchisement ideas in New York, see Sven Beckert, *The Monied Metropolis* (Cambridge, 2003).

The question contained multiple meanings and invited conflicting answers. In the Free Labor framework of the 1850s and 1860s, individual self-development and the making of a society composed of men possessing positive freedom were regarded as co-constitutive processes. During Reconstruction, however, "*durch Bildung zur Freiheit*" placed education prior to freedom, implying a course of individual uplift without fundamental social change—or, worse yet, serving as a pretext for the disempowernent of the insufficiently educated. Flipping the order of operations, the formulation "*durch Freiheit zur Bildung*" demanded structural change in society to enable individuals to develop their capacities toward positive freedom fully.

Through the travels and writings of early education reformers such as Henry Barnard, Calvin E. Stowe, and Horace Mann, American educators had become acquainted with the organizational structures and pedagogical methods in the German states prior to the Civil War. In the 1830s and 1840s, they had travelled to Europe to discover how a nation could improve itself morally while becoming more efficient via public school instruction.[26] Their writings primarily introduced Americans to the institutional mechanisms that guaranteed the skill of German teachers; however, they also focused on how these teachers encouraged independent thought and discovery among their pupils.

Mass migration from the German states following the revolutions of 1848 bolstered the implementation of these methods in American schools, public and private.[27] In frontier cities such as Milwaukee, one third to over half of children attended school outside of the public school system prior to the Civil War, partly due to German parents' preference for schools

[26] Karl-Ernst Jeismann, "American Observations Concerning the Prussian Educational System in the Nineteenth Century," in Henry Geitz, Jürgen Heideking, and Jurgen Herbst, eds. *German Influences on Education in the United States to 1917* (Cambridge: Cambridge University Press, 2006), 22.

[27] On German immigration to the U.S. following 1848, see Levine, *The Spirit of 1848;* Wittke, *Refugees of Revolution;* Heléna Tóth, *An Exiled Generation: German and Hungarian Refugees of Revolution, 1848-1871* (Cambridge: Cambridge University Press, 2014).

teaching the German language, singing, drawing, and scientific pursuits beyond the "three R's."[28] Milwaukee law permitted bilingual instruction in public schools. Although German-language instruction began in a public school ward in 1857, austerity measures forced cutbacks in these efforts in the early 1860s. Consequently, Lutheran and Catholic German-Americans turned to developing parochial schools, while Freethinking German-Americans established the Milwaukee German and English Academy. These schools offered a wider array of subjects than the public schools, avoided the rote memorization associated with Anglo-American public schools, and received support from German associations (*Vereine*).

The director of Milwaukee's German and English Academy, Peter Engelmann, stated his aim as "more to educate and train the young for self-instruction, than to cram with undigested knowledge."[29] Engelmann's approach to education included geography, history, nature studies, drawing, and practice in visual memory and comprehension as elementary subjects. Engelmann's German and English Academy, which expanded from forty to 250 students from the late 1840s to 1853, was soon joined by competitors such as the West Side German and English High School and the South Side German and English Academy. In 1859 the school added secondary education for girls in subjects such as singing, drawing, hand work, penmanship, arithmetic, geography, history, natural history, German, English, and French.[30] By 1870, over fifty German-American and "German and English" schools dotted the landscape from Brooklyn, New York to Bay City, Michigan and Burlington, Iowa.[31] Eventually the German and English academies influenced the pedagogy of Milwaukee public schools in general.

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[28] Conzen, *Immigrant Milwaukee*.

[29] Quoted in Conzen, *Immigrant Milwaukee*.

[30] Conzen, *Immigrant Milwaukee,* 180-182.

[31] "Liste deutsch-amerikanischer Schulen (Fortsetzung)," *Amerikanische Schulzeitung* (December 1, 1870): 148.

Milwaukee's German and English Academy instructed older students in the natural sciences, mathematics, and principles of construction. *Konstruktion* in German means drafting, machine design, and fabrication methods. To draw was to make, a conception--or elision--somewhat novel to yet resonant with emergent Free Labor politics. Following the revolutions of 1848, numerous German émigrés had arrived in the United States with liberal nationalist and socialist ideas. After successfully demanding the removal of nativism from the 1850s Republican platform, these "Forty-eighters" wooed a significant contingent of fellow German-Americans temporarily away from the Democratic Party in the election of 1860. Working within a comparative framework a century before Barrington Moore called the U.S. Civil War the "last bourgeois revolution," German-American Republicans generated an unfolding Hegelian narrative, casting slaveholders as belligerent, backward *Junker* aristocrats and proponents of narrow-minded "*Kleinstaaterei*."[32] Some attempted to grow Free Labor cotton in Texas; others contributed to the antislavery press.[33] At the end of the Civil War, one in ten Union soldiers would be German-American.[34]

Alison Clark Efford has argued that German-American adherents to republicanism and liberal nationalism in the 1850s and 1860s unwittingly shifted into a more strident nationalism following Prussia's victory in the Franco-Prussian War and the unification of Germany.[35] In the 1870s, German-Americans displayed this pride by calling on Anglo-Americans to emulate

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[32] Barrington Moore, *The Social Origins of Dictatorship and Democracy* (Boston: Beacon Press, 1967).

[33] On Free Labor cotton in Texas, see Frederick Law Olmsted, *A Journey through Texas: or, A Saddle-Trip on the Southwestern Frontier* (1857), 358; Moral Commerce: Julie L. Holcomb, *Quakers and the Transatlantic Boycott of the Slave Labor Economy* (Ithaca: Cornell University Press, 2016), 184; Richard H. Abbott, *Cotton & Capital: Boston Businessmen and Antislavery Reform, 1854-1868* (Amherst: University of Massachusetts Press, 1991): 47-48; Levine, *The Spirit of 1848*.

[34] Efford, *German Immigrants*.

[35] Ibid.

German institutions and approaches from civil service reform to education policy. Efford links this transformation to a broader rupture in American politics away from the empowerment of freedmen and toward a return to the cultural issues and nativism of the 1850s (battles over bilingual and confessional schooling as well as temperance), which prompted many German-Americans to abandon the Republican Party and renew ties to the Democratic Party via the Liberal Republican movement.[36]

Some contemporary German-Americans, including but not confined to republican radicals and socialists, were partly cognizant of the political shift Efford diagnoses and expressed dismay over it. Amalie Pfund, a Cleveland public school teacher who once submitted a letter on coral reefs to *Scientific American*, wrote to the *Amerikanische Schulzeitung*, published by Swiss-born kindergarten advocate and German Academy director William N. Hailmann in Louisville, Kentucky, to call compulsory school laws then under debate "an evil omen."[37] In republican and Freethinker tones, Pfund feared that a compulsory school law "would probably be the harbinger of other forced regulations, like biblical catechism, baptismal and confirmation codes and similar straightjackets"—all of which she condemned as "monarchical-hierarchical," "high-majesty" notions planted unnaturally in "free soil" meant for "republican simplicity and virtue, energy, sense of self and self-government."[38]

In doing so, Pfund expressly critiqued calls for the implementation of policies based on their success in Prussia:

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[36] Ibid.

[37] Cleveland Public Schools, "Manual of the Schools, 1870-1871," *Thirty-Fourth Annual Report of the Board of Education* (Cleveland, 1871); Amalie Pfund, "The Depths of the Sea," *Scientific American* (August 5, 1871): 84-85; Amalie Pfund geb. Janssen, "Die Volksbildung in den Vereinigten Staaten," *Amerikanische Schulzeitung* (April 1 1873): 298-302.

[38] Pfund, "Die Volksbildung in den Vereinigten Staaten," 298-302.

> One thing does not fit for everybody and all! Should we sow in the soil of free, popular institutions, what is rooted in totally different conditions and afflictions which luckily until now have remained foreign—with that we will arrive eventually at a culture of stereotyped servant-mentality or even form material for continually armed, tax-paying, country-bound [*ländereingrenzende*] monarchists [*Thronstützen*]![39]

Similarly, if less passionately, William Hailmann argued as chair of a special committee on the kindergarten at the National Education Association's 1873 meeting that the United States provided the ideal setting, superior to Germany, for fostering kindergarten expansion due to its lack of repression.[40]

A German-American educator still opposed to "Prussianism" in 1873, Amalie Pfund cited the 1870 census figures on illiteracy for Northern, Southern, and Pacific regions of the country, white and Black citizens, and men and women, to advocate an alternative plan to remedy a situation "in relation to schooling, self-development and education" which remained "very, very dark," and where "more light must be brought to the masses, if our civil [*bürgerlich*] and political freedoms are to be protected through spiritual and intellectual freedom."[41] It is possible that Pfund's use of the census figures and concern for civic integrity comprised a racial dog-whistle, as controversy swirled around the supposed gullibility, venality, or corruption of Black voters and legislators. Indeed, German-Americans were increasingly abandoning their support for freedmen's rights in the 1870s.[42]

However, Pfund paired her disfranchisement-associated subtext with an educational platform she considered superior to compulsory schooling codes: increasing public funds to

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[39] Ibid.

[40] Michael Steven Shapiro, *Child's Garden: The Kindergarten Movement from Froebel to Dewey* (College Park: Penn State University Press, 1983).

[41] Pfund, "Die Volksbildung in den Vereinigten Staaten," 298-302.

[42] Efford, *German Immigrants, Race, and Citizenship;* Eric Foner, *Reconstruction: America's Unfinished Revolution, 1863-1877* (New York: HerperPerennial, 2011).

construct high-quality public schools in the "furthest corners of our great community," and introducing natural sciences into the lower grades of the public school curriculum, something she found wholly neglected except for in the "big cities, where the German influence is mighty enough" to implement them as "teachers Hotze and Klemm and Superintendent Eickhoff had done with physics in Cleveland."[43]

Pfund concluded her appeal with a republicanism familiar to the Forty-eighters. She wrote,

> school, home, society and namely the press, these universal means of popular education should be unified in seeking with untiring tenacity, to gradually infuse in the point of view of the masses the popular belief, that all workers are...equal from the standpoint of our present culture, who through their efforts [contribute to] necessary...work of a nation or of a small community...by the same study lamp, in the teaching rooms, the halls of art and science, the workshops and shops of trade and commerce, in the field of farming, or in and around the narrow areas of the household stove, and that each has not only the right and the duty to work, but also the right and the duty, to develop his natural capacities and gradually bring them to the highest possible level of fulfillment, with which the godly spark of the light of knowledge to nurture...through which alone man elevates himself over animal![44]

Producerism remained central to Pfund's conception of education, and the free polity inherently tied to the process of *Bildung*.

German-American education reformers recruited prominent American educators to the kindergarten cause. Along with Adolph Douai, a Forty-eighter abolitionist and socialist who had edited the antislavery *San Antonio Zeitung* in the 1850s before being forced north and directing a German academy in Boston, William N. Hailmann engaged Bronson Alcott, Henry Barnard, William Torrey Harris, and Elizabeth Peabody, a group he called "clear-headed, true-souled men and women…from city and country, from manufacturing and agricultural districts," in the

[43] Pfund, "Die Volksbildung in den Vereinigten Staaten," 298-302.

[44] Ibid.

kindergarten cause.[45] William Torrey Harris, superintendent of St. Louis public schools and later U.S. Commissioner of Education (1889-1906), had founded the circle of "St. Louis Hegelians" with German immigrant Henry Brokmeyer in 1857, which published the *Journal of Speculative Philosophy* and brought continental European thought to an English-speaking readership.[46] As superintendent of St. Louis public schools in the 1870s, Harris oversaw the founding of fifty kindergartens and a rise in enrollment from 15,000 to 50,000. Throughout the 1870s, Harris promoted a view that Germany stood "foremost among the nations of the world...in matters of education."[47]

The St. Louis Hegelians' educational ideology centered around the concepts of *Bildung* and "self-activity" (*Selbsttätigkeit*). Harris posited that, overcoming self-estrangement, the individual must submit himself to the era's universal ideas, immanent in state and society as well as Art, Science, and Religion—all connected and interdependent with one another along a linear trajectory of progress. The dialectical or conflict-ridden element receded for American interpreters of Hegel following the conclusion of the Civil War. Harris further mapped this trajectory onto a racial-cultural scheme, arguing in an 1870 essay entitled "The Theory of American Education," that the

> nations and peoples of the world rank high or low according to the degree in which they have realized this ideal of humanity. The rude tribes of central Africa and the Polynesian Islands stand at the foot of the ladder. The Oriental people have achieved a higher degree,

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[45] Karl-Heinz Günther, "Interdependence between Democratic Pedagogy in Germany and the Development of Education in the United States in the Nineteenth Century," in *German Influences on Education in the United States*, 49; Quoted in Shapiro, *Child's Garden*, 67.

[46] Rogers, *America's First Women Philosophers*; Charles M. Perry, "William Torrey Harris and the St. Louis Movement in Philosophy," *The Monist* (Jan 1 1936): 59-80; James A. Good, "A 'World-Historical Idea' The St. Louis Hegelians and the Civil War," *Journal of American Studies* 34, 3 (Dec., 2000): 447-464.

[47] William Torrey Harris, *German reform in American education: an essay read before the German American Teachers' Association, at Hoboken, August 3, 1872* (St. Louis, 1872).

> though still very defective...With the ancient Greeks and Romans great progress was made over the highest Asiatic people.[48]

Writing for the Progressive *Monist* in the 1930s, Charles M. Perry succinctly captured and lampooned William Torrey Harris's intellectual trajectory:

> In 1869 he emphasized the value of cultivating industrial talents. In 1870 he thought that self-activity and prescription must go together. In the latter year he thought self-activity the reconciliation of radicalism and conservatism. In 1871 he connected self-activity with our national idea of freedom. Later he connected it with the industrial system. In criticizing Edward Bellamy's *Looking Backward* he made a strong argument for competition. In an article on 'Statistics of Socialism' he characterized capitalism as self-activity. With this characterization in view, when the question of administering our island possessions came up in the later nineties, he stated his belief that whole nations should be apprenticed to industrial civilization even if we had to enforce it by military means.[49]

Dismissing the isolation described in Rousseau's *Emile*, for instance, Harris and the St. Louis Hegelians stressed that individuals came into being only through retracing the steps of predecessors, thus accommodating individual to society and enabling further development.[50] His theorization endowed this vein of German influence on American education reform with the tools to justify capitalism and imperialism.

Speaking before the German-American Teachers' Association in 1871, which hosted the most "noted Anglo-American teachers," Harris issued an implicit rebuke of Reconstruction politics, no doubt thinking of his own St. Louis:

> You have observed the collisions that transpire in the ethical life of the community. It seems that the demon of reflection plunges our people into doubt and denial; and that established usages and fixed customs are challenged again and again. The traditional

[48] David Watson, "The Neo-Hegelian Tradition in America," *Journal of American Studies* 14, 2 (Aug., 1980): 219-234.

[49] Charles M. Perry, "William Torrey Harris and the St. Louis Movement in Philosophy," *The Monist* (Jan 1, 1936): 59-80.

[50] William Torrey Harris, *The theory of American education* (St. Louis, 1871); Rogers, 22.

> teachings of religion and morality are doubted and even practically ignored by many. Vice and corruption flaunt their hateful colors in the public gaze.[51]

He abandoned the connection between *Bildung* and Free Labor ideology.

Engaging his audience, Harris outlined the positions taken by the German-American teachers in three pillars: first, support for “equal rights of all to an education” whose results would be “material wealth as well as culture”; second, a view that the “present system of education” was “inadequate,” proven by “appealing to official depravity and the corruption of public morals,” and; third, that this “inadequacy” was “found to consist in mechanical methods of teaching and, in particular, in the exclusive cultivation of the memory,” for which the “proper remedy to the adoption of the developing method of instruction’, especially as unfolded by Froebel and Pestalozzi.”[52]

Harris accepted the first proposition on the basis of inculcating the “highest culture,” meeting “the exigencies of political economy,” and achieving necessary martial readiness as evinced by the Franco-Prussian war.[53] He embraced the third proposition insofar as he supported the “psychology of play” from the Froebelian and Pestalozzian systems, stressing that “especially in our cities and among the lower strata of society, there is no philanthropic agency half so potent as the Kindergarten, and there should be enough of them to provide all with free admission.”[54] Harris discounted the second position, proposing a different source of public vice and offering training in “self-activity” and the “Americanization” of the kindergarten instead of

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[51] W.T. Harris, “A Discussion of the Theses proposed for Anglo-American Teachers at the German-American Teacher's Association at Hoboken, Aug. 3rd,” *Schulzeitung* (January 1 1872): 197-200.

[52] Ibid.

[53] Ibid.

[54] Ibid.

the German-Americans' preferred use of the "developing method" attributed to Pestalozzi and Froebel.

Perceiving the difference in concepts, German-American teachers rejected Harris's interpretation of European pedagogical ideas in the 1870s. While praising Harris for his freedom from nativism, A. Schneck, a German-American teacher from Detroit, defended the "developing method" against Harris's critique and launched an attack on Harris's preferred notion of "self-activity."[55] Schneck asked:

> How can we develop a child into free rational insight without the developing method? Through his self-activity? I know what Mr. H. means—he means to save, at all hazards, the American method. But which method ensures this self-activity? Only the developing method.[56]

Schneck argued that the "mechanical discipline" which "the majority of our educators are contented with—develops the school into a gigantic machine crushing out the spontaneity of the pupils and building up a hideous framework of formality that will, in time, support the cloak of hypocrisy."[57] Defending the developing method against skeptical Anglo-American educators, Schneck admitted that one "may wait a long time for a fruit-tree to produce a more refined fruit—it must first be ingrafted." Yet, despite the complications of transnational institutional transfer, Schneck was certain that "people who have been instructed according to the true method will never allow their children to be instructed otherwise."[58] Popular agitation among German-Americans on behalf of the kindergarten and curricular expansion in cities such as Chicago would prove him right.

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[55] A. Schneck, "Superintendent Harris und the Theses proposed for Anglo-American Teachers at the German-American Teachers' Association at Hoboken," *Amerikanische Schulzeitung* (April 1, 1873): 293-297.

[56] Ibid.

[57] Ibid.

[58] Ibid.

Schneck critiqued Harris's remarks before the German-American teachers from a staunch republican perspective. He contested Harris's claim about the origins of the "moral defects in our public life" stemming from the "transition now taking place from the old prescriptive morality to a new ethical system, founded on a free insight into the rational necessity lying at the basis of society."[59] Schneck proposed that the "problem of self-government has to be solved by means of universal suffrage, universal education must be the principal factor in the experiments for the solution of the problem."[60] Instead of trying to "invent the constitutional machinery" or "find out those organic forms in which people can govern themselves and do it honestly" (Harris's words), Schneck asserted that "we can surely not invent them, they must be a spontaneous growth which will never make its appearance before the seed is carefully implanted in the mass of the people in the time of their youth—*Erziehung zur Freiheit*, they must be educated for liberty."[61]

Likewise, Schneck noted a curious dissonance between Harris's statement that "in other lands, there is a class trained, carefully educated to govern the rest, here we are trying to solve the problem of self-government by means of universal suffrage" and his argument that "the higher education is essential to the lower and, for the development of directive intelligence, essential to the powerful state."[62] To Schneck, Harris's latter claim smacked of creating the "distinction of classes among the people, and foremost the establishment of a governing class," something to be avoided at all costs.

[59] A. Schneck, "Superintendent Harris und the Theses," 293-297.

[60] Ibid.

[61] Ibid.

[62] Ibid.

He asked simply: “Who in this country shall receive the higher education, and who the lower one?”[63] Writing with a tinge of radical republicanism, Schneck considered it

> essential that the whole youth should have the same training up to the time where each decides himself for a certain vocation, and the difference should then only be in the vocational training; but to govern is no vocation in this country, for this business one must first be elected.[64]

Harris would accept (or repurpose) elements of Schneck’s critique such as postponing vocational training until students had completed a course of general studies--traditional academic subjects in Harris’s case versus a wider array of mental-manual activities (drawing, singing, gymnastics) for Schneck and other German-American educators interested in the “developing method.” However, as Schneck suspected in 1872, Harris would accommodate himself quite easily to an industrial society riven with class distinction.

The 1876 Centennial Exhibition popularized the kindergarten among an Anglo-American audience. Over ten million Americans visited the Philadelphia fair, frequently attending Susan Blow’s live classes in the St. Louis kindergarten exhibit. Manufacturers and retailers of kindergarten equipment and literature, such as Milton Bradley and German immigrant Ernst Steiger, showcased games and globes, maps and planetariums, and claimed that such activities would develop children toward finding a vocation.[65] Whereas Steiger had once published educational tracts in German and exhorted German-Americans to establish kindergartens for their own children, he used the opportunity in 1876 to address a wider audience in English, supplying a year’s worth of essays and materials at the fair at no cost.[66]

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[63] Ibid.

[64] A. Schneck, “Superintendent Harris und the Theses,” 293-297.

[65] Shapiro, *Child’s Garden* 71-72.

[66] Ibid., 71-72.

Milton Bradley burnished the reputation of his kindergarten products and elevated the status of German pedagogy among Anglo-Americans by distributing leaflets reading "Our material has been prepared under the direction of PROF. WIEBE, Miss Peabody, Madam KRIEGE and others, with the desire to, as far as possible, adapt it to the wants of American Parents and Teachers."[67] Steiger equally laid claim to kindergarten orthodoxy, publishing a catalogue of "the Most Complete Assortment of Materials, Gifts and Occupations carefully manufactured in accordance with the directions of Mrs. Maria Kraus-Boelte and other Authorities on the Genuine Froebel system."[68]

William Torrey Harris, a Centennial Commissioner for the state of Missouri, perceived in the fair's educational displays on manual training, sloyd (Swedish woodworking), and the kindergarten phenomena consonant with the rapid industrialization the country had recently experienced. Harris's time at the exhibition convinced him that the kindergarten must underpin mass public education.[69] Harris considered pedagogical theories and national development to be joined. Consequently, he appealed to a meeting of the National Educational Association to undertake a new synthesis of American educational methods to suit the altered society around them. Reflecting on the options presented at the fair, Harris concluded that either the public school or the private kindergarten would enable children to acquire necessary mental and manual skills. Should the American elementary school adopt the methods of the kindergarten, or the kindergarten undergo "Americanization?" Echoing his German-American interlocutors from five

[67] Ibid., 72-73.

[68] Ibid., 72-73.

[69] Ibid., 81-82.

years prior, Harris told the NEA that mechanical discipline had transformed the American child into a "machine governed by prescription and conventionality."[70]

But in his view, the "Americanized" kindergarten would strike a middle path, presenting children with the opportunity to come into "self-activity" in the public kindergarten before embarking on the development of rationality and the course of formal liberal studies in subsequent grades.[71] William Torrey Harris refused to endorse all forms of pedagogy emanating from Europe. Later as U.S. Commissioner of Education, Harris wrote tracts and led NEA discussions, which held fast to a program of classic liberal studies and resisted the implementation of Herbartian and Pestalozzian ideas as well as those related to industrial education.[72]

However, German-American educators such as Kraus-Boelte dissented from Harris's interpretation, arguing that the kindergarten was a universal discovery, not an invention embedded specifically within German national culture. As such, it did not in their view call for adjustment or "Americanization."[73] German-American followers of Froebel suspected Harris and other Anglo-Americans of misinterpreting the theory and practice of the kindergarten.

German-American critique of American public schools swelled at the grassroots level as well. In 1879 the *Chicagoer Arbeiter Zeitung* complained, "Of all the German educational institutions of America the Kindergarten has received the least attention; Chicago, especially seems to take very little interest in this matter."[74] The newspaper not only stressed the

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[70] Quoted in Shapiro, *Child's Garden*, 82.

[71] Shapiro, *Child's Garden*, 82.

[72] David Watson, "The Neo-Hegelian Tradition in America," *Journal of American Studies* 14, 2 (Aug., 1980): 219-234.

[73] Shapiro, *Child's Garden*, 82.

[74] "[Popular Demand for the Kindergarten]," *Chicagoer Arbeiter Zeitung* (May 19, 1879).

inadequacy of facilities for Chicago's children under age six, but also underscored the deeper rationale behind kindergarten pedagogy:

> We consider that the education of our children up to the age of six years is only a preparation for later education. Until then, the normal child naturally longs for activity, which it finds only in play. Many parents, although loving their children, do not have the necessary intelligence to guide them, so it would be advisable to entrust our youngsters to competent care. While the child plays it learns and while it learns, it plays. The teachers in Germany made the observation that children who received Kindergarten instruction are much alert and their desire for learning greater.[75]

German-Americans in Chicago introduced Friedrich Froebel's pedagogy through the Froebel Kindergarten Verein, headquartered at the Lincoln Turner Hall in Lake View and based on annual contributions of three dollars. The civil society organization kept its kindergarten open to children unable to pay dues.[76] In 1893 the Kindergarten Verein expanded and requested community financing to "extend this privilege to needy children, although the parents must be respectable and worthy."[77] To this end, the *Verein* attempted to engage Chicago's German community as a whole, promising to report on its progress to a general meeting, at social gatherings, and in the German-language press. The *Verein* cast its mission as the training of "children, who are between three and seven years of age...strictly conducted according to F. Froebel's method and ideas" and emphasized that the kindergarten "is a nursery of German, to guide new generations into those paths, which parents, and teachers think desirable for the cultivation of the mother-tongue and German customs and traits."[78]

Meanwhile, Anglo-American elites had begun to embark on a "kindergarten crusade" aimed at ameliorating urban poverty and elevating the immigrant *classes dangereuses*. 1881

[75] Ibid.

[76] "Deutscher Kindergarten (German Kindergarten.)," *Abendpost* (June 16, 1892).

[77] "German Kindergarten," *Illinois Staats-Zeitung* (June 17, 1892).

[78] Ibid.

witnessed the founding of the Chicago Free Kindergarten Association, which counted Mrs. Potter Palmer, Mrs. George Armour, and Mrs. W.A. Montgomery as charter members.[79] Free-kindergarten associations spread across the United States, numbering 115 and operating 223 schools with a total enrollment of nearly 15,000 children in 1890; in 1915, twelve percent of American children would attend 8463 public kindergartens.[80] Free kindergarten reformer Amalie Hofer described the "self-appointed stewards of the new education" as "a thoroughly organized force," with the "seventy-five officered kindergarten associations form[ing] a ganglia of vitalizing centers throughout our country and constitute what we name the kindergarten movement."[81]

From 1854 to 1877, German constituencies in eight Midwestern and Great Plains states convinced legislators to pass laws offering local school boards or even twenty-five to fifty-person groups of "freeholders" the opportunity to require access to foreign-language instruction in the public schools.[82] By 1870, well over twenty cities had introduced German-language instruction in the public schools, including Columbus, Pittsburgh, Hartford, Louisville, St. Louis, and St. Paul.[83] However, from the late 1870s to the 1890s efforts swelled to eliminate German instruction on grounds of "economy" or the necessity of "Americanizing" immigrants.[84]

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79 Shapiro, *Child's Garden*, 98.

80 Ibid., 171-172.

81 Quoted in Shapiro, *Child's Garden*, 98.

82 David Tyack, *The One Best System: A History of America Urban Education* (Cambridge, MA: Harvard University Press, 2003), 108.

83 "Städte, in welchen die deutsche Sprache als Unterrichtsgegenstand in den öffentlichen Schulen eingeführt ist," *Amerikanische Schulzeitung* (December 1, 1870).

84 Tyack, *One Best System*, 109.

The attacks on “fads and frills” in the public schools by school board members and conservative newspapers such as the *Chicago Tribune* crystallized many of these sentiments.[85] To the *Tribune*’s editors and wealthy Chicagoans, instruction in the arts, physical education, and German language did not merit tax dollars. While German-American teachers had been introducing object lessons, manual activities, and the “developing method” into American schools for decades, the “fads and frills” controversy galvanized wide swathes of German-Americans beyond educators to elaborate a formal defense of the “special subjects.” Their arguments in favor of curricular expansion would speak directly to the role of education in a democracy and an industrializing society.

In some cases, advocates of curricular expansion relied on the erstwhile link between *Bildung* and Free Labor or personal networks that had been forged on this basis. The Chicago *Inter-Ocean*, published from 1865 to 1915, illustrates this point. Jacob Bunn, a personal friend of Abraham Lincoln, founded the newspaper in 1865 as the *Chicago Republican*. The same Bunn had assisted Lincoln in forging ties to Illinois’s flourishing German language press in the election of 1860. Charles A. Dana, the well-known journalist and “eyes of the Lincoln administration” during the Civil War, served as one of its editors. In later years, the *Inter-Ocean* sought to appeal to an enlightened business audience. The *Inter-Ocean* justified taxpayer-financed German classes with the language’s usefulness in developing “the intellectual nature of a pupil” and stressed, “the acquisition of German becomes an element of power in transacting business and in achieving success.”[86] The *Inter-Ocean*’s editors argued that the “Germans, as a

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[85] Paul Peterson, *The Politics of School Reform, 1870-1940* (Chicago: University of Chicago, 1985); *Chicago Tribune*, February 24, 1893; “German Instruction in the Public Schools,” *Illinois Staats-Zeitung*, February 10, 1879.

[86] “German in the Public Schools,” *Chicago Inter-Ocean*, August 17, 1876; “German Instruction: One Hundred and Fifty Thousand Germans Demand its Retention in Curriculum of Public Schools,” *Illinois Staats-Zeitung*, February 22, 1879.

class, are warm friends of our public schools, and in these days of opposition to the system we need to retain every friend and make no enemy." The *Inter-Ocean* feared that Chicago's German population might desert the public schools in favor of parochial schools if the expanded curriculum were removed.[87]

Addressing a standing-room only crowd, Mrs. Brown, president of the Chicago's Women's Alliance, and Mary Burt of the Chicago School Board inveighed against selfish taxpayers who objected to the so-called "special studies." They promoted further expansion of the curriculum, the extension of German to all grades, and ongoing collaboration between German and American women. A Mrs. D. Boettcher authored the meeting's petition to the school board, in English and German, which defended German, gymnastics, singing, drawing, and sewing on account of schools' role in assuring the capacity for self-government via "the education of the masses" and in reducing the danger of students "going astray, or becoming dependent on public charity." Such a fate would contravene both Lincoln's vision of Free Labor and the harsher liberalism then prevailing—"beggars could not be choosers," one could not ask something for nothing.[88]

Boettcher also argued that gymnastics was essential for the "development of the body" to "keep pace with intellectual progress," something she framed as a personal and national asset. Drawing constituted "training in skill which is basic in nearly every trade and profession," while "what drawing is to the boys, needlework is to the girls." The Smith-Hughes Act, which entailed both a debate over the degree of generality in industrial training for boys and contestation over whether girls should be trained for home or factory, would confirm her gendered dictum.

[87] German mothers made just this threat, see "German Women Defend German Instruction in Impressive Mass-Meeting at North Side Hall," *Illinois Staats-Zeitung* (March 12, 1893).

[88] Amy Dru Stanley, "Beggars Can't Be Choosers: Compulsion and Contract in Postbellum America," *Journal of American History* 78 (Mar. 1992): 1265-1293.

Pushing for curricular expansion with public funding, a letter to the editor in Chicago's socialist *Vorbote* asked "Do they [students] learn something other than writing, reading, and arithmetic?" and called upon the public schools to teach children to "know nature...their own bodies or those of animals, plants or something else which could be of use to them."[89] The author honed in on the hypocrisy of the city's elites, who "very quickly have the phrase at hand: only education liberates" and then "typically forget, however, to assure to the worker the means with which he could educate himself."[90] Undercutting elite arguments about the necessity of austerity measures, German-Americans such as the letter-writer lamented that Chicago's "present ruling classes prefer to dissipate the public funds to all other possible and impossible purposes," but could not spare dollars for an "unabridged and truly scientific schooling" for youths or instruction "in the higher sciences after the fourteenth year of age."[91] The result of education cutbacks was clear to German-American radicals at the *Vorbote*. Facing the assessment of school fees, "the worker is put in the position that he does not earn enough to feed his family and must already put the child to work in the factory before he has reached the fourteenth year of life."[92]

The relationship between curricular expansion and *Bildung* had begun to differ along class lines among German-Americans in Chicago. A letter to the editor of the socialist *Vorbote* defined *Bildung* explicitly not as "pretty writing, singing, playing the piano, fine compliments, etc.," referring to these as "dog-dressage [*Hundedressur*]."[93] Instead, the author considered *Bildung* to be "honorable thinking, manly behavior, free thought and, above all, knowledge of

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[89] "(Eingesandt.) Durch Bildung zur Freiheit oder durch Freiheit zur Bildung?," *Vorbote* (1874).

[90] Ibid.

[91] Ibid.

[92] Ibid.

[93] "Correspondenzen," *Vorbote* (April 1, 1876).

self and always looking idealistically toward the future."[94] Citing the fact that a bourgeois once told him that "much reading is not useful to the worker, it only awakens dissatisfaction!," the letter-writer called upon fellow workers to "build yourselves up philosophically" and stressed that "self-help as a class, but not as individuals, leads to the goal."[95] He urged fellow socialists to support compulsory education even in Chicago's "poor quality" public schools because even mere reading and writing would, in his view, further the struggle for class emancipation:

> The bourgeoisie must teach the worker to write and read; what, however, is to be written and read, that is up to the worker to find out, and for that, the mentally educated worker [should] concern himself...to champion the natural rights of man.[96]

Through the course of education debates, German-American socialists elaborated a historical interpretation of transformed work processes and concentrated capital, which precluded individual self-uplift and necessitated fundamental structural change in society.

In doing so, they cast doubt on "*durch Bildung zur Freiheit*," proclaiming instead "*durch Freiheit zur Bildung*" increasingly without reservation. Still criticizing the limited scope of American public education in 1885, a letter to the *Sozialist* began with the assertion that "as long as public education has its present stunted form, the worker will be compelled to pick up in later years what the school did not offer him."[97] But the letter soon gestured toward a wider structural shift, wherein the "need for a greater mass of skills and for education has progressed too deeply, too strongly, in order to repulse it."[98] Looking to education alone was futile, he concluded, when

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[94] Ibid.

[95] Ibid.

[96] Ibid.

[97] "Die Bildung der Arbeiterklasse," *Sozialist* (May 9, 1885).

[98] Ibid.

training in “arithmetic, accounting, geography, history, etc. do not modify the law of wages and do not protect the small artisan master from exploitation by great capital.”[99]

A letter to the *Vorbote* asked, “What can art and science do, what use are all the good schools, theaters, concerts of the whole of humanity, when the working people struggle with poverty and privation?”[100] He pressed further:

> How should one procure an education for himself, when another robs him of the means and the time? How should he reach higher thought, swing upward to higher ways, when he must grapple daily with worrying after nourishment, with bitter privation in life?[101]

Nevertheless the letter-writer also echoed sentiments familiar to fellow German-Americans with a stake in curricular expansion and *Bildung*: “What the poor youth learns...reading, writing, arithmetic...biblical phrases! Is that sufficient to develop the man?”[102] Condemning those “who drape themselves in the mantel of liberality and claim that they would be for the furthest-reaching claims of the people, only the people must be educated,” the author exclaimed: “‘Through Education to Freedom!,’ what an empty, deceitful phrase!”

Correspondence and editorials in the *Vorbote* consistently cast “*durch Bildung zur Freiheit*” as well as the actual content of public education as a trap of bourgeois ideology: “How should the people educate themselves, as all of the Pharisees demand, crying out ‘through Education to Freedom!’"[103] Likewise, a correspondent in the *Sozialist* wrote that the “end-goal of the liberal bourgeoisie was not the liberation of the worker through education, but rather renunciation” of any view skeptical of “the relation between capital and labor as a law of

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[99] Ibid.

[100] “Eingesandt,” *Vorbote* (May 1, 1875).

[101] “Durch Freiheit zur Bildung!” *Vorbote* (February 27, 1875).

[102] Ibid.

[103] Ibid.

nature."[104] Castigating the "educated man, who recognizes this as a law of nature, submits himself to it, resigns himself to it, and tries to make his sad situation as pleasant as possible," he concluded that "the end-goal of education, the full mental freedom of the worker, can only be reached when the barriers erected by the liberal bourgeoisie are thrown away."[105]

In 1875 a letter to the editor of the *Vorbote* inserted a third variable into the increasingly fraught, unraveling relation between education and freedom: progress. The author expounded that the slogan "Education, Progress, Freedom!" would "have its correctness, if the current ruling class did not hold true public education in chains."[106] More specifically, the correspondent claimed that "neither education nor science made humanity aware that the earth is round and revolves around the sun; or how it should make its glass, porcelain or gunpowder, or how steam-power could be made useful," but rather thanked "pure accident" and the "ideas and efforts of individual men" for "all inventions or discoveries."[107] He emphasized the incremental nature of workshop experiment and practice, maintaining that "the progress of experience and knowledge advanced day after day one calls science."[108] Popular education comprised "instruction in different ways" through which this accumulation of experience was to "be made accessible."[109]

Unfortunately, he observed, "progress, with science drawn from it, has rushed until now always forward," while "popular education limped slowly behind it."[110] The unnerving chasm between technical progress and public education would convince German-Americans, especially

[104] "Die Bildung der Arbeiterklasse," *Sozialist* (May 9, 1885).

[105] Ibid.

[106] "Eingesandt," *Vorbote* (May 1, 1875).

[107] Ibid.

[108] Ibid.

[109] Ibid.

[110] Ibid.

in the Midwest, to advocate for and experiment with curricular expansion into crafts and industrial, technological and scientific training within existing schools or new institutions.

In 1896, twenty years after German-American Chicagoans had debated the proposition "*durch Bildung zur Freiheit*" as part of a larger struggle over the meaning of freedom and the role of curricular expansion in public schooling, an editorial in the socialist *New Yorker Volkszeitung* argued that political education was in fact necessary in the face of an industrial system which had engendered eternal dependency. Mourning the impossibility of independence in work, a concept from labor republicanism, the *Volkszeitung* explained that the "progress in industry and the inventions in machinery have cut the artisan off from any prospect of independence [*Selbständigkeit*] if he does not possess assets."[111] The artisan "is placed at the mercy and unmercy of the owners who can make the machines run and erect the large factories."[112] Progress entailed lifelong work for another and "for that he obtains only so much subsistence as the owner is forced to pay under the prevailing conditions. He has become a wage-slave."[113]

Since a "sudden revolution" was "not thinkable" to the *Volkszeitung*, it rallied workers to "agitation and the teaching of the masses" which belonged anyhow "to people of their own class, who possess a full understanding of the social conditions."[114] Seemingly reversing course from Chicago's *Vorbote*, the *New Yorker Volkszeitung* claimed "it is wholly correct to say: Through Education to Freedom!"—that is, when "*Bildung*" meant political education rather than mere

[111] "Durch Bildung zur Freiheit," *New Yorker Volkszeitung* (Jan 26, 1896).

[112] Ibid.

[113] Ibid.

[114] Ibid.

"scientific facts and skills."[115] For the *New Yorker Volkszeitung*, the true kernel of *Bildung* lay in "education which enables the man to understand his position in the society as well as his rights and duties."[116] In the 1870s German-American advocates of "*durch Bildung zur Freiheit*" or "*durch Freiheit zur Bildung*" had implicitly addressed their appeals for uplift or revolution to a single or whole polity of producers, whether or not it actually existed; by the 1890s, tempered by the backlash following the Haymarket Affair and dropping republicanism with the daily advance of mechanization and heightened divisions of labor, German-American socialists explicitly conceived of "*Bildung*" as a means to clear-sightedly demarcate class and foster class consciousness.

Another austerity measure in 1896, Chicago's City Council resolution to underfund the schools by $1,600,000, reignited the "fads and frills" controversy. This time, however, German newspapers such as the *Abendpost* did not focus on the special merit and population numbers of German citizens or the German language particularly. Instead, the *Abendpost* charged that eliminating drawing, gymnastics, and singing meant that Chicago public schools would be "suppressed below the average of the very poorest German village schools."[117] Anticipating Jane Addams's statements at the 1907 NSPIE convention, the *Abendpost* decried "nothing shall be done to develop the body, the eye, and the talent for art," for the sole focus on reading, writing, and arithmetic assumed that "all the pupils are to become 'Grocery Clerks' in their later life."[118]

The *Abendpost* found this petty white-collar fate unacceptable, preferring more muscular work for body and mind, and concluded in despair: "Individual thinking, manual training, and

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[115] Ibid.

[116] Ibid.

[117] "Pleasing Prospects (Editorial)," *Abendpost* (February 26, 1896).

[118] Ibid.

taste are articles of luxury which the rich city of Chicago must deny to her increasing citizenry."[119] Twenty years earlier, a German-American commentator in the more radical *Vorbote* had suggested that the city had only invested in evening schools, as "the bourgeoisie does everywhere," in order "to have cheap draftsmen and cheap accountants, and they have reached their goal, since mental work is almost as poorly paid as physical."[120] In 1890s Chicago, defense of the "fads and frills" became synonymous with defense of the public schools and access to economic opportunity often defined in a distinctly artisanal or mechanic sense.

In 1881, William Hailmann, then principal of the German-American School, chaired a mass meeting of trades unions, socialists, radicals, free thinkers and "social Turners" in Detroit, who had convened to protest Bismarck's Anti-Socialist Laws and garner sympathy and funds for the Socialist to campaign for the Reichstag. Introducing F.W. Fritzsche, German parliamentarian and president of the German Cigarmakers' Union, and Louis Viereck, ex-Judicial Recorder of Berlin, Hailmann cast defense of their cause as true Americanism:

> Whenever we hear the voice of …calling to us for sympathy and aid, it is our duty as freemen to lend a gracious ear and to extend a willing hand. Our broad land, which has thrown off the shackles of a medieval civilization more effectually than any other, which has broken with the religion of hatred and embraced the religion of love more conscientiously than any other, has been the star of hope of the oppressed of all climes, and will, I trust, never lose this proud distinction. For this reason, as an American citizen in the broadest sense, and deeply sensible of the responsibilities this privilege implies, I am here, and I presume, most of you are here tonight to listen to the grievances of a great nation, to which all of us owe filial affection. This is not a narrow meeting with narrow aims. The friends who have called upon me to preside here assure me that it is not intended as the gather of any narrow party or ism, but as a free convention of American men and women who love their own freedom enough to sympathize—actively, if need be—with the oppressed wherever despotism may raise his poisonous head or revel in his orgies of destruction.[121]

[119] Ibid.

[120] "Correspondenzen," *Vorbote* (April 1, 1876).

[121] "GERMAN SOCIALISM: Expounded at Music Hall Last Night What Herr Fritzsche and Louis Viereck Think of the Government of Their Country," *Detroit Free Press* (April 6, 1881): 2.

Hailmann's rhetoric echoed the republicanism and liberal nationalism of post-1848 rallies for revolutionaries such as Hungarian Louis Kossuth in American cities; however, it was not wholly outdated by the time of the Detroit convention. Rather, this politics formed a complex undercurrent of German-American politics, even as many German-Americans returned to the Democratic Party from the 1870s onward.

By 1890 Hailmann's audience extended beyond the confines of the German-American community and press. Hailmann was invited to speak before the annual meeting of the Knights of Labor, membership 700,000, in La Porte, Indiana. Hailmann's address united Froebel's educational ideology with a critique of capitalism. Hailmann stressed the importance of "hand learning," but added that reduced working hours and wage increases would be necessary to pursue broadened education, education being the "child of leisure." He endorsed proposals for the abolition of convict labor, the outlawing of debts to company stores, the institution of an income tax, and the nationalization of communication and transport infrastructures as well as municipal water and gas.[122]

Distorted echoes of Free Labor politics and the Civil War legacy inflected German-American engagement in debates over public education. Challenging advocates of "*durch Bildung zur Freiheit*," *Vorbote* invoked the classic critique of wage-slavery, writing

> if we are to first preserve our social and political freedom only when we are 'educated,' then we can suffer through our lives in political and social serfdom, then we are throughout our lives foreigners on this earth, which according to the sole valid natural law belongs to all, then we must until death furnish value for those, who have confiscated the earth and regard us only as slaves, to whom they need to give meager food, even less than cattle, in order to work...The worker is in the eyes of his oppressor nothing more than a piece of cattle, one gives him half-enough feed, the yields of his work belong to others, who have set themselves up as our masters![123]

[122] Dorothy Hewes, *W. N. Hailmann: Defender of Froebel* (Cincinnati: Froebel Foundation, 2001), 165-168.

[123] "Durch Freiheit zur Bildung!" *Vorbote* (February 27, 1875).

Put off by resurgent nativism in the Republican Party, visible in temperance bills and attacks on bilingual schooling, more politically moderate German-Americans returned to the Democratic Party fold beginning in the 1870s. Their return directly undermined Reconstruction; German-Americans, however, refused to abandon the rhetoric of Civil War service and their peculiar understanding of Free Labor to defend curricular expansion. At a mass meeting held by the German Democratic Central Union in Mueller's Hall on Chicago's North Side in 1892, several thousand German voters convened to support Democratic candidates J.P. Altgeld and Grover Cleveland because they had "promised, freely and honestly, to defend personal liberty, and to fight for the rights of parents in matters of education."[124] The *Illinois Staats Zeitung*, published by Georg Schneider, Lorenz Brentano, A.C. Hesing, and Hermann Raster as a pro-tariff Republican newspaper for "personal liberty" since the days of Lincoln, bolted that year toward the Democratic Party. The newspaper's editor explained to the crowd that the *Staats Zeitung* would support "the candidates of the Democratic party because the Republican party proved itself unliberal and intolerant toward prohibition and the Sunday questions; and because it forsook its glorious past, denied its true principles, and is increasingly inclined to support the alienhaters."[125]

Discussion of the "school problem" at the mass meeting was met with "thundering applause."[126] J. Goldzier, then running for Congress, repeatedly referred to German contributions toward American liberty, asking "When the shackles of slavery were destined to fall from the colored people, were not the Germans among the the first to enlist as volunteers?" and answering

[124] "Victory Is Certain! Enthusiasm of German Voters in Democratic Mass Meeting at Mueller's Hall," *Illinois Staats-Zeitung* (November 02, 1892).

[125] Ibid.

[126] Ibid.

"Many a hill in the South covers the son of German parents."[127] Goldzier pointed out acerbically, "German regiments with German commanders were highly welcome" during the Civil War, "but now the Republicans dare to forbid us our German schools."[128]

"German schools" did not necessarily mean private or sectarian institutions, financed independently or at the public cost. Although an "American Kulturkampf" had been waged between supporters of Catholic versus (normatively Anglo-Protestant) public schools on the parochial school question in the 1870s, most German-American Protestants, Freethinkers, Jews, and also moderate Catholics preferred the inclusion of the German language in public schools rather than the establishment of separate institutions.[129] In 1870 over ninety-two percent of citizens in the German-American stronghold of Missouri voted in a referendum for an amendment to the state constitution, endorsed by the German-language press, outlawing the disbursal of any public funds to sectarian schools.[130]

The German-American Democratic Club of Cook County called for

> an unrestricted continuation of German language instruction, as it is next to English, the most largely used language of our civilization during the present era; gymnastics, drawing, singing, etc., must also be taught in our public schools, as we subscribe to the belief, that America is destined to lead in the field of education, just as it has been a guiding beacon in so many lines of human activity.[131]

Tying its defense of the "special subjects" to the working-class politics of the Democratic Party, the club demanded that "wherever the Star Spangled Banner may wave, it may proclaim equal opportunities in educational matters for rich and poor, a thorough education for all children,

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[127] Ibid.

[128] Ibid.

[129] Efford, *German Immigrants*, 215-223.

[130] Ibid., 216-217; several other states passed similar measures, but the U.S. Supreme Court chipped away at them in the 2017 decision *Trinity Lutheran v. Comer*.

[131] "Solid as a Wall! That Is the German Support for Hesing," *Illinois Staats-Zeitung* (February 13, 1893).

which prepares them in their fight for existence and provides a true enjoyment of life."[132] German-American Democrats rallied behind investment in the city's public institutions, services, and infrastructure alongside protections for worker-consumers (the eight-hour day, regulation or socialization of municipal utilities) and opportunity for their children.

Positioning curricular expansion as a core determinant of their support for one party over another, Chicago's German-American Republicans-turned-Democrats neither viewed "*durch Bildung zur Freiheit*" as a façade for exploitative rule by capital nor accepted it as a guaranteed formula for the achievement of Free Labor. For them, it constituted part of a project inextricably tied to ensuring respect for German culture and a role for German-Americans in urban governance. As Alison Clark Efford has pointed out, German-Americans experienced a surge of nationalism following the Franco-Prussian War and the unification of Imperial Germany. Certain Forty-eighter radicals evinced admiration of Prussia. Liberal Republicans such as Carl Schurz began to advocate for the emulation of the Prussian example in the United States with policies indirectly destructive to democratic rule such as civil service reform as well as policies such as amicable reunion with the South, which directly endangered freedoms. Transformed, the remaining threads of German-American liberal nationalism and labor republicanism were channeled into education reform with support from a key bloc of urban Democratic voters.

In 1887 the *Illinois Staats Zeitung,* midway in its trajectory from a Republican to an independent, then Democratic paper, celebrated an exhibition of schools' craftwork organized by the National Education Association, including a series displays assembled by W.N. Beifield, superintendent of the School of Skilled Trades in Chicago, from schools for skilled trades in Chicago, Terre Haute, Omaha, Toledo and Colorado Springs as well as "mechanical work" from

[132] Ibid.

Illinois's university schools and the Polytechnical Institute of Terre Haute.[133] An exhibit of kindergarten work developed by "that brilliant German pedagogue" W.N. Hailmann, editor of the *Schulzeitung*, accompanied the innovative display of craft and mechanical work undertaken in schools far from the elite centers of literary life. The *Staats Zeitung* took in the scene with elated binationalism: "it fills one with pride and admiration realizing that Froebel's teaching fell on such good soil as this our country, with the result of bearing beautiful fruit."[134]

William Torrey Harris and other St. Louis Hegelians would bring continental philosophy, the kindergarten, and the concept of "self-activity" eastward to Concord, Teachers College, and the federal government. Yet another pool of educational ferment, more committed to Froebel's "developing method" and the joining of heads and hands, would persist, diversify, and spread among German-American communities and their interlocutors in the Midwest.

As economic competition with Germany (and admiration of its school system) heightened, consensus spread over the inclusion of science education and modern languages in the public school curriculum. Linking the educational platform inspired by Rousseau, Pestalozzi, and Froebel to the modern economy in *Studies in Pedagogy*, Thomas J. Morgan advocated "a stronger emphasis of the value in all primary and secondary instruction of the study of nature, plants, animals, minerals, rocks, physical phenomena, and facts pertaining to society, government, etc."[135] Morgan added an argument for a specific type of industrial education:

> An extension of drawing, molding, and designing as a means of awakening and expressing thought. Whatever place in our public schools may be temporarily awarded to industrial training, it is probable that eventually is will survive only so far as it justifies its right to exist as a culture study; that is, as a means of developing the power to think.[136]

[133] "School Work Exhibition," *Illinois Staats-Zeitung* (July 9, 1887):

[134] Ibid.

[135] Thomas J. Morgan, *Studies in Pedagogy* (Boston, 1892), 72.

[136] Thomas J. Morgan, *Studies in Pedagogy* (Boston: Silver Burdett & Co., 1892) 72.

Morgan's words, published in 1892, were prescient. To prevent students from being torn from broad *Bildung* schooling, vocational and industrial educational programs would inject manual activities into the regular public schools instead of establishing separate institutes.

But that fight had not yet occurred, as Morgan envisioned a liberal education for workers' children in the 1880s and early 1890s. In the years that followed, industrialists became increasingly interested in educational projects that could produce youths disciplined for lifelong factory work, while preserving independence for the deserving few who would move up to manage, direct, or invent industrial operations. Others would wonder whether education could usher in a new age of worker autonomy and democratic control.

The politics of the kindergarten and curricular expansion had garnered elite and popular interest alike and set the stage for the vocational education debates that followed. Superintendent of Cincinnati public schools Andrew S. Draper advocated dispensing with memorization and implementing kindergarten methods at every level since they trained pupils "how to act upon their own account" through "the habit of original investigation."[137] Relying on William Torrey Harris's notion of "self-activity," Draper emphasized that the "essential basis of the kindergarten is that children are set to doing things," arguing that "there is more industrial training, more development of the mechanic instinct in the kindergarten straw work than there is in trying to plane boards."[138] Such pedagogy would develop the "widely diffused artistic spirit which our people need" in addition to "the true, national moral sense," according to Draper.[139] His remarks reflected the extent to which a conservative, paternalist vision of social reform had come to the

[137] Andrew S. Draper, "The Duty of the State in Relation to the Kindergarten," *The Journal of Education* 36, no. 6 (Aug. 18, 1892): 106-107.

[138] Ibid.

[139] Ibid.

kindergarten; however, this would only expand its salience to confronting the "social question," imprinting debates over industrial education.

Seeking to explain the politics of school reform from 1870 to 1940, historians have argued that institutional interests and competition from the private sector drove a grand alliance of organized labor, teachers, and reformers to secure curricular expansion and American-style vocational schooling in Chicago, Atlanta, and San Francisco.[140] Indeed, some viewed German parochial schools as a threat to the necessary "Americanization" of immigrants. Likewise, employers such as Baldwin Locomotive Works and General Electric instituted their own apprenticeship programs, while private correspondence schools ballooned to teach whatever technical training could be conveyed without the use of equipment.

These external competitive pressures, however, cannot account alone for the course of vocational education debates. A widespread and longer-term "trickle-up" of German educational norms and local contests over curricular expansion shaped the conceptual resources and constituent bases for such projects. Reflecting on this process as early as 1889, John Peaslee pointed out that the "Quincy methods" attributed to Francis Wayland Parker and lauded by Jane Addams had actually "long prevailed in Cincinnati and other cities and towns of the West" via the influence of German teachers and the "admirable reports of Hon. HORACE MANN and Dr. C. E. STOWE (the husband of HARRIET BEECHER STOWE), who were appointed by the State of Ohio to examine the schools of Germany, and to report on the methods of instruction employed therein."[141] Peaslee underscored that the much-discussed "Quincy Methods" had only arrived in Massachusetts through Colonel Francis W. Parker, "who came to Ohio sometime in

[140] Peterson, *Politics of School Reform*.

[141] John B. Peaslee, "Instruction in German and Its Helpful Influence on Common School Education As Experienced in the Public Schools of Cincinnati," Delivered before the National German-American Teachers' Association at Chicago, Ill. July 19, 1889.

the sixties, taught in the Public Schools of Cleveland, and in the Dayton (Ohio) Normal School, and subsequently returned to his native New England, carrying with him the methods of instruction he had found here, and after a visit to Germany introduced them, slightly modified, into the schools of Quincy."[142]

Industrial Education Between Labor and Capital

Two trends increasingly preoccupied American reformers, labor leaders, and manufacturers over the Long Gilded Age: industrial proletarianization and the competitive threat posed by Imperial Germany's rapid economic development, perceived as based on highly skilled labor. Calling the independent artisan or agrarian ideal effectively dead in 1903, United Mine Workers leader John Mitchell declared that "the American workingman had concluded that he would always remain a working man and that his opportunities for advancement were accordingly becoming less and less."[143] Though taylorized mass production was far from a conclusively settled policy in turn-of-the-century American manufacturing, Lincoln's "Free Labor" had receded into oblivion. The ranks of the self-employed had fallen from over fifty percent of the labor force in 1800 to around thirty-five percent in 1860 to a mere twenty percent in 1910.[144] In many industries, the apprenticeship system had crumbled. As Gilded-Age Americans faced the hollowing of self-directed work combining the "head" and "hand" and yielding the economic independence to underpin republican claims to political subjecthood, the question of skill loomed large.

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[142] Ibid.

[143] John Mitchell, *Organized Labor* (Philadelphia: American Book and Bible House, 1903).

[144] Stanley Lebergott, "The Pattern of Employment since 1800," *American Economic History*, Seymour E. Harris, ed. (New York: McGraw Hill, 1962), 292 cited in John B. Jentz and Richard Schneirov, *Chicago in the Age of Capital* (Urbana: University of Illinois Press, 2012), 2.

At the start of the twentieth century, deskilling and scientific management constituted one direction of American industrial development; however, for some industrialists from the 1880s to the ‘teens, this transformation appeared neither inevitable nor desirable. Looking across the Atlantic, Theodore Search of the National Association of Manufacturers asserted that Germany posed the greatest threat in international commerce and attributed this strength to its highly developed system of vocational education.[145]

In 1908 Otto C. Schneider, erstwhile tobacco tycoon, Union League member, and president of the Chicago Board of Education, had given a lecture at the Art Institute to the city’s school principals calling upon them to emulate Germany and increasingly consider the needs of commerce and industry in education. Schneider lauded the expansion of correspondence schools in the United States, but stressed that teaching “only by mail, in the form of theoretical treatises and courses,” they “do not fully answer the purpose.”[146] Instead he proposed adopting Germany’s system of “commercial schools” and “excellent trade and special schools for mechanics, mining and building, etc.”[147] Schneider justified the expansion of commercial and industrial education on the basis of trade: “There is today, strong competition among the people of the earth, for the world markets and only that nation will emerge a victor which possesses the best and most efficient armor.”[148]

Consequently, the National Association of Manufacturers undertook to study European models of industrial education, commissioning Edwin G. Cooley to report on German industrial

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[145] Arthur G. Wirth, *Education in the Technological Society: The Vocational-Liberal Studies Controversy in the Early Twentieth Century* (Scranton: Intext Educational Publisher, 1972), 25.

[146] “After the German Example,” *Abendpost* (April 04, 1908).

[147] Ibid.

[148] Ibid.

education in 1912.[149] Cooley's *Vocational Education in Europe: Report to the Commercial Club of Chicago* (1912) followed up on John Tilden Prince's *Methods of Instruction and Organization of the Schools of Germany* (1892) and James Russell Parsons's *Prussian Schools through American Eyes; Report to the New York State Department of Public Instruction* (1891).[150] On the municipal, state, and national levels, labor organizations, academics, reformers, and business elites debated German-inspired reforms: the kindergarten, compulsory schooling, normal schools and teacher certification, curricular expansion, and vocational training.

But American education reformers made distinctions within strains of European pedagogy and weighed their applicability to democratic America within the context of the industrial transformation around them. Education professor Ellwood Cubberly, for instance, pointed out that Froebel's system "was not to teach a boy a trade, as Rousseau had advocated, or train children in sense-perception, as Pestalozzi had employed all his manual activities, but as a form of educational expression, and for the purpose of developing creative power within the child."[151] Broad creative power—to use one's mind to draw, draft, and design, to engineer, organize, and direct—would become the normative precept in the industrializing United States.

To philosophers of education, it seemed natural and right; to middle- and working-class parents desiring managerial or professional employment for their children, it made sense. For labor organizations, this redefinition of Free Labor and the educational means to achieve it represented a way to wage labor with dignity and a remnant of independence; to capitalists, it

[149] Cooley would later become superintendent of Chicago Public Schools and a major supporter of separate, industry-led vocational schools.

[150] John Tilden Price, *Methods of Instruction and Organization of the Schools of Germany* (Boston, 1892); James Russell Parsons, *Prussian Schools through American Eyes; Report to the New York State Department of Public Instruction* (Syracuse, 1891); Edwin G. Cooley, *Vocational Education in Europe: Report to the Commercial Club of Chicago* (Chicago, 1912); Cleveland Board of Education, *Report of delegates on European schools* (Cleveland, 1909).

[151] Cubberly, 323.

offered middle-rank engineers whose presence or absence would determine the potential of innovating past foreign competition.

The fight for curricular expansion and later vocational education drew on a diverse set of intellectual resources.[152] Thomas J. Morgan, principal of the Rhode Island State Normal School, compiled a comprehensive snapshot of the period's most respected educational thought in a book entitled *Educational Mosaics* (1887). *Educational Mosaics* included essays from Friedrich Froebel, Johann Pestalozzi, Jean-Jacques Rousseau, and Horace Mann as well as Francis Bacon, Ralph Waldo Emerson, H.W. Beecher, Benjamin Franklin, John Stuart Mill, and Herbert Spencer. Despite these thinkers' differences, a pattern to Morgan's thought emerges: the new education would be scientific, child-centric, and individualistic, focused on enabling the fullest natural development of independent individuals' capacities *to create* within a market society.

Superintendent of Pennsylvania schools N.C. Schaeffer condemned kindergartens which prioritized play in itself over work, whether in Harris's sense of cultivating "self-activity" or in a narrower sense of developing skill. While play activities may be "helpful" or "harmful," Schaeffer asserted, "in the true kindergarten the ruling idea is and is to be play for development of ability to work."[153] However, James MacAlister of Philadelphia's Drexel Institute shot back that the "difficulty is that there is no joy in our work."[154] He celebrated art as work containing joy due to the fact that "there is heart as well as hand and head in it."[155] Parlaying this relation outward from the classroom, MacAlister claimed the "kindergarten puts joy into school life and

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[152] For an excellent discussion of the trans-Atlantic making of progressive education, see William J. Reese, "The Origins of Progressive Education," *History of Education Quarterly* 41 (2001): 1-24.

[153] James L. Hughes, J. M. Green, W. N. Baringer, Philander P. Claxton, J. M. Greenwood, S. T. Dutton, Corinne Harrison, N. C. Schaeffer and James MacAlister, "The Kindergarten and the Public School," *The Journal of Education* 39, no. 10 (Mar):

[154] Ibid.

[155] Ibid.

the school should put joy into the work of life."[156] Whether the introduction of basic fabrication or crafts practices into schools or the reformulation of work processes in their social or technical aspects in the classroom could in fact ameliorate the deteriorating conditions in the workplace of the long Gilded Age divided educators.

National Association of Manufacturers members such as Augustus Jacobson and Charles H. Ham, both active in the Commercial Club of Chicago, believed that manual training could combat the shortage of mid-level industrial workers.[157] Jacobson enthusiastically endorsed Washington University Professor Calvin M. Woodward's Manual Training School in St. Louis. Integrating the curricular expansion and industrial training trends, Woodward introduced a three-stage program culminating in the degree of "Dynamic Engineer."[158] Students took both shop work (joinery, founding, and machining) and courses in mathematics, science, language, literature, and drawing.[159]

Popular in "manual training" movement circles during the 1880s and 1890s, sloyd (Swedish woodworking) revealed fissures between educators over whether and when to introduce general visual, tactile craft skills versus specialized vocational training in schools—particularly in the face of new work processes typified by rampant machine-tool use and working in steel rather than wood.[160] Despite his staunch support for the kindergarten, U.S. Commissioner of Education William Torrey Harris adhered to a liberal program of studies—reading, writing,

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[156] Ibid.

[157] Wirth, 12.

[158] Ibid., 11; for more on Woodward's concept of the "dynamic engineer," see Isaac Edwards Clark, *Art and Industry: Industrial and technical training in schools of technology and in U.S. land grant colleges* (Washington D.C., 1898).

[159] Wirth, 11.

[160] Linda Morice, "Balancing work and intellectual activity: Boston's Sloyd Training School," *History of Education Review* 38, no. 2 (2009): 56-68.

arithmetic, geography, grammar and history—and stressed that students should not commence manual training until their teenage years.[161] Conversely, Teachers' College Nicholas Murray Butler, Calvin M. Woodward, dean of the polytechnic at Washington University in St. Louis and John O. Runkle, president of MIT, supported the early and general training in comprehension and fabrication that sloyd offered. Butler claimed, "manual training is mental training through the hand and eye, just as the study of history is mental training through the memory and other powers."[162]

Given the origins of "manual training" in a wide, variegated movement for curricular expansion, it is not surprising that "manual training" purists such as Charles A. Bennett complained, "it is constantly being confused with laboratory work in science, drawing, and painting, and with objective methods of teaching a variety of subjects."[163] Similarly, the Pratt Institute's Professor Charles R. Richards had told a Chicago audience in 1893 that "manual training can doubtless render service in all of these lines in just the same manner that they can serve manual training; but the time has surely come to recognize tool work, not as the handmaid of the other studies, but as a thing in itself - as an instrument which in itself contributes an invaluable and necessary element to the work of the school; a subject of sufficient dignity to be considered for its own sake."[164]

Resisting such conflation and focused overwhelmingly on materials and tool use, manual training proponents such as Charles A. Bennett and John S. Clark felt compelled to contrast drawing with other manual activities. For Clark, drawing did not count as a manual art but rather

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[161] Ibid.

[162] Ibid.

[163] Charles A. Bennett, "What Is Manual Training?," *The Journal of Education* 41, no. 8 (Feb. 21, 1895): 125-126.

[164] Ibid.

constituted merely the “common language into which and from which thoughts in regard to all manual employments flow,” for an “idea to be worked out in wood or metal can be clearly expressed in drawing, also an idea to be worked out in paper or in sewing can be expressed in drawing.”[165] Instead, Clark cast true manual training as “exercises peculiar to the materials used, whether of wood, or of metal, or of paper” whose “modeling requires manipulations peculiar to itself for the expression of thought; so in regard to the sewing, and there is no exchangeability, as it were, of thought in the one to the thought in the other, - that is, thought expressed in wood requires entirely different manipulations from what is required when expressed in iron or in sewing.”[166]

Many of their contemporaries, however, advocated drawing, drafting, and visual education for precisely these reasons of wide applicability—across arts, manufactures, and sciences—and vocational indeterminateness (though “draftsman” was certainly a growing occupation); several also invoked developmental and sense-perception ideas associated with Froebel and the defense of the “fads” in Chicago.[167] Rather than view manual training as a broad facet of *Bildung* for the person, Charles A. Bennett insisted that it should be considered as “that subject in the school curriculum...designed for the educational development of the worker,” which he took as “an integral part of a scheme of general education.”[168]

Labor organizations, however, quickly assessed the mixed sincerity and power dynamics of industrial and academic efforts to simultaneously out-compete Germany and salvage Free

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[165] Ibid.

[166] Ibid.

[167] D.R. Augsburg, “Something That Drawing Will Do,” *The Journal of Education* 43, no. 20 (May 14, 1896): 329; John C. Miller, “Drawing and Its Relation to Manual Training,” *The Journal of Education* 40, no. 7 (Aug 23, 1894): 124-125; Walter S. Perry, “Art Education in its Relation to Public Education,” *The Journal of Education* 44, no. 5 (July 23, 1896): 98.

[168] Bennett, “What Is Manual Training?,” 125-126.

Labor. They would determine the goals and ideal administration of industrial education for themselves. Fearing the creation of business-led "scab factories," organized labor took action in support of vocational education from the 1880s onward. Opposing early specialization, Terence Powderly of the Knights of Labor thought that "drawing, freehand and mechanical, chiefly with relation to industry…should plainly constitute an integral part of our system" because "it is of great importance to every workman," in "all forms of artistic industry, it is absolutely essential," and in "all handicrafts, it proves eminently useful."[169] He proposed that steeping individuals in scientific knowledge could undo the detrimental effects of increasing mechanization and the heightened division of labor in industrial work. A perspectival, epistemic, and affective shift at the individual level held the potential, according to Powderly, to restore Free Labor:

> The children need to get peeps into the marvels of nature, which open everywhere beneath the common products of mill and factory and workshop. How greatly life would grow in interest, and what zest the daily tasks would yield, were there any such training from childhood upward! Hosts of men are doing mechanical tasks which open to them no springs of pleasure; whereas…Once started upon the track of observation and thought in connection with the daily work, a bright lad would push on unaided…lighting upon the trail which leads up to some great discovery.[170]

Were such statements emancipatory or reminiscent of works by Samuel Smiles? Powderly clearly conceived of his version of industrial schooling as liberating; however, while he criticized existing work processes, he posited that individuals could transcend them through scientific understanding of the world around them, which would serve as an escape valve to social mobility or perhaps a mere palliative during the repetitive doldrums of manufacturing work.

Powderly's vision did not entail a fundamental upending of social relations in production, something proponents of industrial democracy would later explore. Unlike other labor leaders,

[169] Powderly, 534.

[170] Powderly, 536.

Powderly wrote approvingly of Woodward's efforts at Washington University and of the Chicago Commercial Club's Manual Training School.[171] He particularly admired the latter's comprehensive offerings, for the course of study included "mathematics and some of the literary branches of the ordinary high school, together with drawing, freehand and mechanical, carpentry, joinery and turnery, pattern making, modeling and casting, forging, machine-shop work and the study of enginery, including the management of steam-engines and boilers."[172] Yet Powderly would have preferred the workshop schools be integrated into the regular public high schools under strictly public supervision.

While differing from the Knights of Labor in numerous respects, the AFL affirmed much of Powderly's position on industrial education when the subject reached the national stage. A special committee of the AFL condemned "any system of public instruction privately controlled," called attention to such schemes by manufacturers' associations in many localities, and underscored that it was necessary industrial education "be administered by the same authority…which administers our public school systems."[173] The AFL worried that manufacturers had "perverted the term" "industrial education" to mean "narrow and specialized training to the detriment of the pupils, the workers, and the people generally."[174] While the AFL conceded that "modern methods of manufacturing with their division and subdivision and specialization have, to a large extent, rendered nearly superfluous and therefore largely

[171] Ibid., 537.

[172] Ibid., 537.

[173] American Federation of Labor, "Industrial Education: Consisting of an Investigation and Report by a Competent Special Committee: Reports of Officers and Committees: Action of A. F. of L. Convention: the Attitude of Organized Labor" (Washington D.C., 1910), 6.

[174]AFL, 6.

eliminated the all around skilled worker," they remained committed to schools as a last preserve of diversified and general technical training.

The AFL had initially opposed both trade schools and other forms of vocationalism, viewing them as industry's ploy to revoke union authority over apprenticeships and break open the closed shop.[175] Yet Gompers eventually conceded that industrial education was inevitable and determined to have a say in shaping it.[176] At an institutional level, the AFL promoted the "establishment of schools in connection with the public school system at which pupils between the ages of fourteen and sixteen may be taught the principles of the trades, not necessarily in separate buildings, but in separate schools adapted to this particular education." The AFL report rejected the notion of technical education as training for a fixed class of industrial workers alone, praising Germany's industrial schools for their coverage of "the whole educational period": "lower industrial schools, which connect directly with the common schools and thus become continuation schools" as well as "middle industrial schools for pupils who have gone through the lower industrial schools, but who desire to shorten the period of higher education, although they wish to prepare themselves to become upper foremen or assistant superintendents."[177] While accepting stratification as a fact of industrial life, the AFL imagined an array of technical training institutions providing different paths to advancement.

The AFL advocated a broad palette of courses: English, mathematics, physics, chemistry, elementary mechanics, and drawing along with shop instruction for particular trades, the history of the trades, and "a sound system of economics, including and emphasizing the philosophy of

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[175] Fones-Wolf, 44.

[176] Gompers quoted in Fones-Wolf, 46.

[177] AFL, 26.

collective bargaining."[178] Within shop instruction, labor leaders hoped students would learn a wide range of skills in metal work, machining, and pattern making such as "making sketches and working drawings for the construction of a complete tool or scientific apparatus," cutting speeds (a favorite topic of Frederick W. Taylor's research), physics such as "the most important kinds of motion and the fundamental law of inertia," and the Bessemer and Siemens Martin processes. They consciously sought to restore a holism to shop work and viewed the public schools as an effective mechanism to do so.[179]

Accordingly, their report drew a stark contrast between the salutary role of specialization in the growing professions and its detrimental effects on the trades:

> It has been well said that specialists in industry are vastly different from specialists in the professions. In the professions, specialists develop from the knowledge of all the elements of the science of the profession. Specialists in industry are those who know but one part of a trade and absolutely nothing of any other part of it. In the professions, specialists are possessed of all the learning in their professions; in industry the specialists are bereft and denied the opportunity of learning the commonest elementary rudiments of industry other than the same infinitesimal part performed by them perhaps thousands of times over each day.[180]

The AFL's conclusion was unequivocal: "Our movement in advocating industrial education protests most emphatically against the elimination from our public school system any line of learning now taught."[181]

Several reasons lay behind their opposition to over-specialization. As in the case of their support for compulsory schooling and child labor laws, they did not want trade schools to, as John Golden, General President of the United Textile Workers of America, put it, "turn out a

[178] Ibid., 15.

[179] Ibid., 24.

[180] Ibid., 6.

[181] AFL, 6.

young man in a few months time" and "flood the labor market with half-baked journeymen."[182] Further, Golden asserted that skill still comprised an essential component in bargaining with employers, adding: "And let me ask you, why should not the union craftsman jealously guard the only asset he has in the world against those who would not hesitate a moment to depreciate its value? It is the only means he has to maintain his home and provide for those dependent upon him."[183] It was 1909 and, in rhetoric at least, the "house of labor" had not fallen—individual skill was still understood as a possession granting a degree of economic autonomy for the man seeking a "family wage."[184]

John Mitchell struck a more conciliatory note, emphasizing the benefits of broad industrial training for the nation and business itself. He deplored that the apprenticeships existing in private industry had become over-specialized due to the rapid growth of different departments in many firms and that they could no longer foster the "thoroughly trained mechanic." This benefitted no one, argued Mitchell, because "the higher skill possessed by the mechanic, the more valuable is his labor…to himself, his employer, and the community."[185] Again invoking the threat of foreign competition, he considered acquiring "an equivalent to our old apprenticeship system" necessary to "maintain our present standards in the industrial world."[186] Mitchell proposed an intimate connection between the fate of the nation's industries as a whole and the

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[182] "Address by Mr. John Golden, general president of the United Textile Workers of America, July 1909," quoted in United States Bureau of Education, *Report of the Commissioner of Education [with Accompanying Papers], Vol. 1* (Washington D.C., 1909), 155.

[183] Ibid.

[184] David Montgomery, *The Fall of the House of Labor: The Workplace, the State, and American Labor Activism, 1865-1925* (Cambridge: Cambridge University Press, 1987).

[185] Mitchell quoted in AFL, 9.

[186] Mitchell quoted in AFL, 9.

degree of comprehension the individual worker held of the theoretical content of his work, down to knowing why a joint at a certain angle is strongest.[187]

Golden had cast such knowledge in terms of workers' bargaining power, but he too concluded in solidarity: "what is now needed more than anything else is for all classes to get together and cooperate in this great movement, which is not a question of capital and labor, anymore than it is a subject to exploit our fads and fancies."[188] Industrial education was "not a fad, but a stern reality and absolute necessity."[189] Labor's arguments for securing the broadest form of technical education situated within public schools, however, had borrowed significantly from the previous fight for the "fads and frills."

Instead of opposing liberal education, many calls for vocational education had built directly upon the successes of the battle for curricular expansion via vestiges of Free Labor ideology. Historian Jürgen Herbst has emphasized that the German influence on American education that "moved on two levels," as "part of the broad stream of popular immigration and on the more rarified plateau of higher education and elite culture."[190]

Organized in 1906 by James P. Haney, director of art and manual training in New York public schools, and Charles R. Richards, professor of manual training at Teachers College, the National Society for the Promotion of Industrial Education cemented these trends as a clearinghouse for reform literature and as a lobbying agency for federal legislation.[191] The

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[187] Mitchell, 155.

[188] "Address by Mr. John Golden," 155-6.

[189] Ibid., 156.

[190] Jürgen Herbst, "Introduction," in *German Influences on Education in the United States*, 3.

[191] Carroll D. Wright, "The Work of the National Society for the Promotion of Industrial Education," *Annals of the American Society of Political and Social Science* 33 (January 1909); Elizabeth Fones-Wolf, "The Politics of Vocationalism: Coalitions and Industrial Education in the Progressive Era," *The Historian* 46 (Nov 1983): 42.

NSPIE included primarily educators and reformers (Henry S. Pritchett of the Carnegie Foundation, Jane Addams of Hull House, Robert A. Woods of South End House, and Mary Morton Kehew of the Women's Education and Industrial Union) and “enlightened” manufacturers (William H. Pfahler of the Model Heating Company and Frederick W. Sivyer of the N. W. Malleable Iron Company), but also counted a few labor leaders (John Golden, James O'Connell of the International Association of Machinists, and F. J. McNulty of the International Brotherhood of Electrical Workers). The NSPIE refused to endorse any policy that might upset labor or capital since both the AFL and the NAM already suspected the other would control the organization.[192] Eventually the NSPIE succeeded in crafting a coalition that reached from the AFL to the NAM, encompassing the U.S. Chamber of Commerce, American Bankers Association, National Metal Trade Association, the Farmers' National Congress, the National Education Association, and the Southern Commercial Congress.[193]

But compromise was not easy. The deal rested on the vehemently anti-union NAM relinquishing its goal of private trade schools and the AFL yielding on the question of governance by regular public school boards. [194] Crucially, the states were left to decide whether to employ the existing board of education or to create an independent board for industrial education to preside over federally-funded vocational education. Passed with nearly unanimous support in 1917 after years of bargaining, the Smith-Hughes Act relied on a more compromised coalition than that of Northern labor leaders, industrialists, and social reformers (both Frederick

[192] Ibid., 42, 45.

[193] Ibid., 43, 52-53.

[194] Ibid., 54.

W. Taylor and Samuel Gompers endorsed the legislation).[195] Some of its strongest advocates were Southern Democrats. The act's namesake and principal author, Senator Hoke Smith of Georgia, was an architect of New South economic and segregationist policy, which aimed to connect the longstanding exploits of cotton cultivation with a growing textiles sector designed to capture world markets.

Industrial Education and Assimilation Politics in the Indian School Service

Having promoted the kindergarten and Froebelian methods in school systems in Kentucky, Michigan, Minnesota, and Indiana and as president of the department of elementary education of the NEA, William Hailmann became superintendent of the Indian School Service in 1894. The position had existed since 1882, and had grown in the meantime from determining contracts for staff and supplies to managing a bureaucracy and curriculum aimed at achieving the full assimilation of Native Americans.[196]

The federal assimilation project had begun not only by conquest, but in conquest. Richard Henry Pratt, originally a tinsmith from Logansport, Indiana had served in the Civil War and then fought in the Washita River campaign and Red River War as a cavalry officer and commander of Indian scouts from 1867 to 1875. In April 1875, Pratt drove seventy-two imprisoned Kiowa, Comanche, and Southern Cheyenne warriors to Fort Marion, Florida.[197] Two years later, Pratt received the blessing of the War Department to transfer the men to Hampton Institute, the

[195] On the coalition, see Fones-Wolf, "Politics of Vocationalism"; John Hillison, "The Coalition That Supported the Smith-Hughes Act or a Case for Strange Bedfellows," *Journal of Vocational and Technical Education* 11 (Spring 1995): 4-11.

[196] Frederick E. Hoxie, *A Final Promise: The Campaign to Assimilate the Indians, 1880-1920* (Lincoln: University of Nebraska Press, 2001 [1984]), 62.

[197] Hoxie, *A Final Promise*, 54.

Virginia industrial school for freedmen founded by the American Missionary Association and run by General Samuel Chapman Armstrong. Armstrong had spent his youth as a missionary in Hawaii, and he introduced Pratt into a network of evangelical reformers and like-minded congressmen. Due to Armstrong's influence, Pratt came to the conclusion that education could transform Native Americans: "kill the Indian, save the man."

In 1879 Pratt proposed to establish a boarding school specifically for Native Americans and received permission from Secretary of the Interior Carl Schurz, a German immigrant '48er and spouse of kindergarten reformer Margarethe Meyer Schurz. Pratt's curriculum would combine a common-school education with manual training. Schurz approved an initial enrollment of 150 students with a promise of further funding conditional on performance. The War Department donated the barracks at Carlisle, Pennsylvania, twenty-seven acres of land in total. By 1890, the school would house nearly one thousand students. By 1909, Carlisle had expanded to employ seventy-five teachers teaching courses in "Agriculture, Teaching, Stenography, Business Practice, and Industrial Art" on over three hundred acres, including 49 buildings and two school farms.[198]

The industrial education projects at Hampton and Carlisle garnered renown, as the schools' print shops published journals sent at no cost to members of Congress and the Cabinet.[199] Carlisle's superintendent, Moses Friedman, had been born in Cincinnati, one of the vertices of the "German triangle," in 1874, as the son of a German-Jewish immigrant and a Southern belle. He graduated from the Teaching School of the University of Cincinnati in 1899, and proceeded to teach in the private school system (with some likelihood, a German-English

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[198] Moses Friedman, "The Improvements at Carlisle Indian School: By the Superintendent," *The Indian Craftsman* (1909): 3-17.

[199] Hoxie, *A Final Promise*, 55-56.

academy) in the city. Joining the Indian Service in 1901, he was posted to the Phoenix Indian School until 1904, when he moved to the Philippine Service.[200] In 1906, Moses Friedman transferred from government service as a teacher involved in establishing industrial education in the Philippines to the role of Assistant Superintendent at Haskell Indian School in Lawrence, Kansas.[201] While at Haskell, Friedman gained a national audience for his ideas regarding industrial education via publications recounting and analyzing his efforts in the Philippines and in the Indian School Service.[202]

Friedman undertook to elevate vocational training in the Indian School Service from manual labor to mechanical training, and from the agricultural and animal husbandry associated with the civilizing mission of "land of severalty" to industrial and professional skills appropriate for the machine shop, accounting office, or secretarial bureau. [203] Friedman sent fifty of Carlisle's male students to apprenticeships at industrial shops including Ford and General Electric at the wage levels of white workers in the 1910s. Friedman celebrated Carlisle graduates in the trades and in the professions of law, journalism, medicine, and engineering.[204] In reports and issues, he pointed to Leander Gansworth, a "full-blood Tuscarora Indian at Davenport, Iowa," as a "foreman of a large printing establishment" and "secretary-treasurer of the Tri-City Allied Printers Trade Council for Rock Island, Illinois, Moline, Illinois, and Davenport, Iowa." From 1882 to 1885, with growing enrollments at Hampton and Carlisle Institute and the

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[200] Genevieve Bell, "Telling stories out of school: Remembering the Carlisle Indian Industrial School, 1879-1918," (PhD Dissertation, Stanford University, 1998).

[201] "Official Report of Indian School Changes for June and July," *Indian School Journal* 6, No. 10 (September 1906): 48-50.

[202] Bell, "Telling stories out of school."

[203] Bell, "Telling stories out of school," 90.

[204] Friedman, Superintendent, Annual Report: United States Indian School, Carlisle,

establishment of six more off-reservation schools (Dakota; Genoa, Nebraska; Fort Yuma, Arizona; Haskell Institute, Kansas; Fort Hall, Idaho; Chilocco Training Schools in Indian Territory) the number of Native Americans attending off-reservation schools in the Indian School Service doubled.[205]

Hailmann worked on ethnologist Lewis Henry Morgan's assumption that boarding school students would advance quickly from "barbarism" to "civilization" and serve as "missionaries of civilization" upon their return.[206] Appointed to the position by Grover Cleveland and under the auspices of Secretary of the Interior Hoke Smith, Hailmann's assignment included administering all Indian Schools on and off of reservations in matters of personnel, textbooks and general curricula, and maintenance. Hailmann's duties encompassed visiting and inspecting the gamut of schools teaching Native Americans and compiling annual reports on them for the Commissioner of Indian Affairs.[207]

Hailmann built on and modified a model of Indian schooling established by his predecessor, Thomas J. Morgan, a former Baptist pastor who had commanded a Black regiment in the Civil War and led normal schools in Rhode Island and New York. Inspired by Hampton Institute and Carlisle, Morgan proposed a systematized national Indian school system leading to full assimilation and civic equality. Morgan's system included four phases: day schools in every Native community, which would offer an "impressive object lesson" on civilization and prepare students for elementary schools; elementary schools establishing "the foundation work" and

[205] Hoxie, *A Final Promise*, 58.

[206] Jennifer Bess, "More Than a Food Fight Intellectual Traditions and Cultural Continuity in Chilocco's Indian School Journal, 1902-1918," *The American Indian Quarterly* 37, 1 (Winter/Spring 2013): 77-110; "Prof. Hailmann's New Place: Has Accepted the Superintendency of the Dayton, Ohio, Schools," *Washington Post* (16 July 1898): 5.

[207] Hewes, *Hailmann*, 212.

grammar schools, where Native students would begin at age ten to learn trades and regular habits; and government high schools, where academically-inclined Native students would starting at age fifteen enter portals "out from the desolation of the reservation into assimilation with our national life."[208] Hailmann promoted Native American normal schools and instituted a civil service exam for the Indian School Service, which prioritized awareness of "the physical and social hardships [of Indian education]" and ability to "apply their knowledge to children's need" over purely academic concerns. Together, these reforms enabled a tripling of percentage of Native Americans employed as teachers in the Indian School Service from 1888 to 1899.[209]

Beginning in 1891, Morgan integrated Native American children into public schools nearby the reservations. Having expanded from one hundred to 268 students before he took up the post, Hailmann proceeded to double the enrollment of Native American children in regular public schools in his first year. Facing resistance from parents and teachers in white schools, Hailmann drafted a contract detailing the duties the federal government and public schools owed Native American students and defining their rights within them. Hailmann's document asserted that every Native American child receive ten dollars per quarter from the Indian Office and that the schools receiving them include them

> in classes with the white children…in the common English branches, giving to each of said Indian pupils the same care and attention in matter and methods of instruction as is given to the white pupils.[210]

Hailmann's plan also required the public schools to ensure that Native American students would learn free from "ridicule, insult, and other improper conduct at the hands of their fellow-pupils

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[208] Frederick E. Hoxie, "Redefining Indian Education Thomas J. Morgan's Program in Disarray," *Arizona and the West* 24, No. 1 (Spring, 1982): 5-18.

[209] Anne Ruggles Gere, "Indian Head White Man's Head: Native-American Teachers in Indian Schools, 1880-1930," *History of Education Quarterly* 45, 1 (March 2005): 38-65, 48.

[210] Quoted in Hoxie, "Redefining Indian Education,"

and to encourage them in every reasonable manner to attend school exercises punctually, regularly and to perform their duties with the same degree of interest and industry as…the children of white citizens." [211] The model of schooling that Morgan and Hailmann promoted in the 1890s assumed as its ultimate goal full integration of Native American students into white society, reflecting the ideal of the Indian Rights Association that the "solution of the problem lies in a natural and human absorption of the Indian into the common conditions of American life;—annihilation for the Indian race, but a new life for the individual Indian."[212]

Anglo-American missionary, colonial, and Southern education reformers such as Hampton Institute founder Gen. Samuel Chapman Armstrong dithered on biological difference (and predestination for types of work), writing that "homeless and half a vagrant, the great factors of heredity and environment tell against the Indian so largely as to make a tremendous difference between him and the white child."[213] The Swiss-born Hailmann argued that through schooling "we turn his being in another direction; we change his heredity."[214]

Discounting biological difference or an inexorable encrustation of history, Hailmann nevertheless valued the preservation of culture. He was consistently frustrated with members of the Indian School Service who failed to recognize the "habits of life and historical development of the tribes with which they worked."[215] In his Froebelian framework, Hailmann emphasized the role of drawing and music in the curriculum as well as pottery-making and basket-weaving. There was an economic angle to Hailmann's incorporation of crafts into the curriculum. In 1894

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[211] Ibid.

[212] Harmon, "When Is An Indian Not An Indian?" 97.

[213] Ibid., 103-104.

[214] Ibid., 103-104.

[215] Hewes, *Heilmann*, 217-218.

Hailmann proposed, “additional gain might come in the industrial training by taking into account at the different schools the local Indian industries, such as tanning and pottery among the Pueblos, blanket-weaving and silver work among the Navajos, boat-building among the Indians of Puget Sounds, etc.” Anne Ruggles Gere situates Hailmann’s policy within the wider transition away from total assimilation toward the retention of culture aspects such as art capable of being commodified at the turn of the century. Indeed, the *Indian School Journal* advertised retailers selling Navajo blankets and curios, while the Indian Print Shop in Chilocco distributed photographs of Native American women, crafts, and ceremonial dances to buyers nationwide.

Hailmann, however, struggled with the question of commodity production and paid crafts work in the Indian School Service. Beyond the baseline lack of federal funds to implement a broad, Froebelian curricular program, the logics Hailmann employed to grapple with this question reflected strands of German social thought melded with an ideology of economic independence indebted to labor republicanism. Calling for the maintenance and elaboration of specific indigenous forms rather than national standardization, Hailmann hoped students would find a universal species being: “the sweet joys of productive and creative labor which alone make life worth living.”[216]

Although the school service primarily aimed to instruct boys in farm and mechanic work and girls in domestic labor, Hailmann feared that attaching monetary sums to crafts would lead down the path away from education and toward manufacture alone.[217] He had observed that boarding schools focused more on “the pecuniary results” of Native American students’ work

[216] Anne Ruggles Gere, “An Art of Survivance: Angel DeCora at Carlisle,” *The American Indian Quarterly* 28, 3-4 (2004): 649-684; Hewes, *Hailmann*, 217-218.

[217] Hewed, *Hailmann*, 215.

than the educational worth of the activity in making. His first annual report voiced these concerns:

> If the school farm is to produce valuable results in the lives of the boys the farmer who directs their work should look upon this as the chief end of his labors…In many workshops the harness-makers, shoe-makers, tailors, blacksmiths, carpenters, wagon-makers, painters and so on, seem to be intent upon turning out a large number of articles…making the boys unthinking pieces of machinery…mere toilers at jobs, not workmen with intelligent purposes and actuated by the artisan's interest…I am prepared strenuously to recommend that in reservation boarding schools the position of industrial teacher be entrusted only to persons adept in the methods of the modern manual-training school. [218]

For Hailmann, market-oriented serial production threatened autonomy and the "developing method" in reservation and boarding schools. Later in his tenure as superintendent, however, Hailmann advocated the reintroduction of paying Native American students for work as a means to inculcate virtues and habits such as thrift and an understanding of the wage relation. Hailmann also invoked budgetary reasons, claiming that the schools would no longer have to provide Native American students with clothes, which they could purchase with wages earned. [219]

Estelle Reel replaced Hailmann as superintendent of Indian schools in 1898, and began dismantling both the assimilationist and egalitarian elements of his agenda. She abandoned public school integration; the number of districts participating in the program fell from forty-five in 1896 to only a dozen in 1903.[220] Rather than view mental and manual activities as complementary, her 1901 curriculum imposed a stark binary, emphasizing that "higher education has no place in the Indian schools" and asserted that the "theory of cramming the Indian child with mere book knowledge has been and for all generations will be a failure." Reel's six-year curriculum centered on farming, with students moving from "light chores" to caring for

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[218] Ibid., 217-218.

[219] Ibid., 217-218.

[220] Hoxie, "Redefining Indian Education,"

livestock. The remainder of studies included arithmetic, reading, spelling, and history to fashion "good, patriotic citizens" as well as baking, basketry, blacksmithing, canning, carpentry, cooking, harness-making, and upholstery. Working in the Indian school service in Phoenix and elsewhere, Estelle Armstrong lamented, "Education today is a word of broad interpretation."[221]

Armstrong implicitly criticized Hailmann's promotion of Froebelian and *Bildung*-based learning, writing that education "is narrowed to mean the ability to read and write; it is broadened to include the culture and knowledge of centuries." The true role of teacher, in Armstrong's view, was to "cull from the mass of material at hand only those arts and precepts best adapted to the immediate needs of a race or an individual."[222] Formal difference and specificity would govern curricular decisions in the Indian school service from the turn of the century onward.

Reel's recasting of the Indian school service reflected a growing consensus among Indian reformers that races were fundamentally distinct, whether from biology or intractable history. Reel's 1903 report claimed that teachers in the service "must deal with conditions similar to those which confront the teacher of the blind or the deaf." [223] Ella H. Cooper wrote that the "occupations congenial to white men can never be successfully undertaken by the savage," and recommended that vocational training in the Indian School Service focus on basic skills such that "white men at present engaged in these occupations could turn their attention to more intellectual employment."[224] For Cooper, assuring access to fulfilling, remunerative, or joint mental-manual

[221] Victoria K. Haskins, *Matrons and Maids: Regulating Indian Domestic Service in Tucson, 1914-1934* (Tucson, 2012), 98.

[222] Estelle Armstrong, "An Appeal to the Employees of the Indian Service," *Indian School Journal* 13 (May 1913):

[223] Hoxie, "Redefining Indian Education."

[224] Ibid.

work for whites meant subjugating other races. This racial protectionism easily found an audience in the New South, where Hollis Frissell, principal of Hampton Institute in Virginia, explained to fellow educators that Native Americans were "people of the child races." Crafting a single framework, Frissell claimed that "those of us who have to do with the education and civilization of Indians can learn many things from the dealings of our southern friends with the plantation negro" since the plantation constituted "a much more successful school for the training of a barbarous race than…the reservation."[225]

As commissioner, Francis Leupp reoriented the Indian schools toward narrow vocational training, arguing that "most Indians will try to draw a living out of the soil," or otherwise "enter the general labor market as lumbermen, ditchers, miners, railroad hands and what not."[226] He set up an Indian employment bureau with Charles Dagenett, a graduate of Carlisle, whom he told to "gather up all the able-bodied Indians who…have been moved to think that they would like to earn some money, and plant them upon ranches, upon railroads, in mines—wherever in the outer world, in short, there is an opening for a dollar to be got for a day's work."[227] In the three years following its founding in 1906, the bureau expanded from five thousand Native workers employed in Colorado beet fields and on southwestern construction projects and sheep ranches to activities in Wisconsin, California, Montana, and the Dakotas. Working under white foremen, gangs of Native workers labored under contracts, which established a determined amount of time or task and required employers to provide transportation and a campsite. According to one school superintendent in Arizona, employers flocked to the bureau "because they are cheaper than the same grade of white help," earning six to twenty dollars per month rather than fifteen to

[225] Ibid.

[226] Ibid.

[227] Quoted in Hoxie, "Redefining Indian Education."

forty. [228] Leupp celebrated the innovation for identifying and leveraging "certain racial traits of the Indian, such as his lack of initiative, his hereditary lack of competition, etc.," to "woo him into the labor mart." [229]

Titles of speeches given at the 1906 meeting of Indian school officials at Tacoma, Washington give a sense of the racial politics and political economy of curricular narrowing: "Developing in the Young Indian a Strong Sense of Individual Responsibility" (E.L. Chalcraft, superintendent of Salem Indian school, Chemawa, Ore.), "The Importance of studying the Pupil and Acquiring an Intimate Knowledge of His Home Life and Environment, His Ambitions, Capabilities and Individuality, and His Educational Needs in Equipping Him for His Probable Career" (W.P. Campbell, asst. superintendent of Salem Indian school, Chemawa, Ore.), "The Importance of Avoiding, in Our System of Indian Education, Fostering False Conceptions of Life and Manner of Living in the Minds of Pupils" (F.F. Avery, superintendent of Fort Spokane Indian school, Coville agency, Miles, Wash.), "Methods of Teaching Self-Support" (Matthew M. Murphy, superintendent of Western Navajo Indian school, Tuba, Ariz.), "The Importance of Training Pupils for the Work in Which They Will Most Probably Be Engaged After Leaving School" (H.G. Wilson, superintendent of Klamath and Yainax Indian schools, Klamath agency, Ore.), "The Value of Industrial Training and the Need of Better Facilities for This Work at the Smaller Schools," (Claude C. Covey, superintendent of Warm Springs Indian school, Warm Springs, Oregon), "Elementary Industrial Training at Day Schools" (E.C. Scovel, day school teacher, Rosebud Agency, South Dakota and E.E.G. Thickstun, Day school teacher, Pine Ridge Agency, South Dakota).[230]

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[228] Ibid.

[229] Hoxie, "Redefining Indian Education."

[230] "The Meeting at Tacoma," *Indian School Journal 6*, No. 10 (Sept. 1906): 35-36.

By 1914 the Fort Totten School advertised overwhelmingly agricultural schooling complemented by training in basic trades ("carpentry, painting, shoe and harness-making, engineering, tailoring and printing") in the winter. The Fort Totten School stressed that in "vocational work we do not make extravagant claims" since "about ninety-five per cent of our boys and girls eventually make their homes on their farms, and our work is primarily concerned with their preparation."[231]

School leadership underscored this seemingly practical argument with a normative one: "Any attempt to educate these children away from the farm, except in a few cases, would show an ignorance of their inclinations, abilities and opportunities."[232] A culture of yeoman agriculturists often seen by missionizing reformers and legislators such as Senator Dawes as lacking among Native peoples was suddenly ascribed to them as biological destiny in the first decade of the twentieth century. Did this represent a ceiling to "uplift" among white Indian reformers, or a wholesale shift in models?

In August and September of 1905, the year Leupp was appointed commissioner by Theodore Roosevelt, four of eight teaching appointments in the Fort Totten school and Haskell Institute as well as Shoshone, Winnebago, Pawnee, and Pipestone schools were for industrial teachers, the remainder being for two academic teachers, an assistant matron, and a disciplinarian. In the same period, eighteen academic teachers, two kindergarten teachers, and one sloyd teacher resigned from Fort Apache, Colville, Yakima, Fort Peck, Standing Rock, Rainy Mountain, Sherman Institute, Carlisle, the Great Nemaha Day School, Pine Ridge Day School, and Sac & Fox Day School.[233] Throughout the subsequent months and years, the Indian

[231] Bert R. Betz, "The Fort Totten Indian School," *Indian School Journal* 15, No. 1 (Sept 1914): 11.

[232] Ibid.

[233] "Changes Made During August and Sept. in the School Service," *Indian School Journal* 5 (October 1905):

schools focused on hiring industrial teachers and filling positions engaged in fiscal administration and labor management. The gender composition of teachers shifted from women to men. A broad curriculum gave way to skilling, industrial education as open-ended mental-manual work to vocational training.

Other parts of Hailmann's agenda, such as the civil service exam for teachers, also decayed under Leupp. A Mrs. Elmora Washington, a Black woman from Arkansas, achieved a high grade on the exam in 1907 and won an appointment at the Kickapoo Indian agency in Horton, Kansas, with an annual salary of 540 dollars. When she was not allowed to take the position on account of race, she appealed to Leupp. [234] Whether or not Leupp ever responded, Washington's name does not appear on any monthly registers for teachers in the Indian school system for the next five years.[235]

This is hardly surprising given Leupp's racist ideology. In his first annual report, Leupp claimed that the "commonest mistake made by his white well-wishers in dealing with the Indian is the assumption that he is simply a white man with a red skin" and told the NEA in 1907 that the "Indian is an adult child" with "the physical attributes of the adult with the mentality of about our fourteen-year-old boy." [236] Leupp applied this stereotyped thinking to the project of Booker T. Washington, whom he described as

> only medium height, thick-set, broad-backed, with large wrists and powerful hands, he was evidently one who had been strengthened below before he was loaded atop. There was nothing to distinguish him from a hundred other negroes one might meet any day on an Alabama highway except his gray eyes, clear, steady, and intelligent, and his mouth, which, in spite of its African fullness, was well cut and spoke a resolute but kindly temper.

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[234] "Wouldn't Let Negro Teach," *Indian School Journal* 5 (October 1905): 13.

[235] *Indian School Journal* (1907-1912).

[236] Hoxie, "Redefining Indian Education."

In nonchalant carbon copy, Leupp reiterated: “In short, the secret of Washington’s success lies in the fact that the black man is to him a black man, and not merely a white man colored black.” [237]

In promotional materials for Booker T. Washington’s Tuskegee, Leupp criticized schools for Black students that went on “fitting its pupils to take up the law, or lecturing, or some other of the polite occupations which are already overcrowded by the white race, and in which only a negro with miraculous gifts will stand a ghost of a chance for many years to come, in the United States, at any rate.” By contrast, Leupp praised Washington’s school, “where the training of the hands goes along with the training of the wits, with a view to making its graduates the best blacksmiths, the best bricklayers, the best carpenters, the best farmers, in the South, prepared to conquer local prejudice noiselessly through the conquest of the labor market.”[238]

Similarly, Leupp commended Washington as someone who “never did and never would spoil a plowboy to make a man; for his ideal negro is one with character enough to be a man while he treads the furrow, and whose distinction consists in his ability to throw his brain ahead of the plow while his body follows it.”[239] Leupp employed the inseparability of head and hand, once a mainstay of Free Labor ideology, to deny Black students access to the professions, including one would-be teacher in the Indian School Service Elmora Washington.

Synthesizing lessons from Indian schooling and Tuskegee, Leupp interpreted “independence” as freedom from Northern charity and federal funds alike. Leupp argued that Booker T. Washington’s key insight was that

> only hope of the adult negro…was to get out of the atmosphere of pauperism or childish dependence and learn the lesson of self-support. Every free gift like this tended merely to

[237] Francis E. Leupp, “Why Booker Washington Has Succeeded in His Life Work,” *Outlook* (May 31, 1902): 326.

[238] Ibid.

[239] Ibid.

> throw the poor fellow back a way. The only money which would do him good was that which he earned by his own labor and saved by self-denial.[240]

More specifically, Leupp approvingly cited “a Negro teacher” who pointed out that “the first thing to do was to prove to the white people that the Negro could be independent.”

Acknowledging the unequal apportioning of federal education dollars since the 1890 Morrill Act and the Hatch-George Act, Leupp summarized the rest of his reasoning as:

> In Alabama the state could give a Negro school $15 a year or $1,500—just as it chooses. If the Negroes are wise, said he, they will take the $15 dollars when it is offered, and raise among themselves whatever more they need to run their school. This will show their independence better than anything else they could do, and the white people respect independence.[241]

Capitalizing on such statements of “self-uplift,” Leupp’s endorsement of austerity, curricular retrenchment, and racism were deeply intertwined. He argued that investing in capital-intensive machinery was useless for Black and Native students due to the civilizational circumstances and occupational outlooks to which they would and should be fated to return. He asserted that the “curse of our Indian school system and of most of the Negro institutions I have seen is the labor-saving machine” because a

> Negro girl going back to her cottage in the black belt, like the Indian girl returning to her tepee on the reservation, has absolutely no use for the sort of training which he gets in the average school. After she has passed some years in a huge laundry, feeding soiled garments into a steam cylinder, regulating the draughts of the coal furnace which keeps the boiler going, turning the crank of an ironing machine, and that sort of thing, she is as ignorant as a babe unborn of what is awaiting her in the home which she will some day be expected to make for a husband of her own race.[242]

Along with the anti-miscegenation message, Leupp’s downsizing of the curriculum and investment in the Indian School Service found broad resonance among Southern and Western

[240] Leupp, “Booker Washington.”

[241] Francis E. Leupp, *Negro self-uplifting* (Tuskegee, 1902), 10.

[242] Ibid., 17.

congressmen opposed to costly "humanitarian" measures aimed at integrating racial minorities into society and polity. [243] Advocates of American imperialism argued that Native Americans should pursue self-improvement like Filipinos and Puerto Ricans. Arizona territorial delegate Marcus Aurelius Smith criticized Thomas J. Morgan's and William Hailmann's education system as "only frittering away the money in a humane chase after a dream."

In 1903 Smith told the House of Representatives "that when the first steam locomotive went through the Apache reservation…more was done for Indian education generally than the Carlisle school will do in the next century." [244] Leupp's curriculum ushered in an era of manual vocational training based on austerity and the leasing out of Native students; by 1916, a full-fledged federal bureaucracy would draft a similar plan and submit it to over twenty Indian school superintendents on reservations. According to historian Frederick Hoxie, this plan would form the "blueprint for vocational training…part of the government's standard operating policy."[245] The irony of educational austerity, based on claims of intransigent civilizational backwardness, resulting in growing federal bureaucracy seems to have been lost on contemporaries.

Having upended William Hailmann's program of Indian schooling as civilizational *Bildung*, Commissioner of Indian Affairs Francis E. Leupp and his superintendent of Indian education Estelle Reel also invoked the example of Tuskegee's graduation ceremony. In all Indian schools across the country, Reel sought to "eliminate from the curriculum everything of an unpractical nature," establishing a system culminating in a commencement where students in rough work-clothes rather than robes displayed manual skills rather than oratorical ones.[246] The

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[243] Hoxie, "Redefining Indian Education."

[244] Quoted in Hoxie, "Redefining Indian Education."

[245] Hoxie, "Redefining Indian Education."

[246] Ibid.

core impulse of Reel's reforms accorded with Commissioner Leupp's critique of fellow admirers of Booker T. Washington when they referred to him as the "Negro Moses." The proposed "simile" failed, according to Leupp, because,

> Moses led his people out of the region where they had been bondmen, and to the edge of the promised land; Washington tells his people that they are in the promised land already, and that it is theirs to make it a land of wheat and barley and vines, of oil and honey. Moses was a lawgiver; Washington puts forth no laws, but merely expounds the true meaning of laws and conditions already familiar.[247]

Where *Bildung*, mental-manual education, and curricular expansion had once coincided, they were now rent apart; where Free Labor had once implied a politics, inculcating "independence" as virtue—thrift, cheer, hygeine, endurance—now meant quiescence to hierarchical forms of political economy, which racially divided farm from factory and subordinated the claims of Black schools and Black workers within each setting.

The colonial uplift and civilizational exchanges between Indian schools and Hampton Institute had mapped the "Southern Workman" (the title of Tuskegee's school newspaper) onto students from the reservations in the 1890s; by the early twentieth century, however, both schemes had been supplanted by even more racist conceptions of Native and Black ability, more limited horizons of curricula and future prospects for Native and Black students, and even more overt forms of school segregation, funding discrimination, and exploitation, such as Indian schools organizing gangs of Native students for contract labor on infrastructure projects. Reinterpretations of mental-manual education had cut the path from potential citizens to colonized people in the first decades of the twentieth century, as the federal government took up a wider role in education.

[247] Leupp, "Booker Washington."

Industrial Education and the New South

Such a coalition had been presaged in a speech by then-Commissioner of Education and erstwhile "St. Louis Hegelian" William Torrey Harris at the 1895 National Congress of Education in Atlanta. Harris praised the building of a "New South and its cornerstone...the school," particularly the "important subject of race education," where he found "that the statistics are still more to the credit of Southern statesmanship."[248] Harris compared the 1876 enrollment of "571,506 colored children, and 1,827,139 white children" in Southern schools to the 1894 figures of 1,424,995 "colored pupils" and 3,835,593 "white pupils."[249] Beyond the numerical increase, Harris proffered a world-historical argument about the advance of mechanization and the bond between education, efficiency, and prosperity. He argued that education had "increased the productive power of the individual by nearly fifty per cent" and "produced a laboring class that can use machinery to assist the strength of bone and muscle."[250]

But a reckoning awaited workers in Harris's view: "The machine is coming in at one end, and the mere drudge is going out at the other. The uneducated, unskilled man is not needed, for his hands and muscles cannot compete with the machine."[251] Consequently, Harris called for education to outfit men to become "the overseer of the machine" as the "change from hand work to brain work is a necessity."[252] He contrasted "the fertile fields of the South," where "unskilled labor does not bring good wages" with the region's burgeoning cities, where the "skilled laborer...,using tools and directing machinery, earns and receives an average of double the wages

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[248] W.T. Harris, "What the South Is Doing for Education and What Education Is Doing for the South," *The Journal of Education* 42, no. 19 (Nov 14, 1895): 323-324.

[249] Ibid.

[250] Ibid.

[251] Ibid.

[252] Ibid.

that the farm hand gets."[253] The process of urbanization would beget dislocation and opportunity alike in Harris's view, for "machinery is going out from the city to the farm, and the farm too needs fewer laborers, and can furnish more productions" and the "surplus farmers must go into mechanical industries, into transportation and commerce."[254]

During his tenure in the second Cleveland administration, Harris had served alongside then-Secretary of the Interior Hoke Smith (later governor and senator from Georgia). At the Atlanta Exhibition, where Booker T. Washington gave his famous "Atlanta Compromise" address, Harris spoke the language of the New South.[255] Heralding a "great change of vocations from the production of mere raw materials to the production of the finished product," Harris may have inspired parts of Hoke Smith's vision for the New South.

Harris perceived a coming, constantly expanding rift in which

> instead of ninety-nine drudges producing raw material and one person working to furnish and diffuse directive intelligence, it will come to pass in the distant future that one man will, by the aid of machinery, furnish the raw material, another man's labor will make the useful articles for food, clothing, and shelter, ten more will elaborate articles of comfort and luxury, the rest, more than eighty per cent of the community, will take up vocations having to do with protection and culture.[256]

During his tenure in Georgia and national politics, Hoke Smith would work to guarantee to whites the role of skilled "overseer" of the machine, especially in the arenas of "transportation and intercommunication...railroads, telegraphs, postal systems," which Harris had celebrated as "carriers of culture" and sectors with expanding employment opportunities.[257]

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[253] Ibid.

[254] Ibid.

[255] National Education Association of the United States Meeting, "In Memoriam--William Torrey Harris," *Journal of Proceedings and Addresses* 48 (1910): 195-197.

[256] Harris, "What the South Is Doing for Education."

[257] Ibid.

Harris connected his assessment of the rising tide of mechanization and commercial and industrial growth to an endorsement of markets penetrating ever more deeply, enhanced divisions of labor and interdependency, and increased international trade. The constant counterpoint in his narrative of immanently developing economic integration was the preeminence of industry over agriculture. At the turn of the century, Harris wrote that “far-reaching revolutions” in “German thought,” from national economy to civil service, had become “visible to all the world on the fields of Koenigratz and Sedan, and later they can now be seen in the specialization of German industry by which the northern nations have learned how to emancipate themselves from a dependence on the tropical population for sugar.”[258] Interdependence was apparently unacceptable and a measure of economic autarky laudable when the society with protected provision formed part of industrial civilization. A few years earlier in Atlanta Harris had castigated the “family that produces for itself its own food, clothing, and shelter” as “living on a low plane of civilization” and failing to “enjoy luxury or culture as the result of its labor.”[259]

The remedy for Harris, historically irresistible yet also requiring some boosterism, lay in urbanization and commerce, the fact that the

> city makes combinations; it seeks out the producer and buys his product, selling him its equivalent of the merchandise of the world. The city thus connects the people of its environment with the world...It should produce some specialty for the market of the world, and exchange it for a share in all the productions of mankind. Such process of exchange is like a sacramental consecration...It is a sort of living mirror of grace—by giving one’s product to the world, one gets in return manifold.[260]

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[258] W.T. Harris, “Discipline. Formal Discipline,” *The Journal of Education* 53, no. 18 (May 2, 1901): 279-280.

[259] Harris, “What the South Is Doing for Education.”

[260] Ibid.

Hoke Smith may or may not have shared Harris's nigh-providentialist framework; however, he certainly partook of his enthusiasm for capitalism, global trade, and the place of nascent Southern manufacturing within it. As a senator, Hoke Smith would introduce a resolution proposing the first congressional trade delegation to China and participate in it, accompanied by representatives of Southern cotton and textile interests.[261] Although Harris himself had long approached industrial education with suspicion, Hoke Smith's policy solutions, including racist industrial education, reflected core assumptions in William Torrey Harris's Atlanta statement of the problem and promise of the globally-connected, mechanizing world and the New South very much within it.

Hoke Smith had served as Secretary of the Interior under Grover Cleveland before two terms as governor of Georgia and eventually a senatorial career as chairman of the committee on education and labor and senior member of the committee on agriculture and forestry. Smith's 1906 gubernatorial campaign had centered on unleashing racist vitriol and promoting plans to disenfranchise African-American voters in hopes of wooing Tom Watson supporters.[262] According to historian Gregory Mixon, Smith's electoral victories "opened the way for new levels of white supremacy, through a variety of mechanisms, including state legislation, city ordinances, segregated employment, and violence."[263]

Smith focused consistently on reserving skilled, remunerative employment for whites in Atlanta and later in Washington. In the bloody Georgia Railroad Strike of 1909, led by the

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[261] Duane Conan Ellison, The United States and China, 1913-1921: A Study of the Strategy and Tactics of the Open Door Policy (George Washington University dissertation, 1974); "Enters Orient's Trade," *Washington Post* (Oct 2 1916): 3.

[262] Gregory Mixon, "'Good Negro--Bad Negro,': The Dynamics of Race and Class in Atlanta During the Era of the 1906 Riot," *The Georgia Historical Quarterly* 81 (Fall 1997): 593-621.

[263] Ibid., 595.

Brotherhood of Locomotive Firemen and Engineers in reaction to the replacement of white hostlers with black ones at lower wages, then-governor Smith refused railroad general manager Thomas K. Scott's plea for the militia to protect railroad property, claiming that "partisan" action "might increase rather than lessen excitement."[264] He allowed the violence to continue, while calling for arbitration, sending his attorney general to investigate, and releasing a weak statement against citizens impeding the railroad's operation.[265]

In reality, he agreed with the strikers. Having spoken with Smith, E.A. Ball of the Brotherhood of Locomotive Firemen and Engineers found that "he was favorable to not having negro employment upon a train, and he even went so far as to state that, if his term of office had not been drawing to a close, that he would guarantee in a short time that there would be no negroes employed as Engineers, Firemen, Conductors or Brakemen on any of the Georgia railroads."[266] *Harper's Weekly* noted the quite intended consequences: "the strike may culminate in a demand for the complete elimination of negro firemen from the road's service; and it is even predicted that the movement will spread to every railroad in the South…the [black] race is now threatened with complete loss of this occupation."[267]

Hoke Smith brought the same segregationist economic agenda to congressional debates over vocational education. To win supporters among the northern coalition that already formed behind technical schooling, Smith and his Commission on National Aid to Vocational Education, a congressionally mandated group that the NSPIE had pressed Smith to request in exchange for

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[264] Hugh B. Hammett, "Labor and Race: The Georgia Railroad Strike of 1909," *Labor History* 16, no. 4 (1975): 470-484.

[265] Ibid., 475.

[266] Quoted in Hammett, "Labor and Race," 476.

[267] "The Georgia Race Strike," *Harper's Weekly* 53 (June 5, 1909): 5.

support on his agricultural extension bill, donned the mantle of the trans-Atlantic social reformers. The Commission invoked as usual Germany's economic might and its exemplary industrial education in their report. But the Commission's report reflected Smith's success in ensuring a strong southern tilt.[268]

While the Commission noted as its main source Edwin G. Cooley's *Report to the Commercial Club of Chicago*, it offered a new interpretation of German technical education, one aimed at justifying stratification and local rule. It emphasized that vocational education in Germany "undertakes to meet the requirements of every occupation, however simple."[269] Smith underscored that Germany's vocational schools were "almost as diverse in character as are the occupations of her workers" and that their purpose had "been not simply to develop a national system of education, but rather to provide in each locality and for each group of workers, schools adapted to the special needs of the locality and occupations of the workers."[270] Smith co-opted the reform discourse around German pedagogy to his own ends: racially-determined labor markets, especially those designed to keep Black workers in share-cropping.[271]

The vocational education system reached in the Smith-Hughes Act reflected the fact that these questioned were answered in strikingly different modalities in Northern cities, then in the throes of reckoning with the "social question," and the New South, headily entering a racist path of industrialization yet hungry as ever for expanding cotton production and securing cotton

[268] Smith had attempted to secure southern dominance in the makeup of the Commission, and Charles Prosser, secretary of the NSPIE, wrote to Secretary of Commerce William Redfield to express his organization's fear that this would result in "sectional control."

[269] "Appendix A: Vocational Education in Germany," *Vocational education: Report of the Commission on National Aid to Vocational Education* (Washington D.C., 1914).

[270] Ibid.

[271] On the specific measures taken to impose differential funding and curricula, see Regina Werum, "Sectionalism and Racial Politics: Federal Vocational Policies and Programs in the Predesegregation South," *Social Science History* 21 (Autumn, 1997): 399-453.

markets. Moreover, federal investigations touching on crafts, apprenticeships, and the historical significance of industrialism explicitly excluded Black and Native American schools. For instance, Holmes Beckwith's 1913 report on the applicability of German technical training in the American context succinctly cordoned them off:

> Of all the schools or parts of schools in the United States which have an industrial character the following will be omitted from consideration: Agricultural schools, schools for negroes or Indians, higher technical or engineering schools, and industrial art schools. The attempt will be made to discover what has been done to forward industrial education for the great masses in industry.[272]

The "great masses" needing the restorative or uplifting power to practice skill, creativity, or self-determination in industry were assumed to be non-colored, if not quite wholly white yet.[273]

Smith possessed progressive credentials, reflecting the range, malleability, and flaws of progressive social politics.[274] In an address on "Popular Education as the Primary Policy of the South," Smith referred to Northern organizations as "big-hearted, patriotic philanthropists" who had arrived in the South "to confer upon what to us is the most important of subjects—education."[275] As head of the Atlanta school board in the late 1890s following his stint as Secretary of the Interior (and advocate of agricultural, mechanical, and domestic training in Indian schools) under Grover Cleveland, Smith joined the manual training movement, which had so interested Chicago's "enlightened" businessmen, and instituted courses in drawing and

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[272] Holmes Beckwith, "German industrial education and its lessons for the United States," *Bulletin of the U.S. Bureau of Education* 19 (Washington D.C., 1913).

[273] Whiteness was itself under construction in the U.S. in this era. See Matthew Frye Jacobson, *Whiteness of a Different Color* (Cambridge, MA: Harvard University Press, 1999).

[274] On Southern progressivism, see Arthur S. Link, "The Progressive Movement in the South, 1870-1914," *The North Carolina Historical Review* 23 (April 1946): 172-195; Ann Firor Scott, "A Progressive Wind from the South, 1906-1913," *The Journal of Southern History* 29 (Feb. 1963): 53-70.

[275] Smith quoted in Grantham, 122; on relations between Northern philanthropists and Southern progressives, see William A. Link, *The Paradox of Southern Progressivism, 1880-1930* (Chapel Hill, 2000).

modeling in the elementary schools as well as shop for boys and domestic science for girls.[276] The overriding racial premise of Smith's intentions, however, lay close beneath the surface in statements such as "every child in Georgia is entitled to receive a thorough education, suited to the station in life to which he can reasonably aspire."[277] He enthused about Booker T. Washington's Tuskegee, an institution that sparked debate among contemporaries and which many historians view as instilling bodily discipline and social control.[278]

Such ideas—"democratizing" education as a means of paternalist uplift, ultimately aimed at channeling a group quiescently into a predetermined labor market position—were not foreign to Northern educators, who often made similar arguments regarding the children of immigrants.[279] Henry S. Pritchett praised industrial education for immigrant children as more democratic because it offered "an equal opportunity for each, not of acquiring the same knowledge, but of acquiring the knowledge…which…will do the most to make him a useful, contented, and happy man."[280] This line of reasoning translated the push for curricular expansion into the basis for segmentation.

However, Smith's racial protectionism did not imply an education policy of liberal studies for whites and industrial education for blacks; rather, as Horace M. Bond argued in *Negro Education in Alabama: A Study in Cotton and Steel*, within the context of New South

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[276] Smith quoted in Grantham, 119; see also Barry M. Franklin, "Progressivism and Curriculum Differentiation: Special Classes in the Atlanta Public Schools, 1898-1923," *History of Education Quarterly* 29 (Winter 1989): 571-593.

[277] Smith quoted in Grantham, 31.

[278] See, for instance, the introduction to Andrew Zimmerman, *Alabama in Africa: Booker T. Washington, the German Empire, and the Globalization of the New South* (Princeton, 2012).

[279] Sol Cohen, "The Industrial Education Movement, 1906-17," *American Quarterly* 20 (Spring 1968): 95-110; more generally, Matthew Frye Jacobson, *Barbarian Virtues: The United States Encounters Foreign Peoples at Home and Abroad, 1876-1917* (New York, 2001).

[280] Henry S. Pritchett, "Industrial and Technical Training," *Educational Review* 23 (March 1902): 290-299.

development schemes, it meant training whites for skilled, independent, and remunerative industrial employ and blacks for unskilled, marginal, and subservient work in the crafts or agriculture (with the exception of efforts by the Tennessee Coal, Iron and Railroad Company to establish schools for African-American children in hopes of employing them as semi-skilled labor to force down local wage rates to 60 percent of those accorded to steelworkers in Chicago and Pittsburgh).[281]

In the 1890s, Southern advocates for industrial education had argued that academic training was useless for impoverished rural blacks, while opponents had stressed that such education perpetuated and promoted segregation and exploitation.[282] Reflecting on racialized industrial education in the 1930s, Bond wrote:

> Now, by one of the choicest bits of irony it is possible to imagine, there is little opposition to giving an academic training to Negroes anywhere in the South, while Negroes themselves are feeling more and more the need for training in the vocational pursuits of modern life. Thirty years ago, school boards were contemptuous of Latin, French, and German in schools for Negroes, insisting on industrial courses instead, although, to be sure, they appropriated very little money to institute these courses. Today, the Negro high school may have Latin, Greek…but the large appropriations for…machinery go to the white schools.[283]

Nevertheless, African-American educators had harbored hopes for the Smith-Hughes Act, a bill that would not only provide funding for high-school courses in scientific agriculture, industrial trades, and home economics but would also finance training at normal schools to develop a generation of teachers.[284] This promise remained unfulfilled due to provisions that Southern

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[281] Horace M. Bond, *Negro Education in Alabama: A Study in Cotton and Steel* (Associated Publishers, 1939).

[282] Zimmerman, *Alabama in Africa*, 22.

[283] Horace M. Bond, *The Education of the Negro in the American Social Order* (Octagon, 1934), 404.

[284] See, for instance, a 1918 ad placed by Tuskegee in W.E.B. Du Bois's *The Crisis*.

Democrats had required of the bill, prefiguring the way they would use seniority-based positions on key committees to limit social policy in the New Deal.[285]

Indeed, the sixty-third Congress, which passed the Smith-Lever Act for agricultural extension (1914) and the Smith-Hughes Act for vocational education (1917), marked the return of Southern dominance. Through the creation of a one-party state, southerners had come to hold 103 of 291 Democratic seats in the House and 22 of 51 Democratic seats in the Senate.[286] Southern legislators determined that the Smith-Hughes Act, despite apportioning funds based on population (rural for agricultural training, urban for industrial training) on a federal-state matching basis, would ultimately grant individual state boards sway over many financial and curricular decisions.

Fearing that Southern politicians would deny funds to Black colleges, Republican Wesley L. Jones of Washington had introduced an amendment to the Smith-Lever Act for federal funding to be "equitably divided" between white and Black schools in the segregated South. The Senate voted against the Jones Amendment by a 32-23 margin, with southerners casting a dozen votes against and none for. Opposing the Jones Amendment, Senator James K. Vardaman declared that directing agricultural extension work was the purview of the "the Anglo-Saxon, the man of proven judgment, initiative, wisdom, and experience."[287] The funding stipulations of the Smith-Hughes Act mirrored those of the previous Smith-Lever Act with predictable results.

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[285] See also Bond, *The Education of the Negro in the American Social Order*; Charles Wilbur Florence, "The Federally-Aided Program of Vocational Teacher-Training in Negro Schools," *The Journal of Negro Education* 7 (Jul. 1938): 292-302; Doxey A. Wilkerson, "The Vocational Education, Guidance and Placement of Negroes in the United States," *The Journal of Negro Education* 8 (Jul. 1939): 462-488; on Southern Democrats and the New Deal, see Ira Katznelson, *Fear Itself: The New Deal and the Origins of Our Time* (New York, 2013).

[286] Philip A. Grant, Jr. "Senator Hoke Smith, Southern Congressmen, and Agricultural Education, 1914-1917," *Agricultural History* 60, 2 (Spring, 1986): 111-122.

[287] Ibid.

In 1934 Doxey Wilkerson found that in eighteen Southern states, ninety percent of federal funds for vocational education, or $3,297,341 of $3,634,27 total, went to white schools.[288] Based on population numbers, he calculated that Black southerners had received only 48 percent of their share of the vocational education budget—more specifically, 52 percent of their share of funds allocated to teacher-training, 50 percent of those directed toward agriculture, 43 percent of those intended for home economics, and only 29 percent of those aimed at courses in the trades and industries.[289] Wilkerson also found that "compared with the white pupils, in proportion to total enrollments about 53 per cent more of the Negro pupils were enrolled in agriculture and about 47 per cent fewer in trades and industries."[290] While the AFL demanded that industrial students be free learn about the Siemens-Martin and Bessemer processes and not restricted to a single, Taylorized trade, African Americans in the South were confined to the land or a pre-industrial era. Bond wrote with indignation, "the apparatus for teaching shoemaking in the typical Negro schools is as antiquated as that of a medieval cobbler."[291]

Parts of the German-language press followed the nexus of racialized work, skill, and education in the South with keen interest. For instance, in 1909 the *New Yorker Volkszeitung* commented on those obstructing the progress of compulsory schooling laws in the Alabama state legislature—namely, Senators Jones and Reynolds, who claimed that "education spoils n*****" ("*Bildung verdibt Neger*"), a "risk" that they were unwilling to take according to the German-language newspaper. The article concluded with the bitingly laconic observation that Jones "is a large plantation-owner and employs hundreds of blacks." Similarly, in 1914 the *New Yorker*

[288] Wilkerson, "Vocational Education," 478.

[289] Ibid.

[290] Ibid., 472.

[291] Bond quoted in Wilkerson, "Vocational Education," 476.

Volkszeitung attacked Governor Blease of South Carolina, who was "appalled that the colored students of the Port Royal Agricultural School had been inoculated with 'social equality' ['*Soziale Gleichberechtigung*'] and called on the legislature to oppose these goings-on."

In North Carolina and Georgia, vocational education boards instituted under the Smith-Hughes Act authored curricula that differed on the basis of race; a white secondary school student might learn "mill math/calculus" or looming and loom-fixing, a Black secondary school student was more likely to encounter shoemaking and bricklaying.[292] In Texas, "practical shop work" meant "woodwork, electrical construction, machine shop, forging, sheet metal, wood patternmaking, modern building construction, and auto mechanics" for white students; the same category of "practical shop work" for Black students listed courses in "woodwork, blacksmithing, auto mechanics, tailoring and dry cleaning, shoemaking, plumbing, printing, laundry work, stationary engineering, painting, and cement work."[293]

A member of the progressive wing of Southern Democrats, Smith evidently registered less alarm at the possibility of union involvement in policymaking via a designated seat at the Federal Board of Vocational Education than at the specter of the Black engineer. Indeed, in debate over potential racial discrimination in appropriations for agricultural and mechanical training via the Smith-Lever Act, Hoke Smith had asserted, "I never saw a negro (in Georgia) who was a civil engineer. . . or a mechanical engineer," then asked Senator Jones if he would "'waste half of this fund- upon the 900,000 negroes or the rural section of Georgia where there is nobody competent to do the demonstrating?," and declared, "You are dealing with the masses of

[292] Werum, 430-431; Bond, 404-5.

[293] Texas State Board for Vocational Education, "Outlines of plans for vocational education in Texas under the Smith-Hughes Act" (Austin, 1920).

the Negro who are not ready for it."[294] Completing the circuit of disenfranchisement and skills dispossession, some states proposed to finance their matching funds for federal spending on vocational education via poll taxes. This surely would have pleased Hoke Smith's ally from Mississippi, Senator Vardaman, who had explicitly declared his opposition to the Fifteenth Amendment in the course of debate leading up to the passage of the Smith-Lever Act.

A thorny dualism characterized industrial education initiatives. Andrew Zimmerman has explained the janus-faced politics of industrial education at Hampton and Tuskegee Institutes as constituting a "containment" of "black self-emancipation in a double sense."[295] Zimmerman argues that Tuskegee and Hampton "sought to control black struggles for freedom, but...also preserved these efforts." On one hand, drawing on the colonial pedagogy of General Samuel Chapman Armstrong, Tuskegee's form of industrial education aimed to inculcate "aptitude and enthusiasms for physical labor and personal virtues, such as cleanliness, sobriety, thrift."[296] On the other hand, Tuskegee nurtured George Washington Carver's efforts to emancipate Black farmers from dependence on monoculture--and the concomitant threats of commercial or natural disaster and debt peonage--by a science of crop diversification. Prior to their public falling out, Booker T. Washington also attempted to recruit W.E.B. Du Bois to teach at Tuskegee, which Zimmerman imagines in a counterfactual would have recast the institution as resisting and ultimately transforming the political economy of the South.[297]

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[294] Quoted in Seals, "The Formation of Agricultural and Rural Development Policy with Emphasis on African Americans."

[295] Zimmerman, *Alabama in Africa*.

[296] Ibid.

[297] Ibid., 22.

Similarly, NAACP founder and National Association of Colored Women president Mary Church Terrell wrote in her memoirs that she had

> never seen a Commencement like Tuskegee's before. On the stage before our very eyes students actually performed the work which they had learned to do in school as a part of the exercises. They showed us how to build houses, how to paint them, how to estimate the cost of the necessary material and so on down the line. I was completely taken off my feet. I was a convert with all my heart. Here was a school giving just the kind of instruction that the majority attending it needed.[298]

Terrell, who had studied in Berlin in the late 1880s following her graduation from Oberlin in 1884, saw the "lessons (or lack of them) inculcated during slavery" in the fact that "neither the white nor the colored people of the South know any more than they should about injecting system into their work or making accurate calculations."[299] In Tuskegee, itself a product of the colonially-inspired Hampton Institute, Terrell perceived a chance for fellow Black Americans to access autonomy in work and harness the power of scientific civilization. Largely sealed off from Tuskegee discursively and politically by the cordon of the color line, Northern industrial education efforts intended for whites contained a different implicit dualism vis-à-vis accommodation to or revolution against the workplace, that of the Second Industrial Revolution rather than the industrializing New South.

The Caged Simulacrum: World War I, Education Reform, and Industrial Democracy

As with many aspects of German America, the American romance with German educational models largely disappeared following the United States' entry into World War I. The *Journal of Education* reprinted a speech by German-born banker and philanthropist Otto H. Kahn on "Americans of Foreign Descent and America's Cause" in which Kahn condemned

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[298] Mary Church Terrell, *A Colored Woman in a White World* (Amherst, NY: Humanity Books, 2005), 232.

[299] Ibid., 232; Kathryn Kish Sklar, Anja Schüler, Susan Strasser, eds. *Social Justice Feminists in the United States and Germany: A Dialogue in Documents, 1885-1933* (Ithaca: Cornel University Press, 1998).

Wobblie, Socialist, and any fellow "hyphenated" Americans for disloyalty and compared the "degree of guilt as between the German people and their Prussian or Prussianized rulers and leaders for the monstrous crime of this war and the atrocious barbarism of its conduct" to "the man who, acting under the influence of a poisonous drug, runs amuck in mad frenzy and the unspeakable malefactor who administered that drug, well knowing and fully intending the ghastly consequences which were bound to follow."[300] In doing so, Kahn argued that the very "Prussianism" so admired by progressive reformers before the war had been a "devil's bargain," which had given "to Germany unparalleled prosperity, beneficent and advanced social legislation, and not a few other things of value," but taken "in payment the soul of the race."[301]

Kahn applied an existing liberal critique of social policy as engendering dependence and servility to American understandings of German models. He also alluded multiple times to the Civil War struggle and the eradication of slavery, stressing that "as Lincoln called upon Americans of the North to fight their very brothers of the South, so Americans of German descent are now summoned to join in our country's righteous struggle against a people of their own blood, which, under the evil spell of a dreadful obsession, and, Heaven knows, through no fault of ours, has made itself the enemy of this peace-loving nation."[302] Slaveholders and Prussian *Junker* had been compared to each other in German-American circles since the 1850s; repudiating Imperial Germany's models of social policy and disavowing transatlantic kinship despite a visible investment in a vibrant binationalism, now Kahn included German Social Democrats or their ideas (coopted by Bismarck) in the odious equivalence relation. Offering an alternative to peak-level corporatism or state administration as the solution to industrial conflict,

[300] Otto H. Kahn, "Prussianized Germany," *The Journal of Education* 87, 1 (Jan 3, 1918): 6-7.

[301] Ibid., 6-7.

[302] Ibid., 6-7.

Frank Walsh of the U.S. Commission on Industrial Relations had proposed extending the principles of democracy to industry.[303]

From the IWW to thinkers such as Helen Marot and John Dewey, radicals and progressives considered workers' regaining a fuller comprehension of how things were made as essential to democracy in the workplace and, by extension, the nation. Without necessarily confirming a hoary liberalism, Women's Trade Union League leader Marot rejected German education as an extension of Germany's "state socialism." [304] Casting Jane Addams into doubt, Marot claimed that the "humanitarians in the United States who tried to introduce labor legislation in their own country accepted this naive philosophy…which had been so skillfully developed by Prussian statesmen, without appreciating that its result was enervating."[305] For Marot, the Bismarckian state "enervated" citizens, who as "workers and capitalists understand their own interests and are more capable than the state of looking after them," while its school system "enervated" creativity by tracking at ten years old.

Marot and Dewey understood machine industry as an irreversible historical development in its present form corrosive to democracy yet capable of being transformed. Dewey believed that "extreme divisions of work between the skilled and unskilled" were allowing older "divisions of master and subject class…to reinstate themselves in a subtle form."[306] Only with the pursuit of a "social democracy," or "a state of social life where there is a wide and varied distribution of opportunities" and "where there is free circulation of experiences and ideas,

[303] Joseph McCartin, *Labor's Great War: The Struggle for Industrial Democracy and the Origins of Modern American Labor Relations, 1912-1921* (Chapel Hill: University of North Carolina Press, 1997), 29.

[304] Helen Marot, *Creative Impulse in Industry: A Proposition for Educators* (New York, 1918), 68.

[305] Ibid., 69.

[306] Dewey, 140.

making for a wide recognition of common interests and purposes," could one hope to restore a political democracy, Dewey urged.[307] This vision demanded that students comprise one community under a single roof.

Marot endorsed Cincinnati professor Herman Schneider's efforts to adapt the German scheme of education to America by combining academic and shop work within a single apprenticeship.[308] She approved of his classification of "energizing" and "enervating" trades, the former involving "opportunity for self-direction" and the latter "wholly automatic" and inducing "a lethargic state of mind and body," as well as his desire to eliminate the latter. But Marot concluded that even programs such as Schneider's were "pseudo-apprenticeships" if "we cannot reverse our present economic order of things."[309] For Marot, this revealed the ultimate failing of the German education system—it "imposes prevailing methods of industry and technique of factory processes as final and determined."[310]

The interest in German educational models among American reformers ended as it had begun: with an inability to accept an industrial order in which Marot found that even in one of the most "energizing" trades, locomotive engineering, "The big electrical engines which are being introduced in the railroad system are rapidly eliminating the factors of judgment on the part of the engineer and transforming that highly skilled trade into an automatic exercise."[311] Ironically, historian Hal Hansen has argued that this transformation was not the result of

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[307] Ibid., 138; James Kloppenberg, *Uncertain Victory: Social Democracy and Progressivism in European and American Thought, 1870-1920* (Oxford: Oxford University Press, 1986), 373-377.

[308] On energy in fin-de-siècle culture, see Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (Berkeley: University of California Press, 1992).

[309] Marot, 80.

[310] Ibid., 86.

[311] Brotherhood of Locomotive Engineers quoted in Marot, 81.

technological innovation alone, but rather a consequence of the American insistence that industrial education remain wholly in public schools under the governance of state boards. Hansen believes American-style industrial education exacerbated the turn toward more minute divisions of labor in the U.S.—a transition that Philip Scranton has revealed was far from inexorable.[312]

In Imperial Germany, longstanding technical education programs in the Rhineland and the nation-wide Industrial Code of 1897 had granted workshops significant training responsibilities, and this co-determination enabled students to access the latest capital-intensive equipment and related skills. Isolated from the economy, Hansen argues, American students received irrelevant, overly basic training and learned outdated methods; moreover, he claims that the ongoing dearth of skilled and semiskilled workers convinced American employers to deskill their operations yet further.[313] Working within the framework of curricular expansion, American reformers had conflated the object lessons and manual activities of Pestalozzi and Froebel with training for work, which enabled the coalition with manufacturers who hoped manual training would offer semiskilled technicians. This agenda of broad creative and manual training solely within public schools was successfully co-opted by New South legislators, possessors of a near monopoly on state- and local-level public governance, aiming for a hierarchy of technical schooling along racial lines. Only white high schools could attempt anything near a simulacrum of the most up-to-date industry.

Moreover, the AFL could not envision a "dual" public-private system like Germany's working for workers in the United States because they could not imagine coordinating with the

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[312] Philip Scranton, *Endless Novelty: Specialty Production and American Industrialization, 1865-1925* (Princeton: Princeton University Press, 2000).

[313] Hansen, "Caps and Gowns," 500-556.

National Association of Manufacturers, a group then engaged in a large-scale campaign to root out unions as such. Assuming a partially private training system would necessarily be dominated by employers, they entrusted the state with vocational education. This meant giving up the fight over skilling at the workplace—something advocates of industrial democracy began to realize in arguing that public education schemes would achieve little without altering the actual labor market and shop floor.

Chapter Five: Drafting Protection for Immaterial Property in the Age of Heavy Industry
Politics of Patentability in Imperial Germany and the United States at the Fin-de-Siècle

Writing in the midst of the Second Industrial Revolution in *The Engineers and the Price System*, social theorist Thorstein Veblen referred to assets comprising a "joint stock of technical knowledge," normally forgotten in schema of land, labor and capital as the sole factors of production.[1] The traditional "threefold plan," he argued,

> is notable for what is omits. It assigns no productive effect to the industrial arts, for example, for the conclusive reason that the state of the industrial arts yields no stated or ratable income to any one class of persons; it affords no legal claim to a share in the community's yearly production of goods. The state of the industrial art is a joint stock of knowledge derived from past experience, and is held and passed on as an indivisible possession of the community at large. It is the indispensable foundation of all productive industry, of course, but except for certain minute fragments covered by patent rights or trade secrets, this joint stock is no man's individual property.[2]

However, just as Veblen was writing, machinery firms on both sides of the Atlantic had begun pursuing strategies to enclose and develop this "joint stock of technical knowledge" into a means to draw capital.

The lathe is, in its essentials, an approximately 2700-year-old technology. It can be found most places in the world. One can identify a pole lathe in a book illustration from 1395 and the same device in Plumier's *L'art de tourney en perfection* from 1701.[3] Early modern Italian city-states, the inventors of patent regimes to lure and retain artisans capable of introducing new modes of manufacture, rarely if ever saw a need to protect lathes or lathe-makers as such.[4] Yet

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[1] Thorstein Veblen, *The Engineers and the Price System* (New York, 1921).

[2] Ibid., 28.

[3] W. Steeds, *A History of Machine Tools, 1700-1910* (Oxford: Clarendon Press, 1969), 1.

[4] See Torsten Capelle and Hans Drescher, "Drehbank und Drechslerei," in *Germanische Altertumskunde Online: Kulturgeschichte bis ins Frühmittelalter--Archäologie, Geschichte, Philologie*, eds. Heinrich Beck et al., accessed September 14, 2017, https://www.degruyter.com/view/db/gao; the discussion of Jacques Besson's lathe in the making of items for royal *Kunstkammern* and instrument collections in "Drehbank," *Enzyklopädie der Neuzeit Online,* accessed September 14, 2017, http://referenceworks.brillonline.com/browse/enzyklopaedie-der-neuzeit; Liliane Hilaire-Perez, "Dissemination of Technical Knowledge in the Middle Ages and the Early Modern Era: New

between 1870 and 1900, hundreds of patents were successfully filed in the United States for lathes. Approximately sixty patents were awarded for lathes in Germany from 1884 to 1920.[5] Over two thousand years later, did this trend reflect a spike in invention or a growing enclosure of what legally constituted property?[6]

Assuredly much had changed in the fabrication and running of machine tools over the nineteenth century: the introduction of fossil fuels as energy sources, novel kinematic regimes for turning irregular forms, manifold metallurgical improvements, and eventually electric motors.[7] In 1899, for instance, Brown & Sharpe reached out to General Electric about how GE motors would work in a context rife with gearing changes, speed variations, and shifts in the direction of motion. In response, General Electric developed motors to be attached to solo milling and grinding machines in the first decade of the twentieth century.[8]

Approaches and Methodological Issues," *Technology and Culture* 47, no. 3 (2006): 536-565; Marco Belfanti, "Guilds, Patents, and the Circulation of Technical Knowledge: Northern Italy during the Early Modern Age," *Technology and Culture* 45, no. 3 (2004): 569-589; Pamela O. Long, "Invention, Authorship, 'Intellectual Property,' and the Origin of Patents: Notes toward a Conceptual History," *Technology and Culture* 32, no. 4 (1991): 846-884.

[5] From a title and keyword search for "Drehbank" in the European Patent Office database, <https://worldwide.espacenet.com/advancedSearch?locale=en_EP>

[6] On recent IP claims as a "second enclosure movement," see James Boyle, "The Second Enclosure Movement and the Construction of the Public Domain," *Law and Contemporary Problems* 66 (Winter - Spring, 2003): 33-74.

[7] Roderick Floud, *The British Machine-Tool Industry, 1850-1914* (Cambridge: Cambridge University Press, 2006); on kinematic regimes for achieving irregular forms, see Carolyn Cooper, *Shaping Invention: Blanchard's Machinery and Patent Management in Nineteenth-Century America* (New York: Columbia University Press, 1991); on the geographic concentration of coal-based machine industry, see Theresa Gutberlet, "Mechanization and the spatial distribution of industries in the German Empire, 1875 to 1907," *The Economic History Review* (May 2014): 463-491.

[8] Ross Thomson, "Understanding Machine Tool Development in the United States: Uniting Economic and Business History," *Business and Economic History On-line: Papers Presented at the Business History Conference Annual Meeting* 8 (2010), accessed September 14, 2017, http://w.thebhc.org/sites/default/files/thomson_1.pdf.

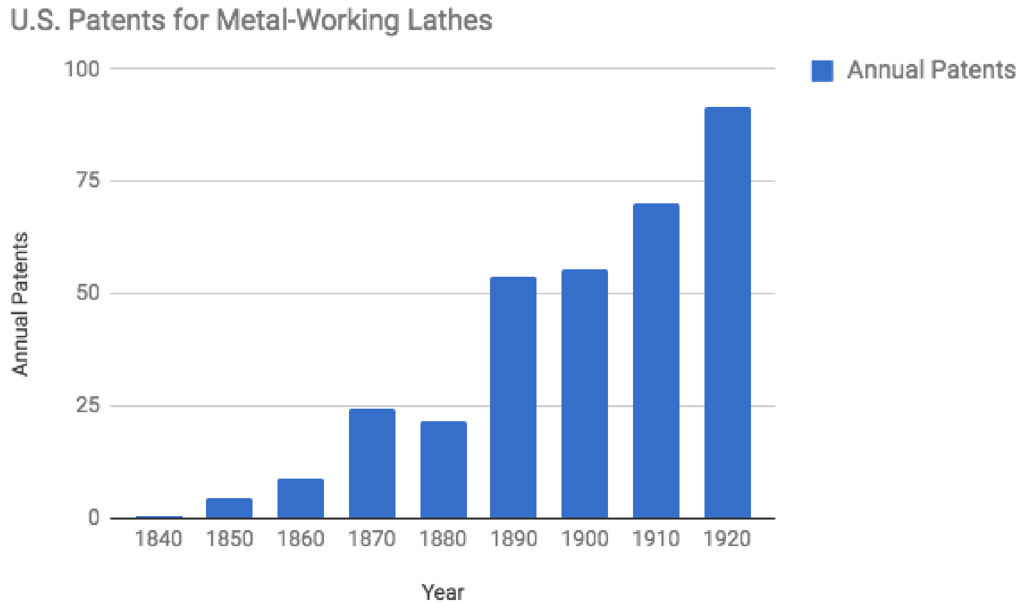

Figure 14: Based on data from Ross Thomson, "Understanding Machine Tool Development in the United States: Uniting Economic and Business History," ***Business and Economic History On-line: Papers Presented at the Business History Conference Annual Meeting*** **8 (2010), accessed September 14, 2017, http://w.thebhc.org/sites/default/files/thomson_1.pdf.**

But did the many patents entailing adjustment to and application of these features of industrial production reflect the "democratization of invention" or the rise of corporate R&D?[9] Amidst explosive growth in capital goods manufacture lurked inexplicable signs of stall-out, or a flight toward safety through a variety of monopolistic or oligopolistic practices. Whereas machine-tool works had accounted for only twenty-six percent of American lathe patents in the twenty years prior to 1865, such specialized firms claimed two-thirds of lathe patents from 1890 to 1901 and nearly seventy percent of lathe patents from 1910 to 1921.[10]

While machine-tools users such as Westinghouse Air Brake, General Electric, and McCormick Harvester also patented lathes, smaller, more general "jobbing" shops for machinery

[9] B. Zorina Khan, *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790-1920* (Cambridge: Cambridge University Press, 2005).

[10] Thomson, "Understanding Machine Tool Development."

had receded from the official annals of invention.[11] American firms entered the Great Merger Movement in the 1890s, forming multi-city machine-tools behemoths such as Niles-Bement-Pond.[12] In Imperial Germany, formal mergers such as that of Maschinenfabrik Augsburg-Nürnberg in 1898 were accompanied by the longstanding formation of cartels.

Beyond the IP strategies and travails of individual inventors in the Second Industrial Revolution, historians have rarely investigated conflicts over intellectual as industrial property as central to the making of corporate capitalism in the late nineteenth century.[13] Although the separation of ownership from management and the translation of control over work processes from workers' tacit knowledge to the routines of accounting bureaus and drafting rooms constitute core components of our understanding of this transition, the dialectic between the shifting material culture of fabrication and design and new approaches to intellectual property-making claims remains to be analyzed. Working at the levels of legal, class, and visual analysis is all the more essential for understanding transformations within German and to a lesser extent American machinery firms since the proprietor or proprietor-family often remained at the helm for decades after incorporation.[14]

The knowledge politics practiced by contemporary industrialists, engineers, and workers cannot be described simply as the triumph of the efficiency-promoting "visible hand" or the

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[11] Ibid.

[12] Naomi Lamoreaux, *The Great Merger Movement in American Business, 1895-1904* (Cambridge: Cambridge University Press, 1988).

[13] For exceptions, see David Noble, *America by Design: Science, Technology and the Rise of Corporate Capitalism* (Oxford: Oxford University Press, 1979); Kees Gispen, *New Profession, Old Order* (Cambridge: Cambridge University Press, 1989) and *Poems in Steel: National Socialism and the Politics of Inventing from Weimar to Bonn* (New York: Berghahn Books, 2002).

[14] Harold James, *Family Capitalism: Wendels, Haniels, Falcks, and the Continental European Model* (Cambridge, MA: Harvard University Press, 2009) and *Krupp* (Princeton: Princeton University Press, 2012).

progressive assault of scientific management on work processes previously controlled by workers on the path from "manufactory" to "factory."[15]

Those involved in the rapidly expanding German and American capital goods industries were acutely cognizant of an epochal transformation around them, a shift they instrumentalized in speeches to cartels and workers' associations and essays in professional journals to make organic-corporatist, liberal, populist, and socialist arguments about intellectual property. Discussions of intellectual property extended to the organization of the firm and the just distribution of profits and bodily security. Part and parcel of struggles among industrialists, shop-floor workers, and the growing cohort of white-collar workers, firms began to confront intermediate technical products—drawings and plans, measurements and metallography—as composing experiential property and started to see technical knowledge as composed of present commodities and future patent corridors.

These concerns would be joined at the *fin-de-siècle* by the internationalization of licensing agreements, the establishment of multinational branch-works in industrial enterprises, and intensifying infringement suits. This chapter analyzes how firms experimented with defining and asserting control over intellectual property in the late nineteenth century against the claims of in-house engineers seeking inventor-based ownership, inventors with an eye to lucrative licensing agreements in the context of expanding international patent accords, and industrial insurance associations who opposed patents for life- and limb-saving industrial devices as contravening the public good. Excavating the labor, legal, and financial controversies

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[15] Alfred Chandler, *Scale and Scope: The Dynamics of Industrial Capitalism* (Cambridge, MA: Harvard University Press, 2009); Alfred Chandler, *The Visible Hand* (Cambridge, MA: Harvard University Press, 1977); David Montgomery, *The Fall of the House of Labor* (Cambridge: Cambridge University Press, 1987); Jürgen Kocka, "From Manufactory to Factory: Technology and Workplace Relations at Siemens, 1847-1873," in *Industrial Culture and Bourgeois Society: Business, Labor, and Bureaucracy in Modern Germany,* ed. Jürgen Kocka (New York: Berghahn Books, 1999), 1-26.

surrounding two processes that reshaped machine-tool manufacture, the Mannesmann process for fabricating seamless steel tubes and the Taylor-White process for hardening tool steel, it shows how capital goods industrialists devoted increasing attention to gathering workplace byproducts, evidence of intermediary phases, and process knowledge to defend intellectual as industrial property.[16]

Depiction played a prominent role in all of these questions. In an 1865 address before the British Society of Engineers, Charles D. Abel argued that a

> badly drawn specification, that does not clearly indicate the nature and the extent of the invention, is a positive loss incurred by the nation, which, supposing the inventor were to die before his invention had been practically made known, would be irreparable; furthermore, it is an obstruction to inventors and manufacturers, who, not be able to ascertain how far the patentee's claim extends, cannot tell what will constitute a patentable improvement upon it, nor what it is they are debarred from using.[17]

Abel's remark built upon early justifications for disclosure under patent law as a means to prevent irretrievable losses to human progress with an inventor's mortality. But his comment also reflected growing international industrial competition, first perceptible via the impressive American performance at the Crystal Palace in 1851. When Abel called for the precise definition of inventions in drawings, he echoed arguments by engineer James Nasmyth in the 1851 British patent reform inquests, which held that an invention should be fully worked out and "matured" before filing (see chapter one). For engineering employers such as Nasmyth, provisional patenting—initially seen as a means for a true-yet-impoverished inventor to make his deal with a sponsoring capitalist—would have only muddled the process and invited suit; instead,

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[16] On the Mannesman process, see Yorck Dietrich, *Die Mannesmannröhren-Werke 1888 bis 1920: Organisation und Unternehmensführung unter der Gründerfamilie, Bankiers und Managern* (Stuttgart: Franz Steiner Verlag, 1991); on the Taylor-White process, see Thomas Misa, *A Nation of Steel: The Making of Modern America, 1865-1925* (Baltimore: Johns Hopkins University Press, 1998), 194-210.

[17] Charles D. Abel, "The Paper on the Patent Laws: read before the Society of Engineers on the 6th of February 1865," British National Archives, Kew, ZLIB 15/30.

engineering employers proposed a system of explicitly defined intellectual commodities with strict legal boundaries. Such boundaries would also enable viewing invention (and writing its history) as the progressive evolution of definite and legible variations upon and departures from a fixed mechanical scheme by single inventors.[18] For Abel, speaking at the moment American machine-tool manufacturers commenced overtaking their British counterparts, this logic applied to proprietary claims on behalf of Britain as a whole.

It is telling that the first international conventions for protecting intellectual property, the 1883 Paris accords, referred instead to legal rights in "industrial property."[19] Legal scholars such as Oren Bracha and Alain Pottage have emphasized the particularly mechanical vision of eighteenth- and nineteenth-century patent law.[20] Anglo-American patent law denied intellectual property rights to claims deemed pure physical principles—understood as the common property of humanity—or those considered merely ornamental modifications to existing technologies. National patent codes often excluded alimentary products and sometimes chemicals (though not in the German case).[21] Patent law posited a unique combination or configuration of physical elements specifically amenable to drawing. The institutionally regulated norms of patent drawing

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[18] For similar conclusions on conceptions and historiographies of invention, see Carolyn Cooper, *Shaping Invention: Thomas Blanchard's Machinery and Patent Management in Nineteenth-Century America* (New York: Columbia University Press, 1991).

[19] Conférence internationale pour la protection de la propriété industrielle, *Convention between the United States and other powers for the protection of industrial property. Revising the Paris convention of March 20, 1883, as modified by the additional act signed at Brussels on December 14, 1900. Signed at Washington, June 2, 1911* (Washington D.C.: Government Printing Office, 1913).

[20] Oren Bracha, *Owning Ideas: The Intellectual Origins of American Intellectual Property, 1790-1909* (New York: Cambridge University Press, 2016); Alain Pottage, "Law machines: Scale models, forensic materiality and the making of modern patent law," *Social Studies of Science* 41, no. 5 (2011): 621-643; William Rankin, "'Person Skilled in the Art' Is Really Quite Conventional: U.S. Patent Drawings and the Persona of the Inventor, 1870-2005," in *Making and Unmaking Intellectual Property: Creative Production in Legal and Cultural Perspective*, eds. Mario Biagioli, Peter Jaszi, and Martha Woodmansee (Chicago: University of Chicago Press, 2011): 55-75.

[21] Eugène Armengaud, *Instructions Pratiques à l'usage des Inventeurs: Commentaire raisonné des lois qui régissent actuellement les brevets d'invention dans les principaux pays industriels* (Paris: Armengaud, 1880).

in the United States, distinct from those employed in design or production in a drafting room or on a shop floor, reflected those of a mid-nineteenth-century "all-round" mechanic even well after such a figure had receded into memory.[22] A fictive "person skilled in the art" was not expected to mentally integrate the bare, perpendicular projections dictated by contemporary drafting norms according to descriptive geometry.[23] The idea of the patentable relied on the potential of pictorial representation of kinematic relationships, not descriptive truth in measure.

Yet by the turn of the century a somewhat different approach to patenting had arisen among capital goods industrialists. Beyond precisely defining discrete mechanical relationships in patenting, capital goods industrialists began to pursue two intertwined approaches to intellectual as industrial property. They began to look more deeply into collecting evidence of work processes through materials science ("strength of materials").[24] And they took initial steps to expand the notion of the patentable in articulating the case for corporate firm-based, rather than individual, intellectual property rights.

Firm-Based Patent Portfolios and Financializing "Industrial Property"

American firms such as Brown & Sharpe and William Sellers & Co. began building significant patent portfolios in the 1860s, a process that accelerated significantly from the 1880s onward. Brown & Sharpe's patents encompassed lathes, milling machines, grinding machines, and gear-cutters as well as metrological devices such as micrometer calipers. Upstream in the

[22] Rankin, "U.S. Patent Drawings."

[23] On the origins of descriptive geometry, see Ken Alder, "Making Things the Same: Representation, Tolerance and the End of the Ancien Regime in France," *Social Studies of Science* 28, no. 4 (1998): 499-545; on drafting in the United States and Europe, see Harold Belofsky, "Engineering Drawing--A Universal Language in Two Dialects," *Technology and Culture* 31, no. 1 (1991): 23-46.

[24] Stephen Timoshenko, *History of Strength of Materials: With a Brief Account of the History of Theory of Elasticity and Theory of Structures* (New York: McGraw-Hill, 1953).

production process they gathered patents for general metalworking and for steam generators. Working in tandem with their customers, machine-tools works experimented with versatility as well as speeds and feeds, precision and rigidity. Improved grinding machines cut a widening array of shapes in metal. Micrometer adjustments and gauges cut down on human measurement error. Smoothing the production process, such machines rendered long runs of standardized metal pieces increasingly automatic while protecting the machine tools themselves from damage with coolant feeds and other devices. As machine capital became more durable, its products ever more numerous, ever more precisely defined, the definition of intellectual property would somehow become more fungible.

Philadelphia machine tools manufacturer William Sellers carefully protected and procured machine designs to develop firm-based intellectual property.[25] Born in 1824 and apprenticed as a machinist to his uncle in Wilmington, Delaware for seven years, William Sellers had risen by 1864 to president of Philadelphia's Franklin Institute.[26] Along the way, he had served as a foreman in the machine shop of Fairbanks, Bancroft & Co. in Providence, Rhode Island in 1845 before leaving to manufacture mill gearing and machinists' tools in Philadelphia in 1848. The Philadelphia works became William Sellers & Co. in 1856 and were incorporated three decades later. Sellers pursued integration backward in the late 1860s and early 1870s, forming the Edgemoor Iron Company, which produced large structural components for the 1876 Philadelphia Centennial Exhibition buildings and the Brooklyn Bridge, and reorganizing the Midvale Steel Company in 1873, which manufactured steel cannon for the U.S. Government.

[25] John K. Brown, "When Machines Became Gray and Drawings Black and White: William Sellers and the Rationalization of Mechanical Engineering," *IA: The Journal for Industrial Archaeology* 25, no. 2 (1999): 29-54.

[26] "William Sellers,1824-1905," (Philadelphia, 1905), 2, HathiTrust Digital Library, accessed September 14 2017, https://catalog.hathitrust.org/Record/100445976.

Sellers began patenting in 1857, eventually accumulating around ninety patents for injectors, rifling machines, riveters, cranes, steam hammers, turntables, and ordnance.[27] The stock of technical knowledge housed in drawn plans and protected by patent law underpinned the key working and commercial capacities of William Sellers & Co.

As the drafting bureau separated from the shop and expanded its ranks, machinery firms sought to establish firm-based intellectual property. William Sellers's signature appears on no surviving plans, but the signatures of draftsmen—a category encompassing the range from mechanical engineers to tracers in the nineteenth century—are scattered across the hundreds of plans held at the Franklin Institute.[28] William Sellers & Co. employees were not permitted to claim ownership rights over any designs; rather, their signatures merely assigned credit or responsibility for the quality of the work within the firm.[29] The stock of patterns, however, formed the basis for further innovations in machine-tool design.

Sellers divided the work of the drafting room into specific design tasks. His own role included roughing out concept sketches, overseeing and suggesting alterations to the plans on draftsmen's boards, and checking completed designs.[30] In addition to the drafting room division of labor implemented by Sellers, draftsmen utilized more and more calculative tools to rationalize design practice in the late nineteenth century.[31] Distinct genres of plans had replaced the general design drawings of earlier nineteenth-century millwrights and mechanics. By the

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[27] Ibid., 5.

[28] William Sellers & Co. Collection, Franklin Institute, Philadelphia.

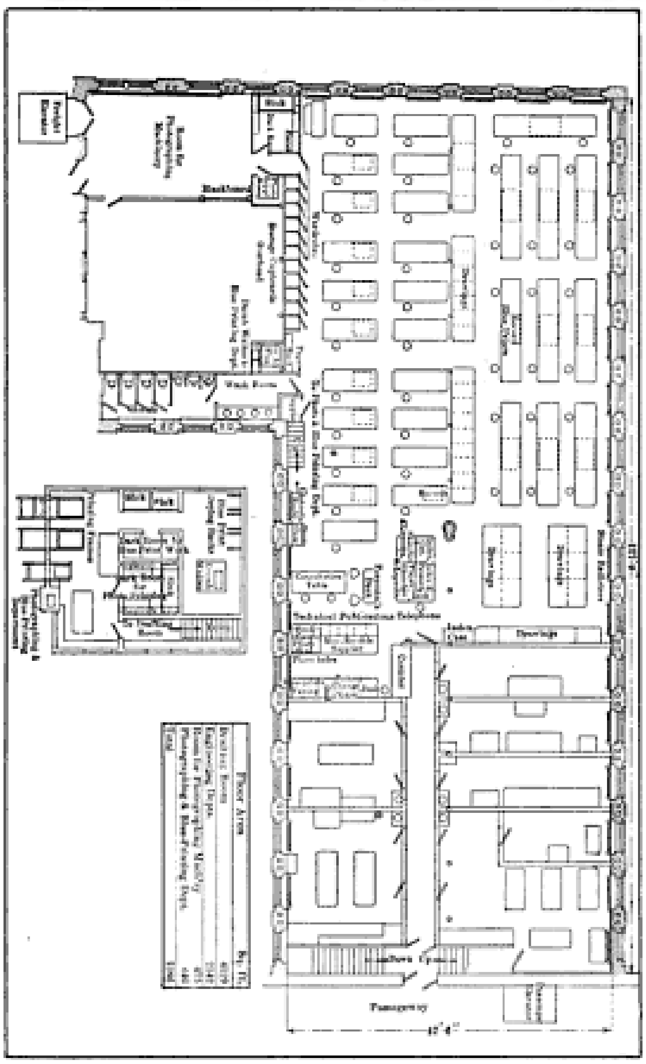
[29] Brown, "Sellers."

[30] Ibid.

[31] Ibid.

1870s, signs of rationalization had begun to extend from the working of materials into working on paper.

THE DRAFTING ROOM OF THE BROWN & SHARPE CO., PROVIDENCE, R. I.



ARRANGEMENT OF DRAFTING ROOM, BROWN & SHARPE MFG. CO., PROVIDENCE, R. I.

Figure 15: L.D. Burlingame, "The Drafting Department as a Factor in Economical Shop Management," *Engineering Magazine* 27, April 1, 1904: 589-604.

Machine tools firms also financialized industrial property, intellectual and otherwise. Internally, firms such as Schwartzkopff (later Berliner Maschinenbau) kept balance sheets tracking the number of drawings and models produced, destroyed and sold annually, depreciating their value at a rate of fifty percent and thirty-three percent respectively.[32] Conceivably, this depreciation could reflect their diminishing usefulness in the face of rapid technological change or the wear and tear experienced by wooden models, sand and loam castings, or piece drawings nailed to workshop walls, smudged and splattered.

In addition to tracking the sheer stock of knowledge incarnate in pictures and forms for particular patterns of machine manufacture, firms assigned them financial value. The British machine-tools manufacturer Craven Brothers assessed their stock of patterns and drawings at £7,836 in July 1886, as compared to £18,856 for their entire fixed working plant at the machine shop (excluding shafting and pulleys as well as small tools) and £2,191 for the fixed working plant at their foundry; by 1913, the pattern and drawing account had grown to £10,640.[33] Berlin's Schwartzkopff machinery works recorded a gain of 90,055.58 Marks worth of drawings and models produced in 1899-1900, resulting in a total of 360,935.58 Marks (and then depreciated to 209,135 Marks); by 1913-1914, they counted an annual accumulation as 195,445.65 Marks, bringing the total to 484,678.65 Marks. Schwartzkopff proceeded to depreciate their 1914 drawing account to 59,004 Marks via the usual discount rates plus a wholesale deduction of the former model account due to the quicker development of new designs with the transition to a new model shop at their recently erected Wildau works.[34]

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32 Geschäftsberichte of Berliner Maschinenbau vorm. Schwartzkopff (1899-1938), Landesarchiv Berlin, A Rep 250-01-30 nr. 20.

33 Balance sheets and books (1886-1913), Craven Brothers, Manchester Museum of Science and Industry, Manchester, UK. YA1971.10/MS0165/CB/B/2.

34 Geschäftsberichte of Berliner Maschinenbau vorm. Schwartzkopff.

In the United States and Germany, capital goods firms not only understood working and design drawings as depreciating assets but also conceived of patents as subject to financial amortization. Such tangible and intangible assets, congealed experience as well as projections of a fixable term of legal protection from competition, imparted a new temporality to industrial accounting and industrial practice. In 1892 the firm Mannesmann, wholly premised on a patented invention to manufacture seamless steel tubing for as diverse products as bicycles, water and steam piping, high-pressure piping for gas, air, water and petroleum, cannons, telegraph poles, and torpedoes, compiled a list of its patents in Germany, England, Austria-Hungary, Italy, and Spain.[35] Between 1885 and 1892, Mannesmann had paid for forty-three patents in Germany and forty-eight in England; between 1886 and 1892, they had assembled a portfolio of forty-four in Austria-Hungary, eighteen in Italy, and fifteen in Spain. Mannesmann projected the cost of maintaining the patents in all four countries with renewal fees as far ahead as 1910, predicting in Germany alone payments amounting to 188,990 Marks until the last expired in 1906, in addition to the 23,211 Marks they had already paid.[36]

On the active side of its balance sheets, Mannesmann displayed a staggering 16,000,000 Marks of patents and licenses in the early 1890s (by comparison, the entirety of their working machinery, tools, furnaces, and general equipment at the Remscheid, Bous, and Komotau works combined in 1891 amounted to 5,228,415.77 Marks); on the passive side, Mannesmann counted 35,000,000 Marks of capital shares alongside a patent amortization account of 2,522,000 Marks annually from 1890 to 1894. The financial wizardry behind the enterprise relied on inventor-industrialist Werner Siemens and his nephew, Deutsche Bank's Georg Siemens, who had

[35] Mannesmann, Geschäftsberichte der Mannesmannröhren-Werke (1891-1910), Deutsches Museum (DM), Munich, FA009/071.

[36] Mannesmann, Patentverzeichnisse Oesterreich-Ungarn, Spanien, Deutschland, Italien, England und Amerika (1892), DM, FA009/202.

expressed keen interest in the Mannesmann's invention, which they had discovered in 1887 through mechanical engineering professor and designer of a vast collection of kinematic models Franz Reuleaux.

Werner Siemens wrote to his brother Friedrich,

> Reuleaux recently brought me samples of the Mannesmann's milled tubes of steel, brass, and copper, which look brilliant. He described the milling method to me, which is really great. The tubes show internally a spiral-form texture...They are milled from a red-blooming, sooty cylinder, wholly automatic to the last end of the mill-block...It is a true revolution in milling methods, and [when] you produce your cheap steel via your new method, steel will in the future wholly rule the world![37]

A week later, Werner Siemens approached Reuleaux in writing to convey that Friedrich Siemens was interested in introducing the Mannesmann process into England via the erection of a steelworks for tubes at their existing establishment in Landore, Wales. According to Werner Siemens, Friedrich

> would also not be disinclined, to take on the exploitation of the English patent wholly, if there are no firm conditions for England. Since Landore has made a great leap in the quality and price of steel and cast iron through the introduction of the large furnaces of my brother with more radiative heating...such a connection certainly would be appropriate and useful on all sides.[38]

The Siemens' and the Mannesmann brothers concluded negotiations for the Landore works of the Mannesmann Tube Co., Ltd. in December 1887.

International Dynamics of Machine Knowledge Transfer

German machine-tool manufacturers purchased and avidly pirated American machines, facilitating decades of trans-Atlantic knowledge transfer. The machinery exhibits at the 1867 Paris world's fair had brought European attention to American tool innovations, culminating in Prussia's purchase of $1,250,000 in orders of jigs, gauges, and machine tools for its armories

[37] 11 Mai 1887, Werner Siemens to Friedrich in Dresden, DM; also quoted in Conrad Matschoss, *Werner Siemens—Ein kursgefasstes Lebensbild nebst einer Auswahl seiner Briefe* (Berlin: Julius Springer Verlag, 1916).

[38] Werner Siemens to Franz Reuleaux, 18 Mai 1887, DM.

from Pratt & Whitney in 1872.[39] Within private industry, the Berlin machine-tool and weapons manufacturer Ludwig Loewe & Co. renovated its workshops after the American model with the help American mechanical engineers in the 1890s, while the J.E. Reinecker machine tool works in Chemnitz began building an arsenal of American machinery in 1877. Reinecker's 1915 insurance log, accounting for its entire machine-tool stock, lists approximately one hundred tools from American firms such as Brown & Sharpe, Pratt & Whitney, William Sellers & Co., and The American Machinery Company.[40] German machinery firms incorporated American product and process innovations, gaining insight into their workings through catalogues with drawings as well as communication among machinery firms about materials and methods for using and servicing tools.

Although scholars have contrasted high-skills, high-quality German production of specialized goods within networks of small- and medium-sized firms with Fordist mass production in the United States, this dichotomy was not starkly defined in the nineteenth century.[41] American firms engaged in specialized and variegated production, while German and American firms alike undertook new managerial regimes. Machinery purchasing and piracy comprised a wide avenue for trans-Atlantic learning and information exchange among German industrial works.

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[39] Ralf Richter, "Technology And Knowledge Transfer In The Machine Tool Industry: The United States And Germany, 1870-1930," *Essays in Economic and Business History* 26, no. 1 (2008): 173-189.

[40] J.E. Reinecker AG, Schätzungsprotokolle über Betriebsgegenstände (1915), Sächsisches Staatsarchiv, Chemnitz, 31007/131; "The Ludwig Loewe A.G. Works at Berlin," *Congressional Serial Set, Reports, Documents, and Journals of the U.S. Senate and House of Representatives* (1909).

[41] Gary Herrigel, *Industrial Constructions: The Sources of German Industrial Power* (Cambridge: Cambridge University Press, 2000); Colleen Dunlavy and Thomas Welskopp, "Myths and Peculiarities: Comparing U.S. and German Capitalism," *German Historical Institute Bulletin* 41 (Fall 2007): 33-64; Philip Scranton, *Endless Novelty: Specialty Production and American Industrialization, 1865-1925* (Princeton: Princeton University Press, 2007).

German firms circulated American shop drawings and copied machinery. One correspondent for the trade journal *American Machinist* reported,

> In going through the shops of a prominent German machine-tool builder who has been in the United States and got a good many ideas therefrom, as well as bought a good line of the best standard machines from which to copy or to vary, in the productions of his own line, I noticed that every solitary American machine, whether from Providence, or New Haven, or Cincinnati, had had the name chipped off and the place painted over.[42]

German machine-tool works only needed to buy one or two of any American model to replicate its design. With lower wages prevailing, German machine-tool works could achieve admirable profit margins passing these facsimiles or re-engineered improved versions off as the American make in European markets. In 1899 the *American Machinist* put it simply: "The best American tool shop is now in Germany."[43] By 1910 German machinery works such as J.E. Reinecker and Werkzeugmaschinenfabrik Union had come to rival American firms in world markets.[44]

Unlike German firms, which built patent and licensing portfolios throughout Europe, most American machine tools works did not apply for foreign patents. Despite consistent complaints about German piracy of machinery, they weighed the high cost of patenting in Germany against the very limited protection offered by it.[45] Incremental improvements in machine tools likely did not merit depositing hundreds or thousands of Marks in renewal fees in their view, especially when infringement would occur nonetheless. Although the Imperial German patent office set high standards for initial patenting, demanding a wholly novel principle

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[42] Richter, "Technology and Knowledge Transfer."

[43] Quoted in Ralf Richter, "Technology and Knowledge Transfer."

[44] "The Ludwig Loewe A.G. Works at Berlin," *Congressional Serial Set, Reports, Documents, and Journals of the U.S. Senate and House of Representatives* (Washington D.C.: Government Printing Office, 1909).

[45] Richter, "Technology and Knowledge Transfer."

rather than a mere reconfiguration, prosecuting infringement was nearly impossible when German works undertook slight variations or rearrangements on American models.[46]

Max, Reinhard, and Alfred Mannesmann held a copy of engineer Eugène Armengaud's extensive guide to international patenting.[47] Armengaud was a former pupil of the *Ecole Centrale des Arts et Manufactures* and a member of the Society of Civil Engineers of France; more importantly, however, he was a publisher of volumes of machine specifications and owner-director of the *Publication Industrielle des Machines, Outils et Appareils*, or those he deemed "les plus recents et les plus perfectionnés."[48] In his "practical instructions for the use of inventors," Armengaud argued in a section entitled "Industrial Property" that the "right to the guarantee of industrial property is a fact in the mores of all civilized peoples today, and one can say that it has become the fulcrum of all progress, since only it can give to the inventor security in the possession of his discoveries and legitimate recompense for his labor."[49] Countering critiques of patents as unjustified monopolies, Armengaud wrote that the "laws which favor him [the inventor] in this sense are laws of equity which enrich the country where they have a character of being useful and liberal."[50]

Despite his engagement in international debates over balancing the interests of inventors, society, and nation in according patent rights, Armengaud's words invoked a distinctively French view of intellectual property, which posited an inalienable right through the inspired act and

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[46] Ibid.

[47] Mannesmann, Lizenz für Société Anonyme d'Escaut et Meuse (1879-1905), DM, FA009/073.

[48] Eugène Armengaud, *Instructions pratiques à l'usage des inventeurs, commentaire raisonné des lois qui régissent actuellement les brevets d'invention dans les principaux pays industriels* (Paris: Armengaud, 1880).

[49] Ibid.

[50] Ibid.

personal toil of invention.[51] Neither Anglo-American nor German patent law recognized such a basis of legal reasoning. Though differing in stipulations, both Anglo-American and German law viewed patent as a purely instrumental tool of government to encourage innovation; their codes were not premised on any transcendent principle or right. This, however, rarely stopped German or American inventors from making rights-based claims. Inventors often compared mechanical invention to literary authorship and artistic creation protected under the different regime of copyright.

National governments understood patent law as a tool for industrial development and altered codes when another country's system appeared more salutatory to invention. Economic historian B. Zorina Khan argues that a combination of strong, affordable patent regulations and weak copyright enabled the United States to forge ahead of other countries in innovation in the nineteenth century.[52] National systems differed in fee structures, terms of length, and conditions such as requirements for putting the invention into use. U.S. patents were inexpensive ($15 upon submittal and $20 upon conferral), accorded rights to the first true inventor, and lasted 17 years; German patents entailed annual renewal fees increasing from 50 Marks in the first year to 700 in the fifteenth and were typically not maintained the full 15 possible years. German patents were normally allowed to expire after a mere five from the 1890s onward. In both countries, a patent secured abroad was required to lapse whenever it first expired anywhere.

The process of redefining machine capital easily crossed borders. The Berlin machine-tools and weapons manufacturer Ludwig Loewe & Co. purchased the patent rights for *Veederguß*, a tin alloy, in Germany and other European countries from C.H. Veeder, an engineer

[51] Peter Baldwin, *The Copyright Wars: Three Centuries of Trans-Atlantic Battle* (Princeton: Princeton University Press, 2014).

[52] B. Zorina Khan, *The Democratization of Invention: Patents and Copyrights in American Economic Development, 1790-1920* (Cambridge: Cambridge University Press, 2005).

in Hartford, Connecticut, home to the machine-tool and metrological firm Pratt & Whitney.[53] Submitting samples to the Imperial Materials Testing Bureau in Lichterfelde, Loewe leveraged the research capacity of the German state to gather information about the properties of the metal beyond what the firm had received when procuring the intellectual property rights. Thus equipped, Ludwig Loewe catalogues advertised the processes for making and using *Veederguß*, the tensile and conductive properties of the metal, and its main applications (the production of electrical devices, clocks, adding machines, etc.).

Most importantly, Loewe emphasized that *Veederguß* fundamentally recast machining work: "one needs no skilled mechanics, rather work can be left to the unskilled as well as female workers."[54] *Veederguß* offered an "enormous precision of forms," from one twentieth to one thirtieth of a millimeter, enabling interchangeable parts manufacture and the mass production of metal pieces until then too complicated for serial fabrication. Eliminating high-waged work, Loewe promoted *Veederguß* as a means to cut out the intermediate processes of working and finishing metal, directly connecting the raw molded pieces to assembly and montage.[55] Remaking industrial labor depended on a transnational process of investigating materials protected by intellectual property rights regimes.

Limiting Capital Mobility

Capital goods firms pursued control over capital and labor discipline together through the very literal protection of industrial property in increasingly managed tool rooms, stamps on

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[53] Ludwig Loewe, *Veederguß (Deutsche Reichs- und andere europäische Patente)* (Leipzig: F.A. Brockhaus, 1908), Technikmuseum, Berlin, III/III.2/07526.

[54] Ibid.

[55] Ibid.

drawings forbidding removal from the workshop, and locked cabinets for drawings.[56] An equally transnational endeavor, German machine tools works employed time checking systems from the American International Time Reckoning Company and padlocks from Sargent & Greenleaf in Rochester, New York to secure recently renovated facilities and workmen's chests.[57]

Law also differentially restrained and routed the mobility of intellectual capital in persons. Imperial Germany's Industrial Code formally sanctioned non-compete clauses restricting the labor mobility of engineers and technicians.[58] Conversely, in the United States, the high mobility of technical workers meant that leading machinery firms such as Brown & Sharpe and Pratt & Whitney generated fractal offshoots. Erstwhile employees and inside contractors left to reproduce techniques beyond New England, whether in burgeoning machine-tools centers such as Cincinnati, Cleveland, and Detroit or abroad.[59] Such transfers had transpired since the illegal emigration of British artisans to the United States prior to the 1824 repeal of laws forbidding their movement. Circulation had typified the founding of the most prominent machine-tools works in antebellum America: Philadelphia machine-tools industrialist William Sellers had worked for Fairbanks and Bancroft in Providence, Coleman Sellers set out to join his cousin William after working for Niles and Company, and William Bement left the Lowell Machine Shop to establish his own works in Philadelphia.[60]

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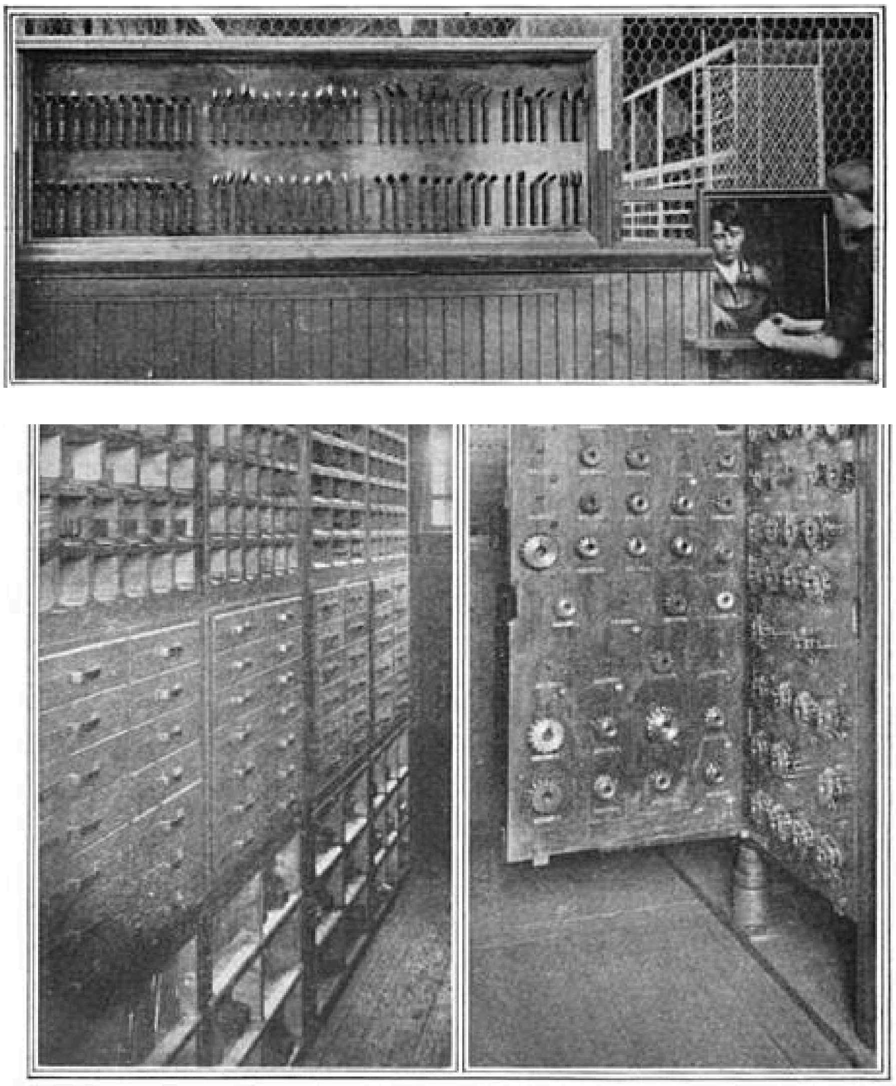
[56] John Ashford, "The Tool Room and Its Functions in Cost Reduction," *Engineering Magazine*, April 1, 1904, 521-548.

[57] "The Ludwig Loewe A.G. Works at Berlin," *Congressional Serial Set, Reports, Documents, and Journals of the U.S. Senate and House of Representatives* (Washington D.C.: Government Printing Office 1909).

[58] Gispen, *New Profession, Old Order*; Gispen, *Poems in Steel*.

[59] Thomson, "Understanding Machine Tool Development."

[60] Doron Ben-Atar, *Trade Secrets: Intellectual Piracy and the Origins of American Industrial Power* (New Haven: Yale University Press, 2008); Thomson, "Understanding Machine Tool Development."



FEATURES OF THE TOOL-ROOM SYSTEM OF THE LINK-BELT ENGINEERING COMPANY, PHILA.

At the top is shown the model board, carrying cast-iron models of all standard lathe tools. The workman consults this and orders the required tool by four-letter symbols. Below on the left is the storage for twist drills, sectional dies, large milling cutters, lathe tools, etc. Main racks are in large multiples of the same size, and interior racks in multiples suited to the large racks. Twist drills up to 1½ inch are kept in the drawers. The workman's check is placed on a peg in front of the pigeon hole, or in a pocket in the drawer. Tools are classified under mnemonic symbols. On the right is

Figure 16: John Ashford, "The Tool Room and Its Functions in Cost Reduction," ***Engineering Magazine*** **27, April 1, 1904: 521-548.**

In a typical German employment contract at the steel tube manufacturer Mannesmann in 1887, owners Max and Alfred Mannesmann bound engineer Julius Pfau, a personal friend of the family, to swear that "he possessed absolutely no knowledge of tube fabrication or of oblique and transverse milling until his successful entry into the firm today" and that in particular the experiments undertaken at Mannesmann in all parts were unknown to him.[61] This foreclosed the possibility of Pfau's claiming any rights to prior invention in any remotely related matter. Pfau was obliged to promise not to work for any competing firm within five years of leaving Mannesmann and not to share any designs, projects, ideas, or experience gained in his current position, unconditionally and eternally.[62] The Mannesmann contract specifically forbade Pfau from making for others or letting be made copies, sketches, working-outs, designs, etc. that would come into his hands in future work. Pfau vowed to neither through himself or others patent anything arising from projects, ideas, constructions, or proposed improvements in fabrication during his engagement at Mannesmann and for five years after his leaving the firm. He would, rather, rely on the Mannesmann brothers to valuate and patent any such technologies and grant him an honorarium according to their assessment.[63]

Patents assigned to the Mannesmann Tube Co Ltd., the branch works at Landore, Wales, included engineer G.E. Vaughan's "improvements in the manufacture of pipes or tubes and in apparatus therefore" and F.J. Dann's "Improvements in the construction and use of apparatus for enlarging metallic tubes" in 1887 as well as Oliver Imray's "Improved manufacture of metal bars and tubes" the next year. Those licensed to Mannesmann included "A new or improved method of machine gearing and apparatus therefore" in 1888 and a "Universal joint coupling for revolving shafts" and an "Improved jointed or articulated coupling for shafts" in 1889. Year by

[61] Mannesmann,Zusammenstellung u.a. von Patentgesuchen, Verträgen mit Firmen und Mitarbeitern (1886-1888), DM, FA009/042; *75 Jahre Mannesmann: Geschichte einer Erfindung und eines Unternehmens, 1890-1965* (Düsseldorf: Mannesmann AG, 1965).

[62] Mannesmann, Zusammenstellung u.a. von Patentgesuchen, Verträgen mit Firmen und Mitarbeitern (1886-1888), DM, FA009/042.

[63] Ibid.

year, Mannesmann cultivated an impressive portfolio of patents between 1885 and 1891—48 in England, 44 in Austria-Hungary, 43 in Germany, 18 in Italy, and 15 in Spain—virtually all accorded either to the firm (or its branch works in Landore, Wales or Komotau, Bohemia) or to individual members of the Mannesmann family (Fritz, Reinhard, and Max Mannesmann as well as their cousin Fritz Koegel).[64] Similarly, American lathe patents typically attributed ownership to the proprietors of machine-tools works, such as half of the patents developed at Pratt & Whitney and nine-tenths of them held by William Sellers & Co. [65] Patenting constituted a key strategy of machine-tools works, with American firms holding between 65 and 641 patents each at the turn of the century.

The Mannesmann brothers found themselves the victims of international intellectual property theft in 1895. Ralph Charles Stiefel, the Swiss-born chief of the design bureau and tube department in their Wales establishment at Landore, had absconded with their process for transverse-milling hollow blocks used, among other applications, in bicycle manufacture. Stiefel had worked for the Mannesmann Tube Company since 1889, following an apprenticeship at the Maschinenfabrik Oerlikon, studies at the Zurich Technikum, and a series of technical positions in Switzerland and France. Max Mannesmann suspected that Stiefel had left the firm outraged that he had not been elevated to works manager when Pfau had received a similar promotion in another Mannesmann branch works. In July 1896, Carl Mannesmann wrote to Max Mannesmann from New York to report that Pfau had joined him in New York to investigate the methods that Stiefel was then engaged in sharing with American manufacturers such as Logier. To his alarm,

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[64] Mannesmann, "Patentverzeichnisse Oesterreich-Ungarn, Spanien, Deutschland, Italien, England und Amerika (1892)," DM, FA009/202.

[65] Thomson, "Understanding Machine Tool Development."

Pfau discovered that Stiefel's disc roller "worked beautifully" and had already manufactured 2,500 tons of tubes.[66]

In his testimony to Carl Mannesmann, Pfau claimed that his view of Stiefel's finishing process had been intentionally obstructed by a wooden railing; however, the Mannesmann brothers suspected that Pfau had indeed witnessed their full process in use and merely refrained from telling them. Their heightened concern correlated tightly with the fact that Stiefel had received American and English patents, whose foreign rights he had sold to a syndicate, and was seeking further patents in Germany, France, and Austria. Stiefel had parted ways with his American patent for $30,000 worth of stock in an American machinery firm where he found employment, a corporation, Carl Mannesmann noted with chagrin, capitalized at $200,000 and offering "dividends of six percent per month!" The American firm had offered Stiefel a five-year contract with a salary of $5000 per year. Stiefel had begun to manufacture the same seamless tubes Mannesmann did with their disc apparatus, and Carl Mannesmann fretted that a second mill with fifty more tube-milling benches was already under construction.

Carl Mannesmann worried that "S. will be our most dangerous competitor if we do not stop him."[67] Hoping to stanch the flow of the Mannesmann process outward, he turned to the patent definition as the sole avenue of recourse. He implored his brother, "Please give us your opinion about S. patent as explicit as possible, and give us your advice what you think you can do against him."[68] But by the time Stiefel returned to Europe from the United States, American firms had rendered themselves largely independent of Mannesmann for transverse-milled hollow

[66] Carl Mannesmann to Max Mannesmann, New York, July 17, 1896, DM, FA009/027; Yorck Dietrich, *Die Mannesmannröhren-Werke 1888 bis 1920: Organisation und Unternehmensführung unter der Gründerfamilie, Bankiers und Managern* (Stuttgart: Franz Steiner Verlag, 1991).

[67] Mannesmann, Patentprozess, DM, FA009/027.

[68] Ibid.

blocks. The confluence of Stiefel's transnational knowledge transfer, savvy national patenting, and quick move to wholly or partially alienate those very rights through sale or licensing implied growing competition and widespread leakage to come.

White-Collar Workers and Rights in Invention

German advocates for the rights of white-collar workers to their inventions would employ arguments ranging from the phenomenology of invention to consequentialist, policy-oriented legal thought. Sometimes they emphasized the undeniability of invention in an "*Augenblick*"—the "aha!" moment—occurring in a single individual (as opposed to the social organism of the firm). At other junctures, they referred to the practical success of the American patent system in fostering technological progress as due to its clause according rights to the "first true inventor."

As early as the 1870s, engineer and National Liberal parliamentarian Hermann Grothe had attributed the industrial success of United States to "the inventive talents of Americans, supported through good patent and trademark institutions."[69] Grothe emphasized that "anyone, be he a citizen of the United States or a foreigner, who is the true and first inventor or discoverer of a new and useful art, machine...or who has invented a new and useful improvement of it, can receive a patent for his invention or discovery."[70] Three decades later, representatives of the twenty-thousand-member *Bund der technisch-industriellen Beamten* such as Julius West also passed easily from policy-oriented, consequentialist claims for the sake of national competitiveness in world markets to individual rights-based arguments.[71] The array of

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[69] Hermann Grothe, *Die Industrie Amerika's* (Berlin, 1877), 77-80, Library Company of Philadelphia.

[70] Ibid., 80.

[71] Julius H. West, *Technische Angestellte und Ihre Erfindungen* (Berlin, 1905), BArch, R 131/27; see also, Alexander K. Schmidt, *Erfinderprinzip und Erfinderpersönlichkeitsrecht im deutschen Patentrecht von 1877 bis 1936* (Tübingen: Mohr Siebeck, 2009).

argumentation reflected technical workers' ambivalent view toward their class position and the stakes of an emerging corporate capitalism, opening the way to a broader debate over the meaning of the person and industrial capital.

The *Bund der technisch-industriellen Beamten*, the most radical union of engineers founded in 1902 and reaching 20,000 members by 1911, asserted engineers' rights to inventions conceived while employed in capital goods firms.[72] Their organizing and legislative efforts reflected recent changes in work processes and the uncertain social and political position of a permanently "dependent" class of white-collar workers (in contradistinction to the old, "independent" middle class, or *Mittelstand*).[73]

In the late 1880s and 1890s firms such as the Rhenish coal-mining, metals, and machining conglomerate Gutehoffnungshütte's Sterkrade machinery works denominated such workers uniformly as *Beamten* in salary lists, only occasionally noting their specific roles as *Meister* or *Obermonteure* (indicating the presence of a "gang method" of assembling machinery, if not a full inside-contract system). Gutehoffnungshütte's wage list from 1907, however, referred to each individual's task performed in divisions ranging from wage accounting and correspondence to ordnance, machinery-building, and bridge-building and design. In total, forty draftsmen, thirty-five secretaries, two engineers, eight technicians, fifteen supervisors, twenty

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[72] Bund der technisch-industriellen Beamten, *Bericht über das Erste Geschäftsjahr 1904 und Protokoll der Ersten ordentl. General-Versammlung abgehalten am 25., 26., und 27. März 1905 in Berlin* (Berlin: Karl Sohlich, 1905). BArch, R131/27.

[73] David Blackbourn, "The *Mittelstand* in German Society and Politics, 1871-1914," *Social History* 2, no. 4 (1977): 409-433; Jürgen Kocka, *Die Angestellten in der deutschen Geschichte 1850-1980: vom Privatbeamten zum angestellten Arbeitnehmer* (Göttingen: Vandenhoeck & Ruprecht, 1981) and *White collar workers in America, 1890-1940: A social-political history in international perspective* (London: Sage Publications, 1980); Gispen, *New Profession, Old Order*; Siegfried Kracauer, *The Salaried Masses: Duty and Distraction in Weimar Germany* (London: Verso, 1998).

assistants, one blue-printer, and a dozen apprentices worked at Gutehoffnungshütte's single Sterkrade machine tool filial.[74]

Moreover, while wage lists from the 1880s and 1890s had assigned a base salary in half-year increments, which varied over time, plus bonuses based on material output akin to piecework ("Prämie"), the 1907 list established strict annual salaries and projected them forward with no increase over a five-year period. Gutehoffnungshütte's Sterkrade works denied the white-collar workers an increase in income or social mobility, evaluating them as fixed capital—drawing and calculating machines capable of a particular output level when presented with discrete problems to solve. Technical white-collar workers would serve as translation apparatuses between heavy, rapid machine tools and the operatives increasingly dwarfed and sometimes mangled by them.

Figure 17: Operative with an automatic grinding machine in J.E. Reinecker AG's catalog for "Schleifmaschine und Drehbänke" (Grinding Machines and Lathes), 1912. Technikmuseum, Berlin.

[74] Gutehoffnungshütte, Abteilung Sterkrade (1907), Rheinisch-Westfälisches Wirtschaftsarchiv (RWWA), Cologne, 130-3001032/7; on the gang system and inside contracting, see Walter Licht, *Working for the Railroad: The Organization of Work in the Nineteenth Century* (Princeton: Princeton University Press, 2014).

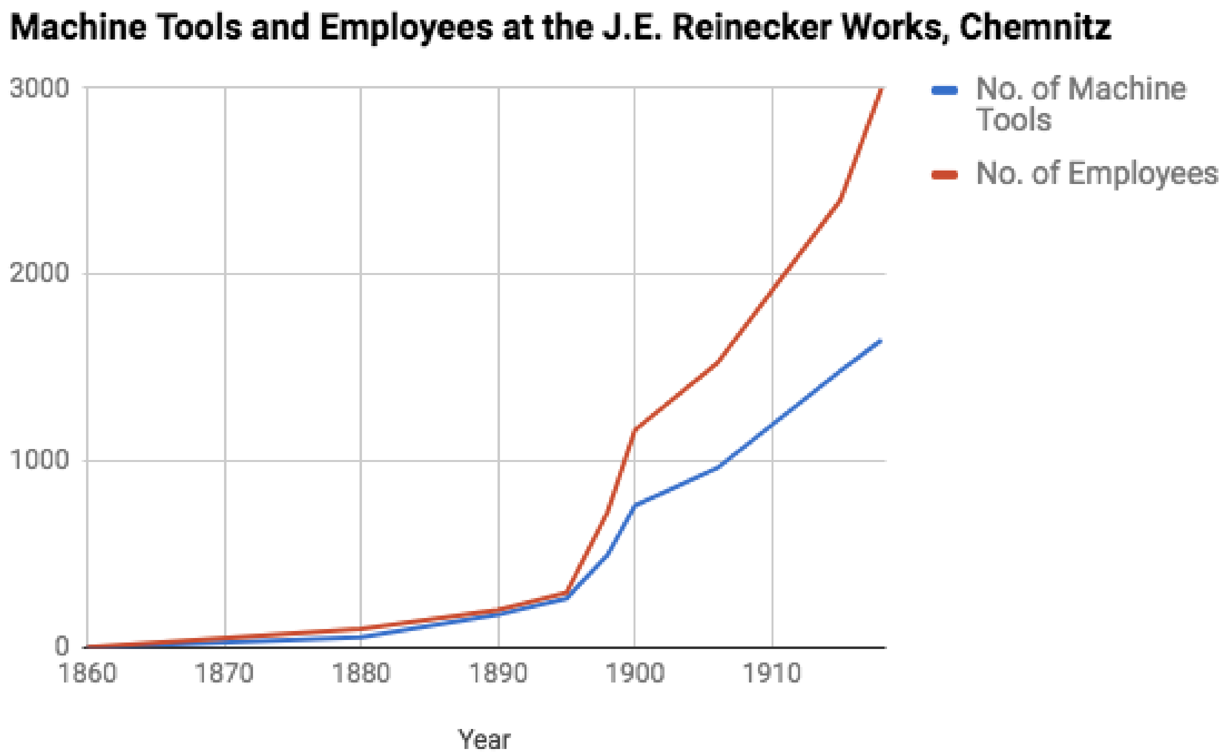

Figure 18: Data compiled from J.E. Reinecker AG, *Universal-, einfache- und Vertikal-Fräsmaschinen* (1920). Deutsches Museum, Munich.

Workers contributed to the drawing of process capital, their inventions usually matching their line of work. In the United States, machinists dominated the patenting of lathes; after 1900, designers, draftsmen, and mechanical engineers made significant contributions to lathe design and manufacture.[75] Sixty-three inventors assigned patents to Brown & Sharpe, forty-six percent of whom were company employees. Taken together, they accounted for seventy-five percent of Brown & Sharpe's patents.[76] Economic historian Ross Thomson thus concludes that innovation "had become a regular, internal part of the company's activity."[77] Industrialists of the late nineteenth century advanced similar arguments about the internalization of research and

[75] Thomson, "Understanding Machine Tool Development."

[76] Ibid.

[77] Ibid.

development, casting it as part of unfolding progress as much as a particular firm strategy. In doing so, they invited renewed debate over the politics and political economy of technical knowledge within and among firms and nations.

Workers in the upstart *Bund der technisch-industriellen Beamten* and the more established *Deutscher Techniker Verband* (founded in 1884) counted 30,000 members in 1911, and disagreed with the characterization of their work as systematic when they asserted a right to invention. Ultimately the contest between the *Bund der technisch-industriellen Beamten* and the *Deutscher Techniker Verband* on one side and the association of German machinery-building establishments (*Verein deutscher Maschinenbau-Anstalten*) including firms such as Maschinenfabrik Augsburg-Nürnberg, Gutehoffnungshütte, Haniel & Lueg, Hannoversche Maschinenbau, Gasmotorenfabrik Deutz, and Krupp, on the other ignited several simultaneous debates: Were corporations eligible to make claims on intellectual property? What was the meaning of individual rights to property and association in a liberal polity? And which, if any, parties merited a say in negotiating private contracts, in addition to defining the statutes governing contract itself?

German capital goods industrialists pursued two main lines of argument to invalidate workers' patent claims. First, they emphasized the conditions of invention in an industrial age—that engineers and draftsmen relied on the firm itself for the sources of inspiration from beginning to end. The framing of technical problems came in a planned manner from higher rungs of management, while the necessary inputs to address these problems--previous designs, experimental and metrological tools, existing materials data--all represented the accumulated property of the firm. This argument leaned on Article 168 of the 1878 Industrial Code, which stated that all "results of work" emanating from a contractual performance of labor remained the property of the employer.[78]

At the same time, German employers invoked statutes reflecting more pre-industrial norms such as the 1876 laws pertaining to the originator's [*Urheber*] rights to patterns. The 1876 laws stated that "in cases of patterns and models which were made by draftsmen, painters, sculptors, etc. occupied in a commercial establishment under contract or account of the owner, the owner qualifies as the originator of the patterns and models."[79] The commissioning and design of objects to be hewn out of or cast into form by another implied a total separation of conception from fabrication, a strict dualism, which neither existed at the time nor exactly reflected the complex work processes and social relations in corporations at the close of the nineteenth century. Industrialists also asserted that engineers and draftsmen had signed contracts employing them expressly to invent; the objects invented had no existence independent of the performance of contractual duty. Taken together, the protection of establishment property and contract in terms of service meant that Imperial German courts ruled consistently that inventions conceived at the workplace belonged to the employer.

Unsurprisingly, technical white-collar workers disputed these claims. In an article entitled "The Right of the White-Collar Workers to their Inventions," Essen industrialist Karl Goldschmidt quoted engineer Julius West's "Protection for Inventions by Technical Employees" with palpable alarm.[80] West, leader of the *Bund der technisch-industriellen Beamten*, had begun his 1909 essay with the words:

[78] "Schrift zu B.J.M. Nr. I d 1596 Q: Das Recht an Arbeitergebnisse," BArch, R 131/28.

[79] Quoted in Julius H. West, *Technische Angestellten und Ihre Erfindungen* (Berlin, 1905). BArch, R 131/27.

[80] Karl Goldschmidt, *Das Recht der Angestellten an ihren Erfindungen, von Karl Goldschmidt, Fabrikbesitzer in Essen-Ruhr* (Halle a.S., Verlag von Wilhelm Knapp, 1909), 5-6. BArch, R131/27.

> Germany guarantees to every inhabitant of the Earth—to the German citizen as well as to the Chinese and the *Australneger*—protection for his inventions; only the professional inventors in their own country are guaranteed no protection for their inventions: German employees [*Dienstnehmer*], whose professional duties include making technical improvements, enjoy no protection for inventions in their professional arena; legislation has forsaken them, and jurisprudence has rendered them without rights, because they have forbade them the right to their inventions and recognized them for the employers [*Dienstgebern*].[81]

Julius West presaged the "reactionary modernism" of the Weimar era in his stridently nationalist and racist discourse while still clinging to the proprietary, possessive individualism promised by liberalism.[82]

Telecommunications industrialist Wilhelm von Siemens, general partner at Siemens & Halske and founder of Siemens-Schuckertwerke, deemed such thinking highly inappropriate in an industrial age.[83] In a lengthy tract entitled "The Right of White-Collar Employees to Inventions," Siemens granted that "objective, scientific criticism of the organization of working conditions is necessary and useful" and suspected that the movement for patent rights among white-collar workers emanated from their awakening to their permanently adverse professional outlook. He held, however, that white-collar workers and their skills toward invention were themselves creations of the firm, which had received them as "callow beginners" entering professional service.

Siemens underscored the significance of the time, costs, capital and risk expended and undertaken to develop a patentable invention, insinuating that they would not be borne without a

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[81] Ibid.

[82] Jeffrey Herf, *Reactionary Modernism: Technology, Culture, and Politics in Weimar and the Third Reich* (Cambridge: Cambridge University Press, 1984); Adelheid Voskuhl, "Engineering Philosophy: Theories of Technology, German Idealism, and Social Order in High-Industrial Germany," *Technology and Culture* 57, no. 4 (2016): 721-752.

[83] W. v. Siemens, "Das Recht der Angestellten an den Erfindungen," *Sonderabdruck aus der Zeitschrift Gewerblicher Rechtsschutz und Urheberrecht* 12, no. 6 (1907): 1. BArch, R131/27.

guarantee of being recouped by the enterprise itself.[84] Besides inviting a cascade of patent suits should the law be altered, Siemens perceived the potential for a more fundamental crumbling of the foundation for invention, which he viewed as engineers and draftsmen, free from the burden of time, costs, capital, and risk, exercising their skills in exchange for a salary. Tracing the internalization of research and development, Siemens essentially celebrated the socialization of invention as a bridge to an organic solidarism. The performance of the firm, he wrote, "must not only be economically successful but also must work to enrich the development of the technical realm falling in its sphere of work, and through this simultaneously serve the general interest."[85] He wielded this maxim as a weapon against any individual "private interest (*Sonderinteresse*)," asserting that a firm is "no conglomerate of individuals, no playground for a struggle for the booty between owners, shareholders, directors, white-collar workers, and workers...it is rather much more an individual itself, of a special and organically-growing sort."[86]

This was an organic ideology with consequences beyond the usual discursive suppression of class conflict within the corporatist creed. Siemens's organicism of the firm, which he also compared to complicated precision machinery, had a metabolism of knowledge and experience. Addressing the issue of patent rights for white-collar workers, Siemens pointed out that "not only the occasion for new suggestions, but also the realization of plans and designs, as well as the testing of creations in practical life...constantly the path leads through mishaps and failures, which are the most valuable, yet simultaneously also the most costly and dangerous learning materials for the firm and its white-collar workers."[87] This, Siemens concluded,

[84] Ibid., 12.

[85] Ibid., 13.

[86] Ibid., 13.

[87] Ibid., 16.

illuminated the point that the “intellectual production” of a firm did not proceed through or belong to its white-collar workers alone, but rather to “all the personalities participating in the intellectual production of the firm,” composing the “entire intellectual life of the firm” in “multitudinous and diverse ways,” with which “all their ponderables and imponderables are connected.”[88] However, Siemens did not consider this unseen, unpredictable knowledge metabolism of the firm autonomous. Since inventive activities “belong to the daily bread of a firm, whose duty it is, whose existence depends on, the further technical development of its realm of operation,” Siemens accorded upper management the task of watching and offering the necessary directives for a “healthy and fruitful development of technology.”[89]

The capital goods industrialists’ vision of a complex and interdependent corporation had its element of truth and, with it, pitfalls for their project of a controlled political economy of industrial knowledge. Without the technical white-collar workers, industrialists acknowledged there would be “no work” to send to the shop floor. “Work” meant procedures and plans—plans drafted, traced, and blueprinted. The separation of mental and manual work rendered both shop-floor and drafting room workers increasingly dependent, their tasks ever-more parceled out and their wages undermined or stagnant; however, the heightened division of labor and its stark interdependency relied on the ready availability of translation mechanisms as “immutable mobiles.”[90] A growing number of accounting, design, and control devices populated the surfaces of technical plans at the turn of the century. Signatures and dates by draftsmen responsible for the design or piece drawings were joined by visual codes for particular materials, symbols for

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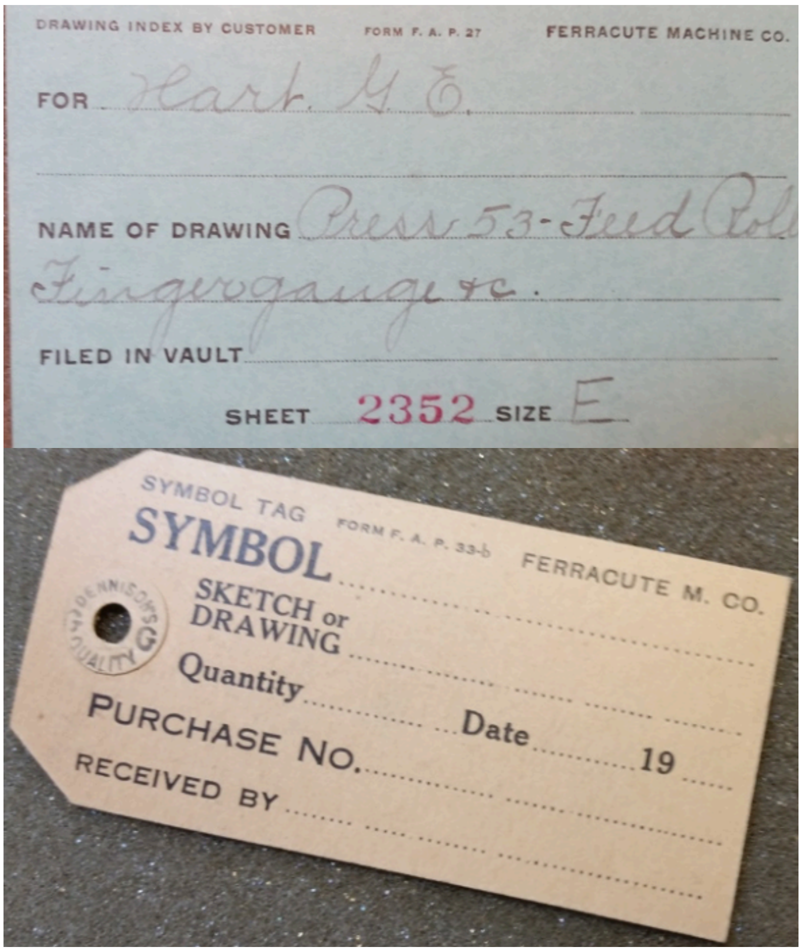
[88] Ibid., 16.

[89] Ibid., 17.

[90] Bruno Latour, “Drawing Things Together,” in *Representation in Scientific Practice*, ed. Michael Lynch and Steve Woolgar (Cambridge, MA: MIT Press, 1990), 19-68.

specific conjoining, cutting, or boring mechanisms and hardware, areas to note alterations to the standard plan, and logs of proofing protocols. Shortly before the advent of Frederick W. Taylor's time-motion studies, management engineers such as Frederick Parkhurst proposed assessing labor time and setting piece rates by tracking the circulation of drawings around the shop floor.[91]



[91] L.D. Burlingame, "The Drafting Department as a Factor in Economical Shop Management," *Engineering Magazine*, April 1, 1904: 589-604.

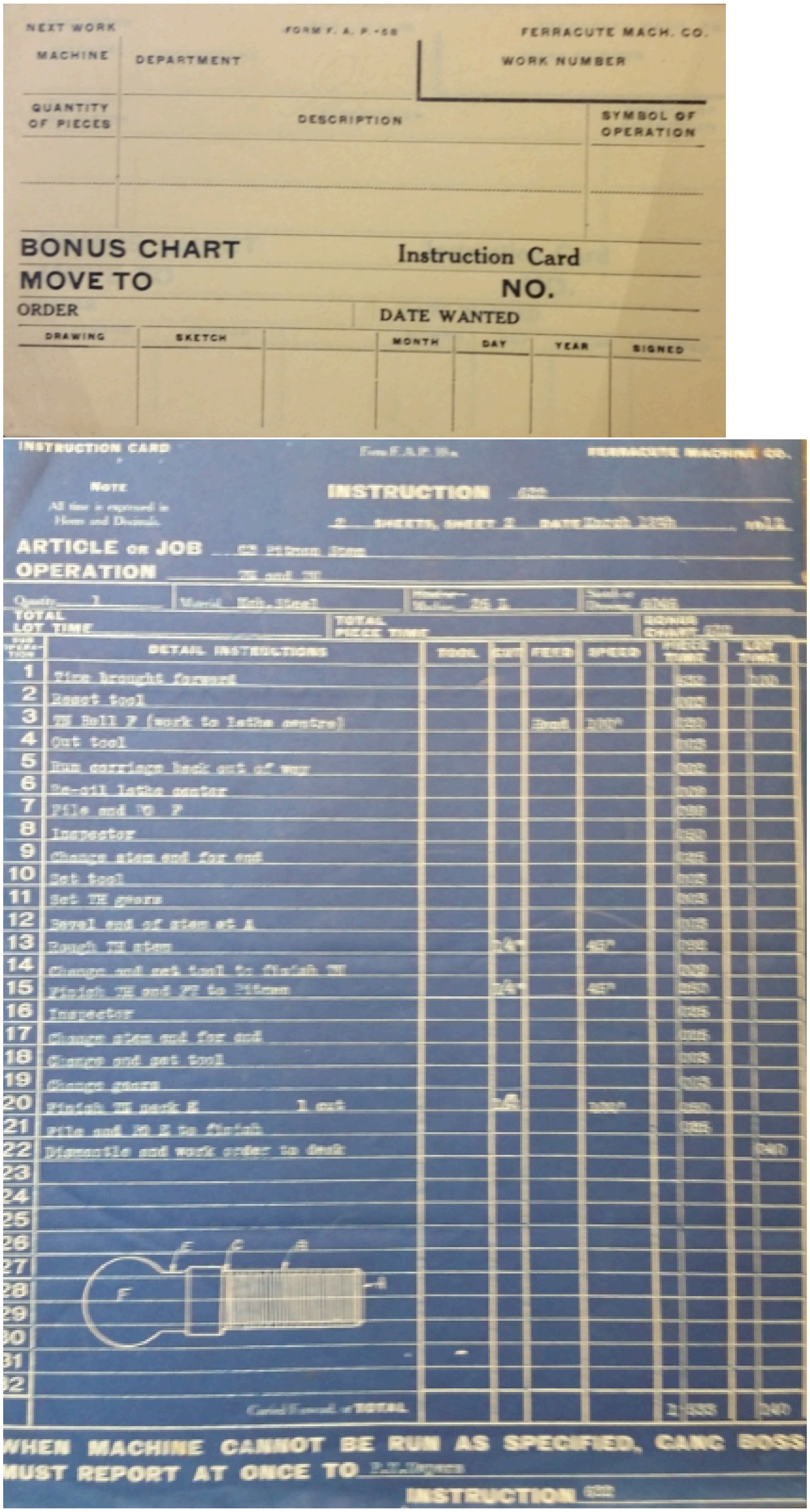


Figure 19: Frederick Parkhurst Studies at Ferracute Machine Company, Hagley Museum.

Yet, while management engineers pursued greater control over work processes, the reformatting of technical work had started to degrade into fixed hierarchies and serial work in the drafting room itself.[92] Firms such as Maschinenfabrik Augsburg-Nürnberg had begun training apprentice draftsmen and apprentice metalworkers in specific trades separately by the opening years of the twentieth century, rather than general apprentices rising through work on the shop floor to the drafting bureau.[93] By World War I, Maschinenfabrik Augsburg-Nürnberg and Ludwig Loewe & Co. had begun psychometric testing would-be apprentices in visually sorting, recalling, and rendering objects and symbols.[94]

[92] For an analysis of similar phenomena in a later period, see Harry Braverman, *Labor and Monopoly Capital: The Degradation of Work in the Twentieth Century* (New York: New York University Press. 1998); for comparable phenomena among architectural draftsmen in the early twentieth century, see George Barnett Johnston, *Drafting Culture: A Social History of Architectural Standards* (Cambridge, MA: MIT Press, 2008).

[93] "Zeichner-Lehrlinge (8 Juli 1914)," "Lehr-Vertrag, Eisendreher (Gregor Raab)," (1911) and "Lehr-Vertrag, Schlosser (August Sachenbacher)" (1900), MAN Museum, Augsburg, 2.2.1.2

[94] "Bericht über die Aufnahme- und Eignungsprüfung für Lehrlinge," MAN Museum, 2.2.1.2; Metropolitan Vickers Electrical Co, *Report on the application of experimental psychology to industry in Germany* (August 1922). Manchester Museum of Science and Industry, Manchester, UK.

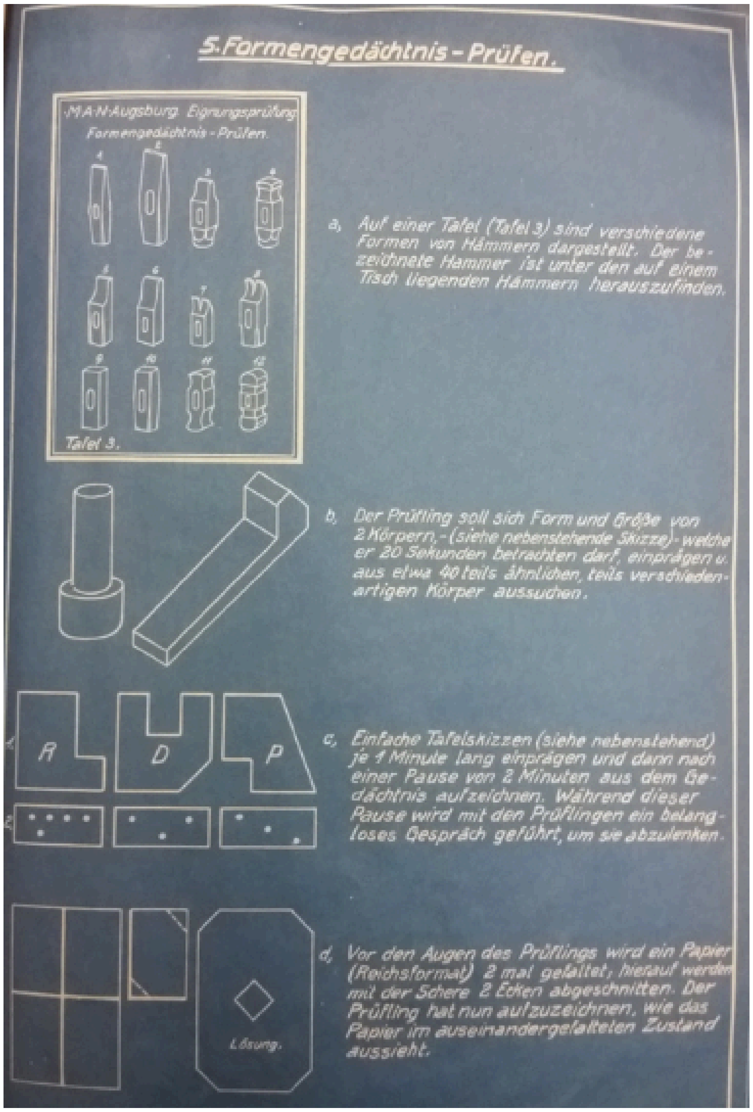


Figure 20: From "Bericht über die Aufnahme und Eignungsprüfung für Lehrlinge" (Report on the Intake and Aptitude Exams for Apprentices), 1923. M.A.N. Museum, Augsburg.

Depictive work did not guarantee social mobility in an era of deepening stratification among technical workers. In the machine-tool works of J.E. Reinecker in Chemnitz, workers in the four technical bureaus earned between 30 and 345 Marks per two weeks in 1910.[95] Skilled workers among Reinecker's 1,837 shop-floor employees earned on average 50 pfennigs per hour

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[95] Lohn-Journal (Jan. 1910-Dez. 1911). J.E. Reinecker AG, Chemnitz-Gablenz. Sächsisches Staatsarchiv, 31007/390.

and worked ten-hour days, suggesting they earned about 60 Marks over a period of two weeks—close to the norm for workers in the technical bureaus.[96] Some apprentice draftsmen would remain tracers or blue-printers.

Figure 21: "Zeichensaal der alten Lehrlingschule" (drafting room of the old apprentice school), circa 1915. MAN Museum, Augsburg

[96] "The Ludwig Loewe A.G. Works at Berlin," *Congressional Serial Set, Reports, Documents, and Journals of the U.S. Senate and House of Representatives* (Washington D.C.: Government Printing Office, 1909).

Figure 22: "Unterrichtssaal der Lehrlingsschule" (1913). M.A.N. Museum, Augsburg. Note the schematics on the boards at the front.

Figure 23: Drafting class of apprentices at Maschinenfabrik Augsburg-Nürnberg. M.A.N. Museum, Augsburg. Note the exercise in orthographic projection (according to Gaspard Monge's descriptive geometry) on the boards.

Drafting may have become distended from design, but drawings themselves mattered ever more. Consequently, groups such as the *Deutscher Arbeitgeberverband* faced the *Bund der technisch-industriellen Beamten*, known to represent only a small fraction of white-collar workers, with increasing trepidation—particularly after the *Bund der technisch-industriellen Beamten* successfully organized a strike among technicians in Berlin's iron construction firms.[97] Employers in the *Arbeitgeberverband* resolved collectively that their white-collar workers must

[97] "Konferenz der Hauptstelle Deutscher Arbeitgeberverbände über die Behandlung der Angestelltengewerkschaften vom 26. März 1912," RWWA, 130-300/038/1a.

"know with certainty that they would be treated exactly like shop-floor workers in the case of a strike."[98]

In November 1911, the directorate of the Rhineland mining and metalworking firm Gutehoffnungshütte wrote to Max Wallraf, mayor of Cologne, that a

> strike of white-collar workers [*Beamten*] is economically much more dangerous than one by workers, because their strike carries with it idleness [*Beschäftigungslosigkeit*] of the shop-floor workers, the latter accounting for ten times the number of white-collar workers.[99]

Gutehoffnungshütte's reasoning emphasized the critical role of ongoing depictive work and its products, a profusion of intermediate media from design to manufacture, to the firm's operations:

> When 100 shop-floor workers strike, the works can go on with its various thousand other shop-floor workers and white-collar workers, when, however, 100 white-collar workers strike, the entire works must come to a standstill. A meager minority is in the position to force a great majority to its will.[100]

When Gutehoffnungshütte's Sterkrade machinery works identified 45 engineers, draftsmen, and technicians as members of the *Bund der technisch-industriellen Beamten* in 1911, the directors immediately sent them notice to sign a disavowal of the group; thirty-eight complied with management, seven refused and were promptly fired and blacklisted.[101] In 1910 a circular of the Ruhr's association of mining firms had simultaneously named 5400 workers as blacklisted. A notice concerning industry in Mannheim-Ludwigshafen revealed 1300 blacklisted workers by infraction:

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[98] Ibid.

[99] Gutehoffnungshütte, Oberhausen to Oberbürgermeister Max Wallraf, Köln a/Rhein, 11 November 1911, RWWA, 130/3001038/1b.

[100] Ibid.

[101] "Zur Bewegung der technischen Privatbeamten," RWWA, 130-300/038/1a.

> Agitatoren, Hetzer, Aufwiegler, Anarchist, Ausschussmitglied, Rädelsführer, Organisator, Streiker, ferner Trinker, Schwindler, Dieb, Simulant, Betrüger, Messerheld, Drückeberger, Kassenschwindler, minderwertiger Arbeiter.[102]

Among shop-floor and drafting bureau workers, such decisions by management quickly invited debates over *Koalitionsfreiheit,* or freedom of organization.

As German industrialists sought to expand and defend firm-based patenting, the *Verband der deutschen Berufsgenossenchaften*, a consortium of accident insurance syndicates inaugurated by Bismarck's 1884 social insurance scheme for industrial and crafts workers across sectors, claimed to defend the public interest by pressing for powers to expropriate patents for workplace safety devices already granted to white-collar workers.[103] In May 1898 Christian Gerhardt, chair of the *Verband der deutschen Berufsgenossenschaften*, addressed a letter to Chancellor Hohenlohe-Schillingsfürst requesting an amendment to the patent law such that "patents for devices for the protection of life and health of workers" could be "acquired against a reasonable compensation…in the absence of an agreement in the legal process."[104] Writing on behalf of upper management at hundreds, if not thousands, of firms in over three dozen sectors, Gerhardt criticized high prices for safety devices in industrial establishments, stressing that the "loss of his

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[102] Paul Umbreit, "Die Gewerkschaften und die Arbeitsvermittlung. Vortrag, gehalten in der Sitzung der erweiterten Ortsverwaltung des Deutschen Metallarbeiter-Verbandes zu Berlin am 7. November 1912," IISH.

[103] On the workplace safety and standard-setting activities of the *Berufsgenossenschaften*, see Verband der deutschen Berufsgenossenschaften, *Unfallverhütungsvorschriften. Systematische uebersicht der von den gewerblichen berufsgenossenschaften des Deutschen Reichs erlassenen unfallverhütungsvorschriften* (Berlin: C. Heymann, 1900); Ernst Wickenhagen, *Geschichte der gewerblichen Unfallversicherung: Wesen und Wirken der gewerblichen Berufsgenossenschaften* (Munich: Oldenbourg, 1980); Timothy W. Guinnane and Jochen Streb, "Incentives That (Could Have) Saved Lives: Government Regulation of Accident Insurance Associations in Germany, 1884-1914," *Journal of Economic History* 75, no. 4 (2015): 1196-1227.

[104] Christ. Gerhardt to Chancellor Hohenlohe-Schillingsfürst, May 23, 1898, BArch, R 131/32.

arm by an unlucky worker can never be offset."[105] "Questionable patents," he argued, constituted one of the "most important questions of public welfare."[106]

The *Verband*'s director complained that such monopolies worked against the gains achieved by the *Berufsgenossenschaften*'s efforts to improve treatment procedures following industrial accidents, implement stricter oversight of work processes, and offer prizes for inventions preventing injuries. Consequently, the organization invoked a precedent from Imperial Germany's existing patent law: the government's right to expropriate military inventions in the interest of public safety. Speakers at the meeting of the *Berufsgenossenschaften* in Berlin's Hotel Kaiserhof asserted that "the same interest, which the state has for the destruction of so many, many human lives, when it comes to inventions and improvements in weapons of war," could be found "in the retaining of so many workers of its own country."[107]

Beyond the emphasis on national manpower, class questions quickly impinged on the *Berufsgenossenschaften*'s lobbying for patent expropriation—namely, the interest of white-collar workers engaged in designing workplace devices. Attendees at the Hotel Kaiserhof discussed the fact that "naturally this question has an overwhelming significance for works safety engineers [*Revisionsingenieure*]…because they are called…to stipulate the facilities for a factory owner, who holds them accountable for the security of the workers."[108]

Arguments by members of the *Verband der deutschen Berufsgenossenschaften* paralleled Siemens's emphasis on the firm as the site—and owner—of learning and experience as well as

[105] Ibid.

[106] Ibid.

[107] "Auszug aus dem Bericht über den XII. ordentlichen Berufsgenossenschaftstag zu Berlin, im Hotel 'Der Kaiserhof' am 29 März 1898," BArch, R 131/32.

[108] Ibid.

the totalizing view of contract through which many industrialists considered design work. For instance, they stressed that "the source of every new construction or design for the protection of workers is experience, which was made via an accident; that is to say, the engineers are those who, by their whole activity, are…dependent on inventing or constructing such new designs." [109] Experience meant capital to the member firms of the *Verband der deutschen Berufsgenossenschaften* in two senses. In addition to the "experience" of a worker losing a limb informing invention by white-collar workers, records of workplace accidents determined categories of workplace risk [*Gefahrklasse*] for sectors within an individual industry covered by a *Berufsgenossenschaft*. These statistics fed into a dynamic calculation of insurance rates paid by firms participating in *Berufsgenossenschaften*.[110]

The "experience" of a workplace accident factored into their rate payments to the *Berufsgenossenschaften* via statistics composing a weighted sum of the number of accidents per thousand workers: a weighting of 10 for fatal accidents, 15 for accidents causing permanent partial disability, and 30 for accidents resulting in permanent total disability. Since Bismarck's 1884 law banned workers from filing suit against employers in cases of workplace injury, firms paid only insurance premiums.[111] Cost-wise, it was preferable for firms for a worker to die, with or without leaving dependents, because widow and orphan benefits were significantly lower than the pensions granted to permanently disabled workers (sixty-six percent of the most recent wage).[112] The rate of serious accidents rose significantly from 1887 to 1914, while the disabling

[109] Ibid.

[110] Guinnane and Streb, "Incentives That (Could Have) Saved Lives."

[111] Ibid.

[112] Ibid.

accident rate fell slightly in the same period.[113] Reform-minded regulators in the *Berufsgenossenschaften* urged firms to allocate funds for adopting workplace safety technologies.[114] However, since wages were low in many industries and accident compensation was proportional to wages, firms felt little incentive to address the high frequency of catastrophic accidents. By embedding the question of employee patent rights in this debate, the *Verband der deutschen Berufsgenossenschaften* shifted culpability for workplace accidents from firms onto technical white-collar workers.

The *Verein der Beamten der deutschen Berufsgenossenschaften*, an association of white-collar workers employed by the *Berufsgenossenschaften* that presumably included the works safety engineers, explicitly rejected the concept of class struggle in politics and workplace negotiations.[115] Despite the conservative stance of the *Verein der Beamten der deutschen Berufsgenossenschaften*, the leadership of the *Verband der deutschen Berufsgenossenschaften* counterpoised the supposed greed of works safety engineers against the public interest, asserting that:

> If it was only a matter of money, simply around the question: is it advantageous for the *Berufsgenossenschaft*, which has an interest in the thing, to buy the invention off from the particular inventor? Then one would have to calculate: are the savings that the *Berufsgenossenschaft* makes with it worth so much that it can pay the entire sum that the inventor put forward for the patent?
>
> But the thing is not so simple. It is not only about the compensation, but also about life and health of a great number of people, whose loss can never be offset by a monetary

[113] Ibid.

[114] Ibid.

[115] Wilhelm Kulemann, *Die Berufsvereine: Geschichtliche Entwicklung der Berufsorganisationen der Arbeitnehmer und Arbeitgeber aller Länder; Deutschland I: Einleitung, Organisation der Arbeitnehmer I (Öffentliche Beamte, Freie Berufe, Privatangestellte)* (Berlin: G. Fischer, 1908), 267; see also, Konrad Jarausch, *The Unfree Professions: Lawyers, Teachers, and Engineers, 1900-1950* (Oxford: Oxford University Press, 1990).

> reimbursement. For the worker the loss of an arm can never be offset…likewise, payments to widows and orphans do little to replace the father of the family. [116]

Machine tool and workplace safety patenting threw into relief the costs of the new corporate order, as the *Verband der deutschen Berufsgenossenschaften* framed a stark choice between saving lives and limbs of shop-floor workers or preserving individual rights in invention for white-collar workers.

Machinery firms drafted protection for intellectual as "industrial property" in labor contracts and debates over the nature of invention, controversies over the historical meaning of the corporation and lawsuits pitting metallography samples against the testimony of workers. Nevertheless inter-firm and transnational leakage occurred, as the Mannesmann brothers found in the case of the disaffected chief draftsman Ralph Stiefel. The rise of R&D and the expanding bounds of firm-based patentability emerged in tandem, out of a struggle over drawing capital and its consequences. Some German engineers and draftsmen would eventually find satisfaction when Nazi technologists, proponents of an idea of racial creativity in contradistinction to the bureaucratic modes of the corporation, faced off against Siemens and Krupp in the 1930s, revising IP law to make patenting more favorable to small inventors—an issue which the NSDAP had employed as a "battering ram" against the Weimar Republic.[117]

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[116] "Auszug aus dem Bericht über den XII. ordentlichen Berufsgenossenschaftstag zu Berlin," BArch, R 131/32.

[117] Gispen, *Poems in Steel,* 150.

Collecting "Ghost Property"

Before and alongside his testing of the limits of man, Frederick W. Taylor occupied himself with the endurance of metal. Early in his career at Midvale Steel, Taylor had received the support of machine-tools manufacturer William Sellers to conduct experiments in metal fabrication.[118] Having integrated backward with the acquisition of Midvale Steel and the Edgmoor Iron Company, William Sellers himself had turned his attention from machine-tool design to metallurgy, developing machinery and methods to make wrought iron by new varieties of puddling machinery. Sellers transitioned from designing individual lathes and milling machines to wholesale plant redesign and process innovations such as a "comprehensive hydraulic plant for making upset rods and eye bars," in which the "latter were first made of iron by a welding process and then of steel by upsetting and flattening," using "a special and original annealing furnace for very long bars."[119] Sellers's encouragement of Frederick W. Taylor's experiments grew out of this increasingly comprehensive view of machining.[120]

At Bethlehem Steel in 1897 and 1898, Taylor partnered with Maunsell White, a New Orleans *bon vivant*, who had witnessed the enslaved men and women abandon his grandfather's cotton and sugar plantation, Deer Range, at the age of six when Union troops arrived in Louisiana in 1862. A decade prior, Maunsell White's grandfather, also named Maunsell White, had advocated for the use of enslaved labor in building railroads in Mississippi, Louisiana, and Texas. Writing in *DeBow's Review*, White proposed that "the most certain, practicable, and

[118] Thomas Misa, *A Nation of Steel: The Making of Modern America, 1865-1925* (Baltimore: Johns Hopkins University Press, 1998); Dominic Vitiello, *Engineering Philadelphia: The Sellers Family and the Industrial Metropolis* (Ithaca: Cornell University Press, 2013).

[119] "William Sellers, 1824-1905," 2-3.

[120] On Taylor, see Robert Kanigel, *The One Best Way: Frederick Winslow Taylor and the Enigma of Efficiency* (New York: Viking, 1997).

economical mode of constructing the rail-road...would be, by means of the labor of our negroes, to be contributed and directed in the following manner, viz.:

> The planters of each parish or country through which the road is to run, should be called upon for one, two, three, or more slaves, according to their respective forces,—which hands should be employed on the nearest section of the road, under competent managers, to clear and grade the track, and do all the work necessary, to prepare the road for the iron. The owners of these slaves should be paid for their labor at a fair rate in railway stock. In this way, it is believed that the necessary labor to contract the road, may be more promptly and surely obtained than in any other way.[121]

An adherent to the mid-century mechanical sublime, the senior Maunsell White assured fellow members of the planter class,

> If, by the withdrawal of this number of slaves from the production of sugar and cotton, the crops of these staples should be diminished, the price could be enhanced, and thus no loss be sustained. In the meantime, when our planters have given such proofs of their earnestness and practical determination to carry out these improvements, capitalists will come forward promptly and liberally, to furnish the means of purchasing the iron for the road; they will buy lands on the line of the road, and thus interest themselves in its success...By the application of modern appliances of machinery, all the difficulties presented by the character of the country, may be easily overcome; and with the facilities and advantages suggested, the cheapest road in the world may be made in the shortest time.[122]

Maunsell White senior died in 1863. His grandson, a valedictorian in engineering who was said to be able to recite *Hamlet* from memory, would not forget these lessons in labor and technology, monopoly and capital.

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[121] Maunsell White and Ambrose Lanpear, "Proposed Plan of Building Southern Rail-Roads: To our Fellow-citizens of Louisiana, Mississippi, and Texas," *DeBow's Review of the Southern and Western States*, New Orleans XII.2 (Feb 1852): 200.

[122] Ibid., 200; On the mid-century mechanical sublime in distinct national contexts, see Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (Oxford: Oxford University Press, 1964) and John Tresch, *The Romantic Machine: Utopian Science and Technology after Napoleon* (Chicago: University of Chicago Press, 2012).

The Taylor-White process for hardening tool steel emerged from a search for alloys to fabricate tools capable of high-speed steel cutting, involving heavy cuts and rising temperatures, without losing shape. [123] Taylor and White undertook a slow, incremental process of experimentation with steps of heating and annealing at different temperatures. Once the team had made their initial breakthrough in late October and early November 1898, Taylor and White wholly took over the project and stopped all workers at Bethlehem from employing the new method for treating tool steel.[124]

Taylor and White proceeded to gather as much information as possible from competing capital goods firms about existing methods for manufacturing self-hardening tool steel for lathes. About three weeks later, Taylor convened a meeting of representatives of the main tool steel firms such as Midvale, Crescent, Carpenter, and Sanderson, who demonstrated their methods of manufacture. Having assembled trade secrets not entirely available in technical print culture, Taylor and White possessed a yardstick against which to measure their innovation and carve out relevant patent claims. They subjected the other manufacturers' methods to their exhaustive testing procedure, finding that Midvale's special treatment could increase by three hundred percent the cutting speed of steel for lathes. [125]

Taylor and White's experiments reduced the number of variables of machine tools manufacture to the speed of the cut and the cutting tool itself, setting the efficiency of a tool at the maximum cutting speed a tool such as a lathe could endure for twenty minutes short of being "ruined." Having cut over two hundred tons of lathe shavings, the Taylor and White experiments established the terms upon which machine tools and metallurgical approaches could be

[123] Thomson, "Understanding Machine Tool Development in the United States."

[124] Misa, *A Nation of Steel*, 188.

[125] Ibid.

quantitatively compared. Taylor and White also sought to translate the visual color assessments of blacksmiths into a standard numerical system of temperatures according with the color of heated metal. Blacksmiths associated colors known from experience such as "bright cherry" with specific work practices such as welding and forging.[126] Using pyrometers, which were still unreliable and finicky devices in the 1890s, Taylor and White attempted to reformat blacksmith knowledge by assigning precise numerical categories to each color. Their experiments translated "light cherry" into 845 degrees Celsius, or 1553 Fahrenheit on December 13, 1898; "dark blood red" became 990 degrees Fahrenheit, "white" 2200. Taylor and White presented their results to the American Society of Mechanical Engineers the next year, celebrating an end to uncertainty. Their report to the ASME opened with, "There is... nothing more indefinite in the industrial treatment of steel," they began, "than the so-called color temperatures [used daily] by thousands of steel workers."[127] However, Taylor and White's experimental procedure had depended on John Nowak, a blacksmith, judging six grades of heat at which tools were dressed, color temperatures then subjected to pyrometer readings.

More than Taylor's labor regimes, which were only haltingly and partially adopted in industrial shops, the use of the Taylor-White process and the material properties of the tool steel produced altered work processes and the balance of power in the workplace. Indeed, on the heels of the two patents being issued for the Taylor-White Process (and assigned to Bethlehem Steel), Frederick W. Taylor himself was dismissed from Bethlehem Steel in April 1901 following labor strife; two months later, company executive Charles M. Schwab dispensed with his labor system. Contemporaries such as James M. Dodge considered "high-speed tool steel…the direct cause of

[126] Ibid., 190.

[127] Quoted in Misa, *A Nation of Steel*, 191.

the now widespread movement toward the reorganization of industrial methods."[128] Adoption of the Taylor-White process replaced the experiential knowledge and existing stock of data among tool-makers, especially blacksmiths formerly tasked with forging and treating shop tools. Superintendents and speed bosses would oversee the manufacture, use, and repair of high-speed steel, not blacksmiths. In terms of machine tool design, proponents of the Taylor-White process advocated for a departure from existing methods of empirical design and toward the use of "experimentally ascertained fact" to work from kinematics to cutting mechanism to achieve the most "rational design."[129] Like much of Taylor's program, materials experiments were meant to culminate in accumulated facts implying stylized routines or algorithms, rather than pure science resulting in equations reflecting the physics of machinery and materials. Indeed, Taylor sought to keep mechanical engineering and science in distinct domains, preferring to present his findings in tables rather than reduce them to equations.

The Taylor-White process more than doubled the cutting speeds of top self-hardening tool steels, from 20-30 feet per minute to 60 feet per minute. Following the introduction of high-speed tool steel at Bethlehem Steel in early 1899, output per hour shot up with monthly production using lathes almost tripling. In the machine shop, the number of pounds of metal removed from pieces cut per hour increased by 340 percent.[130] Frederick W. Taylor and Maunsell White sold their patent for the process to Bethlehem Steel, which entered the long process of redesigning its entire machine tool stock to take advantage of the new alloy's benefits. Equipped with the patent for a lucrative innovation with wide applications, Bethlehem Steel also began to seek licensing opportunities. Sixteen firms had purchased license rights for the Taylor-

[128] Quoted in Misa, *A Nation of Steel*, 201.

[129] Misa, *A Nation of Steel*, 202.

[130] Ibid., 193.

White Process costing around $3000 each by 1903, whereas Bethlehem Steel received $100,000 from Vickers, Sons, & Maxim, Ltd. for patent rights in Great Britain and the same amount from Isador Loewe & Gebrüder and Bohler & Company for rights in Germany and Austria-Hungary.[131]

Instructions that Bethlehem Steel provided to purchasers of its licensees and products for the patented Taylor-White Process covered forging, treating, roughing, finishing, and annealing tools. The metal should be heated "to bright cherry red merging into full yellow" and "no forging should be done below a cherry red, to avoid checks at sharp corners which weaken the tools." [132] Roughing the tools required workers to

> heat the tool slowly to cherry red then bring the cutting portion of tool to a white heat as rapidly as possible, in a soft coal or coke fire, and then placed immediately in a dry cold air blast, it being allowed to remain there until cold.[133]

Bethlehem cautioned users to "provide a good bed of fuel so that the blast does not blow through and strike the cutting edges of the tools." Finished machine tools could be hardened by "heating uniformly as hot as possible without injuring or deforming the shape, and then cooling in air or oil until cold, oil being preferable."[134] Taylor-White steel could be annealed by "being heated slowly and evenly to a bright cherry, then buried in dry warm lime" to be "warmed up with heated fire bricks before the bars of steel or tools are buried in it."[135] Such directives reveal the relevance of tacit assessments of tempering and hue upon which even rapidly rationalizing works

[131] Ibid., 197.

[132] Bethlehem Steel, Archibald Johnston (1865-1948) papers, Hagley Museum, 1770 Series I, Box 16.

[133] Ibid.

[134] Ibid.

[135] Ibid.

such as Bethlehem Steel implicitly relied; however, they also defined nine standard treatment routines yielding specific tool qualities.

They also required toolmakers to stamp the tool with the number of the treatment employed, creating and protecting the market for the high-speed tool steel produced with the Taylor-White process. [136] Bethlehem Steel hoped to protect the users of high-speed steel "against any suit for damages on account of possible infringement, by stamping each bar say every 6-inches of tool steel, with a license stamp." [137] Such a stamp would

> carry with it to the users of the steel the license to use the heat treatment of the Taylor-White process, without any subsequent claim for damages on account of the use of this heat treatment, it being understood that the price at which the tool steel is sold includes this royalty for the right to the use the heat treatment.[138]

In the understanding of Bethlehem Steel's managerial elite, the collusive royalty-generating scheme depended on the main points of the Taylor-White patents being sustained in court. They then wondered about the role of the "license stamp" in securing the process against infringement: "would it interfere with the patents or our ability to recover for infringement in the future?" If a stamped bar indeed authorized the use of the Taylor-White process only within companies party to the United Tool Steel syndicate, "could we [Bethlehem Steel] issue instructions to the users of tool steel in printed form?" [139] Alternatively, if it was legally held that stamping licensure did not "cover the point," they asked, "should we continue to issue our instructions as to treatment only verbally?" [140]

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[136] Misa, *A Nation of Steel*, 197.

[137] Memorandum regarding Taylor-White Tool Steel, Sept 4th, 1906, Hagley Museum, Archibald Johnston (1865-1948), papers, 1770 Series I, Box 16.

[138] Ibid.

[139] Ibid.

[140] Ibid.

It was a puzzling predicament. How would Bethlehem Steel simultaneously protect rights over a process and promote its expanded use among steelmakers and steel-users in the United States and Europe? Could these rights be inscribed in the very metal itself, or factored into its commodity price? What would transpire as high-speed steel components circulated within the highly networked capital goods sector, upstream and downstream in supply chains, to firms beyond the scope of the syndicate? They knew that the "practice of the trade is to issue instructions to users of tool steel in typewritten form, and are not embodied in printed books."[141] Aiming to construct and capitalize on an edifice of processual patent rights, Bethlehem Steel faced a challenging problem in the political economy of industrial knowledge. Bethlehem Steel and its competitors clearly ruled out divulging even patented processes in free-circulating technical print culture; however, private communiqués of typewritten instructions and the flow of license-stamped steel appeared as potential threats to monopoly as well.

The *Iron Trade Review* predicted that the uptake of the Taylor-White Process would result in the "practical exclusion of the foreign brands of self-hardening steel which are now supplying over one-half of the demand and will place the market entirely in the hands of the American steel maker."[142] Based on the Taylor-White patents, Bethlehem Steel Vice President H.S. Snyder imagined forming "a combination of the largest tool steel manufacturers... [which] would be certain to exercise a very great influence upon consumers of steel manufactured by concerns who were not licensed." A price scale could be set at monthly meetings, and imported tool steel could be blocked by enlisting the foreign steelmakers in the combination or legally "proceeding against their customers, the consumer," for infringing the patent rights to the

[141] Ibid.

[142] Misa, *A Nation of Steel*, 196.

process. Snyder proposed to capitalize such a collusive entity at $100,000, baptizing it as the Bethlehem Tool Steel Company or the United Tool Steel Company. Bethlehem Steel would offer the new enterprise exclusive license to the Taylor-White process for high-speed tool steel in return for fifty-one percent of its paid capital stock, while keeping ownership of the IP for itself. The remainder of the capital stock would be acquired via subscriptions from the other major manufacturers of tool steel. Having crafted the United Tool Steel Company as the sole licensee for its process patents, Bethlehem Steel would receive $80,000 annually in royalties.[143] Securing the patents to the Taylor-White Process, itself based on an epistemic reformulation, would mean moving from steelmaking to an IP monopoly. Pioneers of collecting "ghost property," Taylor and White achieved for themselves—and perhaps Bethlehem Steel—a strange alchemy: they made rentiers on experience.

But Bethlehem Steel came to suspect that the Taylor-White Process had been infringed upon by machine-tool manufacturer Niles-Bement-Pond. In August 1905, Bethlehem Steel's patent attorney, Thomas Bakewell, gathered a list of men employed at Niles-Bement-Pond in Philadelphia before Bethlehem had announced its infringement suit against the company. Bakewell assured E. Grant Tice, secretary to the president of Bethlehem Steel, that "if we get one good witness to testify clearly as to the treatment to which the steel is put by the defendant, it will suffice, as we do not think it desirable to take to much testimony in our opening case."[144] Considering shop-floor workers as eyewitnesses, Bakewell emphasized the significance of deciding "which one of the witnesses you name should be called, as I can see it is important to

[143] Ibid., 203.

[144] Thomas W. Bakewell to E. Grant Tice, Bethlehem Steel, August 28, 1905, Hagley Museum, Archibald Johnston (1865-1948) papers, 1770 Series I, Box 16.

select the right one and to take steps for his protection."[145] In an era of industrial espionage and competition alongside roiling class conflict, Bakewell did not trust a worker's deposition to translate into courtroom testimony without adequate "protection." Rather than depend on shop-floor workers, Bakewell's strategy entailed procuring a sample of a Niles-Bement-Pond tool, whose treatment could be analyzed by a chemist. The chemical analysis would then be set against statements by academic experts and Bethlehem Steel's own account of the "practical merits" of the Taylor-White Process. [146]

Bethlehem Steel hoped to prove infringement on the Taylor-White Process on the basis of the heating procedure detailed in the patent claims ("1725 degrees Fahrenheit, 1850, a point verging on the point of fusion") and a composition calling for the combination of chromium with tungsten or molybdenum. [147] The Taylor-White patent infringement suit became a transnational enterprise. In addition to scouring international technical literature, patent attorney Thomas Bakewell assembled a sheaf of foreign patents to establish the "prior state of the art with reference to the common heat treatments of steel."[148] Bakewell and Bethlehem Steel corresponded with Vickers in the United Kingdom and Krupp in Germany.

In preparation for the Taylor-White infringement suit, Bethlehem Steel commenced a foray into industrial espionage. They hoped to compare materials gathered from other firms to their own under the microscope, while also ferreting out the lines through which the process had been communicated to non-licensees. Company secretary E. Grant Tice wrote to one of

[145] Ibid.

[146] Ibid.

[147] Memorandum regarding Taylor-White Tool Steel, Sept 4th, 1906, Hagley Museum, Archibald Johnston (1865-1948) papers, 1770 Series I, Box 16.

[148] Thomas W. Bakewell to M. White, Eagle Hotel, Bethlehem, PA, Oct 2, 1906. Hagley Museum, Archibald Johnston (1865-1948) papers, 1770 Series I, Box 16.

Bethlehem Steel's sales agents to acquire a several foot-long piece of tool steel manufactured by the Crescent Works of the Crucible Steel Company of America. He cautioned the agent, "you will have to be very careful in getting this piece of steel, to avoid their learning for whom it is intended." Tice asked him further to get "from the party selling it to you, instructions as to the method to be adopted in cutting the bar into short lengths," since he wanted "to know what directions are issued by the Crescent people for cutting the bars into short lengths, viz: whether by heating the steel and then cutting into lengths, or by nicking and cutting cold." [149] Tice hoped to procure instructions that Crescent Steel "issued prior to 1899 for the use of their tool holder size bars" in hopes that it would establish the novelty of the Taylor-White patents or enable him to locate the point of knowledge conveyance.

Aware of the knowledge flows within the capital goods industries, Tice reasoned that, if "you find that the Carnegie Steel Company used Crescent tool steel prior to 1899, it is possible that the Carnegie people may have had some trouble with the steel, and no doubt had correspondence with the Crescent Works as to the proper working of the said steel." [150] Tice intended to acquire any potential correspondence by Crescent Steel in which they "specifically give directions as to the proper heat treatment to be applied to remedy any difficulty which the Carnegie Company may have had." [151] Tice stressed to the agent that "all of the above information must be secured with the utmost secrecy, and no one should be approached who is a possible infringer of our patent, and whom we may in the future compel to pay royalty." [152] Tice

[149] E. Grant Tice, Secretary to President, to Edward S. Knisely, sales agent, Bethlehem Steel Co., Pittsburg, PA, April 25, 1906, Hagley Museum, Archibald Johnston (1865-1948) papers, 1770 Series I, Box 16.

[150] Ibid.

[151] Ibid.

[152] Ibid.

had chosen to track the possible diffusion of high-speed steel outward from the Carnegie Company because they had bought a license to use the Taylor-White Process and had formed a close relationship with Bethlehem Steel.[153]

Writing to Tice, Maunsell White believed that “McKenna’s testimony sounds to me as tho’ it had been outlined for him and seems to be too eager and tries to prove too much.”[154] He continued, “I think he is a d-n liar myself.”[155] Hoping to blunt the impact of McKenna’s testimony about the heating procedure, White suggested gathering “old tools,” which would be “tested in some outside shop to that we can have some outside data to put in evidence.”[156] White also instructed Tice to undertake the “collection of all of our analyses on self-hardening steels and have them tabulated as follows: Date\History of Sample\Analysis.”[157] White hoped that the testimony such as McKenna’s would make Taylor “hot enough to want to go on the stand for us,” despite his initial hesitation to do so.[158]

In the patent suit against Niles-Bement-Pond, the attorney Bakewell requested mechanical engineer and Bethlehem Steel general superintendent (soon to be vice-president) Archibald Johnston’s testimony on two points: the British patent sale and the color temperature at which mushet steel at his works was forged. Bakewell hoped that the high price ($100,000) settled upon by the English patent purchasers upon inspection of the process would testify to its novelty, despite the fact that they had allowed the British patents to lapse quickly. Johnston’s

[153] Ibid.

[154] Maunsell White to E. Grant Tice, May 17, 1906, Hagley Museum, Archibald Johnston (1865-1948), papers, 1770 Series I, Box 16.

[155] Ibid.

[156] Ibid.

[157] Ibid.

[158] Ibid.

testimony as to the temperature of forging would prove that steel from his works "was not forged at a temperature higher than the ordinary conventional cherry red heat," an account which would in Bakewell's view "be more forcible that that of any other person," including the accounts of shop-floor workers.[159]

Niles-Bement-Pond successfully undercut Bethlehem Steel's charges of infringement on the Taylor-White Process by using the expert testimony of a metallurgy professor from Sheffield. Concerned that the Taylor-White patents and Bethlehem Steel's planned cartel premised on them would exclude them from the market, Sheffield steelmakers had formed an alliance with Niles-Bement-Pond. [160] Bethlehem Steel appealed the decision, at which point the court invalidated the two Taylor-White patents. The judge's January 1909 decision invalidated Taylor and White's claims to the novelty of their heating process and the chemical composition of its tool steel. He asserted that prior art for high heats did in fact exist, especially in experimentation with new steels of unknown composition.

The judge emphasized that Taylor and White's contribution lay not in invention but rather in their "special facilities, apparatus and methods not embraced in the patents."[161] Whether patentable or not independently (Taylor and White did, in fact, patent a pyrometer), the innovation of the "Taylor-White Process" was not in making a specific variety of tool steel; rather, it was in the experimentation and testing procedure itself, which relied on strict temperature control using pyrometers and thousands of controlled lathe cuttings using a

[159] Thomas Bakewell to A. Johnston, President, Bethlehem Steel, Nov 27, 1907, Hagley Museum, Archibald Johnston (1865-1948) papers, 1770 Series I, Box 16.

[160] Misa, *A Nation of Steel*, 204.

[161] Quoted in Misa, *A Nation of Steel*, 205.

streamlined two-variable analytical scheme.[162] Consequently, the process for fabricating high-speed tool steel spread irresistibly outward.

Seeking to preserve the value of his accumulated data stock of thousands of metal-cutting experiments, Frederick W. Taylor contested the usefulness of the new structure-oriented science of metallography. Pursued avidly in discussions of the properties of steel in the United Kingdom, United States, and continental Europe alike, metallography posited that the physical properties of a metal depended on its temperature history in addition to its chemical make-up.[163]

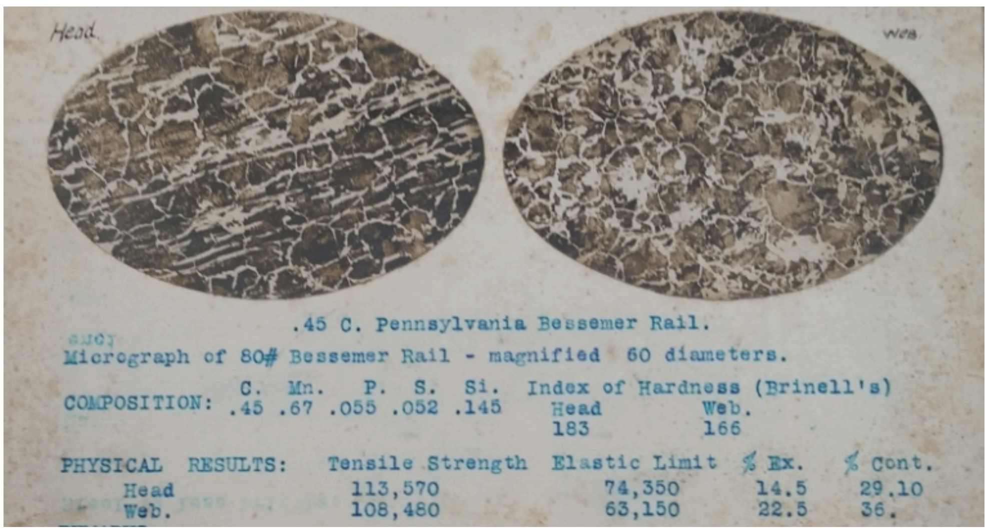

Figure 24: Micrograph of Steel Rail. Archibald Johnston Papers, Hagley Museum.

Metallography and microphotography had gained popularity in American science and engineering circles at the turn of the century with the "rail crisis." Magnifying the surfaces of steel rails 750 to 900 times lent works such as Bethlehem Steel insight into the structures and properties of their Bessemer rails, especially their durability and transformations after "service a great many years." [164] Microphotographs enabled analysts to track the "transformation of pearlite

[162] Misa, *A Nation of Steel*, 205.

[163] Ibid., 206.

[164] C.A. Brace, Asst General Superintendent, Memorandum for Mr. A. Johnston, President, April 27, 1908, Hagley Museum, Archibald Johnston (1865-1948), papers, 1770 Series II, Box 20.

and ferrite into sorbet and martensite," and identify when areas of a rail such as the "martensite on the extreme outside of the head of the rail presents the characteristic of a martensite low in Carbon, as if the steel was decarburized." [165] White lines betrayed "minute cracks" in structures such as martensite, "which probably increase by the wear of the steel."[166] The mediation of the microscope differed significantly from Taylor's use of the pyrometer to quantify blacksmiths' color temperatures—and implicitly challenged the worth of his tables of data and method.

Taylor understood the role of temperature history in the structural claims of metallography and granted that the "critical point" when cooling or heating was halted for a time led to a rearrangement at the molecular level. But Taylor argued that metallography offered an incomplete view because, in his view, tool steels possessed two distinct categories of hardness, at low and high temperatures respectively. He stressed that the snapshots employed in metallography only captured one of these two cases. Moreover, Taylor proposed even greater uncertainty in the methods of metallography by claiming that there was "no traceable relation between the highest cutting speeds and any particular one of the microscopic structures."[167] Neither microscopic views of a metal's structure nor the heating and cooling curves that served as a key device of metallography could accurately predict its behavior in Taylor's view. Heating and cooling curves were insufficient since, according to Taylor, they threw "no light upon the important question as to the exact heat at which the tempering or softening of the high speed tool begins, or as to what range of temperatures this softening process extends." Instead, capital goods firms would have to employ him to learn the art of cutting metal.

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[165] Ibid.

[166] Ibid.

[167] Misa, *A Nation of Steel*, 207.

As a financially successful engineering consultant, Taylor carefully managed the flow of data and experiential information gained and codified through experimental testing. Consulting engineers such as Taylor embedded themselves in capital goods firms, where they received salaries, testing machinery, and skilled workmen in order to provide discoveries in the art and science of cutting metal. Each company engaged in such a contract with a consulting engineer was bound not to disclose any of the data acquired, privately or in print. The workers staffing the ongoing experiments were similarly bound to secrecy. Bolstered by these contracts, collusive interests, and workshop practices as much as by the legal monopolies granted by the patents, Taylor managed to keep most of the "laws" of metal-cutting a secret for a quarter century.[168]

To advance his career and out of a genuine belief in the commensurability of equally scientific tools for managing metal and men, Taylor tied access to data from his metal-cutting experiments for high-speed steel to implementation of his management system, prompting many firms to partially "taylorize" in pursuit of the secrets of the Taylor-White Process. The proliferation of the scientific management depended on widespread interest in strength of materials, the nexus of intellectual property, industrial property, and "ghost property." Frederick W. Taylor died in 1915; his system, however, continued its expansion from mechanical engineering into business education and reform governance on both sides of the Atlantic.

Coda

In January 1919, Heinrich Nicklisch, a professor of management at the Institute for Research on Company Life (*Betriebswissenschaftl. Institut für Forschungen auf dem Gebiete des Betriebslebens*) at the commercial college (*Handels-Hochschule*) in Mannheim, wrote to the Patent Office in Berlin with a question: Could management methods themselves be

[168] Ibid., 207.

patentable?[169] Nicklisch acknowledged that Article 1 of the German patent law explained that patents pertained to "new inventions, which possess a commercial worth," and that these inventions encompassed either "objects" or "objective processes for the production of objects."[170] Yet he proposed that management methods should also be deemed patentable, since "the redesign of a work activity as purely as possible, if it enables a greater performance with the same expenditure of time and energy," contained "a new and commercially valuable invention."[171] Nicklisch found a proximate example in "the so-called scientific management of the Americans and their development toward management science in Germany," which had "shown that the increase in performance and the commercial uses along with it, which can be reached through such a rational organization of the work activities, is of great significance."[172]

But the roots of Nicklisch's conceptual expansion of the patentable lay deeper than the Taylorist fad, which would gain adherents in 1920s Germany. In the name of a "rational organization of work activities," Nicklisch indeed recommended seeking "to dispense with excessive sub-processes (movements and mental processes)" and instead to "design the necessary tasks, such that they can be taken with the slightest expenditure of time and energy."[173] These would be imperatives for industry in the debt-ridden Weimar Republic; however, less than

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[169] Nicklisch to Kaiser. Patentamt, 14 January 1919, BArch, R131/3; "Förderung der Arbeitswissenschaft," *Zeitschrift des Vereines Deutscher Ingenieure* 63, no. 2 (1919): 1297.

[170] Nicklisch to Kaiser. Patentamt, 14 January 1919, BArch, R131/3.

[171] Ibid.

[172] Ibid.; on Taylorism in the Weimar Republic, see Charles Maier, "Between Taylorism and Technocracy: European Ideologies and the Vision of Industrial Productivity in the 1920s," *Journal of Contemporary History* 5, no. 2 (1970): 27-61; Mary Nolan, *Visions of Modernity: American Business and the Modernization of Germany* (Oxford: Oxford University Press, 1994).

[173] Nicklisch to Kaiser. Patentamt, 14 January 1919, BArch, R131/3; on energy discourses and social politics at the *fin-de-siècle,* see Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (Berkeley: University of California Press, 1992).

a year after the conclusion of hostilities, Nicklisch's reasoning resembled the debates over the nature and extent of the *Betriebserfindung* in the *Kaiserreich*.[174]

Patenting management methods mattered for two main reasons according to Nicklisch. First, a "comprehensive, rational organization of all work activities...would be of invaluable worth to private and national industry."[175] Second, to "realize this goal fully, [management] science demands the cooperation of the worker" since "it is essential to win the interest of the worker for questions of work organization, which is only possible under today's conditions if inventions which constitute a rational organization of work activities are patentable."[176] Clearly unsettled by revolution, Nicklisch posited the *Betriebsgemeinschaft* as a normative ideal.

Despite growing industrial photography in the 1910s and 1920s for catalog advertisements, in-house company newspapers, materials research, and instruction of apprentices, owners and directors of industrial establishments forbade workers from photographing within workshops. Industrialists viewed photography by workers as a dual threat. First, workers' photography challenged their operating rights over their property, offering potentially damning views of work processes. Second, workers' photography might endanger their intellectual property through industrial espionage. Whenever workers did rarely snap such shots, it was anonymously and under secrecy.[177]

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[174] Mary Nolan, *Visions of Modernity: American Business and the Modernization of Germany* (Oxford: Oxford University Press, 1994); on Nicklisch's organicist ideology across the First World War, see Wolfgang Burr and Alfred Wagenhofer, *Der Verband der Hochschullehrer für Betriebswirtschaft: Geschichte des VHB* (Wiesbaden: Gabler, 2013), 60-62.

[175] Nicklisch to Kaiser. Patentamt.

[176] Ibid.

[177] Alf Lüdtke, "Industriebilder—Bilder der Industriearbeit? Industrie- und Arbeiterphotographie von der Jahrhundertwende bis in die 1930er Jahre," *Historische Anthropologie* 1 (1993), 421-422.

Although German engineering employers debated whether naming employee-inventors without granting them IP rights might stave off their growing unionization, workers in the drafting bureau could claim no authorship of the ideas contained in what they drew. Workers on the shop floor were denied an independent sight regime altogether, and turned their lenses to photographing urban protests, police brutality, and street scenes. Gathering visual evidence of work processes, making traces and imprints of materials, and depicting scenes of labor reflected and reinforced a particular political economy and legal regime for the protection of intellectual as 'industrial property' and the management of risk in the era of the Second Industrial Revolution.

From the accumulating stock of patterns, models, and drawings directing fabrication and design to the financialization of future patent corridors to be exploited internationally to the assiduous collection and use of materials science in patent suits, repeated struggles over the line between industrial and intellectual property had recast work itself. Work—manual, depictive, or calculative—had come to constitute not merely an object of study but one of supposed invention and potential patenting. The firm as intensifying locus of technical knowledge endowed the term *Betriebserfindung* (company invention) with several simultaneous meanings: an invention *by* and *for* the firm, *within* and *of* and *about* the firm. Drawing capital rarely stops at the drafting table.

Chapter Six: Drafting Empire

Engineering the German Mission Industrialisatrice *in China, 1865-1914*

"A large portion of the plunderers perished by their work, some shot by the police, some encircled by flames; in one house I found 23 bodies turned to coal [verkohlt]."[1] So reported Theodor Freiherr von Grote, German vice-consul in Tianjin, to Consul Paul von Buri in Shanghai on the post-revolutionary violence, which had spread from Beijing to Tianjin's foreign concession in March 1912. Monitoring the disbanded Chinese soldiers' actions, Japanese officials feared a wave of unrest in northern China akin to the Boxer Rebellion. In 1900 the Boxer Movement, having begun in western Shandong province with elements of a religious revival alongside those of an anti-colonial uprising, had hoisted placards bearing the slogans "Rip up the railroad tracks! Pull down the telegraph lines! Quickly! Hurry up! Smash them—The boats and the steamship combine."[2] A dozen years later the treaty port of Tianjin witnessed the "imprisoned soldiers and police, clothed as coolies and hauled to different corners of the city,...under military guard decapitated in the open street."[3]

Von Grote wrote that

> on the four great streets, which were built from the old city walls, lay 17 corpses. The business was continued the next day; so soon there lay bodies everywhere and heads hung on bridge-, telegraph- and lamp-poles.[4]

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[1] "Bericht des Vizekonsuls in Tianjin, Theodor Freiherr von Grote, an den Generalkonsul in Shanghai, Paul von Buri (22-3-1912)," in Andreas Steen, *Deutsch-chinesische Beziehungen 1911-1927: Vom Kolonialismus zur "Gleichberechtigung": Eine Quellensammlung* (Berlin: Akademie, 2006), 72-74; on the March 1912 mutinies in Beijing, Tianjin, and Baoding, see Jonathan Spence, *The Search for Modern China* (New York: Norton, 1990), 277.

[2] Aimin Guo, "United in Righteousness: Slogans and Actions in the Boxer Movement" (PhD Dissertation, Stony Brook University, 2010); on the Boxer Movement more widely, see Paul Cohen, *History in three keys: the Boxer Movement as Event, Experience, and Myth* (New York: Columbia University Press, 1997); Joseph Esherick, *The Origins of the Boxer Uprising* (Berkeley: University of California Press, 1987).

[3] "Bericht des Vizekonsuls in Tianjin, Theodor Freiherr von Grote," in Steen, *Deutsch-chinesische Beziehungen*, 72-75.

[4] Ibid.

Von Grote's gaze enumerated the capital goods of transport, communication, and urban infrastructure, surveying the arc of recent material change in the midst of destruction. He narrated a reinscription of infrastructure imperialism, as British, French, German, and Japanese troops patrolled the streets and occupants of the foreign concession scurried to issue insurance claims for forty million taels of property lost or looted during the events following the proclamation of the new Chinese Republic.

Beyond Tianjin, Western recognition of and preference for Yuan Shikai's regime hinged on the defense of foreign financial and industrial capital in China, which had grown from $788 million in 1902 to $1.61 billion in 1914.[5] Yuan Shikai signed agreements for the continuation of the Qing government's staggering debt burden incurred since the Boxer Indemnity (yearly payments of 46 to 47 million taels, or about half of the late-Qing central budget). Eventually, on the night of April 26, 1913, he would have his finance minister, Zhou Xuexi, accept the terms of the Five-Power "Reorganization Loan," undermining China's fiscal autonomy without the consent of the Chinese parliament.[6]

With strengthening protection for the nearby railway-under-construction with other foreign consuls a priority in March 1912, the first person German diplomat von Grote asked after was Julius Dorpmüller, chief engineer of the Tianjin-Pukou Railway (and later Nazi transport minister). The Tianjin-Pukou line comprised an operation jointly financed and supplied by British and German interests, with its northern terminus at Tianjin. Von Grote feared that "marauding militias" had "poured out onto the land" and "above all, using the Tianjin-Pukou

[5] Spence, *The Search for Modern China*, 281.

[6] Steen, *Deutsch-chinesische Beziehungen*, 59.

railway, pillaged along the rail line."[7] He noted that the German engineers had been called back from the line for several days as a result.

This chapter focuses on the genesis of a peculiar and rapacious model of development politics practiced by German firms in Shandong, part of the emerging coal and steel complex of northeast Asia. The next chapter follows the multilateral expansion and transformation of this model of infrastructure imperialism in the years flanking World War I. Together they present an entangled history of German and American geologists and mining interests, engineers in capital goods firms, financial syndicates, and diplomats in which the contest between the territorial carving up of China into "spheres of influence" on one hand and the "Open Door" for competitive Western market penetration on the other gave rise to a collusive system of multilateral finance tethered to industrial capital. Out of the crucible of the *mission industrialisatrice* in East Asia came the American International Development Corporation, the first U.S.-based financial organization aimed explicitly at developing export trade by using infrastructure to refashion the economic landscapes of entire regions, as well as the first calls for a "World Bank" for the economic reconstruction of Weimar Germany based explicitly on the model of the multipower consortium-based "Reorganization Loan" to China.

On the heels of the nineteenth-century "de-industrialization" of longstanding centers of consumer goods manufacture outside of the West, such as textile production in India, emerged two related movements among finance capital and the engineering industries in Europe and the United States.[8] First, they undertook large-scale infrastructure projects, initially conceived of as promoting the expansion of cash crop cultivation or nationally-defined transoceanic shipping, but

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[7] "Bericht des Vizekonsuls in Tianjin, Theodor Freiherr von Grote," in Steen, *Deutsch-chinesische Beziehungen,* 72-75.

[8] Sven Beckert, *Empire of Cotton: A Global History* (New York: Knopf, 2014).

relying on potential financial returns and soon coming to encompass a much wider notion of "development." This notion extended to municipal hygiene, education, electrification, and tramway endeavors globally in addition to more variable efforts at land reclamation and scientific forestry. Second, they sought outlets for the mechanization of production across sectors in the colonized and especially semi-colonial world, from agriculture to woodworking to mining and metal fabrication. Consequently, they advertised to modernizing—often military—elites a distinctly linear notion of industrial advance in exhibitions, commercial museums, and eventually film reels.

Despite this foment immediately preceding World War I, current literature on the origins of development politics tends to focus on four nodes: the rise of the social sciences, expert networks and international institutions in New York, London, and Geneva in the context of shifting prospects for empire and decolonization during the interwar period; the 1930s romance with "high modernism" in projects such as the Tennessee Valley Authority as the road to modernization projects globally; the construction of an international financial architecture embodied in the IMF and World Bank following the Second World War; and development as a mutable and multifaceted tool to promote or stave off the global advance of Soviet or U.S. influence in the Cold War.[9]

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[9] David Ekbladh, *The Great American Mission: Modernization and the Construction of an American World Order* (Princeton: Princeton University Press, 2010); Kiran Klaus Patel, *The New Deal: A Global History* (Princeton: Princeton University Press, 2016); Jamie Martin, "Governing the World Economy: Economic Expertise and the Reshaping of Global Order, 1916-1948" (PhD Dissertation, Harvard University, 2015); David Engerman, ed., *Staging Growth: Modernization, Development, and the Global Cold War* (Amherst: University of Massachusetts Press, 2003); Daniel Speich, "The use of global abstractions: national income accounting in the period of imperial decline," *Journal of Global History* 6, no. 1 (March 2011): 7-28; Odd Arne Westad, *The Global Cold War: Third World Interventions and the Making of Our Times* (Cambridge: Cambridge University Press, 2005); Niels Petersson, *Anarchie und Weltrecht: das Deutsche Reich und die Institutionen der Weltwirtschaft, 1890-1930* (Göttingen: Vandenhoeck & Ruprecht, 2009); Hubertus Büschel and Daniel Speich, eds., *Entwicklungswelten: Globalgeschichte der Entwicklungszusammenarbeit* (Frankfurt: Campus, 2009).

Meanwhile, historians of Germany have increasingly emphasized private enterprise in the making of Wilhelmine imperialism and considered whether industrial, commercial, and financial interests in the *Kaiserreich* and Weimar Republic pursued neo-imperial relations with eastern and southern Europe.[10] Historians have posited a distinction between an overseas "hard *Weltpolitik*," arising out the Berlin Conference scramble for Africa and associated with colonies in China and Samoa and the build-up of naval power, and a "liberal *Weltpolitik*," involving the projection of soft power over the European continent via cultural diplomacy to promote German exports.[11] Envisioned by Foreign office bureaucrats, bankers, publicists, and academics, this "liberal *Weltpolitik*" did not aim at the formal imperialism of overseas colonies or settlements in Eastern Europe. Instead, figures such as Walther Rathenau, Karl Helfferich, and Ernst Jäckh imagined a bloc, connected via the Berlin-Baghdad Railway, opening markets to German exports and investment.[12] Stephen Gross contextualizes their view as contiguous with those of British

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[10] Steven Press, *Rogue Empires: Conmen and Contracts in Europe's Scramble for Africa* (Cambridge, MA: Harvard University Press, 2017); Stephen Gross, *Export Empire: German Soft Power in Southeastern Europe* (Cambridge: Cambridge University Press, 2016); Uta Poiger, "Imperialism and Empire in Twentieth-Century Germany," *History & Memory* 17, no. 1 (2005): 117-143; Reinhardt Opitz, *Europastrategien des deutschen Kapitals* (Cologne: Pahl-Rugenstein, 1977); Volker Berghahn, *Quest for Economic Empire: European Strategies of German Big Business in the Twentieth Century* (New York, 1996); Keith Tribe, *Strategies of Economic Order: German Economic Discourse, 1750-1950* (Cambridge: Cambridge University Press, 2007); Harold James on Hjalmar Schacht's vision of a central European commercial zone as informal empire in *The End of Globalization: Lessons from the Great Depression* (Cambridge, MA: Harvard University Press, 2001); Mark Mazower, *Hitler's Empire: How the Nazis Ruled Europe* (New York: Penguin, 2008); on the cultural history of German imperialism, see David Ciarlo, *Advertising Empire: Race and Visual Culture in Imperial Germany* (Cambridge, MA: Harvard University Press, 2011); George Steinmetz, *The Devil's Handwriting: Precoloniality and the German Colonial State in Qingdao, Samoa, and Southwest Africa* (Chicago: University of Chicago Press, 2008); Sebastien Conrad and Jürgen Osterhammel, eds. *Das Kaiserreich Transnational: Deutschland in der Welt, 1871-1914* (Göttingen: Vandenhoeck & Ruprecht, 2004); Sebastian Conrad, "Rethinking German Colonialism in a Global Age," *The Journal of Imperial and Commonwealth History* 41, no. 4 (2013); Bradley Naranch and Geoff Eley, eds. *German Colonialism in a Global Age* (Durham: Duke University Press, 2014); Nina Berman, ed., *German Colonialism Revisited: African, Asian, and Oceanic Experiences* (Ann Arbor: University of Michigan Press, 2014); Klaus Mühlhahn, *Herrschaft und Widerstand in der 'Musterkolonie' Kiautschou: Interaktionen zwischen China und Deutschland, 1897-1914* (Munich: Oldenbourg, 2000).

[11] Stephen G. Gross, *Export Empire: German Soft Power in Southeastern Europe, 1890-1945* (Cambridge: Cambridge University Press, 2017), 28.

[12] Gross, *Export Empire*, 34-35.

and French elites of the time, including Minister of Foreign Affairs Jules Ferry's denomination of colonies in North Africa and Indo-China as receptacles for French surplus capital and overproduction.[13]

Though useful (and sometimes invoked in various forms by contemporaries), the distinction between formal imperialism and "liberal *Weltpolitik*" should not be overdrawn. German financial and industrial interests invested the formal imperial project in Qingdao with commercial, cultural, and industrial aspirations much like those Gross finds in Eastern Europe. Despite naval jurisdiction of the port, Shandong province was also a laboratory of soft power, employing tools of education and engineering expertise alongside bullets.

Moreover, the turn-of-the-century transition British historians locate in the term "development" from a "passive" to an "active" sense in the colonial policy of Joseph Chamberlain does not necessarily work well in the German.[14] The German press used the terms *Erschließung* and *Entwicklung* frequently and together. From early modern cameralism to the (continental) national political economy of Friedrich List to the German Historical School, "development" in German had been an active project to begin with—whether of ordering, enclosing, managing, connecting, integrating, or accumulating.[15] While the goals of German financiers and industrialists were comparable to those of other European empires (and eventually those of the United States), the multiple and sometimes conflicting dimensions of development as project would make their mark on Qingdao and wider German neo-imperialism.

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13 Gross, *Export Empire*, 36.

14 Gross, *Export Empire*, 257; H.W. Arndt, "Economic Development: A Semantic History," *Economic Development and Social Change* 29, no. 3 (April 1981): 457-466.

15 Keith Tribe, *Strategies of Economic Order: German Economic Discourse, 1750-1950* (Cambridge University Press, 2007).

Most capital goods exports from Imperial Germany around the turn of the century, whether locomotives or machine tools, were destined for locales in Europe (France, Russia, Austria-Hungary, Romania, Italy, and Spain); however, capital goods shipments to Japan, the Ottoman Empire, Argentina, Chile, and Brazil were increasing in the years leading up to World War I. In 1901-1902, Borsig exported over a dozen locomotives to Spain and Italy each; by 1903, Borsig had broken into the Indian market with an order for 32 locomotives in four months.[16] Borsig's 1903 locomotive orders embraced not only Spain, Romania, Denmark, Belgium, the Netherlands, Russia, and Chile but also Indo-China, Java, and Mauritius. The next year Borsig locomotives were destined for the Ottoman Empire, Portugal, Argentina, Paraguay, Sweden, and Surinam in addition to those locales already mentioned.[17] In the two years preceding World War I, Borsig exported locomotives to Bolivia, Brazil, Bulgaria, Chile, Colombia, France, German East Africa, Guatemala, Indo-China, Indonesia, Italy, Japan, Luxembourg, Norway, the Ottoman Empire, Russia, Sardinia, Serbia, and Switzerland.[18] Capital goods exports both diversified and expanded enormously immediately prior to 1914.

Investment capital underwrote capital goods export in most of these contexts, whether under the auspices of trade or empire (or within another power's empire), in neighboring countries or overseas. The names of the German overseas banks, organized as stock companies by consortia of the major "D-banks," particularly Disconto-Gesellschaft and Deutsche Bank, from the 1880s onward, themselves hint at a wider story: the *Bank für Chile und Deutschland*, the *Bank für Brasilien und Deutschland*, the *Deutsch-Südamerikanische Bank*, the *Deutsch-*

[16] Borsig Order Book, Technikmuseum, I.2.001.

[17] Ibid.

[18] Ibid.

Westafrikanische Bank, the *Deutsch-Ostafrikanische Bank*, the *Deutsch-Palästina Bank*, and the *Deutsch-Asiatische Bank.*[19]

Frequently embedded within infrastructure imperialism and capital goods export, the projecting filiales of German finance, having eliminated competition in foreign domains via fusion, did not distinguish meaningfully between opportunities within the formal empire and without. In 1913 the overseas banks with the greatest investment capital were the *Deutsche Ueberseeische Bank* (39.5 million Marks), the *Bank für Brasilien und Deutschland* (21.2 million Marks), the *Deutsch-Südamerikanische Bank* (20 million Marks), the *Deutsch-Palästina Bank* (20 million Marks), and the *Deutsch-Asiatische Bank* (18.75 million Marks plus 4.6 million in reserves).[20] Imperial Germany's colonies scattered from Southwest Africa (Namibia) to Samoa attracted relatively little investment and did not contribute significantly to trade. Overall, exports to China hovered around one percent of the German total between 1895 and 1913, though the value of these exports more than tripled over the course of this period. In 1913 only about three percent of Sino-German trade passed through the port of Qingdao itself.[21]

The German *mission industrialisatrice* in Qingdao and wider Shandong was neither representative of Wilhelmine formal imperialism in Southwest Africa (Namibia), East Africa (Tanzania), or Samoa nor at the center of Imperial Germany's highly export-oriented capital goods sector. Under naval administration, the "model colony" of Qingdao was imagined and ruled differently from other German Imperial holdings.[22] Although German urban planners

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[19] Karl Christian Schaefer, *Deutsche Portfolioinvestitionen im Ausland 1870-1914: Banken, Kapitalmärkte und Wertpapierhandel im Zeitalter des Imperialismus* (Münster: Lit, 1995).

[20] Ibid.

[21] William C. Kirby, *Germany and Republican China* (Stanford: Stanford University Press, 1984), 12-13.

[22] Steinmetz, *The Devil's Handwriting*.

racially segregated the town of Qingdao and colonial codes restricted Chinese residents' freedoms of speech, assembly, and movement at night, the wider province of Shandong remained in the hands of Chinese governors, including prominent political figures such as Sun Baoqi (1909-1911) and Yuan Shikai (1899-1902), who employed political, diplomatic, and commercial channels to retain and recapture sovereignty over territory and mining resources.[23] Likewise reflecting the uncertain status of Shandong's economic space, historians have not categorized the *Deutsch-Asiatische Bank*, which provided the loans for German infrastructure-building projects in China, as a colonial bank, nor did contemporaries undertake such a classification.

Looking to late Qing and Republican China offers a simultaneous glimpse into the inter-imperial dynamics of contested economic sovereignties and the role of railroading and engineering-based political economy for emerging notions of development and development finance. There are suggestive links between the infrastructure-building ventures of industrial and finance capital in the "semi-colonized" world—China, the Ottoman lands, and Latin America—in the years leading up to World War I on one hand and the thought behind later international economic governance on the other.[24] This chapter and the next attempt to uncover the origins and nature of those structural and intellectual links.

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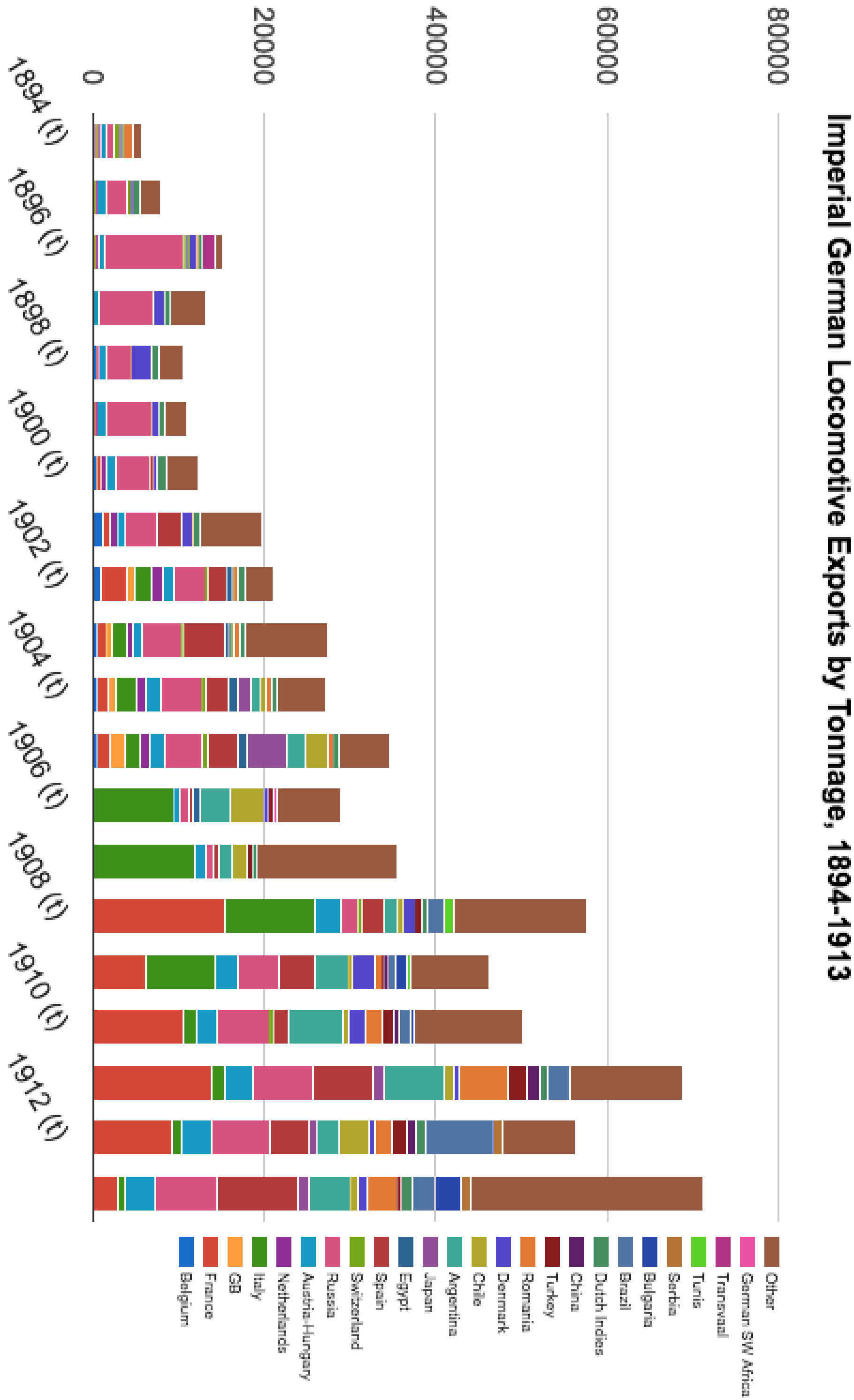
[23] John Schrecker, *Imperialism and Chinese Nationalism: Germany in Shantung* (Cambridge, MA: Harvard University Press, 1971).

[24] On infrastructure imperialism, see Dirk van Laak, *Ueber alles in der Welt: deutscher Imperialismus im 19. und 20. Jahrhundert* (Munich: Beck, 2005); Clarence Davis and Ronald Robinson, eds., *Railway Imperialism* (Westport, CT: Greenwood Press, 1991); Marc Linder, *Projecting Capitalism: A History of the Internationalization of the Construction Industry* (Westport, CT: Greenwood Press, 1994).


Imperial German Locomotive Exports by Tonnage, 1894-1913
0
20000
40000
60000
80000
1894 (t)
1896 (t)
1898 (t)
1900 (t)
1902 (t)
1904 (t)
1906 (t)
1908 (t)
1910 (t)
1912 (t)
Belgium
France
GB
Italy
Netherlands
Austria-Hungary
Russia
Switzerland
Spain
Egypt
Japan
Argentina
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Denmark
Romania
Turkey
China
Dutch Indies
Brazil
Bulgaria
Serbia
Tunis
Transvaal
German SW Africa
Other

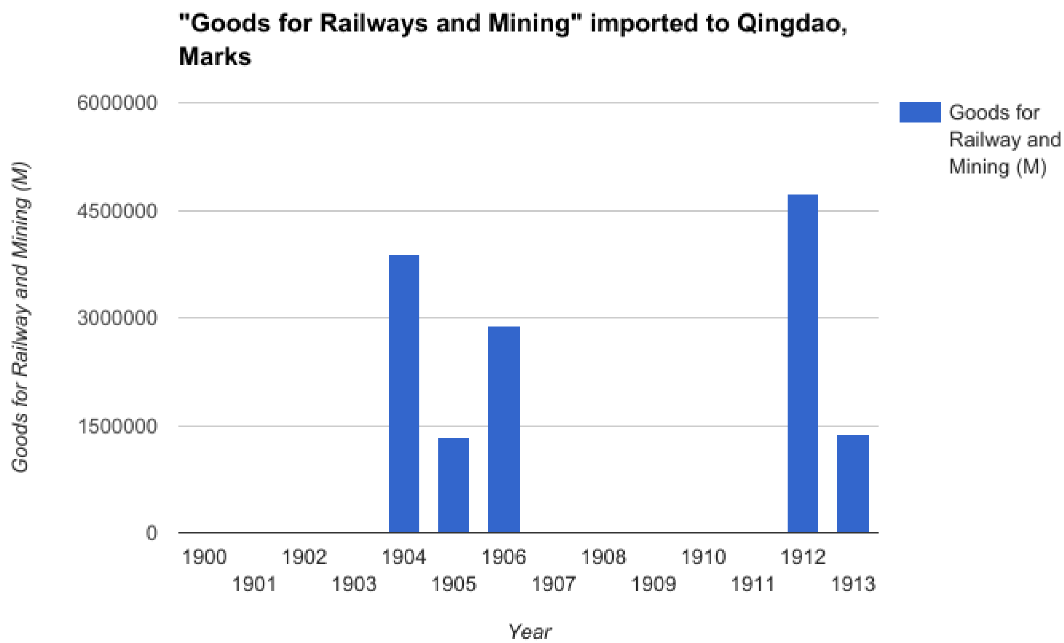

Figure 25: Statistische Reichsamt, *Statistische Jahrbücher für das deutsche Reich* (1909-1914); data categorized in this way unavailable for missing years. See chart below for a reconstitution of specific capital goods imports available from categories in previous statistical collections.

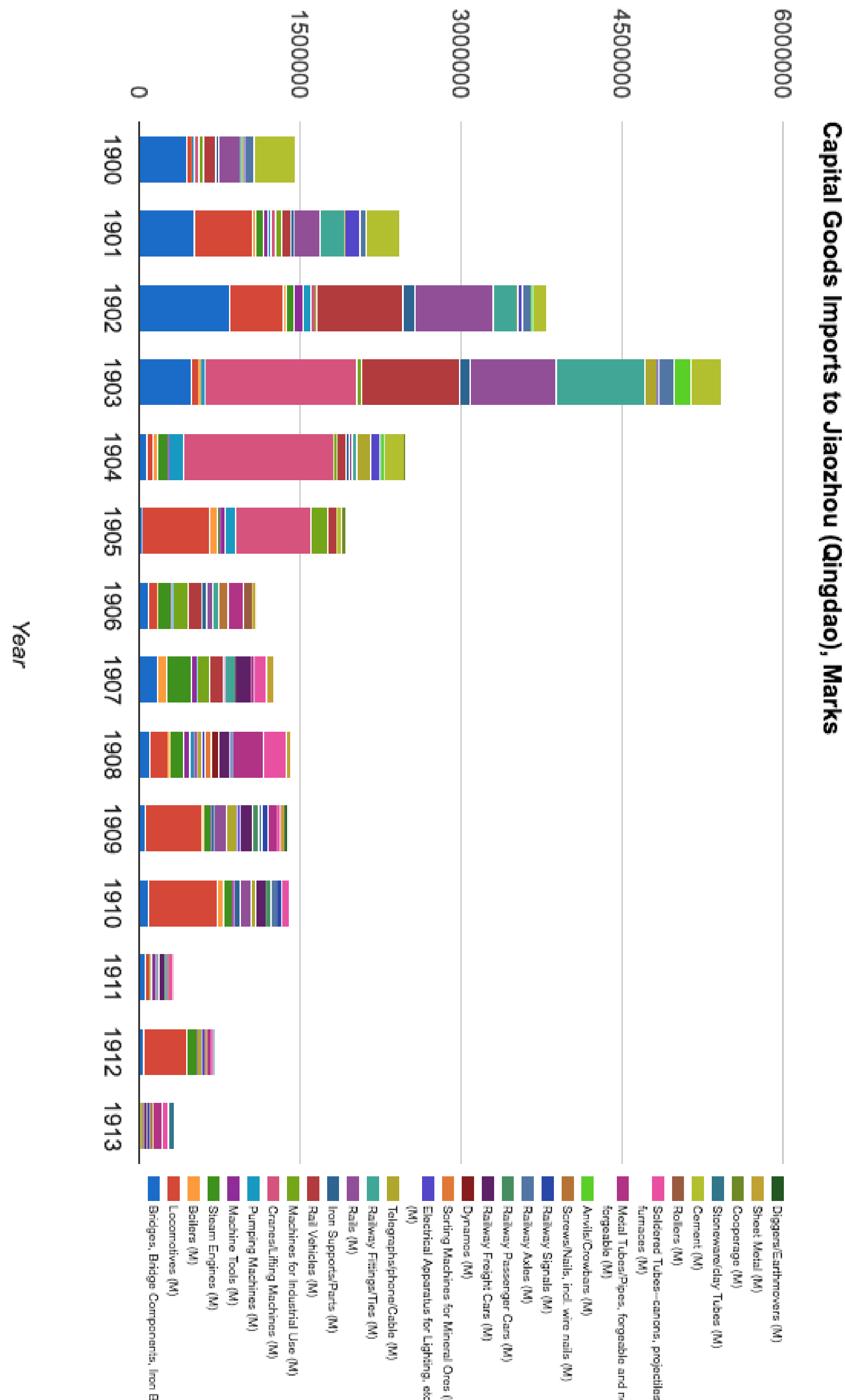

Figure 26: Statistisches Reichsamt, *Statistische Jahrbücher für das deutsche Reich* (1894-1914). Note: Categories vary year to year. http://www.digizeitschriften.de.ezp-prod1.hul.harvard.edu/dms/toc/?PID=PPN514401303_1908

Classic historiography of late Qing and Republican China noted the correlation of Boxer resistance along railroad routes and the search for economic defense and autonomy beginning with the Self-Strengthening Movement. In reference to Shandong in particular, historians argued in the 1960s that Chinese authorities successfully checked German assertions of territorial control, effectively resisting (in terms of mining concessions) or coopting (in terms of railroad concessions) infrastructure imperialism in political and commercial if not financial terms.[25] More recently, historian Shellen Wu has argued that German geological surveys, while discovering little beyond what Chinese already knew of coal deposits, introduced understandings of such minerals as a finite resource, prompting the vigorous growth of nationalism in their defense.[26] Consequently, Wu proposes refocusing late Qing and early Republican historiography away from railroads and toward the commodity that fueled them. Navigating between these insights, this chapter suggests that thinking about capital goods broadly means examining the territorial, financial, commercial, and labor relationships governing the proliferation of machinery and mineral extraction.

Would the economic dimension of Imperial Germany's *Außenpolitik* mean securing areas of raw goods export to Germany (and assuming such regions remained raw-goods exporters) or providing outlets for Germany's capital goods in zones perceived as destined for industrial development? Metals and minerals conjoined the two impulses, sometimes uneasily, and potentially bound together as diverse factions as the cutting-edge, globally competitive electrical industry represented by AEG and Siemens in Berlin, the older cartelized and traditionally pro-

[25] John Schrecker, *Imperialism and Chinese Nationalism: Germany in Shantung* (Cambridge, MA: Harvard University Press, 1970).

[26] Shellen Wu, *Empires of Coal: Fueling China's Entry in the Modern World Order, 1860-1920* (Stanford: Stanford University Press, 2016). and "The Search for Coal in the Age of Empire: Ferdinand von Richthofen's Odyssey in China, 1860-1920," *American Historical Review* 119, no. 2 (2014): 339-363.

tariff heavy industry of the Ruhr, and the seafaring, free-trading commercial sector of Hamburg.[27]

Mineral Cultures

Sitting atop coal, the provinces of northeastern Chinese occupied a critical place in this emerging debate and its resolution. German geologists were quick to perceive that Chinese fields more than rivalled the extensive coal seams of Pennsylvania. Having undertaken the first survey of China's mineral wealth following a stint in the American West (California, Nevada, and Arizona from 1865 to 1868), geologist Ferdinand von Richthofen pointed out that the Chinese province of Shanxi alone encompassed 55,000 square miles of coal land in comparison to Pennsylvania's mere 20,000.[28] Richthofen had originally arrived in China in 1860, prior to his American sojourn, as part of a Prussian delegation aimed at establishing trade relations between China and the Zollverein states, with the additional purpose of scouting for a potential German naval base. Returning to Shanghai with funding to identify coal deposits in China from the Bank of California, Richthofen laid the groundwork for the industrial developmentalist vision. In this vision, he tended to erase China's social and cultural landscape; unlike Sinologists of the era, Richthofen never learned more than basic Chinese.[29]

The eventual execution of his vision, based on railroad and mining concessions, destroyed Chinese familial gravesites and provided some of the most palpable cause for the

[27] Cornelius Torp, *The Challenges of Globalization: The German Empire in the World Economy, 1860-1914* (New York: Berghahn, 2014).

[28] Ferdinand von Richthofen, *Tagebücher aus China* (Berlin: Reimer, 1907); Wu, *Empires of Coal*; Richard G. Beidleman, *California's Frontier Naturalists* (Berkeley: University of California Press, 2006); Grace Yen Shen, *Unearthing the Nation: Modern Geology and Nationalism in Republican China* (Chicago: University of Chicago Press, 2014).

[29] Jürgen Osterhammel, "Forschungsreise und Kolonialprogramm: Ferdinand von Richthofen und die Erschließung Chinas im 19. Jahrhundert," *Kulturgeschichte* (1987): 150-195.

Boxer Movement.[30] A U.S. consular report on "Far Eastern Markets for Railroad Supplies" wrote, "One item of construction expense in China that has caused much comment in the past has been the removal of graves," which are "located in the middle of a cultivated area" and "occur all over China literally by the thousands."[31] Fortunately, the circular continued, "It is probable that the growing sentiment in favor of railways and the Government regulations for building new lines will greatly simplify this trouble in the future."[32] Widely read by American geographers and geologists, many of whom had trained at the Freiberg School of Mines, Richthofen's account gave rise to the American appropriation of a heroic role in sparking China's "re-awakening" via missionary activities and capital investment after Germany had been forced out of East Asia in the First World War.[33]

Mining and machining shaped racial identities and conceptions of civilizational progress among late nineteenth-century German engineers. Franz Reuleaux, professor of mechanical engineering at the *Technische Hochschule* in the elite Berlin suburb of Charlottenburg and chief technical delegate to the Philadelphia and Sydney World's Fairs, divided humanity into two levels of development: *Atlantiker* as *Manganisten*, a term he derived from the Greek *Manganon*, or "an artificial structure or construction through which something unusual could be achieved [*künstliche Vorrichtung, Einrichtung, durch welche Ungewöhnliches geleistet werden konnte*],"

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[30] On the Boxer Movement, see Esherick, *The Origins of Boxer Uprising*; Cohen, *History in Three Keys*.

[31] "Far Eastern Markets For Railway Materials Equipment and Supplies: Part 1 China," *Special Agents Series* 178-182 (Washington D.C., 1919).

[32] Ibid.

[33] Jürgen Osterhammel, "Forschungsreise und Kolonialprogramm: Ferdinand von Richthofen und die Erschließung Chinas im 19. Jahrhundert," *Kulturgeschichte* (1987): 150-195; Bernard Debarbieux and Gilles Rudaz, *The Mountain: A Political History from the Enlightenment to the Present* (Chicago: University of Chicago Press, 2015); Richthofen, *Tagebücher aus China*; Warren Alexander Dym, "Freiberg and the Frontier: Louis Janin, German Engineering, and 'Civilisation' in the American West," *Annals of Science* 68, no. 3 (2011): 295-323; David Ekbladh, *The Great American Mission: Modernization and the Making of an American World Order* (Princeton: Princeton University Press, 2011).

to mean those who unleashed the latent energy of fossil fuels via combustion machinery, versus *Naturisten*, those who relied on the work of animals and natural forces alone.[34] In an article entitled “Kultur und Technik,” which circulated as far as the American Philosophical Society in Philadelphia, Reuleaux called coal the “most essential factor for *manganistische* work,” now extracted “in a great mass of over 400 million tons yearly and overwhelmingly sent to industrial ends.”[35]

“For each of the 300 work days of the year,” Reuleaux continued, “we have 1 ⅓ million tons of coal, which are applied to chemical, mechanical and physical-technical purposes”--“around 90 million horsepower if accounted for as dynamic performance,” he calculated. Since each horsepower equalled that of six strong men, Reuleaux equated this with 540 million “manpower, active during 12-hour days.”[36] He crowed, “we *Atlantiker*, one sixth of the earth’s inhabitants, can perform with our *manganistischen* work over four times as much as any other.” He held that the “domination of the *Manganisten* over the *Naturisten* is thus not a random occurrence [*ein zufälliges*], but rather will be acquired and paid back [*Heimgezahlt*] through useful work, and achieves its justification through it...thus scientific technology becomes the carrier of culture [*Trägerin der Kultur*], the powerful, untiring worker in service of the ethos [*Gesittung*] and education of humankind.”[37] With such a telos, he predicted, “the mastery of the Earth belongs to the *manganistischen* Nations.”[38]

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[34] On comparable British, French, and American thought, see Michael Adas, *Machines as the Measure of Men: Science, Technology, and Ideologies of Western Dominance* (Ithaca: Cornell University Press, 1989).

[35] Franz Reuleaux, “Kultur und Technik,” *Sonderabdruck aus der Zeitschrift des Vereines deutscher Ingenieure* 29, no. 24 (Berlin, 1885), Deutsches Museum, NL 069/219.

[36] Franz Reuleaux, *Die mechanischen Naturkräfte und deren Verwertung* (Berlin: Paetel, 1901), 36.

[37] Reuleaux, “Kultur und Technik,” 8; Reuleaux, “Kultur und Technik,” *Prometheus* I, 40 (Berlin, 1890), DM, NL 069/234.

[38] Reuleaux, *Die mechanischen Naturkräfte*, 36.

Mechanical inventiveness notwithstanding, Reuleaux returned to the power of coal, noting that "England will have emptied its coal fields at the latest in 200 years, a threat that has already induced it to search for back-up in China's mighty coal seams."[39] Consequently, he spotted in China an opportunity, or "conditions...appropriate, to make foreseeable a future shift in the industrial strength of countries."[40] As early as 1880, the British engineer C.W. Kinder had constructed a 10-mile tramway with a small locomotive, "the Rocket of China," for the Kaiping coal mines at Tangshan. British capital had extended the line to Tianjin and eventually to Shanhaikwan in 1894, where, as American engineer William Barclay Parsons explained to a Philadelphia audience twenty years later, "the Great Wall ends at the sea."[41] That was where the project ended for British capital; however, for \ engineering professor Franz Reuleaux and geologist von Richthofen, coal implied considerably more. Coal implied machine civilization.

In 1897, when Kaiser Wilhelm and the German navy seized the opportunity presented by the killing of two German Catholic missionaries in Shandong to make a claim on Jiaozhou Bay and extract an indemnity of 450 million Taels (approximately 1239 million Marks), Admiral Alfred von Tirpitz concurred.[42] Citing Richthofen's surveys, Tirpitz hoped to establish Qingdao as a "model colony," a German "Hong Kong."[43] Tirpitz planned for the ninety-nine-year leasehold to serve as considerably more than a coaling station for the German navy and merchant

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[39] Ibid., 36.

[40] Ibid.

[41] William Barclay Parsons, "An American Engineer in China," *Journal of the Franklin Institute* CLXXIX, no. 4 (April 1915): 381.

[42] Karl Christian Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 499.

[43] Alfred von Tirpitz, *Erinnerungen* (Leipzig: K. F. Koehler, 1920), 61-66.

marine in East Asia.[44] He stressed that the "most important condition" in choosing a location for colonization was the "economic development potential [*Entwicklungsfähigkeit*]."[45] Tirpitz focused on the exploitation of Shandong province's coal reserves as a stepping stone to erecting iron and steelworks, enabling "the settlement [*Ansiedlung*] of industrial undertakings."[46] According to Tirpitz, "no ironworks in all of East Asia and western America had comparable prospects," for the "iron and steel markets there had come into our hands, and the expanded economic significance of Germany must also raise our political position and positively affect all of the relevant German export industries."[47]

The causes and consequences of industrial export and investment thus intertwined, Tirpitz expected the "increase in value [*Wertsteigerung*] of Qingdao," particularly with the Shandong railway as a means to "enclose and develop" ("*erschließen*"—a word frequently used in German colonial discourse, high and low—means both) the city's hinterland.[48] Many German plans for enclosure and development announced in 1898, such as railroading concessions deep in the interior of Shandong province from Yanzhou to Kaifeng via Jining and Caozhou and from Jinan to Xundefu via Changqing, Chiping, Zhangdefu, Nanle, Weixian, and Pingxian, would not come to pass. Instead, these lines were first renegotiated by the Republican government in 1913, then ceded to Japan in World War I, and finally scrapped by a Chinese government preferring to

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[44] Bert Becker, "The German Colony of Kiaochow and Its Postal Steamer Service, 1898-1914," *International Journal of Maritime History* 21, no. 1 (2009): 201-238; on how Qingdao's uncertain sovereignty served as an example for the U.S. acquisition of Guantánamo Bay, Cuba, see Steven Press, "Sovereignty at Guantánamo: New Evidence and a Comparative Historical Interpretation," *The Journal of Modern History* 85, no. 3 (September 2013): 592-631; on naval competition and energy security, see Peter Shulman, *Coal and Empire: The Birth of Energy Security in Industrial America* (Baltimore: Johns Hopkins University Press, 2015).

[45] Tirpitz, *Erinnerungen*, 62.

[46] Ibid., 68.

[47] Ibid., 68.

[48] Ibid., 68.

stem further Japanese intrusions.[49] Mourning the loss of German Qingdao following Versailles, Tirpitz recalled, "we stood before limitless possibilities for economic growth."[50]

Similarly, in 1904, August Etienne had envisioned German economic interests in China within the context of developmentalism. Establishing purchasing power as a relevant unit of analysis, Etienne anticipated China's take-off from poverty via growing consumption of capital goods in exchange for its rich array of mineral ores.[51] An investigation of the significance of Chinese markets for "West German industry" stressed that China already held the "preconditions for economic development," namely "a hard-working populace, good and cheap inland water transportation, and, above all, raw materials of immeasurable value."[52] The investigator viewed these conditions as the natural complements to German industrial investment and determined that the "question as to whether Germany can, in the future, survive without the Chinese market must be answered unconditionally in the negative."[53]

The Shandong and Tianjin-Pukou Railroads and the *Mission Industrialisatrice*

The financial syndicate behind the German railways that were built, the Shandong and Tianjin-Pukou lines, formed as early as 1885 when Adolph von Hansemann founded a

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[49] Kenneth Pomeranz, *The Making of a Hinterland: State, Society, and Economy in Inland North China* (Berkeley: University of Chicago Press, 1993), 147.

[50] Tirpitz, *Erinnerungen*, 68.

[51] Quoted in Kirby, *Germany and Republican China*, 14; August Etienne, *Deutschlands wirtschaftliche Interessen in China: Betrachtungen über die handelspolitische Lage im asiatischen Osten* (Berlin: Guttentag, 1904).

[52] Quoted in Kirby, *Germany and Republican China*, 14; H. Serchinger, "Der chinesische Markt und die westdeutsche Wirtschaft" (1913) cited in J. Schickel, ed. *China—Deutschlands Partner? Politik, Wirtschaft, Kultur* (Frankfurt: Fischer, 1974), 199.

[53] Quoted in Kirby, *Germany and Republican China*, 14.

consortium to investigate Asian business opportunities. From the start, Hansemann's efforts engaged Disconto-Gesellschaft, Deutsche Bank, Mendelssohn & Co., S. Bleichröder, M.A. von Rothschild & Söhne in Frankfurt a.M., Sal Oppenheim, Jun. & Cie in Cologne, the Dortmunder Union, the Phönix Mining A.G., and several locomotive manufacturers.[54] The banking consortium had determined that it would seek concessions for railway construction in overseas countries. On Christmas day 1885, Bismarck, Deutsche Bank, and Disconto-Gesellschaft sent experts Heinrich Hildebrand, A.H. Exner, and Curt Erich to China to scout for the most promising rail routes *and* mineral deposits, ensuring that the German syndicate responsible for railroad construction would lobby for the path most advantageous to German industry.[55]

The founding of the Deutsch-Asiatische bank was delayed by the conflicting interests of the main investors--Hansemann, Bleichröder, and Deutsche Bank--whose struggle was only resolved when Gerson Bleichröder suggested that the undertaking "could not be realized as a purely private enterprise and must be set up on another basis, with the participation of public funds to bring it to life."[56] Consequently Bismarck and the Prussian state bank (*Seehandlung)* entered discussions to organize a meeting of German bankers, which nevertheless yielded no immediate result.[57] In 1889, however, the study consortium enlarged to form a consortium for Asian business, which eventually transformed into the Deutsch-Asiatische Bank headquartered in Shanghai and holding a nominal capital of five million Haikong Taels (22 million Marks).[58]

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[54] Hermann Münch, *Adolph von Hansemann* (Munich: Drei Masken Verlag, 1932), 218; Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 495.

[55] Vera Schmidt, *Die Deutsche Eisenbahnpolitik in Shantung, 1898-1914: Ein Beitrag zur Geschichte des deutschen Imperialismus in China* (Wiesbaden: Harrassowitz, 1976), 66; Münch, 218; Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 496.

[56] Quoted in Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 496.

[57] Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 495.

[58] Ibid., 495.

At its founding, the Deutsch-Asiatische Bank issued 5000 shares, primarily to major German banks and institutional investors: 805 to Disconto-Gesellschaft, 555 each to Deutsche Bank and S. Bleichröder, 470 each to the Berliner Handels-Gesellschaft and Jacob S.H. Stern, and 380 to the Norddeutsche Bank in Hamburg. The Bank für Handel und Industrie, R. Warschauer, Mendelssohn, M.A. v. Rothschild in Frankfurt, the Bayerische Hypotheken- und Wechselbank in Munich, Born & Busse, and Sal. Oppenheim jun. & Co. soon took sizeable shares in the enterprise, as did the Prussian *Seehandlung* (175 shares) according to Bismarck's request. The German government formally backed the syndicate, reserving the right to confirm the president of the supervisory board for the Kaiser.[59] They were eventually joined in East Asian finance and investment by industrial firms such as Friedrich Krupp AG and Maschinenfabrik Augsburg-Nürnberg, merchant houses such as Carlowitz & Co., landholders such as Count Dönhoff-Friedrichstein, Colonel von Moltke, and Prince Fürstenberg, and additional banks such as the Dresdner Bank, years before the acquisition of the colonial leasehold of Qingdao on Jiaozhou Bay and years before the related railway contracts were secured.[60]

Without a base for investment, the Deutsch-Asiatische bank foundered in its first year, easily surpassed by its more established British rival in East Asian trade and finance--the Hongkong & Shanghai Banking Co. Nevertheless, from the mid-1890s onward, the Deutsch-Asiatische Bank established branches in treaty ports such as Tianjin, Hankow, and Qingdao in hopes of garnering a greater market share.[61] Following the loss of the Sino-Japanese War, the

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[59] Werner Plumpe, *Deutsche Bank in China* (Munich: Piper, 2008), 15.

[60] Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 496; Schmidt, *Die Deutsche Eisenbahnpolitik in Shantung,* 65.

[61] Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 497.

"scramble for concessions" accompanied the weakening of the Qing government after 1895, and Adolph von Hansemann's banking consortium was ready for it. The Deutsch-Asiatische Bank undertook to collaborate in a European financial syndicate involving the British Hongkong and Shanghai Banking Co. and the French Banque de l'Indochine for financing in equal parts China's war reparations of 200 million Haikong Taels (approximately 540 million Marks) as determined in the Treaty of Shimonoseki.[62] This venture into multilateral financing of state debt foreshadowed subsequent inter-imperial ventures in China and, indeed, the origins of development politics.

A year after Germany had concluded the Bay of Jiaozhou lease agreement with China, Hansemann repeatedly pressed on behalf of commercial and industrial interests for railway and mining activities to begin in Shandong. An 1898 agreement forced China to concede railway-building and mining rights to Germany in Shandong, sparking interest among four groups of would-be investors: the Consortium for Asian Business, a group of private individuals surrounding Fürst v. Fürstenberg, a bevy of China-oriented trade firms based in Hamburg and Cologne, and a cohort of industrialists centered around the Dresdner Elektrizitätsgesellschaft. As had been done with the different financial interests who formed the Deutsch-Asiatische Bank, the Imperial German government intervened to merge the competing groups (most of whom were, indeed, members of the Deutsch-Asiatische Bank) into a single syndicate, which accepted the rights to the Chinese railway and mining concessions from the *Reichskanzler* in June 1899.[63] That month witnessed the establishment of the Shantung Eisenbahn-Gesellschaft, which, with a starting capital of 54 million Marks, commenced rail construction immediately from Qingdao to

[62] Ibid., 497.

[63] Schmidt, *Die Deutsche Eisenbahnpolitik in Shantung,* 101.

Jinan, the province of Shandong's capitol. Completing a triangle from the line's endpoints toward Yizhou in southern Shandong, the Schantung Eisenbahn-Gesellschaft had laid 435 km of track by completion in 1904.[64] Nevertheless, dividends were meager, varying between 3.25 and eight percent. This, however, did not prevent contemporaries from referring to the railway as the "Canada-Pacific of the East."

Evincing a particular understanding of economic space, the alliance of German financiers, industrialists, and diplomats sought to create a closed circuit of land concessions, financial advantages, and construction privileges. They conceived of the railway as means to enclose and develop ("erschließen") the hinterland of Shandong on behalf of the commercial colony on Jiaozhou Bay, particularly the coal seams near Poshan via the newly formed Shantung Bergbau-Gesellschaft. Financially, the influence of Hansemann's banking syndicate extended well beyond railroads and mining and into currency for the entire province of Shandong. The *Far Eastern Review* summarized in 1906:

> The concession of the German-Asiatic Bank for issuing and circulating bank notes in the German Protectorate of Kiauchou and the German settlements in China, runs for 15 yrs. The bank notes will be of the value of 1, 5, 10, 25 and 50 dollars, and 1, 5,10, and 20 taels. In the Chinese Province of Shantung only notes of the money standard of Tsingtau can be circulated. The dollar, as mentioned in this concession, is the current Mexican dollar or a coin which in general commerce is recognized as equal in value at the various places of issue or is made so by law. The bank agrees to pay 1 per cent per annum on the yearly average amount of the daily circulation of the bank notes. The sureties for the security of the notes are the Bank of Commerce and Industry, of Berlin; the Commercial Association, of Berlin; S. Bleichroeder; the German Bank [Deutsche Bank]; the Disconto Association [Disconto Gesellschaft], and Mendelssohn & Co., of Berlin.[65]

On the construction side, the German imperial delegation had secured a guarantee from the Chinese government that it would depend on German experts, capital, and technology for the

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[64] Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 500.

[65] "German Money-Issue in China," *The Far Eastern Review* (October 1906): 174.

province's development. The treaty section specifying that German firms had to be approached first "arguably made all of Shandong province an exclusive German sphere of influence" and was thus "in some ways the most important, since it virtually guaranteed the continued expansion of German influence in China."[66] Approximately half of the building sum for the Shandong railroad returned to Germany as orders for German industry, while Chinese firms and individuals received about thirty percent via land purchases, stone and earthworks, and wages. This portion of the thirty percent included wages for some twenty- to twenty-five thousand Chinese workers during construction.[67] Between June and December 1900, Borsig delivered no fewer than six locomotives to the Schantung-Eisenbahn-Gesellschaft.[68]

Having completed the Shandong railways, the *Deutsch-Asiatische Bank* turned its attention to securing the commission to construct the 1085 km-long Tianjin-Pukou Railroad. Negotiations over the route had begun as early as 1897 between the Chinese government on one side and the Deutsch-Asiatische Bank and the Hongkong and Shanghai Banking Co. on the other. The German and British interests merged for the financing of the railway construction and undertook the loan for over 150 million Marks, with the German group financing the northern section and the British the southern section.[69] This apportionment accorded the German syndicate two-thirds of the loan sum and the British one the remaining third.[70] Negotiations with the Qing government in 1908 resulted in the commission being awarded to an Anglo-German Syndicate comprised of the *Deutsch-Asiatische Bank*, Shanghai and Messieurs Jardine Matheson

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[66] Elleman, *Manchurian Railways and the Opening of China*, 10.

[67] Schmidt, *Die Deutsche Eisenbahnpolitik in Shantung*, 89.

[68] Borsig order book, TM, I.2.001.

[69] Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 502-503.

[70] Ibid., 502-503.

& Co. as Agents for and on behalf of the Chinese Central Railways Limited of London, which would collectively offer a 30-year loan, "repayable after ten years at 102.5 and at par after 20 years."[71] What began as a £5 million loan by the Anglo-German syndicate in 1908 was increased via an additional loan by the same group of financiers of over £4.8 million in 1910. Once constructed, the Tianjin-Pukou line would connect Jinan, Shandong's capitol, with Tianjin and Nanjing and join together two emerging rail networks, a Chinese-Russian enterprise encompassing Tianjin-Beijing-Shenyang [Mukden] and a British one from Nanjing to Shanghai.[72]

In practice as well, German capital and expertise would direct the northern section of the railway; British, the southern. During construction, four to five percent building interest was paid. The first year of operation brought in a profit of 2,064 Million Marks, already a dividend of 3.25%.[73] The Chinese Revolution of 1911, along with a drop in materials transport due to a poor harvest and flooding, harmed the railway's stock price. In 1912, however, dividends climbed again to 7.5% and the profit-sharing of the participation papers [*Genussscheine*] reached 12.50 Marks. That year, 1,230,043 people and 8,520,001 tons of goods, including 471,808 tons of coal, were transported on the railroad.[74]

The Tianjin-Pukou Railroad was more than an opportunity for German investors. The 1898 contract had held that the

> appointment and functions of all the employees of the Railway, Chinese and foreigners, *with the exception of the Engineers-in-Chief who shall be nominated by the Deutsch-*

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[71] "Acta der Kaiserlich Deutschen Gesandtschaft für China betreffend Tientsin-Chinkiang Eisenbahn," Baker Business Library, HBS; *The Far Eastern Review* (November 1909): 223.

[72] Schaefer, *Deutsche Portfolioinvestitionen im Ausland*, 502.

[73] Maximilian Müller-Jabusch, *Fünfzig Jahre Deutsch-Asiatische Bank, 1890-1939* (Berlin: Deutsch-Asiatische Bank, 1940), 146.

[74] Ibid., 147.

> *Asiatische Bank and the Chinese Central Railways Limited respectively and approved by the Director-General, as well as their salaries*, including those of the officials of high rank referred to in the following paragraphs, are to be made and fixed by the respective Boards of Commissioners and reported to the Director-General.[75]

The syndicate of financiers, industrialists, and diplomats approached overseas infrastructure-building as an export opportunity and, further, a chance to reap profits from overseeing the industrial development of an entire region. White-collar workers and expertise stood at the center of many political contests for control. Assuring preferential treatment for a wide array of German industrial goods fell to the railroad's chief engineer—in the northern section, Julius Dorpmüller, later transport minister of the Third Reich.

German financial, industrial, and diplomatic apparatuses worked in concert to ensure that they could name the engineer responsible for purchasing decisions. On May 23, 1898, Dr. Franke of the bank Disconto-Gesellschaft wrote to foreign minister Bülow to assert that the "entire stretch" of the Tianjin-Pukou railway "should be built with German money and materials and through German engineering."[76] Furthermore, he emphasized that there should be "German influence in the management, at least for the next 35 years, that is, until the full repayment of the loan."[77] For Disconto-Gesellschaft, these were the "decisive" aspects to be implemented in the contract and any "small changes in the original arrangements" which the foreign office found not "absolut contra coeur" should be allowed.[78]

The German ambassador in Beijing explained the role of the railroad's chief engineer to the appointee, Julius Dorpmüller:

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[75] "Acta der Kaiserlich Deutschen Gesandtschaft für China betreffend Tientsin-Chinkiang Eisenbahn," Baker Business Library, HBS.

[76] Dr. Franke, Disconto-Gesellschaft, to Bernhard von Bülow, 05/23/1898, Baker Business Library, HBS.

[77] Ibid.

[78] Ibid.

> I made it understood to him, that the emperor's government had not used its influence on the proceedings of the railroad agreement, to then see the materials orders go to England and America: to him lies the absolute commitment, to ensure, that the lion's share of the orders fall to Germany.[79]

When the Tianjin-Pukou railway stood completed, Dorpmüller had managed to concede only a part of the cement to Tongshan, a small portion of the tracks to China's official Hanyang Iron Works, and the railroad ties to a Japanese firm.[80] All told, the benefits to the German economy amounted to around 50 million Marks, including 44 million in orders for railroad materials, 2.4 million in profits from the loan, and 3 million in salaries for the 82 German white-collar workers onsite.[81]

Working with Borkowetz, an engineer from Maschinenfabrik Augsburg-Nürnberg in charge of construction at the Yellow River Bridge, Dorpmüller made a deal with "a 'Chinese Consortium', to which predominant officials belonged, after which this consortium would take up the orders of the railroad administration in the name of Chinese industry, and then they would however—against the expressed allocation—underhandedly give them to German enterprises."[82] A British trade publication alleged that despite Chinese attempts in the loan negotiations to secure

> a check on the possible extravagance of the Foreign Chief Engineer in ordering materials,…[to] keep down the cost, and prevent favoritism," the "Chinese Managing Director of the Northern Section was married to a German lady, and had strong Teutonic tendencies and connections. Complete harmony existed from the outset between him and the German Chief Engineer, and the work of construction was pushed ahead rapidly.[83]

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[79] Quoted in Schmidt, *Die Deutsche Eisenbahnpolitik in Shantung*, 133.

[80] Müller-Jabusch, 164-165.

[81] Schmidt, *Die Deutsche Eisenbahnpolitik in Shantung*, 184.

[82] Ibid., 134.

[83] George Bronson Rea, "Railway Loan Agreements and Their Relation to the Open Door," *The Far Eastern Review (*November 1909): 223.

But the success of Dorpmüller and other officials and engineers in monopolizing parts orders for Germany was by no means solely attributable to the Chinese Managing Director's marital ties; rather, terms in the labor contracts of on-site white-collar workers gave the German Chief Engineer equal authority to the Chinese Managing Director.

While the latter alone controlled the railroad funds, the "contract of engagement" signed by accounting assistants and other such employees "recognized the Chief Engineer as equal in authority to the Managing Director, despite the stipulation of the loan," which, given previous experiences with Western exploitation, had subordinated the Chief Engineer to the Managing Director.[84] Thus, Fritz Schott, a longtime coworker of Dorpmüller's writing retrospectively during the Nazi period, cast the effort in a friendlier light, while still emphasizing the importance of exploiting parts commissions to Germany: "The railroad took effect as the most modern and best railway in the entire far east, its Hwang He Bridge is known worldwide, the rail operations proceed in an exemplary and productive manner. Against the keenest foreign competition…he [Dorpmüller] brought it to completion, that the allotted monies from Germany to the railway flowed back in the form of orders to German factories such that our workers brought home bread and earnings."[85] Dorpmüller had succeeded in his task of creating a closed circuit of German finance and industry to profit from railroad-development in China, reterritorialization as the would-be vessel for capital accumulation and Ruhr employment.

With the help of Borkowetz, he managed to implement German regulations, set German standards, and secure the commission for virtually all the track materials for the German Steelworks Association, "even bypassing the legitimate claims of the Han-yang-iron works."[86]

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[84] Ibid.

[85] Fritz Schott, "China-Erlebnisse mit Dorpmüller," *Deutsche Bergwacht* 169 (1939): 9.

[86] Schmidt, *Die Deutsche Eisenbahnpolitik in Shantung*, 134.

The official Hanyang Ironworks incidentally employed German machinery, too, such as three Siemens-Martin open-hearth furnaces in 1912.[87] The example of the Hanyang Ironworks serves as a reminder that infrastructure-building meant direct *and* indirect means of profit for German industry and myriad opportunities for white-collar workers. Beyond seeking parts orders in the Shandong and Tianjin-Pukou railroad-building projects, German industrial firms attempted to use the railroads as a platform to dominate economic regions and monopolize their development. In the years between 1902 and 1906, imports for railway and mining machinery in Qingdao ranged between 1,324,000 and 6,578,000 Marks.[88]

At Poshan, a coal-rich area in the Shandong Peninsula, a glass factory was erected on a branch of the Qingdao-Jinan Railway, equipped entirely with German machinery and costing the governor of the province "15,000 taels and a Tientsin firm 10,000 taels toward the project."[89] A German firm won a contract from the Chinese Ministry of Commerce and Industry to establish a Sino-German beet sugar refinery company along another northeastern railway and imitated the railroad-building strategy in microcosm—the firm sold a complete package of machinery costing 600,000 Taels while also offering working capital of 200,000 Taels, while China ceded land in Manchuria of equal value in return.[90] Sometimes entire factories were shipped from Germany. A German manufacturing firm, "shipped to the Chinese state powder factory Hanyang, at Hankow, a complete nitrate plant for the manufacture of smokeless powder," the components of which filled 13 double railroad cars.[91] It was the third nitrate plant the firm had supplied to the Chinese

[87] *The Far Eastern Review* (July 1912): 56.

[88] Statistisches Reichsamt, *Statistisches Jahrbuch für das Deutsche Reich* 29 (Berlin, 1908), 382.

[89] "German Machinery in China. Glass Factory," *The Far Eastern Review* (August 1906): 106.

[90] "Chino-German Refinery," *The Far Eastern Review* (December 1912): 331.

[91] "Smokeless Powder Machinery for China," *The Far Eastern Review* (May 1907): 386.

national factories.[92] From glass to beet sugar to smokeless powder, German firms perceived and pursued potential profits from guiding the course of Chinese raw-goods refining and manufacturing capacities in the areas surrounding the original railway and mining concessions.

Intent on providing outlets for German machinery exports, the *Schantung-Bergbau-Gesellschaft* ignored Richthofen's observation from the 1870s that coal in neighboring Shanxi "lay in horizontal seams" with protruding outcrops on hillsides "so that mining was very easy." Richthofen had noted that the

> most basic mines were simply holes dug into the hillside by two or three laborers and worked for a few months until the coal ran out and the workers moved on to the next outcrop. Such operations had no capital at all unless one counted the few simple tools used by the miners.[93]

Instead, the *Schantung-Bergbau-Gesellschaft* invested in machinery to use in the thirty-*li* (ten-mile) zone along the German railroad concessions; Gutehoffnungshütte's Sterkrade machinery works alone delivered a two-cylinder steam-engine with a 1.3-ton load in 1904, another two-cylinder steam-engine with a 2.2-ton load in 1905, one with a 2-ton load and one with a 4-ton load to the syndicate's "Schacht Annie" in 1906, and another with a 1.9-ton load in 1909.[94] Despite the *Schantung-Bergbau-Gesellschaft's* workforce of over sixty European managerial and technical workers (*Betriebsführer*, *Steiger*, *Maschinisten*, *Vorarbeiter*), over two thousand Chinese miners in the Fangzi field, and four-to-five hundred Chinese miners in the Poshan valley, they were soon outcompeted by Chinese miners using manual methods and simple

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[92] Ibid.

[93] Jacob Eyferth, ed., *How China Works: Perspectives on the Twentieth-Century Industrial Workplace* (London: Routledge, 2009).

[94] GHH, Sterkrade Maschinenbau, "Lieferverzeichnis über die Dampffördermaschinen von 1824-1949," RWWA, 130-30411/13.

pumps.[95] An entrepreneurial failure (if an opportunity for German machine-tools exports nonetheless), the *Schantung-Bergbau-Gesellschaft* found itself in 1913 absorbed by necessity into the more successful *Schantung-Eisenbahn-Gesellschaft*, which had begun paying 2% dividends as early as 1904 and grown to 5% dividends and 2.5% super-dividends by 1913.[96]

Imperial Germany's foreign legation attempted to sustain dependency relations by establishing German-language schools for the emerging class of Chinese railway engineers and industrial technicians. The 1898 "Tientsin-Chinkiang Eisenbahn" agreement read,

> When deemed necessary a school for the education of Chinese in the construction and working of railways shall be undertaken by the Boards of Commissioners subject to report to and approval by the Director-General.

Imitating the apprentice program at the *Schantung-Eisenbahn-Gesellschaft's* repair yards on a much larger scale, the German leasehold government at Qingdao established a shipyard training school in 1901.[97] Between then and the loss of the colony in 1914, 150 to 320 Chinese apprentice machinists trained in the yards every year. Four hundred had completed the program to become journeymen by mid-1911. Alongside the apprenticeship program, two hundred to two thousand Chinese artisans worked at the Imperial German navy yards at any given time, on projects ranging from repairing steamboats to constructing boilers, masts of telegraph lines, steam-shovels, and the machinery for an electricity generating station in Tainan.[98]

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[95] "Denkschrift betreffend die von dem Konsortium für asiatische Geschäfte hervorgerufenen deutschen Unternehmungen in China, August 1906,", BArchiv, R901/81239.

[96] Horst Gründer, *Geschichte der deutschen Kolonien*, 6th ed. (Paderborn: Schöningh, 2012), 229-231.

[97] Dirk Seeleman, "The Social and Economic Development of the Kiaochou Leasehold (Shantung, China) Under German Administration, 1897-1914" (PhD Dissertation, University of Toronto, 1982).

[98] Ibid.

Figure 27: "Pfeiler III. des Modell für die Hochschule Tsinan," (Pillar III of the model for the Tsinan technical school), M.A.N. Museum, Augsburg.

The Far Eastern Review, a British trade journal, reported that "Germany and the United States are making a very serious bid for the education of the Chinese engineer," wherein "the Germans" particularly "with their model dockyard at Tsingtao, have properly organised engineering works where young Chinese of the right class are encouraged to attend and learn thoroughly, not only the German language, but engineering and dockyard practice, and large sums of money are expended in bringing to Germany the right class of Chinese for their engineering training."[99] The *Review* went on to emphasize that "German manufacturing engineers on their own have an association for dealing with their overseas interests, and have subscribed a large sum for the purpose of creating three purely German engineering schools in China," schools which were to be "effective nurseries for the German machinery trade."[100] The *Review* also noted the growth in engineering and industrial journals from the United States and

[99] "German and American Influence on Chinese Education," *The Far Eastern Review* (January 1916), 296.

[100] Seeleman, "The Social and Economic Development of the Kiaochou Leasehold," 213.

Germany "catering for Chinese requirements," and observed that "one of these German journals has an English title, and is printed throughout in English," indicating a twofold German strategy of "spending large sums of money to create and foster a knowledge of the German language by their technical schools, and on the other are utilising the English language to secure trade pending the realisation of their scholastic ideals."[101]

German-run technical schools had sprung up in Qingdao, Tainan, Guangzhou, and Hankou; along with the Tongji University in Shanghai and the Qingdao Hochschule, they prepared students for further engineering studies in Germany.[102] Although American and British institutions of higher education attracted greater numbers of Chinese students, 368 Chinese students attended German universities in 1913.[103] Underpinning German efforts in technical-cultural diplomacy was the maxim that "today in China it is a general rule that machines will be purchased in the land [that has aided] the leading engineer in his education."[104] Despite years-long critique of appropriations for Qingdao in the Reichstag, proposals were advanced in earnest for a five million Mark stipend to expand German education in China and to institute German as an obligatory foreign language (with English) in Chinese schools on the eve of World War I.[105]

In August 1913, the *Deutsch-Chinesische Hochschule* in Qingdao wrote to the firm Gutehoffnungshütte in the Ruhr city of Oberhausen to thank them for the pictures and drawings provided as viewing materials for the students, a projection window for visualizing an industrial

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[101] Ibid., 213.

[102] Kirby, *Germany and Republican China*, 15.

[103] Ibid., 15.

[104] Ibid., 15.

[105] Ibid., 16.

future.[106] A few months before, the *Deutsche Ingenieurschule für Chinesen* in Shanghai had written to Gutehoffnungshütte to emphasize that the

> great economic take-off, which China will doubtless achieve in the coming years, suggests that German industry must with forcible necessity secure for itself a strong influence on the young up-and-coming Chinese engineers in order to provision an almost limitless market.[107]

In 1911 engineer Behrend had ordered for the workshops and laboratory at the technical school in Shanghai a steam engine of 75 HP from the manufacturer Eggestorff in Hannover, a steam engine of 40 HP from the Maschinenfabrik Augsburg-Nürnberg, a Diesel motor of 32 HP from the Gasmotorenfabrik Deutz, a locomobile of 45 HP from the firm Wolff-Buckau, a locomobile of 45 HP from Lang, an entire pumping system from Weise & Monski in Halle, and thirty machine tools from a variety of firms.[108]

Via the *Vereinigung zur Errichtung deutscher technischer Schulen in China*, engineering schools such as the establishment in Shanghai remained in close contact with industrial concerns such as Gutehoffnungshütte, submitting annual reports of their activities and growth and participating in the information-sharing efforts of institutions representing German "organized capitalism" such as the Stahlwerks-Verband AG in Düsseldorf.[109]

Such efforts in engineering education extended far beyond China. Writing to Bethmann-Hollweg from the German consulate in Rio de Janeiro, one trade expert, Goering, enumerated three rules to predict machine-tools imports in Brazil: "machine tools follow the nationality of industrial capital," "machine tools follow the nationality of technical personnel," and "machine

[106] GHH, Hauptverwaltung, Verein für chinesische Schulen (1911-1916), RWWA, 130-300125/1.

[107] Ibid.

[108] Ibid.

[109] *Bericht über die Deutsche Ingenieurschule für Chinesen in Shanghai, für die Zeit von Chinesisch-Neujahr 1912 bis Chinesisch-Neujahr 1913 (Erstes Schuljahr)* (Shanghai, 1913); Stahlwerks-Verband, AG in Düsseldorf, 1 März 1913 to Herrn Kommerzienrat Reusch, Oberhausen, GHH, RWWA, 130-300125/1.

tools follow the nationality of prime-movers (*Antriebsmaschinen*)."[110] "Industrial capital" meant syndicates for financing "railroad-, sea- and river transport enterprises, docks, mines and mining operations as well as undertakings serving communal interests for lighting, water management, transport, etc." Infrastructure-building thus entailed making markets not only in the sense of opening up coastal access to inland raw goods and hinterland consumers, not merely in the sense of displacing or destroying existing merchant networks, but also in stoking demand for a wide array technological products for the workshops to repair, maintain, and expand infrastructure and utility systems themselves.[111] Since most of the financial syndicates were headquartered in London, Paris, Brussels or New York, Goering lamented, British machine tools had thus far dominated the market in Brazil.

Yet Goering hoped that what German industries lacked in deep, readily available pools of finance capital they could make up for in other areas. He nevertheless perceived obstacles: English, French, and Belgian engineers already held most of the influential and middling technical positions in the country, platforms from which to impart their methods, habits, and measurement norms. The "English foot" and the "English" (Whitworth) screw thread offered "free help for English influence."[112] He proposed combatting the English precedent by leveraging German firms' lead in "modern industries, namely...electrical, chemical, and

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[110] Goering to Bethmann-Hollweg, "Bericht über den Import von Werkzeugmaschinen, Kaiserlich Deutsches General-Konsulat, Rio de Janeiro, den 11. August 1911, Auf den Erlass N2 92 vom 30. Mai 1911, An den Reichskanzler Herrn Staatsminister Dr. von Bethmann Hollweg, Exzellenz," Einziehung von Nachrichten über Absatzmöglichkeiten deutscher Industrieprodukte im Ausland, Werkzeugmaschinen, Mai 1911-Dez 1911, BArchiv, R 901/2474.

[111] On displacing and destroying previous merchant networks, see Beckert, *Empire of Cotton*; William Cronon, *Nature's Metropolis: Chicago and the Great West* (New York: Norton, 1992); Alfred Chandler, *The Visible Hand: The Managerial Revolution in American Business* (Cambridge, MA: Harvard University Press, 1977), wholesaling chapter; On systems thinking and electrification, see Thomas Hughes, *Networks of Power: Electrification in Western Society, 1880-1930* (Baltimore: Johns Hopkins University Press, 1993).

[112] Einziehung von Nachrichten über Absatzmöglichkeiten deutscher Industrieprodukte im Ausland, Werkzeugmaschinen, Mai 1911-Dez 1911. BArchiv, R 901/2474.

brewing" and attempting to increase means to expand "intellectual influence" among Brazilians such as opening "Tor und Tür" German educational institutions, particularly technical schools (*technischen Mittelschulen*), to them.[113]

For Goering, access to German technical education would be "effective propaganda for our products, a bridge upon which an ever greater circle of people from this country [Brazil] would be acquainted with our products, our work processes, etc."[114] Seemingly reversing the logic of the mercantilist past, Goering claimed, "nothing would be lost" by providing such education, "for we cannot and should not attempt to hinder the technical development of foreign countries [*technischen Entwicklung des Auslandes*]."[115] He denied static views of the world economy. Geography had long been destiny for economists ranging from David Ricardo to Friedrich List, who had divided the earth into "torrid" zones for cash crop cultivation and "temperate" zones for industrial advance.[116]

The *mission industrialisatrice* partly upended this view, while aiming to establish sustained dependency relations of another sort. Goering tasked engineers with this transformation. "Machines," he argued "are more or less complicated constructions, which are not to be shipped like a batch of coffee. It demands a spiritual [*geistiges*] bond between the exporters and the importers and only on the basis of mutual, personal relations is a successful,

113 Ibid.

114 Ibid.

115 Ibid.

116 Friedrich List, *Das nationale System der politischen Oekonomie: Der internationale Handel, die Handelspolitik und der deutsche Zollverein* (Stuttgart: Cotta, 1841); Roman Szporluk, *Communism and Nationalism: Karl Marx Versus Friedrich List* (Oxford: Oxford University Press, 1993).

long-lasting market for machine tools possible. If we want to export machine tools, we must introduce services in the handling of machinery."[117]

The Ruhr mining, metals, and machining firm Gutehoffnungshütte responded by partnering with the *Deutsch-Südamerika-Institut* to establish a scholarship fund, publish technical works in Spanish and Portuguese, support Germans working as engineers, merchants, doctors, and professors in South America, and support German-language schooling and the expansion of German print culture.[118] Gutehoffnungshütte also worked with the *Deutsch-Argentinischen Central-Verbands* to assure scholarships for Argentines to attend German T*echnische Hochschulen*.[119] In concert with the state, the German capital goods sector was collectively envisioning a *mission industrialisatrice* in the years leading up to the First World War: the neo-imperial, infrastructural dimension of development politics.

Chinese nationalists were highly aware of the dangers of technical reliance and trade lock-in. In 1908, the *Peking and Tientsin Times* condemned "the price asked by the German engineers for the plans and specifications" of the Tianjin-Pukou railway—200,000 Taels—as "exorbitant" and proposed instead that China itself make new surveys.[120] After the 1911 Revolution, the Ministry of Transportation and Communication (*jiaotong bu*) commenced an effort to develop technical expertise independently among Chinese within three major railroad engineering schools (*jiaotong daxue*) in Shanghai, Tangshan, and Beijing.[121] Nevertheless, in

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[117] Einziehung von Nachrichten über Absatzmöglichkeiten deutscher Industrieprodukte im Ausland, Werkzeugmaschinen, Mai 1911-Dez 1911, BArchiv, R 901/2474.

[118] GHH, Hauptverwaltung, Deutsch-Südamerika-Institut (1913-1922), RWWA, 130-300125/3.

[119] GHH, Hauptverwaltung, Studienfonds D.A.C. (1912-1919), RWWA, 130-300125/2.

[120] "Tsinpu Railway Survey," *The Far Eastern Review* (July 1908): 59.

[121] Elisabeth Köll, "Chinese Railroads, Local Society, and Foreign Presence: The Tianjin-Pukou Line in pre-1949 Shandong," in *Manchurian Railways and the Opening of China*, ed. Bruce Elleman, 133.

analyzing the long-term effects of the joint British-German Tianjin-Pukou Railway, business historian Elisabeth Köll notes that only after the 1949 Revolution did the Tianjin-Pukou and other railways stop importing all rolling stock from Germany, Britain, and the United States and begin import substitution for engines and parts.[122]

The Tianjin-Pukou Railway's Yellow River Bridge, the technological feat that earned the most international acclaim and stoked the pride of German engineers, illustrates white-collar workers' roles in wresting profits not only through legal negotiations, parts commissions, accounting practices, and Chinese shell companies but also via exploitative approaches to labor. The bridge rested on "nine 91.5 metre truss spans and three cantilever spans over the main channel, made up of two anchor arm spans of 128.1 metres and a central span of 164.7 metres"—in total, *11,000 tons of steel*, the clear majority of which went into the bridge's superstructure.[123] In designing the base, the engineers "found [it] impossible to rest…the masonry piers…on solid rock," so they devised a system of driving in reinforced concrete piles, using "pneumatic caissons in and near the stream." But the German engineers were neither immersed in water nor piling concrete. Most of all perhaps, their work meant overseeing the real work of the railway, "the clearing of the terrain, preparation of the railroad bed, and construction of the tracks…undertaken by Chinese day laborers recruited from villages close to the section under construction" who worked within "the traditional contract-labor (*baogong*) system under Chinese foremen (*gongtou*) who were in charge of recruiting and paying these construction workers."[124]

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[122] Ibid., 141.

[123] "The Tientsin-Pukow Railway: A Detailed Historical and Descriptive Account," *The Far Eastern Review* (January 1913): 339.

[124] Köll, "Chinese Railroads, Local Society, and Foreign Presence," 130.

The British *Far Eastern Review* summarized the process: the Yellow River Bridge and the rest of the Tianjin-Pukou line were built by "thousands of coolies…employed at the numerous brick kilns erected at the different points to employ ballast for the line," who "displayed exceptional ability in using modern methods in this direction," toiled as "the sole laborers employed on the erection of steel work, exhibiting great adaptability in this direction and performing the work of the thorough satisfaction point about 20 miles north," who "distributed [the components] over the first 100 miles by way of small streams and by pack labor, wheelbarrows and carts, and also by construction trains," who delivered "supplies for the mountainous, heavy portion, just north of the Grand Canal,…at Yenchowfu over the grade from Tientsin," and who shipped them "by way of the Grand Canal to Hanchwang," despite the canal's shallow depth [4 feet] and the extreme difficulty of navigating it.[125]

In addition to revealing the perils of transporting parts for the Chinese laborers, the *Review* recounted with admiration an incident, which indicates the extent to which the German engineers cared about parts and were indifferent toward workers:

> During a phenomenal flood at the River the bridge in course of construction carried away and one section of the steel work, weighing something like 300 tons, was displaced and sank in the stream. The Chinese undertook to raise the sunken section and after a time accomplished the task, ultimately landing it intact on the river bank, whence it was subsequently placed in position. The foreign engineers, knowing the capacity of the Chinese in heavy weightlifting, interfered, in no way with the effort, and contented themselves by merely supervising the operation.[126]

[125] "The Tientsin-Pukow Railway: A Detailed Historical and Descriptive Account," *The Far Eastern Review* (January 1913): 341.

[126] Ibid., 341.

Securing the Shandong and Tianjin-Pukou railroads reflected and exacerbated combat for political control of territory. Such economic exploitation and destabilization, together with the "colonial-lord-style bearing" of German white-collar workers, encouraged nationalist resistance in Shandong.[127] During construction of the railroad, the *Schantung-Eisenbahn-Gesellschaft* complained about "a wave of unexplained thefts of small iron parts like nails, screws, fishplates,

[127] Schmidt, *Die Deutsche Eisenbahnpolitik in Shantung*, 87.

etc. from the platforms and about intentional destruction of the telegraph lines of the railroad, for which Hildebrand blamed the defective supervision of Chou Fus troops."[128] Because of Hildebrand's abusive and overbearing behavior toward Chinese workers and officials, the Qing government later refused to accept him as chief engineer of the Tianjin-Pukou railway, and the post went to Julius Dorpmüller.[129]

[128] Ibid., 87.

[129] Ibid., 132.

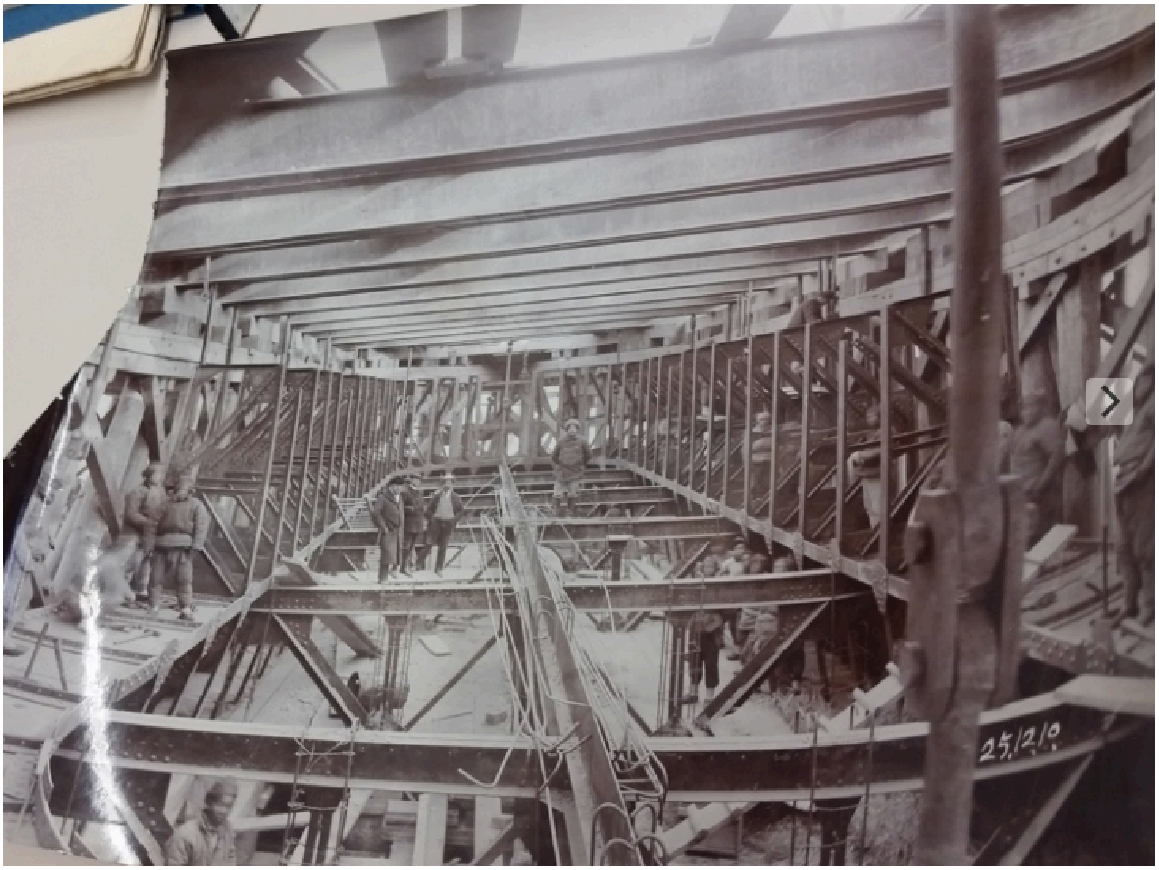

Figure 28: Images from the Shandong and Tianjin-Pukou Railroads, M.A.N. Museum, Augsburg.

Engineering Social Imperialism: White-collar Workers in the "*Mission Industrialisatrice*"

In 1912 an advertisement in a British trade journal, *The Far Eastern Review,* ran:

> Henschel and Sohn are the largest suppliers of Locomotives to the Prussian State Railways, and their Engines have been exported in considerable numbers to Russia, Italy, France, Roumania [sic], Servia [sic], Denmark, Turkey, Egypt, the Argentine Republic, Brazil, Chili [sic], Mexico, Japan, China and to other countries. Numerous locomotives have also been supplied to German and other Colonies in Africa and Asia. The majority of these engines represent types created by the firm, and are specially adapted to the conditions in those countries, where they have given great satisfaction. The firm employs a staff of over 150 skilled engineers and draftsmen, who are ready at all times to prepare new designs of locomotives. Henschel and Sohn do not, however, confine themselves to the construction of locomotives of their own special types, but build to any design and specification that may be submitted to them.[130]

[130] "The Locomotive Works of Henschel & Sohn at Cassel," *The Far Eastern Review* (July 1912): 61.

Just one of dozens of German industrial firms competing to carve out markets around the world at the turn of the century, Henschel exemplified a reliance on endless customization, flexible production, and, selectively, yet at key junctures, the German state.[131] All three export-oriented strategies depended on and tended to promote the expansion of white-collar work—drafting, designing, surveying, accounting, and correspondence.

Contemporaries such as Max Weber, Georg Simmel, and eventually Siegfried Kracauer noted these transformations in work processes and social structures as a paper economy of symbols, which flattened experience, rewarded analytical thought, and engendered alienation.[132] Historians from Alfred Chandler to Jürgen Kocka have offered a compelling picture of the rising class of *Angestellten* within the firm and within the metropolis, and to a lesser extent within the domestic politics of the American and German nation-states respectively.[133] In both cases, the rapid growth of white-collar work coincided with the advent of formal and informal empire.

In 1882, white-collar workers in industry, trade, and transport numbered only 205,061. By 1895, a decade after the Berlin Conference and two years before the awarding of the Jiaozhou Bay concession, the number of white-collar workers had grown to 448,944 (a 118% increase).[134] Contemporary sociologist Johannes Wernicke marveled that the "increase of the middle class in trade, transport, and tourism has become extraordinarily strong, almost five times greater than

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[131] This tripartite approach to the international economy reached its apotheosis in the state-backed *Deutscher Werkbund*, founded in 1907 by designers Peter Behrens, Hermann Muthesius, and Richard Riemerschmid in Munich to promote global exports through particularly German "quality design." By World War I, the *Werkbund* included major firms such as AEG, BASF, Bosch, Siemens, and Mercedes Benz.

[132] Siegfried Kracauer, *Die Angestellten* (Frankfurt: Frankfurter Societäts-Druckerei, 1930).

[133] Chandler, *Visible Hand*; Olivier Zunz, *Making America Corporate, 1870-1920* (Chicago: University of Chicago Press, 1992); Jürgen Kocka, *Die Angestellten in der deutschen Geschichte 1850 bis 1980: Vom Privatbeamten zum angestellten Arbeitnehmer* (Gottingen: Vandenhoeck & Ruprecht, 1981); Jürgen Kocka, *Industrial Culture and Bourgeois Society: Business, Labor, and Bureaucracy in Modern Germany* (New York: Berghahn, 1999).

[134] Johannes Wernicke, *Kapitalismus und Mittelstandspolitik* (Jena: Fischer, 1907), 343.

that of the general population," which had grown from 45.7 million to 52 million.[135] By the turn of the century, the majority of the middle class had moved out of small farming, petty commerce, and artisan trades and into white-collar work and the free professions.[136]

Figure 29: Postcard showing the completion of the Yellow River Bridge (1912), MAN Museum.

In German engineering and heavy industrial firms, in-house monthly magazines such as the *M.A.N.-Zeitung* advertised the exploits of the firm's engineers in China, the Ottoman Empire, and South America interspersed among issues honoring the employee-veterans and veteran employees, dead and living, of the Franco-Prussian War (and eventually the First World War).[137] Echoing the arresting photo of the Yellow River Bridge's completion reproduced in countless lithographic print materials, postcards, and newspapers, the *M.A.N.-Zeitung* reported that the "two halves of the bridge met at the center opening of the Hoangho Bridge, where the free montage from North and South had reached toward each other for weeks,...at 10 in the morning

[135] *Statistisches Jahrbuch für das Deutsche Reich* (Berlin, 1904).

[136] Wernicke, *Kapitalismus und Mittelstandspolitik*, 343.

[137] "Werk Gustavsburg, Abteilung B. Freiherr Marschall v. Bieberstein über die Karaköi-Brücke," *M.A.N.-Zeitung* 6 (November 1912), "Werk Gustavsburg—Pneumatische Gründung der Hoangho Brücke," *M.A.N.-Zeitung* (February 1912), "Fertigstellung der Hoangho-Brücke in China," *M.A.N.-Zeitung* 6 (November 1912), MAN Museum.

on October 9th." The *M.A.N.-Zeitung* proudly conveyed the span of the bridge ("9 x 91.5 m — 128.1 m—164.7 m—128.1 m") as well as congratulations from Prince Heinrich of Prussia, sent via a telegram from Qingdao: "Best wishes for a work of German culture, which is a new milestone of engineering and which will be a blessing for coming generations."[138]

The February 1912 issue of the *M.A.N.-Zeitung* delved into a particular division (the generically-named "Abteilung B") of the firm's Gustavsburg works to document the design of the pneumatic pillars supporting the Yellow River Bridge. Four framed images portrayed the stages of erecting the 30x10 m pillars for the bridge, which had been thrust into depths of up to 26 m below the usual water table. The structure depended on a process of pressurized air for the substructure, through which compressed air forced the water out of a part of the pillar sealed with a cover. Among other angles, the appended images showed an inner view of the caissons, the lower part of the fundament along with the worker's chamber during erection.[139] Taken together, these scenes from the *M.A.N.-Zeitung* enabled the company's growing cadre of white-collar workers to see the imperial and developmentalist outcomes of their everyday work and to view these products as monuments to the German nation.

Beyond M.A.N.'s cultivation of a firm-based political culture, the professional journal of the *Verein Deutscher Ingenieure* devoted multi-page spreads to the technical specifications and work-process photos of the Tianjin-Pukou Railway's Yellow River Bridge as well as to the Shandong Railways.[140] The photos printed in the *Zeitschrift des Vereines deutscher Ingenieure*

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[138] "Fertigstellung der Hoangho-Brücke in China," *M.A.N.-Zeitung* 6 (November 1912): 17, MAN.

[139] "Werk Gustavsburg—Pneumatische Gründung der Hoangho Brücke," *M.A.N.-Zeitung* (February 1912), MAN.

[140] "Die Hoangho-Brücke, bearbeitet von Regierungsbaumeister a.D. Bruno Schulz in Berlin-Halensee und der Maschinenfabrik Augsburg-Nürnberg AG, Werk Gustavsburg," *Sonderabdruck aus der Zeitschrift des Vereines deutscher Ingenieure* (1914): 241; Alex Wenz, "Allgemeines und Technisches vom bau der Schantungbahn," *Zeitschrift des Vereines deutscher Ingenieure* (1907), MAN.

typically surveyed the imperial-infrastructural workplace from above or adopted angles mirroring those of the projections in architectural and technical drawing (elevations). Unsurprisingly, photographers for the *Verein deutscher Ingenieure* selected work-sights suited to engineering and managerial viewpoints, which invited readers in the Kaiserreich to undress structures' design principles while practically analyzing multi-stage building processes or revelling in the frenzied, violent scene of the *mission industrialisatrice*.

As early as the 1890s, naval interests around Tirpitz had tried to stimulate support for investment in the construction of naval vessels and overseas infrastructure development via claims that such projects offered Germans jobs--a path out of cyclical market downturns and toward general prosperity.[141] The *Reichsmarineamt* and its allies published articles and pamphlets consistently arguing that a naval build-up would promote the development of trade as well as heavy industry, dock industries, and the transport and shipping industry, which it cast as a means of ensuring employment opportunities.[142] By 1912 infrastructure imperialism had become more than a conspiracy by sometimes-fractious elites; it had entered the daily lives, lexicon, and work of significant swathes of the fastest-growing class--white-collar workers, or *Angestellten*.

In civil society organizations such as the *Deutsch-Asiatische Gesellschaft*, engineers and engineering students could socialize with members of the diplomatic and military corps, editors and journalists.[143] The Dresdner Bank, Disconto-Gesellschaft, and Deutsch-Asiatische Bank enjoyed membership in the *Deutsch-Asiatische Gesellschaft* alongside Willy von Siemens, C.F.

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[141] Michael Epkenhans, "Großindustrie und Schlachtflottenbau, 1897-1914," *Militärgeschichte Mitteilungen* (Jan. 1988): 65.

[142] Ibid., 66-67.

[143] 1903 - 1924 Deutsch-Asiatische Gesellschaft Enthält u.a.: Mitgliederverzeichnisse.- Satzung.- Einladungen.- Rundschreiben, LABerlin, A Rep. 226 Nr. 75.

von Siemens, and engineer Carl Koettgen representing Siemens-Schuckert Werke and Krupp von Bohlen und Halbach, Mr. Ahlers, a manager at Krupp, and Richard Pflaum, a Krupp representative in foreign markets.[144] Representatives of bankers such as Sal. Oppenheim & Co. and S. Bleichroeder took part, as did capital goods firms such as Rheinische Metallwaaren und Maschinenfabrik, Berliner Maschinenbau (vorm. Schwartzkopff), Mühlenbauanstalt und Maschinenfabrik (vorm. Gebr. Seck), and the locomotive-builder Borsig. Shipping lines such as the Rickmers-Linie, the Norddeutscher Lloyd, and the Hamburg-Amerika Linie sent members. To this extent, the Deutsch-Asiatische Gesellschaft simply reprised the union of interests in the consortium surrounding the Deutsch-Asiatische Bank. However, the *Deutsch-Asiatische Gesellschaft* also brought these existing factions together with those of chemicals and explosives firms such as Chemische Fabrik (vorm. E. Schering), Koeln-Rottw. Pulverfabriken, Dynamit-AG (vorm. A. Nobel), Farbenfabriken (vorm. Fried. Bayer & Co.), and Kalisyndikat GmbH. Expanding beyond the bounds of Großindustrie, the Deutsch-Asiatische Gesellschaft linked these firms with geologists and geographers, conjoined in their efforts to chart the worlds of *Erdkunde* und *Völkerkunde*, and colonial societies from Berlin, Breslau (Wroclaw), Halle, Kassel, and Gelsenkirchen.

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[144] Ibid.

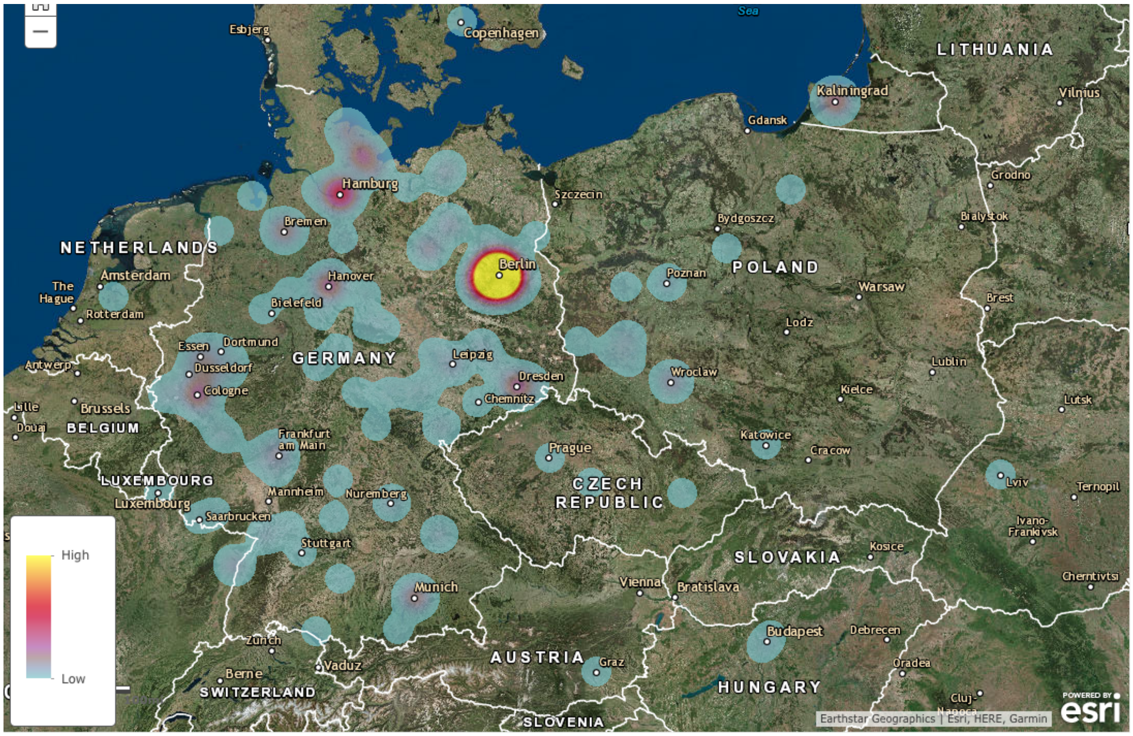

Figure 30: Deutsch-Asiatische Gesellschaft Membership, 1913-1914. Data gathered from Landesarchiv-Berlin.

Eight months after the outbreak of violence in Tianjin had forced the German engineers away from the railway line, on November 16, 1912, chief engineer Julius Dorpmüller presided over a celebration honoring the last link in the completion of the behemoth Yellow River Bridge for the Tianjin-Pukou Railway, whose parts had been delivered mainly by the Maschinenfabrik Augsburg-Nürnberg (MAN).[145] Dorpmüller took the occasion to direct attention to the Ruhr as well as MAN's Gustavsburg Works:

> In the direction of the sinking sun, many thousand miles away from here, lies in western Germany a complex of cities, grown up together from a great number of works,

[145] Julius Dorpmüller, "Ein deutsches Bauwerk in China, Rede des Chefingenieurs Baurat Dorpmüller zur Feier des letzten Nietschlags der Hoanghobrücke am 16ten November 1912," *Der Ostasiatische Lloyd* 49 (December 6, 1912); "Die neueste Hoangho-Brücke," *Frankfurter Zeitung* (December 30, 1912); M.A.N. Druckschrift (1975), MAN Museum, Augsburg; "Die Einweihung der Hoangho-Brücke am 16. November 1912, aus der 'Deutschen Japan-Post vom 7. Dezember 1912," in *Der Auslandsdeutsche, Illustrierte Vereinszeitschrift des Hauptverbandes Deutscher Flottenvereine im Auslande*, Berlin W35, Karlsbad 10 (Afrikahaus) (Januar 1913) 2, No. 1; "Fertigstellung der Hoangho-Brücke in China," *M.A.N.-Zeitung* 6 (November 1912): 17; "Die Hoangho-Brücke, bearbeitet von Regierungsbaumeister a.D. Bruno Schulz," ; on Dorpmüller, see Alfred Bernd Gottwald, *Julius Dorpmüller, Die Reichsbahn und die Autobahn: Verkehrspolitik und Leben des Verkehrsministers bis 1945* (Berlin, 1995).

communities and cities to a powerful center of industry, in which the work never rests day and night, where hundreds and hundreds of chimneys and smokestacks thrust their smoke into the air and in the night the radiating purple shine of flaming furnaces vies with the sun's splendor in the red evening sky. Restlessness and life are the signs of this region. The ground pounds from the thunder-strikes of steam hammers, and the air shivers from the roar of rollers. Iron is the one and all of this monumental territory. This is the site, which created the iron for the chains, which now carry China's most dangerous torrents. Several hundred miles from there…where the Rhine and Main marry their floodwaters, lay fifty years ago a small workshop. Engineers from Bavaria, from Nürnberg and Augsburg…sat there by icy work to build a bridge over the Rhine in Mainz. The steadily growing weight of locomotives and wagons had made the then so many to marvel at bridge works over the Rhine yield to a magnificent new construction; what remained, however, to this day is the old workshop, which matured into a bridge-building institution of world renown, which extends its tentacles over the entire globe. Wherever there is large-scale construction of difficult engineering work to erect, the Gustavsburg Works appear on the plan. This is the place, where the Yellow River Bridge was born.[146]

Addressing the audience of assembled diplomats and Chinese dignitaries, Dorpmüller denied the class politics or "social question," which had defined Imperial German politics for decades. The Social Democrats may have reached over a third of seats in the Reichstag, police officers may have been attending every meeting of the unions in the coal and steel region he so admired (and had been assiduously submitting transcripts of them to management).

For Dorpmüller, however, the social relations of production meant that

while the miners were still handling the ore and coal from the deeps of shafts, while the metallurgists were forcing the…serpents of red-hot iron into the form of sheets and bars, a restless flock of bridge engineers worked busily in Gustavsburg, hunched over calculating machines and drafting tables, to determine the form of the Yellow River Bridge, in which the banks of the river should be bound with each other.[147]

Dorpmüller validated the still-uncertain position of the rapidly emerging class of white-collar workers within the heroic context of infrastructure empire, pointing out that it "was our colleagues, who did not make the journey abroad but were equally committed [*ins Blut*

[146] Julius Dorpmüller, "Ein deutsches Bauwerk in China."

[147] Dorpmüller, "Ein deutsches Bauwerk in China"; for examples of union meeting transcripts taken by police in the Ruhrgebiet, see GHH, RWWA, 130-35014/2.

geschlagen] as us, truly not the worst of our discipline, [who found] their satisfaction in fulfilling the old promise of engineering, to reach the greatest with the least means."[148]

Figure 31: "Einweihung der Brücke mit dem damaligen Chefingenieur Dr. Julius Dorpmüller der K. Chin. Staatsbahn Tientsin-Pukow," (Inauguration of the bridge with then-chief engineer Dr. Julius Dorpmüler of the Imperial Chinese Railway Tianjin-Pukou), MAN Museum.

[148] Dorpmüller, "Ein deutsches Bauwerk in China."

Figure 32: "Besuch an der Brücke von Chinas größtem Staatsman Sun Wen; der Salonwagen wurde 1900 von MAN-Nürnberg gebaut," (Visit by China's greatest leader Sun Wen to the bridge; the salon car was built in 1900 by MAN-Nürnberg), MAN Museum.

Echoing Tirpitz's formula from the Navy Bill debates of the late 1890s, Dorpmüller reserved special praise for the capital goods industries: mining, steel, railway-building and ship-building.[149] He embedded capital goods within a specific geography and industrial ecology, with overtures to Germany's free-trading shipping sector based in Hamburg, asserting,

> Without a rail connection between the industrial region and the seaports, without the colossal ships, which travel the world's seas in defiance of many a typhoon, it would have been impossible to deliver the machines and materials to our engineers out here, which are the ground conditions for their work.[150]

A broad array of the German press covered Dorpmüller's vision of railway construction with enthusiasm, from more expected venues such as the colonialist *Auslandsdeutsche*, the

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[149] Dorpmüller, "Ein deutsches Bauwerk in China"; Kees Gispen, *New Profession, Old Order: Engineers and German Society, 1815-1914* (Cambridge: Cambridge University Press, 2002); for Weimar engineering discourse, Jeffrey Herf, *Reactionary Modernism: Technology, Culture, and Politics in Weimar and the Third Reich* (Cambridge: Cambridge University Press, 1984).

[150] Dorpmüller, "Ein deutsches Bauwerk in China."

commercially-oriented *Der Ostasiatische Lloyd*, and the professional journal of German engineers to the *Frankfurter Zeitung* and Berlin's *Tägliche Rundschau*.[151]

Imperialist newspapers such as the *Illustrierte Vereinszeitschrift des Hauptverbandes Deutscher Flottenvereine im Auslande* reprinted the same company images of the Yellow River Bridge completion and excerpts of chief engineer Julius Dorpmüller's speech. He had uttered a formula for domestic social cohesion, among economic sectors and in the industrial workplace. More than half-wittingly, less than fully consciously, he had also sketched a blueprint for development.

[151] Dorpmüller, "Ein deutsches Bauwerk in China"; "Die neueste Hoangho-Brücke," *Frankfurter Zeitung*; *M.A.N. Druckschrift* (1975), MAN; "Die Einweihung der Hoangho-Brücke am 16. November 1912, aus der 'Deutschen Japan-Post vom 7. Dezember 1912," in *Der Auslandsdeutsche, Illustrierte Vereinszeitschrift des Hauptverbandes Deutscher Flottenvereine im Auslande*, Berlin W35, Karlsbad 10 (Afrikahaus) (January 1913) 2, No. 1; "Fertigstellung der Hoangho-Brücke in China," *M.A.N.-Zeitung* 6 (November 1912): 17; "Die Hoangho-Brücke, bearbeitet von Regierungsbaumeister a.D. Bruno Schulz"; "Asien: Erfolge der deutschen Industrie in China," *Kölnische Volks-Zeitung* (December 3, 1912).

Chapter Seven: Machining the *Mission Industrialisatrice*

Capital Goods Exports and the Financial Origins of Development Politics, 1909-1924

On April 27, 1911 a consortium of German engineering firms attended a secret meeting in Berlin hosted by the Interior Ministry. Encompassing the entire swath of capital goods industries, they included representatives from associations of machine-tool builders and foundries, motor-factories and ironworks, agricultural machinery makers and steel industries, steam-engine and sewing-machine works.[1] Alongside the densely networked trade organizations and the professional association of German engineers, top capital goods firms such as Maschinenfabrik Augsburg-Nürnberg (machinery from printing presses to Diesel motors), Allgemeine Elektrizitäts-Gesellschaft (electrical works), Borsig (locomotives), Gutehoffnungshütte (mining and metalworking), Gasmotoren-Fabrik Deutz (motors), and Henschel (locomotives) sent delegates. Reflecting the nature of the conference proceedings, they were joined by an international shipping giant, the Hamburg-America Line.[2]

[1] Participants included: the Association of German Machine-tool Builders (*Verein Deutscher Werkzeugmaschinenfabriken*), the Central Association of German Industrialists (*Zentralverband Deutscher Industrieller*), the Society of Industrialists (*Bund der Industriellen*), the Association of German Machine-building Establishments (*Verein Deutscher Maschinenbau-Anstalten*), the Association of German Foundries (*Verein Deutscher Eisengießereien*), the Association of German Ironworks (*Verein Deutscher Eisenhüttenleute*), the Association of German Iron and Steel Industrialists (*Verein Deutscher Eisen-und Stahlindustrieller*), the Association of German Motor-Vehicle Industrialists (*Verein Deutscher Motorfahrzeugindustrieller*), the Association of Manufacturers of Agricultural Machinery and Tools (*Verein der Fabrikanten landwirtschaftlicher Maschinen und Geräte*), the Association of Large Gas Machine Manufacturers (*Verband Großgasmaschinen Fabrikanten*), the Association of Small-Motor Manufacturers (*Vereinigung der Kleinmotoren-Fabrikanten*), the Association of German Sewing-Machine Manufacturers (*Verein Deutscher Nähmaschinen-Fabrikanten*), the Association of Steam-Engine Manufacturers (*Verband der Dampfkraftmaschinen-Fabrikanten*), and the Association of German Engineers (*Verein Deutscher Ingenieure*).

[2] "Einziehung von Nachrichten über Absatzmöglichkeiten deutscher Industrieprodukte im Ausland, Werkzeugmaschinen, Mai 1911-Dez 1911," BArch, R 901/2474.

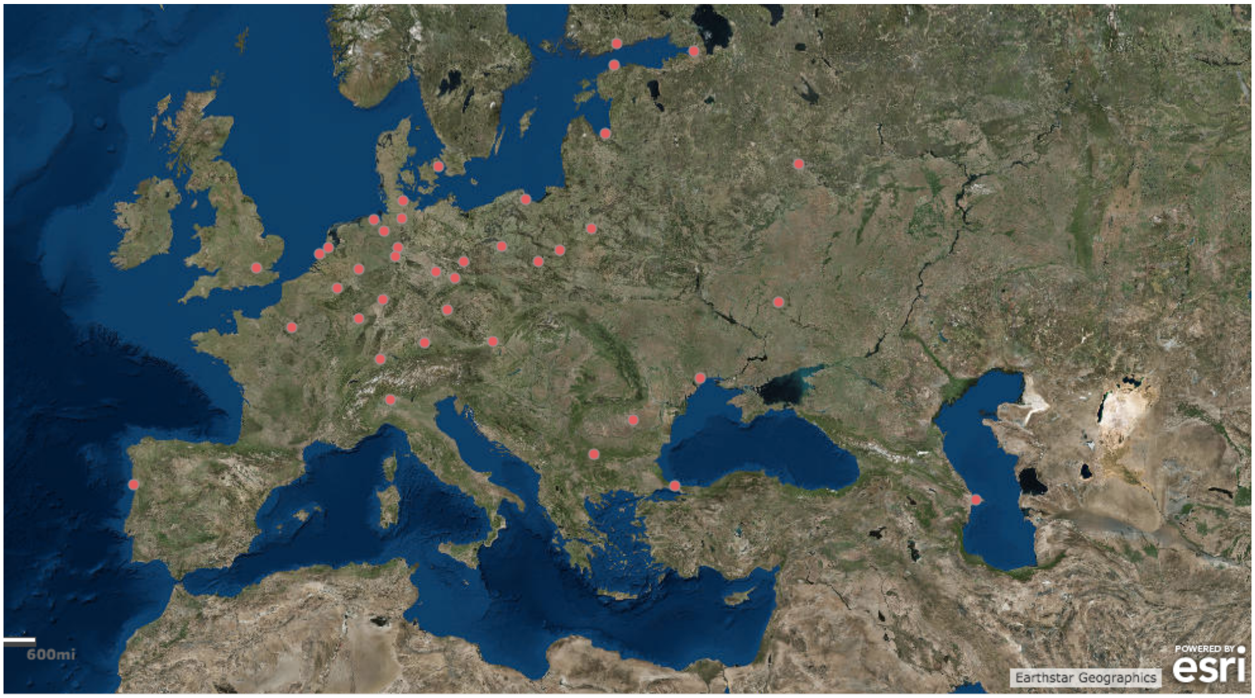

Figure 33: Sales agents for Borsig Locomotive Works (n=40) in 1913. Data assembled from Borsig firm archive, Landesarchiv-Berlin.

The organized machinery and machine tools manufacturers requested that Imperial German diplomats report on the state of demand for their products in Egypt, Argentina, Brazil, Bulgaria, China, Finland, Japan, British India, Canada, Mexico, Portugal, Romania, Serbia, Spain, and Turkey. Their survey detailed a slew of potential industrial applications and asked in rapid succession, "Which countries are currently fulfilling this demand? What types of firms are the customers? How can one succeed in the place? A good agent? Catalogues? Where are the major and minor workshops of the railroads? What are the tariff rates?" Over the course of the next year and a half, they received over three hundred reports from locales as far-flung as Aleppo and Alexandria, Smyrna and Shimonoseki, Belgrade and Beirut, Constantinople (Istanbul), Madrid, Mexico City, Mosul and Mukden (Shenyang), Nanjing, Pakhoi, and Rio de Janeiro.

This chapter investigates American interest in as well as uptake and transformation of the German *mission industrialisatrice* in the years surrounding World War I. It focuses on the articulation of logics linking currency reform, trade expansion, and infrastructure-building. Theorized by German and American economists in the 1890s, these logics became practice among financial syndicates in concert with capital goods-based holding companies with the expertise necessary for constructing railways, bridges, dams and earthworks to refashion the economies of entire regions. Although historians have discovered the afterlife of "Dollar Diplomacy" and inter-imperial engineering and financial dealings in the Japanese project to simultaneously develop and exploit Manchuria as "Manchukuo," this chapter traces out the legacies of the multipower "Reorganization Loan" to China beyond East Asia to metrics of development, to multilateral investment in infrastructure-building projects, and to the concept of a "World Bank."[3]

Away from Protection, the Machinery of Global Trade

Two months prior to the secret meeting between the capital goods industries and the Interior Ministry, in February 1911, thirty-six representatives of the machinery and machine-tools industries had met with Dr. Richter, Müller, and Delbrück of the Interior Ministry and Dr. von Leibnitz of the Prussian Ministry for Trade and Commerce to discuss fully stemming the incursion of American machine tools into the German market without resorting to a tariff hike (an option Richter framed as closed anyhow due to the existing rates set to last until 1917). Through the course of discussion, their horizons turned increasingly global.[4] Richter called on the participants to restrict the conversation to improving relations between "consumers and

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[3] Mark Metzler, *Lever of Empire: The International Gold Standard and the Crisis of Liberalism in Prewar Japan* (Berkeley: University of California Press, 2006).

[4] "Aufzeichnung über die Besprechung im Reichsamt des Innern am 8. Februar 1911, betreffend die Förderung des Absatzes deutscher Werkzeugmaschinen," Einziehung von Nachrichten über Absatzmöglichkeiten deutscher Industrieprodukte im Ausland, Werkzeugmaschinen, Mai 1911-Dez 1911, BArch, R 901/2474.

producers" of machine tools, in essence the capital goods industries, domestically and to overcoming prejudices against German machinery abroad.

The machinery makers offered varied assessments of the world market for machine tools. Von Borsig of the eponymous locomotive works emphasized American firms' quicker delivery times, better-attuned sales staff, and superiority in specialized machinery. Fritz Neuhaus, engineer and director at Borsig, argued that American machine tools were less innovative in design, but more reliable and honed from long experience. Dr. Waldschmidt, director at the small arms machinery-maker Ludwig Loewe & Co., stressed that they were not there to seek a tariff increase (though, he confessed, it would be nice if the Americans were willing to lower theirs) and acknowledged the need for better catalogues, developing more specialized machinery, and publicizing their recent success at the Brussels World Fair. Achievement at Brussels offered a chance to repair the reputation they had garnered at the 1876 Centennial Exhibition in Philadelphia when Franz Reuleaux, famed mechanical engineering professor at the *Technische Hochschule* in Charlottenburg, referred to German manufactures as "cheap and nasty."[5] Dr. Guggenheimer, director at Maschinenfabrik Augsburg-Nürnberg, also asserted that "experiments" with tariff rates should be avoided, while pointing out that modifications to models slowed delivery times by German firms.

Fröhlich, the engineer heading the *Verein deutscher Maschinenbau-Anstalten*, underscored the role of the U.S. government in assembling and disseminating expert reports on foreign markets. Concluding the meeting, Richter at the Interior Ministry endorsed Fröhlich's analysis and offered to have trade experts at German consulates periodically report on the demand for machine-tools worldwide. Their discussion had twinned anxiety and ambition. What

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[5] On the "cheap and nasty" controversy, see Andrew Bonnell, "'Cheap and Nasty': German Goods, Socialism, and the 1876 Philadelphia World Fair," *International Review of Social History* 46, no. 2 (2001): 207-226.

Richter could not offer and the machinery and machine-tools industries would not accept in tariff protection was compensated for by information and a way of seeing and assessing a world waiting for industrialization.

Foundations of Machinery Exports

Lathes, boring machines, milling machines—machine-tools as capital goods can be put to extractive or constructive ends. Whether drilling into the earth in search of coal or petroleum or into a piece of cast or sheet metal, the tools of heavy industry, industrial agriculture, and industrial mining often shared common networks of firms, capital, and knowledge. The fact that the 1911 meetings took place--and that their transcripts were marked and underlined "vertraulich!"--reflected several peculiarities of the Wilhelmine economy, well-known to historians and recognized by contemporaries, having come into a single dialogue encompassing the domestic "social question" intertwined with the industrial and financial dimensions of international trade, development, and empire.[6]

These peculiarities included: the concentration of investment capital in the "D-Banks" (Deutsche Bank, Disconto-Gesellschaft, Dresdner Bank, Darmstadter Bank), the cartelization of heavy industry, and the overwhelming export dependency of German industry, above all in the capital goods sector. Krupp exported on average one third of sales between 1895 and 1913, in certain years as much as half of its output; the Hannoversche Maschinenbau AG (Hanomag) sold 40 percent of its total locomotive production abroad between 1910 and 1913. Siemens exported 36.2 percent of its products in 1913, while the electrotechnical sector as a whole did 46 percent.[7]

[6] Hans-Ulrich Wehler, *Bismarck und der Imperialismus* (Köln: Kiepenheuer & Witsch, 1969).

[7] Torp, *The Challenges of Globalization: Economy and Politics in Germany, 1860-1914*, 54-67.

Across the sector, German machinery and machine-tools works averaged an export percentage of 26.4 percent in 1913.[8] Reflecting the range of overseas capital flows, the firm Mannesmann, a producer of seamless steel tubes and the apparatus to make them, plotted investments in and sales to sugar plantations in Brazil, mines in Morocco, and branch steelworks in Bohemia in the years leading up to World War I.[9]

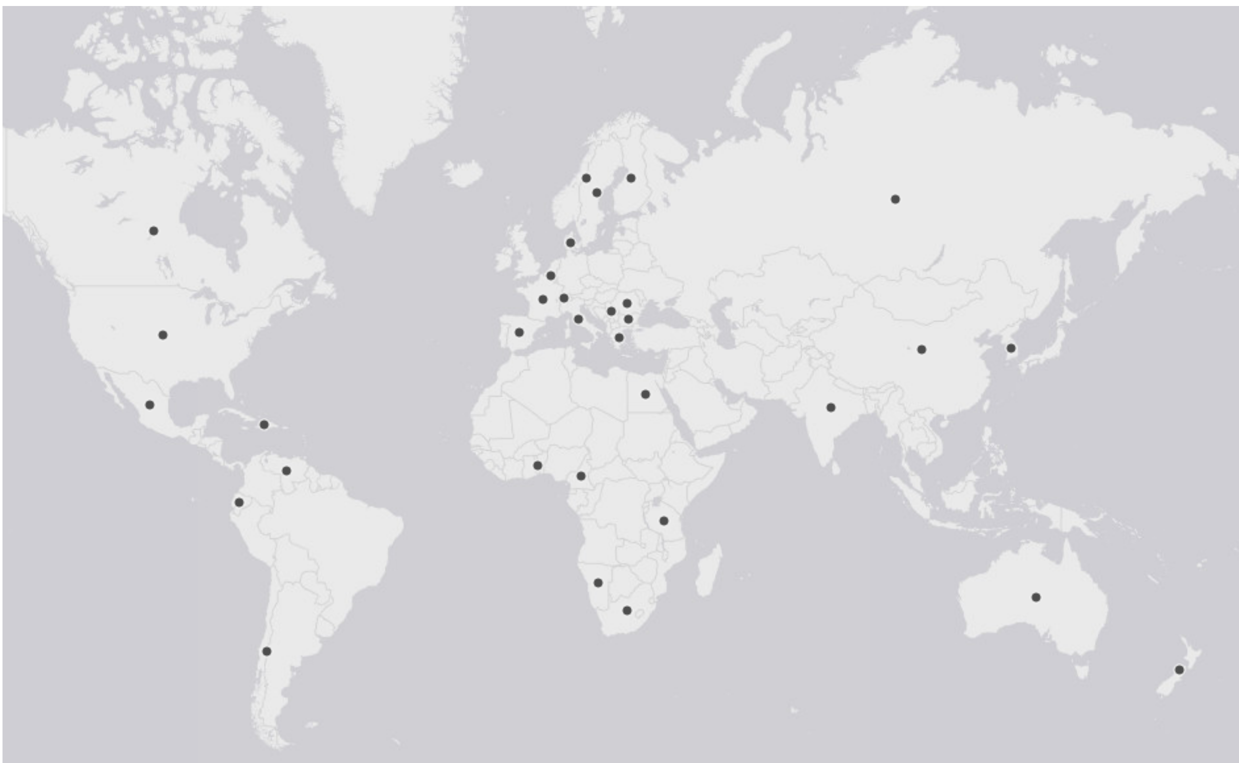

Figure 34: Countries included in a report providing detailed information on iron, steel, coal, and machine tariffs; most favored nation status; and dates of tariff negotiation, assembled by the Stahlwerks Verband AG. GHH, Hauptverwaltung, Zolltarife ausländischer Staaten (1908-1910). RWWA, Cologne.

[8] Niels P. Petersson, "Das Kaiserreich in Prozessen ökonomischer Globalisierung," in *Das Kaiserreich transnational: Deutschland in der Welt 1871-1914*, eds. Sebastian Conrad, Jürgen Osterhammel (Göttingen: Vandenhoeck & Ruprecht, 2004).

[9] Mannesmann collection, Deutsches Museum, Munich; Frank Nellißen, *Das Mannesmann-Engagement in Brasilien von 1892 bis 1995* (Munich: C.H. Beck, 1997); Petersson, "Kaiserreich in Prozessen ökonomischer Globalisierung," 56.

While the U.S. possessed a significantly larger domestic market and richer natural resources than Imperial Germany, their shared "second-developer" status imparted a somewhat different approach to that of British ventures in the mining and railroading projects that overtook much of the world during the "new imperialism." Perhaps they were more aware of development as a project, indeed as a state-supported project, due to their own recent paths. More importantly, they were not creditor nations prior to World War I--railroading and mining abroad meant scrounging funds from centralized finance capital and collaboration among institutional investors to support an export drive, increasingly of capital goods promoted as the foundation of development efforts.

By contrast, the middling sorts in Britain popularly invested their savings in the railroad projects of the Empire as well as in the United States and other countries they perceived as politically stable via coverage in the flourishing financial press.[10] Financial returns (on average 5.72% for overseas securities compared to 4.50% for domestic ones) dominated British infrastructure imperialism, alongside the longer-standing interest in expanding access to raw materials and penetrating markets for factory-made consumer goods such as textiles. Magee and Thompson conclude that, "Ceteris paribus, [British] savers were more likely to know and invest in railroad construction in Canada than in a similar plan proposed by promoters in China."

Although John Maynard Keynes claimed in retrospect that "we built the railways ourselves with British engineering skill, with our own iron and steel, and rolling stock from our own workshop," the history of British imperial infrastructure-building projects such as the

[10] Gary B. Magee and Andrew S. Thompson, *Empire and Globalisation: Networks of People, Goods and Capital in the British World, c. 1850-1914* (Cambridge: Cambridge University Press, 2010), 176; I. Stone, *The Global Export of Capital from Great Britain, 1865-1914* (Basingstoke: Macmillan Press, 1999).

Transvaal's electrification indicates otherwise.[11] Working in concert in 1907, German banks and AEG embedded their interests within the consolidated Victoria Falls Power Company by buying shares of it from a British-controlled African Concessions Syndicate at an "exorbitant price." With German finance serving German industry, they aimed to capture the South African market for electricity-generating machinery, sparking outrage at the Transvaal Institute of Mining Engineers. Mining magnates and their government ignored the British engineers' protests against German tactics, focused intently on the potential mechanization offered to increase productivity and undercut reliance on African workers. Reflecting or internalizing the German vision, the government sought to quiet the British engineers by stressing that the increased availability of cheap electricity benefitted the Transvaal's economy so immensely that open bidding for machinery contracts was not necessary.

The commissioning of the Victoria Falls Power Company's new Vereeniging station in 1911 prompted comparisons to a "South African Sheffield on the Rand"--however, Magee and Thompson rightly conclude that it "would have been better likened to Berlin—the industrial heartland of AEG."[12] Similarly, as early as the 1880s, when Georg von Siemens as director of Deutsche Bank pioneered the German investment drive into the Ottoman Empire, he countered concerns about the dearth of German syndicates devoted to railway construction abroad with a scheme to co-opt the efforts of Count Georges Vitali, the director of a French railway construction concern to procure the majority of the infrastructure materials from German firms.[13]

[11] John Maynard Keynes, quoted in Magee and Thompson, *Empire and Globalisation*, 143.

[12] Magee and Thompson, *Empire and Globalisation*, 143.

[13] Marc Linder, *Projecting Capitalism: A History of the Internationalization of the Construction Industry* (Westport, CT: Greenwood Press, 1994), 78.

In Germany financial interests were overlaid with a more embedded as well as temporally dynamic understanding of infrastructure imperialism, emanating from the desire to ensure continuous exports of capital *goods*--engineered and engineering products. Historian Niels Petersson has argued that British capital pursued a liberal developmentalism in China focused on the power of railroading projects to naturally expand markets and solidify central government rule, a political prerequisite for stable returns to capital. However, the constant consideration of capital goods themselves among German interests fostered an understanding of zones of capital accumulation premised on links between fossil fuels, the machinery downstream, and the bolstering of purchasing power in the mined and railroaded territory.[14] Developmentalism depended on the visible hand as much as the invisible, an understanding evinced by the greater frequency the term "industrial development" enjoyed in German print culture as compared to American and especially British publications.

Fellow Republics? The "Mission Industrialisatrice" Americanized

Watched closely by competing powers jostling for access to the legendary Chinese market, the German initiative in Shandong was only partly unique. American engineer William Barclay Parsons had conducted mining and railway surveys in China in 1898 and 1899 as Chief Engineer of the American-China Development Company, after having designed the first New York subway and founded the civil engineering and construction firm now known as Parsons-Brinckerhoff.[15]

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[14] Niels P. Petersson, *Imperialismus und Modernisierung: Siam, China und die europäischen Mächte* (Munich: Oldenbourg, 2000); Niels P. Petersson, *Anarchie und Weltrecht: das Deutsche Reich und die Institutionen der Weltwirtschaft, 1890-1930* (Göttingen: Vandenhoeck & Ruprecht, 2009).

[15] Parsons-Brinckerhoff is the construction conglomerate responsible for the "Big Dig." It currently employs 36,000 people with the deep technical expertise, financial reserves, and lobbying capacity to undertake public works

The American-China Development Company had formed in 1895 when Rockefeller representatives, Jacob Schiff of Kuhn, Loeb and Co., E. H. Harriman and other American railroading tycoons, Carnegie Steel and the American Sugar Refineries combined to compete with European syndicates interested in the "scramble for concessions" following the Sino-Japanese War. Prior to World War I and continuing in the 1920s, the American-China Development Company pursued infrastructure-building activities in close consultation with U.S. diplomats such as Secretary of State Philander Knox and Willard Straight, consul at Mukden [Shenyang] and later J.P. Morgan associate. From 1906 to 1913, these interests prowled after the "Open Door" and "Dollar Diplomacy" alike, engaging in the purchase of the Chinese Eastern and South Manchurian railroads and the construction of the Chinchow-Aigun and Hukuang railways alongside seeking to establish a Manchurian Bank to finance industrial development in China.[16]

Trained in civil engineering at Columbia University, Parsons, who had begun his literary career with technical volumes such as *Turnouts: exact formulae for their determination, together with practical and accurate tables for use in the field* (1884) and *Track, a complete manual of maintenance of way, according to the latest and best practice of leading American railroads* (1886), became a staunch proponent of the American "commercial invasion of China," which shared features with the *mission industrialisatrice*.[17] Publishing in the popular magazines

projects worldwide; on the railway surveys in southeastern China, see Emil Fischer, "Financing China," *Millard's Review of the Far East* (1919-1921); Apr 30, 1921: 456.

[16] Duane Conan Ellison, "The United States and China, 1913-1921: A Study of the Strategy and Tactics of the Open Door Policy" (PhD Dissertation, George Washington University, 1974).

[17] William Barclay Parsons, *Turnouts: exact formulae for their determination, together with practical and accurate tables for use in the field* (New York: Engineering News Pub. Co., 1884) and *Track, a complete manual of maintenance of way, according to the latest and best practice of leading American railroads* (New York: Engineering News Pub. Co., 1886); William Barclay Parsons, "The American Invasion of China: A Personal Survey of Commercial Conditions in the Interior of China," *McClure's Magazine* 14, no. 6 (Apr 1900): 499.

McClure's, *Engineering*, and *Harper's Weekly* at the turn of the century, Parsons penned essays about his railway survey on behalf of the American-China Development Company (compiled into a monograph entitled *An American Engineer in China*) that bridged engineering and economics while also introducing an analytical genre perhaps best termed "industrial anthropology." Parsons emphasized that his perspective reflected "not merely...the point of view of the manufacturer or the vender of some particular line of articles, but...the standpoint of basal principles, from the outlook of the organization."[18] Such an investigation, he argued, would enable an assessment of "China and the Chinese from the stand-point of industrial development as it exists at present and along the lines it is likely to follow in the future."[19]

Parsons based his analysis on a survey of Hunan, a province presented as heretofore untouched by a delegation of foreigners, which he conceived as part of a single global phenomenon of industrial advance. He considered the final frontier breached, writing

> at the close of the nineteenth century, when the ever-rising tide of industrial development has succeeded in sweeping over Europe, America, the better portion of Africa, Western Asia, and India, it is the Chinese Wall alone that resists its waves. The movement, however, is irresistible, and not even the exclusiveness of the Chinese and their extreme disinclination to change their ways will be a sufficient protection against it. The recent so-called 'Boxer' outbreak will probably prove to be the death-knell to Chinese resistance. Whatever may be the outcome of this outbreak, in so far as it affects the government or the political integrity of the country, it can be predicted with safety that the commercial and industrial life of China will be revolutionized, and the beginning of the twentieth century will be found to make the dawning of a new era.[20]

Parsons looked in part to German plans for Shandong as a model. Enumerating the stipulations of the Jiaozhou Bay leasehold agreement enabled Parsons to sketch in his 1900 monograph what precisely a developmentalist invasion meant. He noted with particular significance that Germany

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[18] William Barclay Parsons, "The American Invasion of China"; Parsons, *An American Engineer in China*, 7.

[19] Parsons, "The American Invasion of China"; Parsons, *An American Engineer in China*, 7.

[20] Ibid., 15.

held the right to construct public works within the leasehold "without reference to China."[21] He quoted verbatim two key clauses regarding the provision of investment capital and building materials in the wider province:

> If at any time the Chinese should form schemes for the development of Shan-tung, for the execution of which it is necessary to obtain foreign capital, the Chinese Government, or whatever Chinese may be interested in such schemes, shall, in the first instance, apply to German capitalists. Application shall also be made to German manufacturers for the necessary machinery and materials before the manufactures of any other power are approaches. Should German capitalists or manufacturers decline to take up the business, the Chinese shall then be at liberty to obtain money and materials from other nations.[22]

Further, he stressed that, although the leasehold encapsulated a mere 100 *li* (33 miles) of shoreline, the "Germans, availing themselves of the special commercial concession" had "thrown a sphere claim over the whole province of Shan-tung, an area as large as New England."[23] Having attentively followed the leveraging of the toehold in Qingdao, Parsons began to investigate a diverse array of possible infrastructural improvements and industrial projects, materials and men, in China.

Parsons reported on minerals—gold and silver, copper, lead, and antimony in addition to petroleum and the coal and iron fields in Zhili, Shanxi, Shaanxi, Sichuan, Jiangxi and Hunan, "where all varieties from soft bituminous to very hard anthracites are found," the former for "both coking and non-coking, fit for steel making or steam uses, while of the latter there are those adapted for domestic use, with enough volatile matter to ignite easily, and others sufficiently hard to bear the burden in a blast furnace and yet so low in phosphorous, sulphur, and volatile substances as to render them available for the manufacture of Bessemer pig, as is

[21] Parsons, *An American Engineer in China*, 35-36.

[22] Ibid.

[23] Ibid., 41.

done in Pennsylvania."[24] Parsons, on the precipice of making a career of moving earth for the subterranean labyrinths which either power sky-scrapered cities or circulate their denizens, was ablaze with prospecting the interior of China.

To his pleasure, Parsons discovered "in the shop windows at Chang-sha," the "capital of Hu-nan,...one of the most interesting cities in the whole Empire, as marking the very highest development of Chinese exclusiveness," articles with "American, English, French, German, Japanese, and other brands" on display--from a "good assortment of American canned fruits and vegetables" to a "stock of Munich beer."[25] Far from the treaty ports, this convinced Parsons that

> the Chinaman will buy, that he will adopt foreign ways, there is no question; and he is just as ready to make the greater changes in his life that must result from the introduction of railways as to buy a few more pieces of cotton or a few more tons of steel.[26]

Anticipating this transformative opening up, Parsons celebrated the "awarding of the Hankow-Canton railway concession to an American syndicate" as the future "backbone of China's railway system, since it will connect the metropolitan district in the north, through Hankow, the commercial metropolis of the interior," referred to as the "Chicago of China," with "Canton and Hongkong, the gateways to the south, and will pass through the richest section of the Empire."[27]

Writing in the immediate aftermath of the Boxer uprising, Parsons assured his American readers that "in my journey through the interior I found a strong desire to learn, and to learn intelligently, what a railroad was."[28] As a further palliative to those wary of foreign adventures, he noted that

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[24] Parsons, *An American Engineer in China*, 35-36.

[25] William Barclay Parsons, "The American Invasion of China."

[26] Ibid.

[27] Ibid.

[28] Ibid.

> when objections were made against it, they were of the same nature as those that were urged in England when railways were first projected there—as, for example, that the coolies, who now carry goods and produce over the little highways one their backs, 100 pounds at a load, or the boatmen who own a slow-moving junk requiring possibly two months to go from Hankow to Chang-sha, 300 miles, with a cargo of American kerosene, would be ruined by the new order of things.[29]

A question of sovereignty thus reduced to a tutelary discussion of Luddism, Parsons recalled,

> When it was explained to them that similar fears had been found in other countries to be groundless, and that railways gave increased employment at higher wages by developing unknown means of trade, the local merchants, almost without exception, urged my speedy return.[30]

While regional "gentry" did at times welcome or lobby for the coming of the railroad in late Qing China, Parsons' account reveals an abiding focus on machines to first suit and then uplift men, the corollary to contemporary American missionizing in China.

What I am calling Parsons' "industrial anthropology" encompassed both a calibration of overall technological progress and an emphasis on encultured consumer preferences. He prodded American manufactures to "make a careful and intelligent study of the Chinaman in his tastes and habits" if "we wish to sell him goods, we must make them of a form and kind that will please him and not necessarily ourselves, a fact too frequently overlooked by both the English and ourselves, but one of which the German, who may be our real competitor in the end, takes advantage."[31] He recounted one such failure, relayed by the U.S. Minister to China Edwin H. Conger:

> The representative of a large concern manufacturing a staple article in hardware, let us say screws, had been working hard to secure an order for his screws, which he knew were better than the German article then supplying the demand, At last he obtained a trial order, amounting to $5,000, which he cabled out; but it was given with the condition that the screws be wrapped in a peculiar manner, say in blue paper, according to the form

[29] Ibid.

[30] Ibid.

[31] Parsons, "The American Invasion of China."

> which the native merchant had been accustomed to buy them. Was the order filled? Not at all. The company cabled back that their goods were always wrapped in brown paper and that no change could be made. The order then went to Germany. To the American concern an order for $5,000 was of small moment, perhaps; but they overlooked entirely the fact that this was the thin edge of the wedge, opening a trade that could be developed into tremendous proportions.[32]

Drawing on his experience in the engineering and capital goods sector, Parsons realized that technical complementarities in hardware comprised the "thin edge of the wedge" from which subsequent orders could be assured and expansion accelerated.

But whereas German naval and industrial interests in Qingdao and wider Shandong had sought to establish the most up-to-date machinery works for a zone of capital accumulation and German national prestige, Parsons cautioned against discontinuous civilizational development in China. Seeking to export machine-tools, German industrialists, diplomats, and engineering educators imagined their Chinese pupils realizing "the advantages of backwardness," catapulting over intervening steps to modern industrial practice.

Parsons preferred a more natural evolution, arguing, it "is no use to send to China, to be sold in the interior, tools, for instance, of the same high finish and quality that our mechanics exact in their own" since a "Chinamen's tools are handmade, of rough finish, and low cost."[33] Depicting a scene in anthropological detail, he wrote that "in the interior cities one sees a tool-maker take a piece of steel, draw all the temper, hammer it approximately to the shape of the knife or axe, chisel or razor, or whatever other article he may be about to make; then, with a sort of drawing-knife pare it down to the exact shape required, re-temper it, grind it to an edge, and fix it in a rough wooden handle."[34] Such practices would present severe market competition. He

[32] Ibid.

[33] Ibid.

[34] Ibid.

pointed out that "this work is done by a man at a wage of about ten cents a day, and this is the competition that our manufacturer must meet," yet, "in spite of the difference in cost of labor he can do so, because his tools are machine-made, and are better; but he must waste no money on unnecessary finish."[35] Parsons had transcribed an ethnography of unit costs, taking in the work processes of Chinese craftsmen as the basis for an appropriately tailored "commercial invasion."

Consequently, Parsons recommended more or less reprising the American nineteenth century in China via American sales of semi-fabricated machine tools, prime movers, and component parts. He suggested there "awaits the American manufacturer an outlet, especially for tools, machinery, and other articles in iron and steel," especially "for the smaller and lighter machines, rather than the larger ones."[36] American capital goods firms "must appeal," he underscored, "to the individual worker who exists now, rather than aim at the needs of a conglomeration in a factory which will come about in the future."[37] This meant that the "tools should be simple in character, easily worked and kept in order, and without the application of quick-return and other mechanical devices so necessary for labor-saving with us." Parsons' proposal to export "light wood-working machinery...to supplant the present manual-labor methods" and "all kinds of pumps, wind-mills, piping, and other articles of hydraulic machinery" differed in important ways from the German project in Shandong, while partially resembling what trade experts such as Goering would report to the German Interior Ministry and consortium of machinery manufacturers in 1911.[38]

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[35] Ibid.

[36] Ibid.

[37] Ibid.

[38] Ibid.

A civil engineer, Parsons was not yet thinking primarily in terms of capital shortages, capital centralization, or capital accumulation either blocking or facilitating the uptake of the latest capital goods abroad in 1900. Nor had he begun to grasp fully the role of financialized trade or central banking. He weighed the tools men tempered, and attempted to measure their receptivity to change. The railroad was non-negotiable for Parsons (he was, after all, sent on its behalf), but he promoted a "small is beautiful" approach to machinery exports to suit his assessment of the current stage of the industrial arts in China. Yet the realms of international infrastructure-building, finance, and development would not remain isolated for engineers involved in American projecting abroad.

Less than two years after the publication of Parsons' *An American Engineer in China*, in January 1902, the U.S. embassy in Berlin requested three copies of "the White Book recently transmitted to the Reichstag, entitled a--'Denkschrift betreffend die Entwicklung des Kiautschou-Gebiets in der Zeit vom Okt 1900 bis Oktober 1901.'"[39] Two months later, on March 1, 1902, the American ambassador in Beijing telegraphed Washington that Germany was in no case seeking new concessions in Shandong at the moment and had merely struggled in discussions with the Chinese government against exorbitant tax claims in the interest of all of the powers.[40] By tax claims, they presumably meant *lijin* (inland commercial tolls), for China possessed no tariff autonomy at the time, with its maritime customs bureau staffed by Westerners collecting a fixed five percent ad valorem since the Treaty of Nanjing. Western industrial and commercial interests and their diplomatic representatives complained ceaselessly about *lijin*, which, despite the formally preferential half-tariff-rate (2.5%) they received inland, disrupted

[39] Die wirtschaftliche Erschließung von Kiautschou, vom Aug 1901-Nov 1902, Barchiv, R901/81206.

[40] Die wirtschaftliche Erschließung von Kiautschou, vom Aug 1901-Nov 1902, BArchiv, R901/81206.

their capacity to realize the imperialism of free trade in the Chinese interior. Following the Taiping Rebellion and without tariff autonomy or other sizeable sources of revenue, the Qing state had introduced *lijin* as a key fiscal strategy to redistribute surplus between provinces and to accrue capital for the industrial projects of the Self-Strengthening Movement in the 1880s. In the wake of the European railway concessions, Chinese provincial authorities seized upon railway stations as new loci for *lijin* collection.[41]

Trade and fiscal politics became further intertwined under the Mackay Treaty of 1902, when the Chinese government assented to the eventual abolition of *lijin*, presenting a further deterioration of the tax base in the face of ever-growing expenditures on military, educational, and railway reform projects of the late Qing.[42] Interestingly, certain industrial development loans were themselves tethered to *lijin* as the basis for securitization, as in the April 1911 agreement for a "Chinese currency reform and industrial development loan" by the French Banque de l-Indo-Chine, the German Deutsch-Asiatische Bank, the British Hongkong & Shanghai Banking Corporation, and the American Group comprised of JP Morgan & Co., Kuhn, Loeb & Co, the First National Bank, and the National City Bank of New York.[43] In anachronistic terms, a structural adjustment program for China's debt and development was on the horizon, the vague lineaments of which had begun to take form, at times separately and at times together, among industrial export interests, financiers, diplomats, and economists. It would go by the moniker of a "consortium," "currency," or "reorganization" loan.

[41] Stephen Halsey, *Quest for Power: European Imperialism and the Making of Chinese Statecraft* (Cambridge, MA: Harvard University Press, 2015); Robert F. Dernberger, "The Role of the Foreigner in China's Economic Development, 1840-1949," in *China's Modern Economy in Historical Perspective* (Stanford: Stanford University Press, 1975), 44.

[42] S.A.M. Adshead, *The Modernization of the Chinese Salt Administration, 1900-1920* (Cambridge, MA: Harvard University Press, 1970), 42.

[43] John Van Antwerp MacMurray, ed., *Treaties and Agreements with and Concerning China, 1894-1919* (New York: Oxford University Press, 1921).

American machinery manufacturers developed similar outwardly-oriented aspirations as their German counterparts in the same era, relying equally on state support for their initiatives. Having realized imperial ambitions in the Pacific in the Spanish-American War, U.S. mining enterprises drew on Richthofen's work as the basis for surveys of the Zamboanga region in the Philippines.[44] More generally, although the American capital goods industries enjoyed a much larger domestic market than their counterparts in Imperial Germany and were thus less export-dependent, the machining centers of the U.S. offered strong political support for reciprocity treaties with Latin America, where they hoped to establish a Pan-American "Zollverein," or customs union.[45] Such a trading zone, without internal tariffs but with a common external one, might expel European competitors from the hemisphere, offer a boon to expensive capital goods exports, and establish a circuit between the machining metropoles of the U.S. northeast and Ohio River Valley and the extractive and plantation economies of Latin America. In short: the imperialism of free trade, with a preferential tariff.

[44] W.D. Smith, "Mining Operations: Mining Prospects in Mindanao, Philippine Islands," *Mining American* 57 (February 13, 1908): 175.

[45] Cornelius Torp, *The Challenges of Globalization: The German Empire in the World Economy, 1860-1914* (New York, 2014); Wharton Baker, "American Commercial Union," *North American Review* (1904); "Wants Closer Relations BETWEEN THE UNITED STATES AND SOUTH AMERICAN NATIONS," *The Rock Island Argus* (February 23, 1886);); "The American Zollverein," *The Washington Post* (Aug 25, 1889).

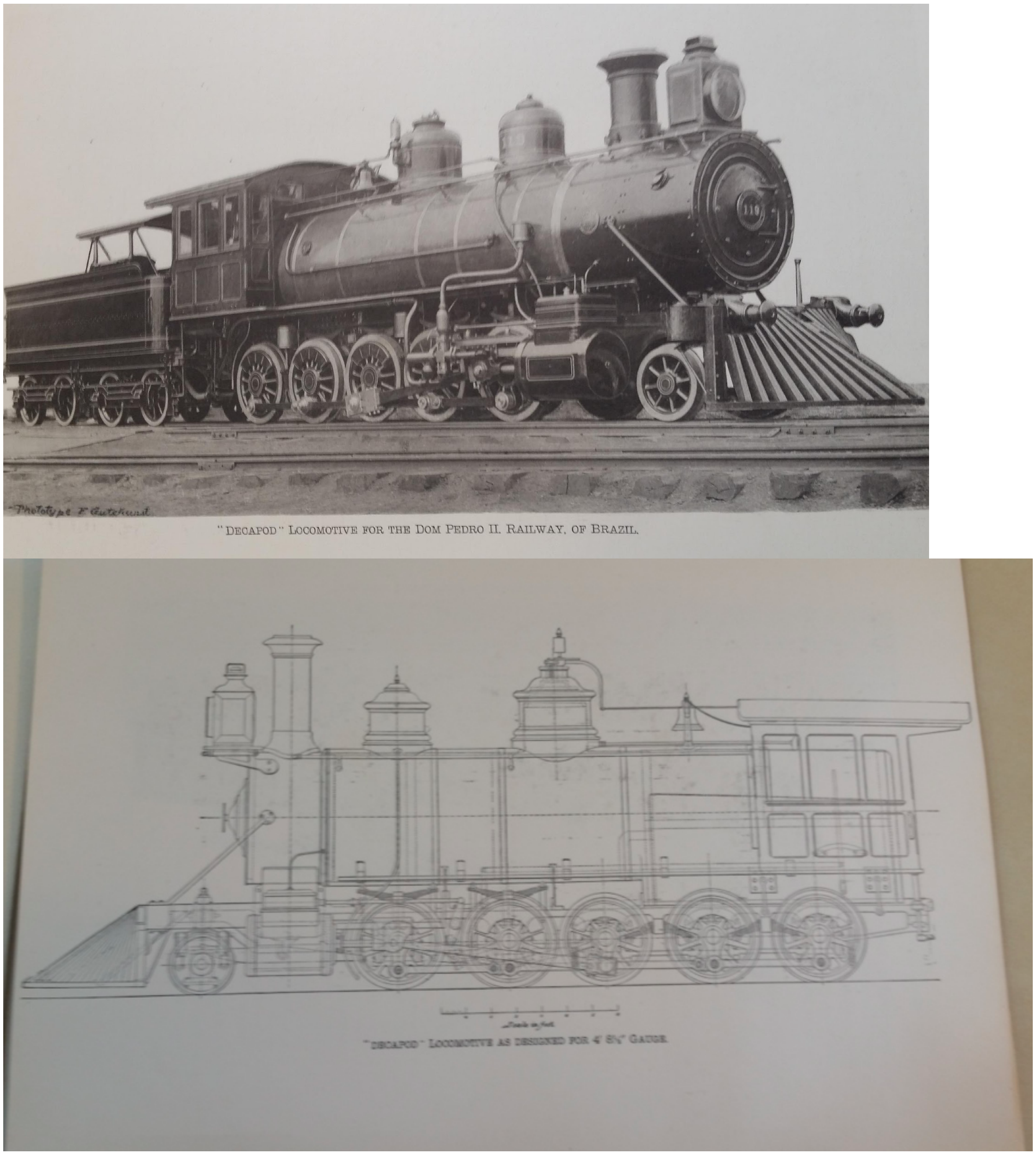

Figure 35: Baldwin Locomotive (Philadelphia) for Brazilian railways. William Liseter Austin Papers, Hagley Museum.

Largely based on existing assumptions about static regions for primary versus secondary economic activity, the plan for an American *Zollverein* lacked the dynamics of the German *mission industrialisatrice* in Shandong. But with the opening of the Panama Canal, itself a massive infrastructural venture reliant on racial labor regimes, the export drive of the capital goods sector precipitated a turn to the Pacific as well as a turn to finance in the form of currency reform, or "Dollar Diplomacy."[46]

Lenin famously argued that surplus capital in the European core fueled the feverish "new imperialism" of the fin-de-siècle.[47] For Lenin of course, this constituted the highest and final stage of capitalist development, a stabilization strategy destined for failure. Revisionists by contrast, held that imperialist projects could very well promote the stabilization of corporate capitalism in the industrial core. Historians Martin Sklar and Carl Parrini have shown that American economists of the period such as Jeremiah W. Jenks at Cornell and financial journalist Charles A. Conant, key advisors to the McKinley and Roosevelt administrations, took this assessment more as programme than as heuristic and advocated for the construction of an international investment system based on a gold-exchange standard for lubricating trade between industrial and non-industrial countries.[48]

Representing the wing of Progressive thought that accepted the concentration of corporate capitalism while deploring its recurrent crises (as in the "corporate liberalism" of groups like the National Civic Federation), Jenks and Conant centered their analysis on surplus capital in excess of investment opportunities and the concomitant economic "congestion."[49] They believed the problem of surplus capital could be resolved through four routes: state socialism as "the abandonment of saving" in favor of the entire application of output to current consumption;

[46] Julie Greene, *The Canal Builders: Building America's Empire at the Panama Canal* (New York: Penguin, 2009).

[47] V.I. Lenin, "Imperialism, the Highest Stage of Capitalism," (1917); J.A. Hobson, *Imperialism: A Study* (London, 1902); see also, Rosa Luxemburg, *Die Akkumulation des Kapitals* (Leipzig: Frankes Verlag, 1921).

[48] Carl P. Parrini and Martin J. Sklar, "New Thinking about the Market, 1896-1904: Some American Economists on Investment and the Theory of Surplus Capital," *The Journal of Economic History* 43, 3 (Sep., 1983): 559-578.

[49] Martin Sklar, *The Corporate Reconstruction of American Capitalism, 1890-1916: The Market, the Law, and Politics* (Cambridge: Cambridge University Press, 1988); members of the National Civic Federation such as Frank Vanderlip were also highly interested in German industrial education, see Frank Vanderlip, "Address," *Proceedings of the Organization Meetings of the National Society for the Promotion of Industrial Education* (New York, 1907).

increased social welfare expenditure; war as consumption of capital; and imperialism. Conant dismissed the first three as unrealistic or unethical and proceeded to push for government-business collaboration toward overseas investment of surplus capital.[50]

From 1901 to 1904, Conant and Jenks elaborated their vision of the "Open Door Policy" and "Dollar Diplomacy" under the auspices of the McKinley and Roosevelt administrations' efforts to integrate currencies in East Asia and Latin America with the international gold standard as a platform for investment. Secretary of State Hay, Secretary of Treasury Lyman J. Gage, and Secretary of War Elihu Root sent Jenks to the Dutch and British colonies in Asia and Conant to the Philippines, where he designed a Filipino gold-exchange standard with then-governor William H. Taft. Passed by Congress in March 1903, the Filipino gold-exchange standard became the basis for monetary reform in Mexico, Panama, and Nicaragua.[51] Conant and Jenks pursued the gold-exchange project with equal fervor in China to ease the outflow of American investment capital and secure safe returns.

In a series of treaties with the U.S., Britain, and Japan from 1901 to 1903, the Qing government assented to "take the necessary steps to provide for a uniform national coinage."[52] This, however, did not necessarily entail adopting a gold-exchange standard. Indeed, the British government opposed a direct transition to the gold standard in China, suggesting instead that China adopt a nationally consistent silver coinage and even considered the then-fluctuating silver currency preferable to gold. Parrini and Sklar point out that this "implicitly positioned the British

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[50] Parrini and Sklar, "New Thinking about the Market."

[51] Parrini and Sklar, "New Thinking about the Market, 1896-1904" ; on the dollar and American imperialism, see Leo Panitch and Sam Gindin, *The Making of Global Capitalism: The Political Economy of American Empire* (London: Verso, 2012); Emily S. Rosenberg, *Financial Missionaries to the World: The Politics and Culture of Dollar Diplomacy* (Durham: Duke University Press, 2004); Herbert Feis, *Diplomacy of the Dollar: First Era, 1919-1932* (Hamden, CT: Archon Books, 1965).

[52] Parrini and Sklar, "New Thinking about the Market, 1896-1904."

government against the United States's objective of an investment Open Door in China," as new investment would be discouraged beyond the concessions granted within "spheres of influence."[53]

In March 1903, the U.S. Congress approved a plan by President Roosevelt, Secretary of State Hay, and Secretary of War Elihu Root to establish a Commission on International Exchange "to bring about a fixed relationship between the moneys of the gold standard countries and the present silver using countries." While Britain under Chamberlain experimented with an "imperial *Zollverein*" or "colonial reciprocity," the American Commission on International Exchange sought to solve the problem of surplus capital by ousting the fluctuating silver standard from the as-yet-undeveloped world.[54]

Staffing the Commission on International Exchange, Jenks, Conant, and Hugh Henry Hanna promoted the gold-exchange plan among financial and government interests in Britain, France, Germany, the Netherlands, Russia, and Japan. They argued that an international investment system based on the gold standard would benefit all of the powers since

> the bankers and financiers of Europe with the immense accumulated savings under their control and with the equipment of those countries for production for domestic needs nearly complete, know full well how great is the fund of capital seeking investment throughout the world.[55]

British interests remained unmoved by the American Commission on International Exchange's agenda, and all of the other powers concurred with an implicit defense of the territorial-commercial "spheres of influence" in China--with the exception of Germany. The German

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[53] Ibid.

[54] Marc-William Palen, "Protection, Federation and Union: The Global Impact of the McKinley Tariff upon the British Empire, 1890–94," *The Journal of Imperial and Commonwealth History* 38, 3 (September 2010): 395-418; Frank Trentmann, *Free Trade Nation* (Oxford, 2008), 161; Sydney H. Zebel, "Joseph Chamberlain and the Genesis of Tariff Reform," *Journal of British Studies* 7, 1 (Nov., 1967): 131-157.

[55] Parrini and Sklar, "New Thinking about the Market, 1896-1904."

representatives--Rudolph Koch of the Reichsbank, Karl Helfferich, Roland Lucke, a director of Deutsche Bank, Arthur Salomonsohn, of Discontogesellschaft, and Fritz Urbig, director of the *Deutsche-Asiatische Bank*--endorsed the American plan. Parrini and Sklar note the irony: "'Free-trade' Britain supported investment 'protectionism' in China; 'protectionist' Germany and the United States favored investment 'free trade.'"[56]

One way to square this puzzle is to take account of the two countries' increasingly concentrated capital goods sector and the concomitant *mission industrialisatrice*. As early as August 1900, Tirpitz had written to Kaiser Wilhelm in defense of the "Open Door," asserting, "It does not recommend itself from a political standpoint, to give the impression that we want to grab further the province of Shandong. Other parts of China, above all the Yangtze area, are much more important for German trade; the politics of the open door is the only correct one for the furtherance of it [exports]. England would gladly cede Shandong, if we wanted to renounce the Yangtze. We must expand our political influence in all of China and [we] may not let ourselves be confined to this small corner. Shandong will later fall to us like ripe fruit in the lap, so we do not need to stretch out hands after it now."[57] Although Tirpitz's advice entailed a territorial goal, quelled for the moment by Germany's geopolitical isolation, it equally stressed access to the entire Chinese market irrespective of "spheres of influence." This included market penetration for capital goods, where German and American machinery manufacturers had begun to surpass their British counterparts in price, quality, and innovativeness.

The members of the American Commission on International Exchange wrote that the "accumulation of capital seeking investment and failing to find it at a profitable rate" constituted

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[56] Ibid.

[57] Quoted in Horst Gründer, *Geschichte der deutschen Kolonien* (Paderborn: Schöningh, 2012), 228.

"one of the most serious economic problems of our time." Solving it necessitated cooperation among the powers to lay the groundwork, technically, monetarily, fiscally, and politically for foreign investment in a world waiting for development. In a prescient statement, the Commission on International Exchange concluded, "In some respects, the finding of outlets for this capital is more important than increasing the annual exports of manufacturing countries."[58] Yet sizeable outlets for capital, in overseas infrastructure-building and public works justified on the basis of transforming regional economies and ecologies, tended to be major outlets for capital goods. The tail had begun to wag the dog in economic theory; in practice, finance, once envisioned as a lubricant to capital goods exports overall too shy to venture the risks of overseas investment when returns could be secured at home, would commence thinking—and perhaps directing—the *mission industrialisatrice*.

Banking on (and for) Trade

In a review of geologist Richthofen's translated works in 1908, the English journal *Nature* fixated on his conclusion that China would one day surpass the West industrially, writing "On almost every page of the narrative stand prominent, not merely the sources of China's weakness, but also the enormous latent power of the country, and there is borne in upon one an almost oppressive feeling that a China awakened, reformed, and patriotic could set the world at nought, and a China ambitious besides would be a real yellow peril."[59] While the "yellow peril" discourse enjoyed an equally wide audience in the United States in the era of Chinese Exclusion and Philippine colonization, American finance and industry dissented from this assessment,

[58] Parrini and Sklar, "New Thinking about the Market, 1896-1904."

[59] "Von Richthofen's Chinese Diaries," *Nature* 78 (1908): 195.

preferring the first part of Richthofen's analysis--the promise of the *mission industrialisatrice* in a "reawakened" China, hoping to reap the profits of industrial developmentalism abroad.[60]

Emil S. Fischer, an Austrian-born accountant who had worked for *Deutsch-Asiatische Bank* in Shanghai, also promoted the German understanding of the *mission industrialisatrice* among American financiers and industrialists at the turn of the century.[61] Fischer argued that in light of the recent acquisition of colonies in Hawaii and the Philippines, American capitalists should establish centralized banks with foreign branches to take up and foster foreign investment, particularly as part of the "contest among the civilized nations of the world for political, financial and commercial supremacy in the Far East."[62]

With a nod to the currency reform efforts of Taft, Fischer pointed out that the

> War Department and civil authorities governing the Philippines have constantly recommended that the vast receipts and disbursements of the United States funds should be entrusted to an American banking institution with headquarters at Manila, and acting as fiscal agents of the United States Government.[63]

Moreover, he cited strong interest expressed in "the establishment of an American bank with branches extending to the large financial trading centers and settlements of the East, in order to enter the profitable field of foreign banking in the Orient" at the October 1899 International Commercial Congress in Philadelphia.

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60 Paul Kramer, *The Blood of Empire: Race, Empire, the United States, and the Philippines* (Chapel Hill: University of North Carolina Press, 2006); Matthew Frye Jacobson, *Barbarian Virtues: The United States Encounters Foreign Peoples at Home and Abroad, 1876-1917* (New York: Hill and Wang, 2001); Moon-ho Jung, *Coolies and Cane: Race, Labor, and Sugar in the Age of Emancipation* (Baltimore: Johns Hopkins University Press, 2009).

61 "The Americanization of Emil S. Fischer," *The China Weekly Review* (July 19, 1924): 222.

62 Emil Fischer, "The Expansion of American Banking in the Far East: American Banks Would Promote American Commerce. European Banking Activity. The Profits Derived from Oriental Banking. China's Increasing Foreign Trade," *Bankers' Magazine* 64, 1 (Jan. 1902): 19-27; Emil Fischer, "Financing China," *Millard's Review of the Far East* (Apr. 30, 1921): 456.

63 Fischer, "Financing China."

Fischer emphasized that the U.S. was the sole country to neglect the financial backing of nationally-defined commercial missions, while the "large trading nations especially so Great Britain, Germany and France, have kept a watchful eye for the fostering of their foreign trade, which they encouraged by the passage of laws furthering the opening of branches in the Colonies, or making provisions for the establishment of National banking institutions in foreign countries."[64] He echoed civil engineer and railway surveyor William Barclay Parsons' observation that "in the making of Chinese foreign commerce and the opening of the country to trade and industrial enterprise, the position taken by European governments has been to foster and support the efforts of their subjects, while the "policy of the United States in this regard has been distinctly negative, and whatever has been accomplished in this regard has been accomplished by our citizens is the result of individual energy without national support."[65]

Parsons, however, perceived a sea change, writing in 1900 that in the "investigation of the transition of the American position the future historian will point to the mass of statistical information now being made, which will show that the status of our country changed from being open to invasion by foreign capital to being capable of invading other lands with its own capital, about the year 1895."[66] Rather than attribute this reorientation in capital flows to the Great Merger Movement of the 1890s, Parsons instead focused on the "latent force given life by the Spanish War," which awakened "attention to foreign affairs" and "land acquisitions."[67] These were culminating in a "singular confirmation of the movement toward a broadening out on the

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[64] Fischer, "Financing China."

[65] Parsons, *An American Engineer in China*, 44.

[66] Ibid.

[67] On the Great Merger Movement, see Naomi Lamoreaux, *The Great Merger Movement in American Business, 1895-1904* (Cambridge: Cambridge University Press, 1988).

part of American capital for foreign invasion" through "the securing of the concession of the railway from Hankow to Canton, consummated by the signing of the grant in Washington in April, 1898, by H.E. Wu Ting-fang, the Chinese Minister, and by a singular coincidence just one week before the declaration of war, which was to establish the United States as a colonizing power."[68] To Emil Fischer as well, colonies and foreign countries presented themselves as nearly synonymous fields for capital investment, reflecting his infrastructure-centric understanding as well as his experience with the *Deutsch-Asiatische Bank* in China, a country facing semi-colonial status with pockets of alternative and contested sovereignty abutting each other cheek-by-jowl as in the leased Bay of Jiaozhou, the segregated "model colony" of Qingdao, and the Chinese province of Shandong.

Fischer stressed the significance of German financial syndicates in promoting trade and the acquisition of railway and mining concessions. He pointed out that the "leading banking institutions of Hamburg, Berlin, Dresden, Frankfurt, Cologne, and Munich combined for the purpose of establishing German banks abroad," a conscious design which included Disconto Gesellschaft, the Deutsche Bank, the Norddeutsche Bank, the Dresdner Bank, the Royal Seehandlung, the Bank für Handel und Industrie, the Handelsgesellschaft, S. Bleichroeder, Mendelssohn & Co., Robert Warschauer & Co., and M. A. von Rothschild & Soehne. These, in turn, had founded filiales, which Fischer enumerated: "in Argentine, the Banco Aleman Transatlantico, with its main office in Buenos Ayres; in Brazil, the Brazilianische Bank für Deutschland, with its seat in Rio de Janeiro; in the Far East, the Deutsch-Asiatische Bank at Shanghai and Calcutta, and other prominent trading centers; on the South American West Coast,

[68] Parsons, *An American Engineer in China*, 45.

the Bank für Chile und Deutschland, at Valparaiso."[69] He perceived the results of these undertakings in the expansion of the German merchant marine's tonnage by "over 150 percent in the international trade alone" and in increases in trade with the "United States, Mexico, Central and South America, and the Far East and Australia" by over 100 percent, 300 percent, and 500 percent respectively.[70]

In terms of support for railroad concessions, Fischer contrasted American dependence on foreign banking institutions with the British railway development in the Yangtze Valley via the Hongkong and Shanghai Banking Corporation, German railroading in Shandong via the *Deutsch-Asiatische Bank*, and Russia's Manchurian Railway concession, which required that the Qing government "deposit several million taels with the Russo-Chinese Bank" as a "guaranty for the fulfillment of this agreement by the Chinese to build the Manchurian Railway from the Siberian frontier in connection with the Trans-Siberian continental line to the southern borders of the Gulf of Pechili."[71] Globally, Fischer underscored that consistent support from the German financial syndicates meant that "Germany" had acquired "large railroad and mining concessions" and had come to "own and control important Egyptian and South African roads, several Brazilian and Venezuelan lines, the Shantung Railroad in China, the Turkish railways, which constitute the connecting link between the Bosporus and the Persian Gulf."[72]

Fischer argued that the U.S. had already fumbled opportunities offered by railway and mining concessions due to a lack of domestic financial organization and support, such as the concession the Qing government had granted American Calvin Brice for the Hankow-Canton

[69] Fischer, "Financing China."

[70] Ibid.

[71] Ibid.

[72] Ibid.

Line. Relying on the surveys completed by engineer William Barclay Parsons in 1899, Fischer noted that the line "passes from its Southern terminus, Canton, through a rich, important and very populous section of the country" and "ends in Hankow, a city surrounded by an immensely rich iron and coal area."[73] He expressed concern that the "Belgians now have their connecting line [to the American concession] half-finished," whereas "the Americans have not yet begun building."[74] His sole consolation was that the project stood secured since "J.P. Morgan has given his strong financial support and at the recent election of the board of directors of the American-Chinese Railway, Chief Engineer Wm. Barclay Parsons was chosen president."[75] Finance capital at last backed engineering capital, which had traversed and mapped the terrain's resources into an "immutable mobile," a reference point for advocates of banking infrastructure imperialism.[76]

With an eye to commerce and infrastructure, Fischer called upon American banking institutions to "foster both sides of the Oriental trade, whereby it will make substantial marginal profits."[77] By "both sides," he meant commerce and infrastructure, larger imports of "raw material and colonial products" in exchange for "more and more goods from the United States" alongside "increased purchasing power...along with the development of Oriental resources."[78] Fischer elaborated on the assessment of civil engineer William Barclay Parsons, who had asserted that "in order to buy more, the Chinaman must be able to sell more; for no matter what

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[73] Ibid.

[74] Ibid.

[75] Ibid.

[76] On "immutable mobiles," see Bruno Latour, "Drawing Things Together" in *Representation in Scientific Practice* (Cambridge, MA: Harvard University Press, 1990).

[77] Fischer, "Financing China."

[78] Ibid.

his inclination may be, unless he has something to give in return, he cannot trade."[79] Fortunately for Fischer, Parsons had found that "the resources, both agricultural and mineral, are at hand to permit a foreign commerce to be carried on—to pay the cost of building of railways and to provide sustenance for a commercial invasion."[80] In such a vision, seeking returns from exchange and development depended on high finance, and a state willing to make markets safe and legible for it.

This, however, presented a conundrum for a country which had purportedly refrained from entering the "scramble for concessions" of the late 1890s, contrasting itself with the European powers who had sought to carve the Qing empire into spheres of influence via railroad and mining concessions. Congratulating China on its republican revolution in the *Journal of Race Development*, Harvard professor of History and Government Albert Bushnell Hart condemned the six powers (Britain, U.S., Germany, France, Japan, Russia) seeking to fix a loan agreement for further railroad concessions as a new "Holy Alliance." The "basal idea," Hart explained, was that a "combination of European powers" constituting "six associated foreign nations can better decide than the Chinese themselves what shall be the future government and the destiny of that great empire."[81] Hart traced Western financial, political, and military cooperation in China to the indemnities imposed following the suppression of the Boxer Uprising, yet identified a novel clarification of their aims then underway: according to Hart, the "underlying principle" of the loan consortium was "to keep China weak politically while trying

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[79] Parsons, "The American Invasion of China."

[80] Ibid.

[81] Albert Bushnell Hart, LL.D., Professor of Government, Harvard University, "The New Holy Alliance for China," *The Journal of Race Development* 3 (1913): 255-267.

to make her industrially strong and to see that the results of commercial gain shall not get out of the control of those who now take responsibility for its finances."[82]

American railroading and currency reform projects had already overtaken much of the Western hemisphere. In 1909, for instance, the *New York Times* reported that "American bankers have come to the assistance of the Republic of Honduras, and are just about to complete arrangements to to provide funds for an arrangement with the republic's foreign creditors and the enlargement of its railroad system," adding that President Taft's had asserted in the state of the union address to Congress that "a strong Honduras would tend immensely to the progress and prosperity of Central America."[83] "Strong" meant stable for and receptive to American capital.

Noting that Japan by contrast had "[known] better" and "almost dispensed with foreign financial engineers and managers," Hart perceived in the Six Power Loan the bankers' attempt to assert fiscal control over China, for "the power to supervise the expenditure of that money includes the power to control much of the finances and the public works" and "involves an inspection and regulation of the internal financial administration of the country."[84] He traced the contours of a conspiracy back to the fact that "each group of bankers expects that the Chinese will spend at least a part of the loans for materials and supplies, and that the orders will go through the loaning bankers to their friends and commercial connections."[85] Consequently, he disentangled the virtuous and the vile, the demand-side and supply-side, in the Six Power

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[82] Ibid.

[83] "TAFT'S MESSAGE ASKS FOR LITTLE: President Wants No Further Corporation Laws Until the Present Ones Are Tested. DELAYS IN TARIFF REPORTS May Be Ready for Next Congress -- Revision Schedule by Schedule When It Comes," *New York Times* (Dec. 7, 1910): 9; See also, Peter James Hudson, *Bankers and Empire: How Wall Street Colonized the Caribbean* (Chicago, 2017).

[84] Hart, "The New Holy Alliance for China."

[85] Ibid.

Consortium's project of placing "a $300,000,000 loan" to "do people good against their will."[86] Hart granted that China lacked capital and that "an infusion of borrowed wealth would enable the country rapidly to develop its means of transportation and its immense physical resources."[87] But he condemned the Consortium as a "commercial combination" seeking railroad and mining concessions and investment on "terms which they themselves lay down."[88]

Interpreting American involvement in the scheme, he viewed it as an affront to the Monroe Doctrine and a concession to the "money power" in dictating foreign policy, just "when we are trying to curb corporations which menace the existence of democratic government in America to go out into the Orient to use the authority of the United States in aid of the projects of similar aggregations of capital."[89] But such aggregations of capital--and contemporary understandings of them held by adherents of corporate liberalism such as Jeremiah Jenks and Charles Conant--had contributed structurally and ideologically to the outward projection of capital goods investment, and disaggregating development from the *mission industrialisatrice* would not prove simple.

Opposing Albert Bushnell Hart, B. Atwood Robinson, president of the St. Louis-based Chinese-American Company, argued strenuously for emulating the German approach to China and overseas trade in general. With offices in Hankou and Beijing, the Chinese-American Company was an import-export firm and contracting company, which partnered with American industrial interests such as Rolla Wells, president of the American Steel Foundry Company, and Edward Goltra, owner of the Mississippi Valley Iron Company, to secure orders for capital

[86] Ibid.

[87] Ibid.

[88] Ibid.

[89] Ibid.

goods in China in 1916.[90] Other St. Louis firms followed suit in late 1916: in Manchuria, the American Car and Foundry Company embarked on rail-building and the provision of rolling stock and the U.S. Steel Products Company sold materials to Japanese infrastructure-building projects.

In a 1913 article in the same issue of the *Journal of Race Development*, Robinson argued that the U.S. was uniquely poised to provision and profit on China's industrial development. "America," he asserted, "is the one country from which China does not fear armed invasion but cordially welcomes invasion of trade and commerce."[91] "America," he continued,

> by virtue of her extensive Pacific Coast line is nearest neighbor to the Far East, while the opening of the Panama Canal will afford the manufacturers of the eastern states the opportunity of reaching that part of the world with their products on a very favorable basis.[92]

He called upon American capital and the nation's diplomatic corps to undertake "a careful study of the country, its resources, its people and their requirements," for he understood China as

> a country so rich in natural resources that with the opening up of railway and other modern means of communication the development of these resources will greatly increase the purchasing power of the people by opening up to their products the markets of the world.[93]

Similarly, the American railroad financier J. Selwyn Tait observed during a 1915 tour of China that

> Some few years ago, an investigation of the effect which railroad development had upon the commercial growth of China showed that between the years 1900 and 1907, the increase of 45$ in China's railroad mileage had brought about an increase in her net imports and exports amounting to 156$ during the same period. Suppose we were to

[90] Henry W. Berger, *St. Louis and Empire: 250 Years of Imperial Quest and Urban Crisis* (Carbondale: Southern Illinois University Press, 2015), 141-142.

[91] B. Atwood Robinson, "America's Business Opportunity in China," *The Journal of Race Development* (April 1913): 438-456.

[92] Ibid.

[93] Ibid.

> extend these figures and estimate the future business of China, on the basis of an expenditure of her railroads equal to twenty dollars per capita of her population. Can you form any idea what the volume of her business then would be?[94]

Between America's longstanding Open Door policy and the German *mission industrialisatrice*, projectors such as Robinson and Tait located "tremendous possibilities of development" in China and began to establish and measure metrics such as transport-dependent purchasing power to justify outlays of capital.[95]

Challenging skeptics of China's potential for rapid development, Robinson asserted that the "natural resources of a country have a most important bearing on its commercial activity" and that these "resources of China are almost wholly undeveloped" since "her vast mineral deposits have scarcely been touched."[96] He added that a "single province is estimated to have a world's supply of coal for a thousand years and coal exists in at least fifteen provinces," with "present annual output of the mines...upwards of 10,000,000 tons."[97] Complementing this particular vision, Robinson noted that there "is a great abundance of iron and the manufacture of steel and iron products has already assumed quite large proportions," the U.S. having begun to receive large shipments of pig iron from China already.

Robinson concluded that the "precious metals are being produced in ever increasing quantities adding greatly to the purchasing power of the country."[98] Echoing a conversation about development and purchasing power once held between German diplomats and engineers in Shandong, purchasing power mattered as a unit of analysis for Robinson, for "as we increase our

[94] Duane Conan Ellison, The United States and China, 1913-1921: A Study of the Strategy and Tactics of the Open Door Policy (George Washington University dissertation, 1974).

[95] Robinson, "America's Business Opportunity in China."

[96] Ibid.

[97] Ibid.

[98] Ibid.

purchases of China's products so will she buy more largely from us."[99] Robinson also reproduced the arguments underpinning the erstwhile coalition between German free-traders of the Hamburg-America Line, naval authorities, and the capital goods industry in raising the alarm over "the fact that a large proportion of the shipments to this country from China are made through foreign firms and nearly all come in foreign ships" and calling on Americans

> in view of the approaching opening of the Panama Canal...to awake to the importance of rehabilitating our merchant marine not simply for the profit arising from the carrying trade but as a means of building up our foreign commerce especially in the Far East.[100]

The St. Louis businessman combined the practical concerns of a Rathenau with the imperial sentimentality of Kaiser Wilhelm in a potent, midwestern *Weltpolitik*.

Robinson stressed that "which of the great countries of the world shall most largely profit by the increasing foreign trade of China will depend largely upon the relative activity intelligence and perseverance of the manufacturers, exporters, and business organizations of these countries."[101] He twinned the questions "What shall be the part of the American businessman in this development?" and "What indeed shall be the part of the great American nation therein?"—and lamented that "we hear much these days often in derision of dollar diplomacy."[102] Looking to Imperial Germany, Robinson called American business and government "really only children learning the a b c's of the game."[103]

For Robinson, only the *Kaiserreich* had mastered "real dollar diplomacy" via "intelligent study of conditions, the careful training of men, and the lavish expenditure of money" in order to

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[99] Ibid.

[100] Ibid.

[101] Ibid.

[102] Ibid.

[103] Ibid.

build “up a great foreign commerce that is bringing to her wealth and a great world influence.”[104] He reserved particular praise for German government efforts by which “large numbers of young men are taught the languages of foreign countries to which they are subsequently sent as missionaries of commerce.”[105] Robinson perceived with satisfaction the beginnings of an American *mission industrialisatrice* in the “recent activity of our government through its consular and diplomatic agents in cooperating with commercial organizations in developing and extending our trade with foreign countries.”[106] The First World War, along with revolutionary conflicts in China, Mexico, and Russia, stanched briefly capital flows from the United States toward infrastructure empire.

“Reorganization” and the Consortium Loans

Suppression of the Boxer Movement and imposition of the Boxer Indemnity in 1900-1901 had brought together the imperial powers in China in defense of invested capital, industrial property, and the opportunity of commercial expansion into the interior. The powers collaborated once again in the Tianjin mutiny 1912, focusing on protection of the foreign concession in the treaty port and above all the Tianjin-Pukou railway then under construction. Reflecting on these outburst of violence in the wake of industrialization from without, American minister to China (and former doctoral student of Frederick Jackson Turner) Paul Reinsch compared China to England during the Industrial Revolution and warned,

> we can imagine what serious disturbances may arise . . . so that the revolution may be even more intense than it was in the cotton manufacturing districts of England, and will certainly be more formidable on account of the vastly greater multitudes affected. . . . All

[104] Ibid.

[105] Ibid.

[106] Ibid.

> this must be taken into account in framing any policy of opening the resources of China to European exploitation. Inevitably the disastrous consequences which reform always brings in its train . . . will be attributed to 'foreign devils' and the prejudiced multitude . . . may go to the length of inflicting the greatest damage on foreign industrial property.[107]

In the Consortium Loans, the powers ventured beyond collective defense of "foreign industrial property" and began to elaborate a positive program of jointly pursuing, regulating, and securing investment opportunities in China--and dividing the spoils in financial returns and orders for their respective national capital goods industries. What had begun as a particular practice in multinational railway construction projects such as the joint German-British Tianjin-Pukou line and the multilateral Hukuang railways expanded in scope and meaning toward approximating an institution.

The Chinese Consortium Loans, culminating in the "Reorganization Loan" of 1913, marked the zenith of cooperative financial imperialism. Having begun in 1909 with banking representatives from four powers (the British Hongkong & Shanghai Bank, French Banque de l'Indochine, German Deutsch-Asiatische Bank, and American group surrounding J.P. Morgan) and expanded to include Russia and Japan before the American withdrawal under the Wilson administration in March 1913, these concerted negotiations with the Qing government in its final years and the Chinese Republic in its opening shifted discussions of control and dependency away from territorial-commercial "spheres of influence" and toward questions of technical expertise and fiscal control.

Indeed, American Secretary of State Philander Knox had engineered the invitation of Japan and Russia into the financial Consortium in hopes of curbing their incursions into

[107] Quoted in Duane Conan Ellison, THE UNITED STATES AND CHINA, 1913-1921: A STUDY OF THE STRATEGY AND TACTICS OF THE OPEN DOOR POLICY (George Washington University dissertation, 1974).

Manchuria and "neutralizing" the region for the "Open Door."[108] Formally embraced by the powers, the "Open Door" was not in practice synonymous with free trade. Following their joint suppression of the Boxer movement, the European powers had begun to orchestrate a quota system for business opportunities in China.[109] In a consular report, Graf v. Rex, the German envoy in Beijing, stressed that "apart from the profits from the loan and the expected orders for our industry, the goal should above all be the successful positioning of Germanness in the Yangtze Valley."[110] Von Rex looked beyond the borders of Shandong toward a reorganization of infrastructure imperialism throughout China.

The deterritorialization within this transformation away from "spheres of influence" did not represent the abandonment of the *mission industrialisatrice.* Rather, the consortium's goals and methods had been prefigured in the terms of and debate over the Tianjin-Pukou railway contract which brought together German and British capital and engineering to construct the north-south line. Known as "Tientsin-Pukow terms" (and applied in subsequent construction agreements), the agreement with the Deutsch-Asiatische Bank and the Hongkong and Shanghai Bank stipulated in theory that the borrower possessed the right of control and administration in the railroad, including the appointment of the chief engineer; however, the creditor ultimately determined whether the appointment was approved or not. Tianjin-Pukou terms placed control of funds and receipts with the borrower, yet granted the creditor the right to inspect all accounts and verify payments. Lastly, in cases of default, the terms asserted that the revenue "pledged for its

[108] Footnote 61, Steen.

[109] Schaefer, *Deutsche Portfolioinvestitionen im Ausland 1870-1914,* 504.

[110] Quoted in Schaefer, *Deutsche Portfolioinvestitionen im Ausland 1870-1914,* 503-504.

service will only be transferred to be administered by the maritime customs," a body staffed by Westerners although in the service of the Qing government.[111]

When the *Deutsch-Asiatische Bank* agreed to the advance of £40,000 to the Tianjin-Pukou Railway Administration, the agreement signed by negotiator Heinrich Cordes stated that the "arrangements made between the Berlin Purchasing Agency and the Tientsin-Pukow Railway Northern Section for payments of materials purchased at Berlin will remain unchanged" and that "requisitions on this advance will be drawn by order issued and signed by the foreign Chief Accountant of the Tientsin-Pukow Railway Northern Section and approved and countersigned by the Managing Director or his Representative."[112] Further, the agreement with Cordes notes that

> until complete repayment with interest of this advance and of all former advances made by the Deutsch-Asiatische Bank to the Tientsin-Pukow Railway Administration, the latter will treat all their traffic Receipts on the Northern Section as funds for construction works and or the Loan service and will deposit with the Deutsch-Asiatische Bank such amounts thereof as the Engineer-in-Chief will not require immediately for construction purposes. The Foreign Chief Accountant of the Northern Section shall every ten days furnish to the Managing Director for the information of the Engineer-in-Chief a statement of earnings from all sources.[113]

The leveraging of technical expertise was transposed from engineering to accounting, though the two had long been entangled in railroading pursuits.

Understood as among the most generous of terms among Western powers at the time, the Tianjin-Pukou terms invited harsh scrutiny from diplomats and financiers such as the erstwhile American representative to China and later J.P. Morgan affiliate Willard Straight who pointed to

[111] Min-ch'ien T.Z. Tyau, *The Legal Obligations Arising Out of Treaty Relations Between China and Other States* (Shanghai and London, 1917).

[112] John Van Antwerp MacMurray, ed. *Treaties and Agreements with and Concerning China, 1894-1919* (Oxford, 1921).

[113] Ibid.

opportunities for graft (without specifying whether he meant on the Chinese or German side).[114] "Tientsin-Pukow terms" were contrasted with "Hukuang terms" for railway construction in southern China, which provided stricter oversight.

In 1911 the banking groups from the four powers (Germany, Great Britain, France, and the U.S.) concluded an agreement with the Chinese government for a loan of over £6 million at a nominal 5% interest rate destined for railway construction in southeastern China.[115] Railway construction based on the Hukuang loan commenced, but was soon thwarted by uprisings in southern China. Nevertheless, Russian and Japanese governments pressed to include opportunities for their banks in railway finance for southern China in 1912. The consortium expanded to include Russian and Japanese syndicates in April of that year. The subsequent Six-Power Consortium advocated a currency reform program plus the implementation of international debt administration based on a £60 million loan.

Fierce Chinese opposition to the foreign debt administration initially stymied the loan agreement.[116] In February 1911, the Qing government had accepted the appointment of a foreign expert from a "neutral" country to undertake currency reform in China in response to the American-led effort for the adoption of a gold-exchange standard, now embedded within the portfolio of the Four-Power Consortium. The Beijing representatives of all four requested that American Secretary of State Philander Knox propose a plan to the British, French, and German governments to have their respective banking interests meet in Paris to determine the Dutch, Belgian, or Swiss currency reform advisor-to-be. They hoped that devolving the responsibility

[114] Willard Straight, Representative of the American Banking Group, "China's Loan Negotiations," *The Journal of Race Development* 3 (1913).

[115] Schaefer, *Deutsche Portfolioinvestitionen im Ausland 1870-1914,* 503-504.

[116] Ibid., 504.

onto the bankers in the joint currency reform and loan agreement would exempt discussions from the faultlines of European politics while also blocking Japanese or Russian intervention in the matter. The Hamburg bank M.M. Warburg & Co., which was closely connected to one of banks representing American interests (Kuhn, Loeb & Co.), suggested Dr. Gerard Vissering, the president of Java Bank who had been at the center of Dutch colonial and East Asian finance. The Qing transport minister Sheng Xuanhuai demanded that the currency reform project follow the program he had already assembled, but the bankers within the Four-Power consortium insisted that it be redrawn according to Vissering's input.[117]

The 1913 Reorganization Loan for £40 to £60 million rested on analogous premises, as if the railway plus the reformed currency had become the nation. The loan was to be secured via the revenue from the salt tax, which was slated to rise under "modern" management in a bureau staffed by European experts under the leadership of British colonial administrator Sir Richard Dane.[118] To address China's staggering public debt and solidify his hold on power, Yuan Shikai accepted these terms--without the consent of the Chinese parliament, in breach of the Chinese constitution, and against the protests of Sun Yat-sen and others. They had feared that foreign banks' direct receipt of the salt tax revenue would mean foreign control of the circulation of money in China. Yet for Yuan Shikai, the dire financial straits included the need to pay off over 850,000 disbanded troops, as minister-president Tang Shaoyi put it.[119] Eventually what loan

[117] Ling Zhang Arenson, "The United States and the Chinese currency reform, 1903-1914" (Northern Illinois University Dissertation, 1998).

[118] Petersson, 87; S.A.M. Adshead, *The Modernization of the Chinese Salt Administration, 1900-1920* (Cambridge, MA, 1970).

[119] Andreas Steen, *Deutsch-chinesische Beziehungen 1911-1927: Vom Kolonialismus zur "Gleichberechtigung": Eine Quellensammlung* (Berlin: Akademie, 2006) , 57.

funds were disbursed before the outbreak World War I went to fighting the Chinese civil war instead of toward railroad-building as had been intended.[120]

Politically, the Reorganization Loan bound the powers together in fortifying Yuan Shikai's regime. The contract negotiations for the loan had assured Germany two of the five advisory accounting and control roles, an issue which inflamed debate in the Kaiserreich, particularly when the Reichstag met to consider appropriations for the occupying troops in Jiaozhou Harbor adjacent to Qingdao. In May 1912, Dr. Herzfeld of the Social Democrats took the opportunity to decry international finance's sway over the result of the Chinese revolution: "High finance is the power that immediately decides, over the power of the Chinese people and over its form of government. If it [high finance] gives the money, so constitutes the government, so constitutes the form of state; if it is not given, perhaps the matter would be different."[121]

The Consortium Loans represented the highwater mark of cooperative financial imperialism, which historians note disappeared in China with the outbreak of World War I. But what if the transition in China, from territorial-commercial "spheres of influence" to multilateral loans partnered with private capital with links to networks of capital goods cartels or infrastructure-oriented holding companies, foretold a wider transformation in global forms of domination? The U.S. withdrew from the Six-Power Loan negotiations in 1913 in the wake of division over the issue of international debt administration in China, a move commonly attributed to Woodrow Wilson's refusal to let financial dealings draw the U.S. into the internal politics of China.[122] However, the Wilson administration ultimately followed its predecessors in "Dollar Diplomacy" by continuing to push for currency reform in China. As significantly,

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[120] Schaefer, *Deutsche Portfolioinvestitionen im Ausland 1870-1914*, 505.

[121] Quoted in Steen, *Deutsch-chinesische Beziehungen 1911-1927,* 56-57.

[122] Schaefer, 505.

American involvement in the Consortium Loans had whetted private capital's interest in the *mission industrialisatrice*.

Capital Goods at War

In 1914, before the outbreak of war in Europe, Philadelphia's Franklin Institute, a gathering place for engineering and business interests, had invited civil engineer William Barclay Parsons to address them on the topic of "An American Engineer in China." By the time of his 1915 talk, Parsons' areas of focus had shifted from the premises of his turn-of-the-century publications as well as from his pre-war thinking in general. Only a few months prior, he explained, "it appeared as if industrial development" in China "would continue to progress or remain stationary, just as it had been doing for some years in the past, regulated largely by the intrigue of European politics, and in which the American engineer was destined to play but a small part."[123] In the world of yesterday, the "possibility of a war which would embroil all of the European powers which had interests in China was scarcely within the realm of probability."[124] Now conditions had changed so fundamentally that "it is not impossible that the position of an American engineer in China may be greatly altered, and, if so, it can be altered only to his benefit."[125] Consequently, Parsons called for an American reappraisal of three facets bound to determine China's future: the country's "engineering development," its "mineral wealth," and the "factors," chiefly political, that "have influenced such development."[126]

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[123] Parsons, "An American Engineer in China."

[124] Ibid.

[125] Ibid.

[126] Ibid.

More than anything, Parsons' 1915 reflections and projections displayed a stronger sense of the need for standardization than his forays into "industrial anthropology" from his fin-de-siècle trip to Hunan as well as a deeper engagement with the nexus of geopolitics and international finance. At the Franklin Institute, which had set the Sellers standard screw thread for the American continent in the 1860s, Parsons deplored that "inaccuracy, or perhaps one should say entire failure to appreciate the necessity for, or even the existence of, accuracy, is met at every turn in China."[127] He extended this critique seamlessly across units of physical and valuative measure, never stopping to distinguish between the verifiably objective and the politically contentious or expedient. The "monetary unit, the tael, has no physical existence as a coin, being nothing more than a weight in silver, and its value is almost as indefinite as its form, there being more than 60 taels recognized throughout the country, differing quite distinctly in value."[128] "So it is," Parsons continued,

> with the Chinese system of weights and measures. The Chinese foot, the basis of measurement, varies from 8.6 to 27.8 inches, and there are over 100 different kinds of feet in use in China. Apart from the length of the foot varying locally as the tael does in value, each trade has its own standard foot; that is, the carpenter, the mason, the tailor, and the junk builder each has his own foot. The mow, which is the unit of superficial measurement of land, and which in Shanghai is taken at about one-sixth of an English acre, as a matter of fact varies according to locality from 3840 square feet to 9964 square feet. In going through the country it is quite impossible to ascertain distances. As coolies are paid by the lie (one-third of a mile) for portage, wholly arbitrary and fictititous scales of distances between villages have been adopted, always in excess of the actual figures, but which the native will not see, or at least admit, are not accurate.[129]

Fragmentation and variability were themselves the obstacles to progress for Parsons. For markets in land and labor to work, for machinery to function, and eventually for the Chinese fisc to support a foreign *mission industrialisatrice*, units needed to be standardized. The currency

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[127] Ibid.

[128] Ibid.

[129] Ibid.

reform pursued in the Consortium Loans was tied inextricably to a project of engineering capitalism, an ontological sleight of hand between standard weights and standard coins alongside slippage from standard lengths to fares to values.

Parsons did not deny the necessity of state-building for refashioning norms to fit legible standards; like longtime British diplomat Sir John Jordan, Parsons understood that strengthening aspects of China's central state would be necessary to protect and promote international commerce and capital accumulation. Parsons had concluded that the "great stumbling block to the new development in China is the government itself, which lacks vitality, as it is a government neither of nor over the people."[130] "There are no general laws," he repeated, "nor even generally recognized customs, that can deal properly and thoroughly with railways, mines, land reclamation, river improvements, highways, etc."[131] Parsons found infrastructure-building efforts by government officials stymied at birth by a refusal to disturb or oppose the local "gentry," a class he called "too frequently controlled by prejudice and quite ignorant of the remedy for their own local troubles of poverty and suffering."[132] Parsons diagnosed a concomitant timidity on the part of central authorities as well as local distrust of high officials and foreigners as major causes for China's "retarded development."[133] He hoped, however, that overcoming this "barrier" and establishing a "free field...for industrial development" would mean "a great opening for the American engineer" in China.[134]

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[130] Ibid.

[131] Ibid.

[132] Ibid.

[133] Ibid.

[134] Ibid.

Parsons connected the lack of a "general railway law" in China, where railway development unfolded according to special concessions and contracts "obtained after long and very tedious negotiations, during which the promoters have been supported by the minister of their own country and usually opposed by the ministers of all other countries," to a particular form of political economy practiced by the European powers vis-à-vis their respective banking and industrial sectors. Offering the example of the latest concession to a British syndicate for the Pukou-Xinyang Railway (1913), Parsons explained to his American audience that the undertaking was based on "a definite bankers' commission of 5% points on the actual selling price of the bonds, and in addition a purchasing commission of five per cent upon all materials purchased for the line."[135] Funds procured through the bond sales would be deposited in the British Hong Kong and Shanghai Banking Corporation. The railway concession agreement, like those with the German interests for the Shandong and Tianjin-Pukou railways, granted the British syndicate the nomination of the engineer, the manager, and the chief accountant. Parsons anticipated that his audience would wonder why the British syndicate would pursue such investment at all when "capital could be very much better employed in any one of the British colonies, for instance, or even in the United States, at a very much higher remuneration than 5 per cent bankers' commission and 5 per cent purchasing commission on materials alone."[136] In fact, he was certain an American syndicate would object to investment on these grounds.

The key to the puzzling situation, Parsons explained, lay in the fact that European nations had

> been seeking the acquisition of land abroad, into which to divert unemployed population or the excess products of their factories and commercial enterprises, and no European

[135] Ibid.

[136] Ibid.

> government has hesitated to support openly through official channels the efforts of the people of its country to expand commerce or to seize unoccupied fields, and have even entered into secret alliances with specially-favored groups.[137]

Consequently, the European powers had, according to Parsons, given "their financiers and large contractors not only official encouragement but instructions to secure every railway concession."[138] Parsons attributed the growth of European trade in China and elsewhere to such "government support and alliance," which he found wholly wanting in the United States.

Parsons explained to his American audience that the European syndicates took on Chinese concessions seemingly less profitable than other ventures because the bankers "took little risk and no responsibility" where the

> securities to be issued for the cost of the work were the direct obligations of the government, and China has never yet failed to meet its foreign or domestic obligations as they became due if the railways themselves were profitable, the syndicate received 20 per cent of its net profits; if they were not profitable, the principal of the cost of the work and the interest were guaranteed by the government.[139]

Under these conditions, Parsons found, the European bankers received "a quite liberal...commission for making an issue at a price to be determined by them at which the issue was certain to be taken by the public."[140] Rather than an inexplicable financial gambit or a manifestation of a purely geopolitical arms race, European infrastructure-building presented itself as a model of political economy—partly deserving of censure, partly worthy of imitation—to the American civil engineer.

Parsons' analysis of the political economy of European infrastructure imperialism in China extended further, to the everyday construction of railways themselves. The American civil

[137] Ibid.

[138] Ibid.

[139] Ibid.

[140] Ibid.

engineer located the “keystone” of the structure in the clause in every concession stipulating “that the engineer, and in some cases the manager and accountant, shall be of the nationality of the syndicate to whom the concession is granted and to be named by them.”[141] Consequently, although the construction profits were “not so immediately apparently generous” since the syndicates were “limited to a commission of five per cent,” the provision of supplies—with decisions “rendered nominally by the Chinese Director General”—was far from as open to international bidding as it appeared on paper.[142] In practice, Parsons noted, the “specifications can be, and usually are, so drawn as to limit the purchase of materials to certain selected concerns.”[143] Drawn to fit specific industrial enterprises thanks to well-positioned engineers and accountants, such plans united the interests of bankers, contractors, and railway manufacturers in Chinese infrastructure-building as a “very good opportunity to realize profits without risks.”[144]

Parsons traced the coordinated and directed flows:

> The bankers get their commission as stated above, the manufacturers are able to sell their materials at generous figures against very restricted competition, with assured payment, because the actual cash is in the hands of their own bankers, and then, after the railway is completed, to be able to continue to supply railway' material on reorders because the management of the railway is in the hands of their own appointees.[145]

In such a closed circuit, the European syndicates attempted to quite literally draw capital, from the technical specifications to the bond issues. While the close tethering of finance capital to capital goods themselves had once been somewhat of a German peculiarity, it had become common practice among other powers, European and Japanese, in China. Such a confluence of

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[141] Ibid.

[142] Ibid.

[143] Ibid.

[144] Ibid.

[145] Ibid.

interests and strategies had also become of increasing interest to American industrial concerns and equally assimilable to plans by American financiers to replace European syndicates then occupied with waging war.

However, Parsons criticized the system of railway development in China overall as "highly injurious" to China's "best interests," since the "promotion has usually been not for the construction of the lines of the greatest local requirements, but those which would most strengthen the political aims of the government of the country of the promoters" and which would secure profits "in proportion to purchases of materials and sales of bonds."[146] In engineering fashion, Parsons deplored this approach to railway development as "wasteful," but explained that the Chinese government was unlikely to abandon it since their officials perceived distributing concessions among many nationalities an effective means to counterbalance any individual power's influence and play the imperial powers off of one another.

Listing the Chinese railways most likely to be proposed or currently under survey, including a line in the Yangtze Valley between Hebei and Sichuan under survey by American engineers due to the participation of American banks, Parsons reminded his audience that

> whatever will be the extent and force of European influence in China after the great realignment of the 'powers' after the present war is ended, it is obvious that such influence will certainly spring from new political combinations and may be pressed much less energetically, as requirements at home for rehabilitation and repairs of the waste of war will probably deter capital from seeking such foreign investment, and that perhaps European nations for a while will not be so keen in the race to establish 'Spheres of Influence.[147]

(In casting the "waste of war" as a competing sponge for mopping up excess congealed capital, Parsons echoed the analyses of economists Jeremiah Jenks and Charles Conant, who had deemed

[146] Ibid.

[147] Ibid.

it a possible, though morally repugnant, "solution" to the crisis overaccumulation.) Parsons spotted in the Great War "America's opportunity."[148]

According to Parsons, seizing this opportunity entailed adopting European methods as much as discarding European territorially imperialist aims. Such an effort, he cautioned, would require more "than sending manufacturers' catalogues or even skilful salesmen with the expectation of cabling back profitable orders."[149] Appreciating investment's role in promoting trade, Parsons the civil engineer deemed China a "rich field" "without capital" that "has to be carefully developed."[150] He advised American manufacturers to emulate the European powers with efforts to

> establish and maintain a commercial organization at least the equal of similar heretofore existing organizations of other nations, and in that organization to keep in mind the importance of the engineer, who must possess diplomatic ability, commercial acumen, as well as scientific knowledge and experience.[151]

The core of the *mission industrialisatrice* transcended strict boundary claims of "spheres of influence."

A year after the Chinese Consortium Loans, the zenith of cooperative financial imperialism, had fallen into abeyance and three years after the Wilson administration had withdrawn the U.S. from such multilateral ventures, Parsons nevertheless chose to critique territorial claims in China alone. "If this [war] will jar China loose from some of its shackles," the civil engineer mused, "there will be some gain to offset the otherwise appalling loss."[152] The "shackles" that Parsons perceived, however, remained limited to "foreign intrigue" premised on

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[148] Ibid.

[149] Ibid.

[150] Ibid.

[151] Ibid.

[152] Ibid.

a carving up of China, on one hand, and the lack of centralized authority for the standardization of measure and currency in China itself, on the other. America's long-standing "Open Door" approach never equalled laissez-faire, even in contemporary thought. Administrative reform--in essence the restructuring of domestic sovereignty and global exchange--defined the agenda for infrastructure projectors such as Parsons.

When World War I interrupted the flow of capital from European syndicates, bankers and industrialists in the U.S. did in fact forge similar coalitions and institutions for directing and sharing foreign investment opportunities. Organized in 1915 by Frank A. Vanderlip of the National City Bank with the help of J.P. Morgan, the American International Development Corporation (initially referred to as the International Finance and Development Corporation) operated as a holding company for firms interested in investment in South America, Russia, and China. The American International Development Corporation brought together some of the most prominent financiers and industrialists in the United States as principal investors: J.P. Morgan himself, Cyrus McCormick of International Harvester, James J. Hill, the "Empire Builder" of the Great Northern Railway, James Stillman of the National City Bank, George F. Baker of the First National Bank, James H. Perkins of National City Bank, Percy A. Rockefeller of Standard Oil, Charles A. Coffin of General Electric, J.B. Fortan of the First National Bank, and J. Ogden Armour of Armour & Co.

Unlike British popular investment in infrastructure imperialism, there would be no public offering of stock in the corporation. Capitalized at $50,000,0000 for the development of foreign trade, the American International Development Corporation faced no comparable financial conglomerate in Europe according to the *New York Times*, excepting the parallel found in the "large German banks."[153] Among its directors were Charles A. Stone of the engineering and construction firm Stone & Webster in Boston, A.H. Wichen, President of the Chase National Bank, Otto H. Kahn of Kuhn, Loeb & Co., Charles H. Sabin, President of the Guaranty Trust Company, and Willard D. Straight, who had worked as an American diplomat in China before joining J.P. Morgan & Co.

In February 1917, the Chinese government granted the American Siems-Carey Co. (a subsidiary wholly owned by the American International Corporation, associated with Frank Vanderlip's National City Bank) a contract to construct 200 miles of railway from Zhaojiagou [Chowkia-Kow] to Xiangyang [Siang-Yang] in Hubei, in addition to the 1,100 miles of rail in other provinces the Minneapolis firm already held under contract, amounting to over $100,000,000 in orders.[154] Peter Siems, the senior half of Siems-Carey, was a German-American railway contractor who had immigrated to the U.S. in 1865 at the age of twenty-three.[155] Siems had begun with a transport contract delivering mail overland from Fargo to Bismarck in the Dakota Territory in 1875 and in the early 1880s operated stagecoach lines on the mining frontier. When he returned to St. Paul in 1884, he joined the railway contracting business of D.C. Shepard & Co., which became Shepard, Siems & Co., the firm responsible for thousands of miles of railroading in the Northwest, including the Great Northern line to the Pacific.

[153] "RAISE $50,000,000 FOR WORLD TRADE: Americans Form Great Company to Develop Resources of Distant Lands. TO FLOAT SECURITIES HERE F. A. Vanderlip, Otto H. Kahn, A. H. Wiggin, and C. H. Sabin Are Among the Projectors," *New York Times* (Nov. 23, 1915): 1.

[154] *Contract for the Construction of Railways in China: Copies of Agreements and Correspondence between the Republic of China and Siems and Carey and between the Republic of China and the American International Corporation* (New York, 1916); "BEGINS RAILROAD IN CHINA: Siems-Carey Co., of Minneapolis, Starts Survey Under Contract," *The Washington Post* (Feb 4, 1917); "Obituary: Peter Siems," *Engineering Record* 75, 12 (1917): 488; Mazuzan, "'Our New Gold Goes Adventuring,'" 43.

[155] "Obituary: Peter Siems," *Engineering Record* 75, no. 12 (1917): 488.

Reorganized under the financial auspices of the American International Corporation, Siems-Carey was to provide materials for Chinese railroads and the Huai River conservancy, originally a Red Cross project now taken over by the financial syndicate. Arranged by American minister Paul Reinsch, the conjoining of bankers such as Frank Vanderlip at National City Bank and Siems-Carey as the Siems-Carey Railway and Canal Company for the engineering and construction work closed the circuit of capital accumulation embedded in China according to the model that the American International Corporation intended for much of the world to be reawakened, reclaimed, engineered, and perhaps industrialized.[156]

The United States transitioned from a debtor to a creditor nation in the course of World War I. Japanese forces occupied the German foothold in Qingdao in 1914, seizing Shandong's rail lines and extinguishing Germany's formal influence in East Asia. In the wake of these events and facing the advent of domestic insurrections and civil conflicts, the Chinese government awarded the Pratt & Whitney Co. of Hartford, Connecticut a $1,200,000 order for machinery and military tools.[157]

Works manager B.M.W. Hanson told the *Hartford Courant* that "for some time past we have maintained relations with practically all the large foreign governments" and that "as soon as the war is finished, or possibly if a lull in the conflict occurs, we anticipate a large amount of new business" in addition to the "business still on hand," which he called "considerable." "We are running," he remarked, "very close to full time." A few weeks later, the order grew to encompass shipping an entire arsenal to Hanyang, costing $1,250,000 and including equipment capable of turning out 100 Mauser rifles, the rifle in widest use in early twentieth-century China,

[156] Mazuzan, "'Our New Gold Goes Adventuring,'" 43.

[157] "WORKING ON CHINA'S MILITARY ORDER: Pratt & Whitney Company Busy in War Time," *The Hartford Courant* (Aug 27, 1914): 6.

with interchangeable parts per day. Arsenals in England, Germany, France, Belgium, Russia, and Austria relied wholly on Pratt & Whitney machinery; Japan, Sweden, Spain, and Italy did partly. Naturally, Pratt & Whitney expected follow-up orders in response to the Chinese arsenal construction.[158]

Beginning in October 1918, the journal *Machinery* ran a series of articles on Pratt & Whitney's gauging system for rifle and heavy ordnance manufacture for the "United States, Great Britain, Australia, Russia, Spain, Servia, and China."[159] Engineer Erik Oberg observed that weapons manufacture had historically placed a stronger emphasis on "gaging systems and the adoption of suitable tolerances" in comparison with "the manufacture of machines and mechanisms used in peaceful pursuits."[160] As such, the experience gained in the course of war had been a means of drawing capital in another sense. Oberg explained that

> while the gaging systems described are based upon the experience of the Pratt & Whitney Co. in equipping complete arsenals all over the world, it is evident that the principles laid down are equally applicable to interchangeable manufacture of any kind, be it sewing machines, typewriters, cash registers, or any other mechanisms that are made in sufficient quantities to require a complete gaging equipment.[161]

Oberg continued the pitch, "As the originator of these complete gaging systems the Pratt & Whitney Co. is, of course, in the field to handle any proposition of this kind whether it be war or peace work."[162] (Still capitalizing on war and peace in equal measure, Pratt & Whitney is

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[158] "CHINESE GENERAL COMES TO WATCH WORK ON ARSENAL: LIU TSCHING EN IN HARTFORD TO SPEND A YEAR FAMILIARIZING HIMSELF WITH BIG PLANT BEING BUILT FOR CHINA BY PRATT & WHITNEY COMPANY," *The Hartford Courant* (Sep 14, 1914): 4.

[159] Erik Oberg, "Developing A Gaging System," *Machinery* (December 1918). Pratt & Whitney, UConn Special Collections.

[160] Ibid.

[161] Ibid.

[162] Ibid.

currently a division of the conglomerate United Technologies, a manufacturer of aerospace systems.)

The processual capital and intellectual property Pratt & Whitney had drawn in the course of whole-arsenal construction relied on novel methods of ensuring interchangeability in different shops, tools for locating and gauging identical points on different machining methods and tools, and "proper component drawings," which "express clearly and definitely the required conditions."[163] Depending on "close cooperation" between "designers of the components, tools, and gages," proper component drawings could only be achieved when "each important surface" was "dimensioned with tolerances from only one point in the same straight line and the "locating points for these dimensions" were established as "identical with the gaging and holding points."[164] In pursuit of the workmanship of utter certainty, Oberg asserted that "every effort should be made to have all important functional dimensions given directly so that importance of them will be apparent" and that "the component drawings should not be considered as completed until the tool and gage lay-out has been finally adopted."[165] Such requirements for work processes drew machine toolmakers and tool-users in the capital goods industries together ever more tightly, further expanded their drafting rooms, and cemented the infrastructure of production logistics necessary for massive precision work at a distance, on shores unseen.

Moreover, in an era of international standard-setting and distinctly national weapon forms alike, the translation and conversion potential offered by Pratt & Whitney's metrological devices would have proven especially alluring to competing Chinese factions equipped with entirely

[163] Ibid.

[164] Ibid.

[165] Series No. III, Box 24, Pratt & Whitney, UConn Special Collections; on the workmanship of risk versus the workmanship of certainty, see David Pye, *The Nature and Art of Workmanship* (Cambridge: Cambridge University Press, 1968).

disparate firearms yet vying to acquire any inputs for war.[166] Drafting specifications had underpinned Imperial German aims for a national *mission industrialisatrice* in Shandong, linking machinery manufacturers, shipping interests, and financial syndicates in a political economy premised on technical complementarities--the dominance of form alongside nepotism and cultural diplomacy as "soft power." Drafting equally contributed to the dissolution and reconstitution of form via measuring devices such as Pratt & Whitney's gauges, which enabled "working backward" from final product (firearms and ordnance) to model.

"Internationalization" and "Neutralization" in the New Consortium

Despite having been forced out of Qingdao by Japanese troops in 1914, Imperial German diplomats attempted in 1915-16 to rekindle economic activities in China by proposing a "continental bloc" encompassing Russia, itself, and China (via a separate peace with Japan). A Rhenish industrialist involved in the plan still hoped that China would serve as "an enormous source of supplies and market outlets" in exchange for German and Russian investment, infrastructure-building, and technical training to "help its development."[167] With the exception of Japan, poised to capture the entire trade and development of Manchuria, Mongolia, and Shandong, all of the wartime powers had abandoned territorial-commercial "spheres of influence" and turned to multilateral visions of joint reforms in railway and canal-building as well as fiscal and administrative bodies throughout the whole of China.

As early as 1910, Taft had praised the multilateral loan for the Hukuang railway as "one of exact equality between America, Great Britain, France and Germany in respect to financing

[166] Thanks to Prof. Fei-hsien Wang for the point about incompatible weapons systems among factions in the Warlord Period.

[167] Quoted in Kirby, *Germany and Republican China*, 15.

the loan and supplying materials" and endorsed Secretary of State Philander Knox's call for the "internationalization" and "neutralization" of the Manchurian railroad network.[168] The "Open Door" entailed not free competition but active collaboration. Following the financial transformations of World War I and the shifting balance of power in East Asia, U.S. diplomats under Wilson sought to revive consortium-based investment in Chinese industrialization, ecological reclamation, and administrative reform under American auspices. They envisaged enveloping China in networks of railroads, canals, and surfaced roads to advance Western market penetration along with infrastructure for flood control, the founding of Chinese-American banks, and technical assistance to generate purchasing power, credit, and liquidity while shaping a generation of reformist elites.[169]

In preparations for the Paris Peace Conference and the Washington Naval Conferences (1921-1922), American diplomats focused on methods of financing, profit, and control for the New Consortium's activities in China. They settled on plan by which the members of the Consortium would receive twenty percent of all net profits for a term of 50 years; for the next thirty years, however, at least one half of the remaining Chinese share (eighty percent) of net profits was to be directed toward contractually-defined expansion projects for the construction of new railway lines by the U.S. and other powers.[170] This recursive equation bounded Chinese sovereignty while ensuring profits for Western finance capital and the capital goods industries to pass through the "Open Door."[171]

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[168] "TAFT'S MESSAGE ASKS FOR LITTLE: President Wants No Further Corporation Laws Until the Present Ones Are Tested. DELAYS IN TARIFF REPORTS May Be Ready for Next Congress -- Revision Schedule by Schedule When It Comes," *New York Times* (Dec 7 1910): 9.

[169] Ellison, "The United States and China."

[170] Ibid.

[171] Ibid.

Engineering concerns remained central to the New Consortium's plans for China given that standards differed significantly between American and European construction techniques and materials. Financial collaboration in the Consortium had been envisaged as a means for Western powers (now excluding Germany) to jointly enjoy the profits of loan offerings and capital goods exports for railway, canal, and harbor improvements collectively channeled through the "Open Door." But questions of compatibility stood in the way, as "neutralization" or "internationalization" of form lagged behind that of finance despite a flurry of international conferences devoted to the standardization of weight and measure under the metric system.

Prior to the New Consortium's abandonment of "tender clauses," which had ensured that engineers funneled parts and materials orders to their nation's industrial firms, American contractors and locomotive works complained that

> According to the terms of International Treaty between the Powers, 'at equal rates and qualities,' goods manufactured by the loaning Power shall be given preference over other goods of foreign origin, but in the final consideration of the tenders only the interests of the loaning Power are regarded. . . . . it is very easy to see that with this broad general term, the question of qualities can be regarded in such a light as to practically exclude all except the favored few.[172]

Since U.S. banks had been unable legally to establish foreign branches prior to the Federal Reserve Act to float infrastructure-building loans abroad, the American capital goods industries had fallen behind in infrastructure-imperial ventures beyond the Western Hemisphere. In 1912 American diplomat Calhoun confessed that China's railways "now built and in operation are all equipped with machinery of European types and standards. In this way, and for this reason, a European standardization may be said to be an accomplished fact."[173]

[172] James Davis, General Foreign Sales Agent, Lima Locomotive & Machine Co. to Senator Charles F. Dick, Letter, 26 February 1910, cited in Ellison, "The United States and China."

[173] Ellison, "The United States and China."

In 1915 U.S. works had designed and manufactured only around fifteen percent of the 648 locomotives in service in China. Despite an embargo, American diplomats and industrialists seized the opportunity presented by the war to displace European standards; thirty-nine of fifty-six new locomotives ordered by China during World War I were under construction by American firms to American makes in addition to twenty-one more intended for privately-owned roads (presumably in China's emerging industrial establishments).[174] Erstwhile American ambassador to China Charles Denby urgently advocated the export of American locomotives to China across the embargo, hoping to establish American norms by sheer numbers before the Chinese Government formally adopted a standard.

The U.S. State and Commerce departments backed Denby's efforts, asking John S. Williams, Director General of the American Railroads, to authorize railway materials sales to China from the American Locomotive Sales Corporation. Moreover, the U.S. Commerce Department and the State Department's Division of Far Eastern Affairs hoped to secure sales for American rolling stock in China by entering negotiations with foreign banks to dismiss the stipulations giving their industries preference in the loan contracts concluded prior to the outbreak of war.[175] Standardization of machinery and materials relied not only on the laying aside of "spheres of influence" but also on the removal of the legal clauses tying credit to capital goods exports, reflecting a certain political economy. This standardization would, in turn, underpin a consolidation and expansion of the transportation network in China, ostensibly benefiting all of the powers.

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[174] John F. Stevens, "Memorandum on Chinese Railway Supplies," enclosure to Despatch, Reinsch to Secretary of State, 14 May 1918, cited in Ellison, "The United States and China."

[175] Ellison, "The United States and China."

Yet following the cessation of hostilities, national differences in technical standards reemerged as a thorny issue at Versailles, thornier than the negotiations by which financial collusion superseded the old territorial-commercial “spheres of influence.” By early 1919, the foremost American locomotive manufacturers had combined into Charles Denby’s proposed China Car Trust, organized by Mr. G.M. Gest of the Guaranty Trust Co. and ready to pursue the China market.[176] Although Chinese officials had long pursued a strategy of playing the powers off each other in industrial concessions, the leading factions in the Republican government accepted the consolidation of the railway network in the American-led New Consortium, a lesser of the evils compared to Japan’s territorial assertions. Former Vice Minister of Communications and Special Commissioner for Promoting Industries Yih Kung-cho visited General Electric, A. B. Johnson’s Baldwin Locomotive Works, and Frank Vanderlip of the National City Bank on a commercial mission to forge “personal relationships with prominent railway men and financiers in the United States with a view to future cooperation in Chinese railway development.”[177]

[176] Ibid.

[177] Ibid.

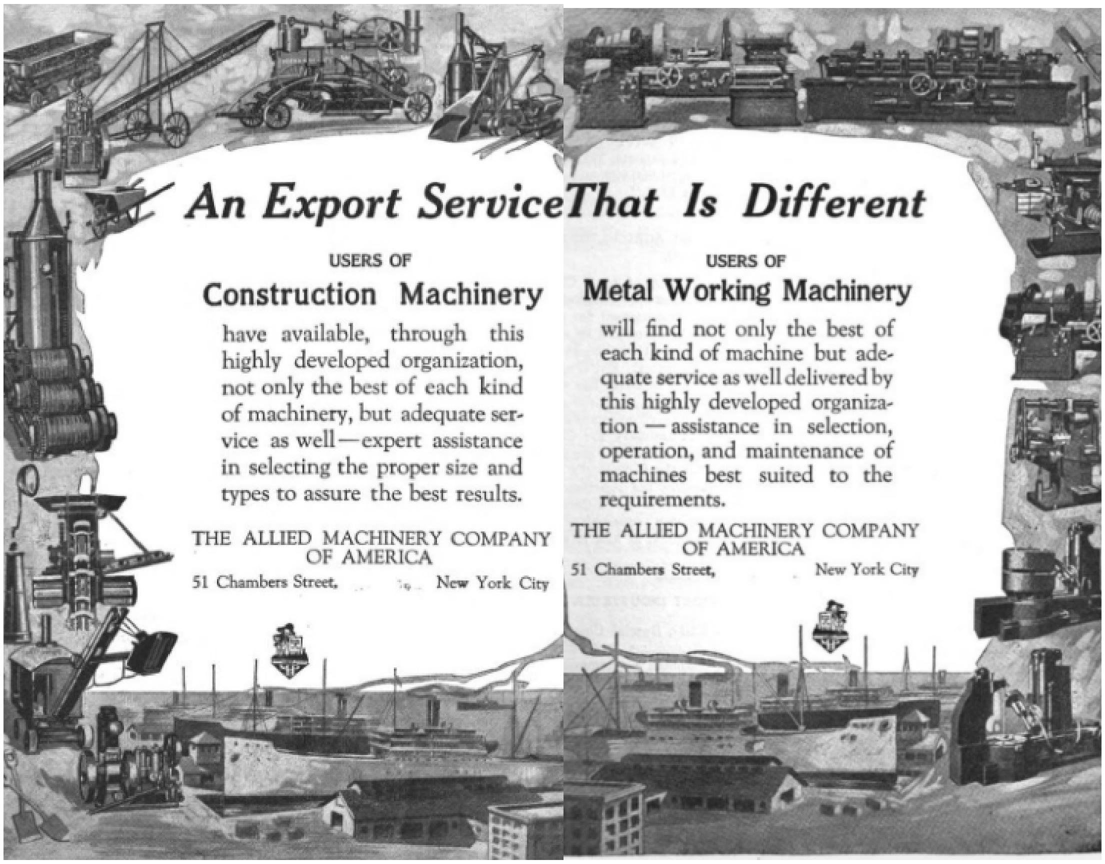

Figure 36: Advertisements for American machinery and machine tools in *The Chinese Students' Monthly* (1920-1921).

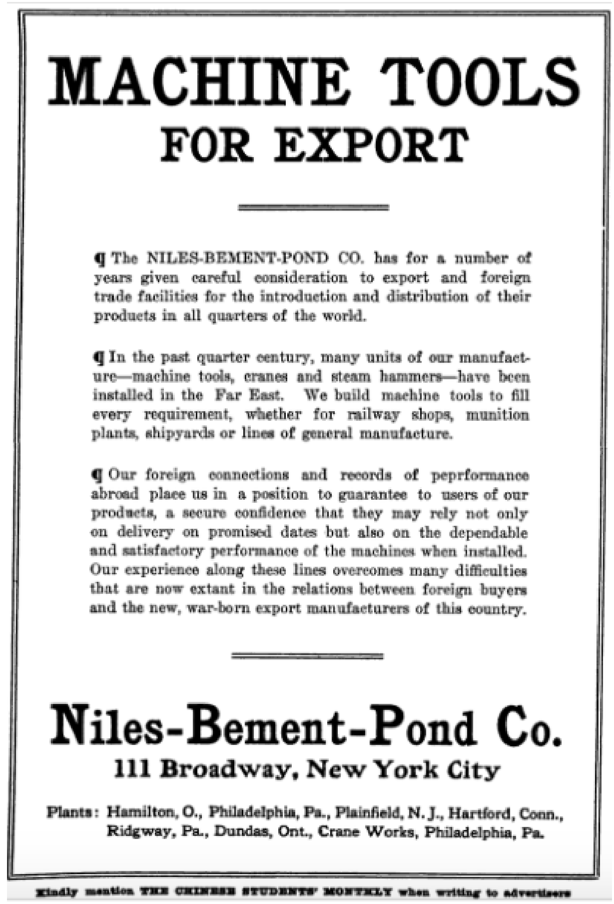

Figure 37: Advertisements for American machinery and machine tools in *The Chinese Students' Monthly* (1920-1921).

Interestingly, American industrialists and engineers in the capital goods sector were not wholesale partisans of universal standardization. The same A.B. Johnson, president of Baldwin Locomotive Works, authored an article in the *Nation's Business* in the midst of World War I arguing vehemently against the standardization of rolling stock on U.S. railways. First, Johnson asserted that to "introduce a government standard upon all lines as an entirely new proposition, would be simple enough, but to introduce it on lines already equipped, and throughout the entire country, would be a different matter."

Looking upstream to the repair yards, Johnson feared that such a plan would "compel all lines to provide themselves with stores of repair parts adapted to the government standard locomotives," complicating "instead of simplifying the problem of locomotive maintenance." Though wartime and concomitant nationalization might prove fleeting, Johnson insisted that such complications arising from the additional government standards would "last far beyond the period of government control" and "would continue as long as the railroad standard and the government standard locomotives operated side by side upon the same lines." Moreover, Johnson criticized standardization on principle as necessarily constituting a form of lock-in—an obstacle to progress. "Every improvement," he stressed, "in some sense involves the destruction of standardization." (Ironically perhaps, the basis of Baldwin Locomotive was destroyed by the advent of Ford's Model T.) Resisting transport standardization and nationalization alike, Johnson claimed,

> It would be an evil day for American engineering and American progress in the art of transportation which should see the introduction of a policy of discouragement of new and useful improvements in the art.[178]

American standards would serve to unify markets in China, but standardization would only serve to stymie and restrict innovation in America. One wonders whether Johnson shared these sentiments with his Chinese interlocutors such as Yih Kung-cho.

Certain invasive and developmentalist aspects of the German *mission industrialisatrice* in Shandong persisted into both the Japanese regime in Manchukuo and the American-led New Consortium aimed at unifying China's transport network, modernizing its landscape, and reforming its fiscal administration beyond "spheres of influence." Purchasing power as a unit of analysis remained central, as did the assumed multiplicative power of infrastructure. U.S. diplomat Baker argued, for instance, "every coolie profitably employed means a potential buyer for the products of other concerns." The "coolie" was inseparable from the railroad, the water-

[178] "Danger Inseparable from Standardization," clipping in William Liseter Austin Papers, Hagley Museum.

soaked bridge caissons, the earthworks to reclaim land for cultivation while taming the waters of the Yellow River [Huang he] to stave off recurrent bouts of famine. Though particularly significant in German political economy, infrastructure and the capital goods that composed its projects had been generalized into the basis, groundwork, and foundation of development in a multiplicity of senses--commercial, agricultural, technical, industrial, spiritual—a notion which lived into the "high modernist" schemes of planned projects in the 1930s to 1950s.

Reflecting this expansiveness, Dr. Charles Ferguson, the U.S. State Department's adviser on Far Eastern affairs, and pre-war currency reform advocate Jeremiah Jenks jointly approached Woodrow Wilson with a plan to create a "Technical Priorities Board" alongside the New Consortium. This board would in effect direct development in China. Seriously entertained by the U.S. State Department but never implemented in the 1920s, Ferguson's plan proceeded explicitly from the understanding that

> control of foreign loans in a country of economic passivity— involves control of the latent 'credit-capital' of the country (i.e., the capitalization of its skills, its practical arts and sciences, and the sum total of its social creative powers) amounting to a kind of sovereignty over all its life sustaining processes.[179]

While other victorious powers envisaged political tutelage for much of the world under the mandate system, U.S. diplomats and economists took up the *mission industrialisatrice*, defining the contours of industrial tutelage with concepts about the everyday life of socio-technical systems nearing Thorstein Veblen's "joint-stock of technical knowledge."[180]

The premises and agenda of developmentalism in the era of the First World War were simultaneously highly concrete and enormously metaphysical: Would machine parts fit together?

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[179] Charles Ferguson to President Wilson, Letter, 20 July 1919. See also Charles Ferguson to President Wilson, Letter, 16 July 1919, cited in Ellison, "The United States and China."

[180] Thorstein Veblen, *The Engineers and the Price System* (New York: B. W. Huebsch, 1921).

Could the outlook, life patterns, subjectivities of an entire society be transformed? Between the two lay the railway and, somewhat uncomfortably, the single market.

Beyond infrastructure, though still tightly tied to it, American minister to China Paul Reinsch conceived of the New Consortium as a way to protect foreign investments by solidifying China's credit through industrial development and a balanced budget. This budget was to be based on the Consortium itself "reorganizing" China's revenues and taking on all of its short-term administrative loans. In addition to this nucleus of fiscal receivership and restructuring program, Reinsch imagined the Consortium taking responsibility for the disbandment of "excessive" Chinese troops in 1918. Providing funds for administrative and industrial loans was merely a single facet of a far-reaching plan discussed in Paris by the nationally-defined banking groups with long experience in China, who ultimately denounced the territorial-commercial "spheres of influence" in favor of an international financial architecture somewhat more familiar to our own times.[181]

[181] Ellison, "The United States and China."

Conclusion

A World Bank?

Drawing explicitly on the example of the multilateral Chinese Consortium Loans, Gerard Vissering, now chief of the Netherlands Bank, proposed founding a "World Bank" in 1924 to achieve currency stabilization and economic reconstruction in the Weimar Republic.[1] Citing his experience as head of the six-power consortium behind the Reorganization Loan to China, the former Dutch colonial administrator argued that a neutral country should host the institution. Supposed political independence, objectivity, and legibility were the hallmarks of Vissering's scheme for central banks, a framework developed in conjunction with the earlier American advocates of the gold-exchange standard for a trustworthy currency for commerce between the industrial and non-industrial world as well as infrastructure loans from the industrial nations to recipients of the *mission industrialisatrice*.

Curbing the threats of devaluation and hyperinflation in Germany, products of a dangerous politicization of central finance in Vissering's view, had their origins in the pre-war quest, pursued and theorized by German and American interests, to find investment opportunities for domestic surplus capital, oftentimes through infrastructure imperialism in semi-colonial contexts such as China. Among Vissering's close interlocutors and correspondents were bankers such as Frank Vanderlip of National City Bank (erstwhile promoter of industrial education and capital goods exports on the German model) and Franz Urbig of the Deutsch-Asiatische Bank (who, following World War I, became a representative of the German peace delegation, a board member of the Bank für Chile und Deutschland, and director of Disconto-Gesellschaft in the

[1] G. Vissering, "Suggests World Bank to Salvage the Mark: Dutch Financial Expert Proposes an International Bank of Issue in a Neutral Country to Re-establish German Currency Values--Plan Tried in China," *New York Times* (13 Jan 1924): XX11; see also, G. Vissering, "Review: Zur Frage der ausländischen Finanzkontrolle in China," *Weltwirtschaftliches Archiv* 20 (1924): 253-259.

1920s and 1930s), international "money doctors" such as American Edwin Kemmerer (who proselytized central banking and currency reform throughout Central and South America), and a young John Maynard Keynes.[2] Vissering's efforts in the "Bankers' Memorial" and a League of Nations conference in 1920 on the economic reconstruction of Europe resulted in the creation of a financial committee in the League as well as deliberations over the ter Meulen loan scheme; though the ter Meulen plan failed to come to pass, Vissering would play a significant role in the Bank of International Settlements.[3]

Vissering's proposal for a World Bank would not materialize until after the Second World War. German industry began a recovery in the 1920s.[4] Beyond the rationalization fever, Weimar industry stoked its export capacity with growing arms shipments to conflicts abroad, including China's civil war, a role it took up in the wake of restrictions on the domestic stockpiling of weapons (and continued in more and less visible forms through the Cold War to this day).[5] Denied legal extraterritoriality and other privileges fellow Westerners enjoyed, representatives of German firms received booming commissions in 1920s China, where Chinese

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[2] "Stukken betreffende de deelname als vice-president aan de Internationale Financiële Conferentie van de Volkenbond te Brussel inzake de na-oorlogse wereldeconomie, gehouden van 24 september tot 8 oktober 1920," 1919 - 1921. Nationaal Archief, Den Haag, De Nederlandsche Bank N.V., Archief van president Gerard Vissering (1912-1931), 2.25.69.10; "BRAZIL-GERMAN BANK GAINS.: 15 Per Cent. Dividend--Chile-German Bank Elects Urbig," *New York Times* (08 Jan 1921): 14.

[3] Philip S. Cottrell, "Austrian Reconstruction, 1920-1921: A Matter for Private Business or the League of Nations?," in *Business in the Age of Extremes: Essays in Modern German and Austrian Economic History*, eds. Hartmut Berghoff, Jürgen Kocka, Dieter Ziegler (Cambridge: Cambridge University Press, 2013), 62.

[4] On the taylorization of German industry, see Mary Nolan, *Visions of Modernity: American Business and the Modernization of Germany* (Cambridge: Cambridge University Press, 1994); on the Weimar economy, see Detlev Peukert, *The Weimar Republic: The Crisis of Classical Modernity*, tr. Richard Deveson (New York: Hill and Wang, 1993) and Charles Maier, *Recasting Bourgeois Europe* (Princeton: Princeton University Press, 1975).

[5] On German arms exports to China, see William Kirby, *Germany and Republican China* (Stanford: Stanford University Press, 1984) and Anthony B. Chan, *Arming the Chinese: The Western Armaments Trade in Warlord China, 1920-28* (Vancouver: University of British Columbia Press, 1982).

officials and businessmen perceived a leveling of the geopolitical field while also admiring German military and technical expertise.[6]

Whereas Henry Carey had advocated "soft money," paper currency and abundant credit, and a stiff tariff for the United States, the six powers had demanded that Republican China adopt a gold-exchange standard and continue to yield sovereignty over its tariff policy (as done under the Maritime Customs Service). The *Journal of Race Development*, the periodical in which Americans from Harvard professor Albert Bushnell Hart to St. Louis tycoon B. Atwood Robinson debated U.S. intervention in currency reform and infrastructure undertakings abroad, became *The Journal of International Relations* (1919-1921), before settling on the title *Foreign Affairs*. The wages of drafting empire in engineering projects or financial architectures, railway bridges or balance sheets, followed the color line, and were remitted across it.

B.H. Fairchild, *The Art of the Lathe* (1998)

In 1998 poet B.H. Fairchild (1947-) published a collection described by critics as an ode to the working-class Midwest. The titular poem goes thus:

Leonardo imagined the first one.
The next was a pole lathe with a drive cord,
illustrated in Plumier's L'art de tourner en perfection.
Then Ramsden, Vauconson, the great Maudslay,
his student Roberts, Fox, Clement, Whitworth.

The long line of machinists to my left
lean into their work, ungloved hands adjusting the calipers,
Each man withdraws into his house of work:
the rough cut, shearing of iron by tempered steel,
blue-black threads lifting like locks of hair,
then breaking over bevel and ridge.

[6] On Max Bauer as a military advisor in China as well as the use of German experts in industrial engineering, urban planning, and mineral resource development, see Jonathan Spence, *The Search for Modern China* (New York: Norton, 1990), 396-402.

Oil and water splash over the whitening bit, hissing.
The lathe on night-shift, moonlight silvering the bed-ways.

The old man I apprenticed with, Roy Garcia,
in silk shirt, khakis, and Florsheims. Cautious,
almost delicate explanations and slow,
shapely hand movements. Craft by repetition.
Haig and Haig behind the tool chest.

In Diderot's Encyclopédie, an engraving
of a small machine: forge and bellows in back,
in the foreground a mandrel lathe turned by a boy.
It is late afternoon, and the copper light leaking in
from the street side of the shop just catches
his elbow, calf, shoe. Taverns begin to crowd
with workmen curling over their tankards,
still hearing in the rattle of carriages over cobblestone
the steady tap of the treadle,
the gasp and heave of the bellows.

The boy leaves the shop, cringing into the light,
and digs the grime from his fingernails, blue
from bruises. Walking home, he hears a clavier—
Couperin, maybe, a Bach toccata—from a window overhead.
Music, he thinks, the beautiful.
Tavern doors open. Voices. Grab and hustle of the street.
Cart wheels. The small room of his life. The darkening sky.

I listen to the clunk-and-slide of the milling machine,
Maudslay's art of clarity and precision: sculpture of poppet,
saddle, jack screw, pawl, cone-pulley,
the fit and mesh of gears, tooth in groove like interlaced fingers.
I think of Mozart folding and unfolding his napkin
as the notes sound in his head. The new machinist sings
Patsy Cline,
I Fall to Pieces. Sparrows bicker overhead.
Screed of the grinder, the bandsaw's groan and wail.

In his boredom the boy in Diderot
studies again through the shop's open door
the buttresses of Suger's cathedral
and imagines the young Leonardo in his apprenticeship
staring through the window at Brunelleschi's dome,
solid yet miraculous, a resurrected body, floating above the city.

Outside, a cowbird cries, flapping up from the pipe rack,

the ruffling of wings like a quilt flung over a bed.
Snow settles on the tops of cans, black rings in a white field.
The stock, cut clean, gleams under lamplight.
After work, I wade back through the silence of the shop:
the lathes shut down, inert, like enormous animals in hibernation,
red oil rags lying limp on the shoulders

of machines, dust motes still climbing shafts
of dawn light, hook and hoist chain lying desultory
as an old sparrow pecking on the shores of oil puddles—
emptiness, wholeness; a cave, a cathedral.

As morning light washes the walls of Florence,
the boy Leonardo mixes paints in Verrochio's shop
and watches the new apprentice muddle
the simple task of the Madonna's shawl.
Leonardo whistles a canzone and imagines
a lathe: the spindle, bit, and treadle, the gleam of brass.[7]

What is a historian to do with Fairchild's line cut across time? Is work at a lathe during the Renaissance the same, in subjective essence, in immediate sensorium, as doing so in a twentieth-century machine shop? The elements—spindle, bit—remain more or less constant, recognizable. What of the nested visions of apprentices, back to the boy in the workshop engraving on a page of the *Encyclopédie*, back to a young Leonardo?

But Leonardo, for all of his inventions, did not imagine the first lathe. We have drawings of, for instance, a thirteenth-century nun working a lathe.

[7] B.H. Fairchild, *The Art of the Lathe* (Farmington, ME: Alice James Books, 1998).

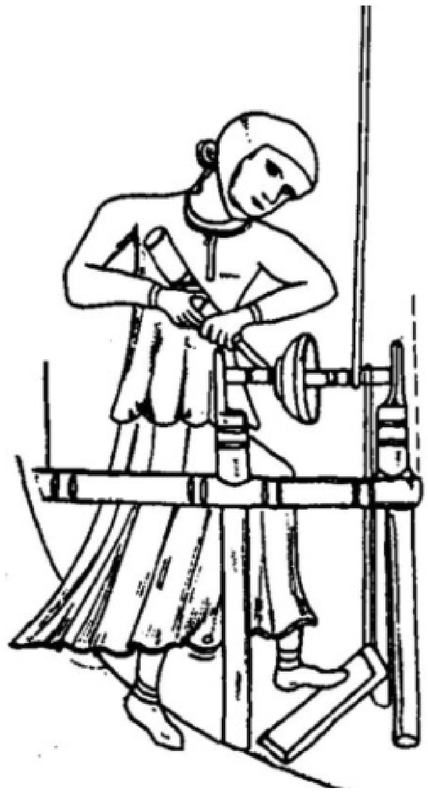

Figure 38: Nun at a lathe from an image in a 13th-century manuscript, in Torsten Capelle and Hans Drescher, "Drehbank und Drechslerei," ***Germanische Altertumskunde Online.***

Honoring workmanship, Fairchild connects machinists to a legacy of genius in everyday acts of creation. The simultaneous truth and conceit is that, to use Marx's term, "species being" is, in fact, eternal and unalienable.[8] Excepting the references to Maudslay and Whitworth, favorite subjects of Samuel Smiles in *Industrial Biography*, Fairchild's poem does not dwell on the nineteenth century in its montage of bench scenes.[9]

Despite its vivid language—pungent and erudite, auratic and down-home, above all intensely, auratically visual—its conceit relies on a world of unarticulated objects and relations. How are the lathes made? Beyond the shafting, what powers the lathes? Hand or foot or steam or electricity? What are the men, and they all seem to be men, turning at the lathes? Shoe lasts? Gun

[8] Karl Marx, "Economic and Philosophic Manuscripts of 1844," in Robert C. Tucker, ed. *The Marx-Engels Reader* (New York: W.W. Norton, 1978).

[9] Samuel Smiles, *Industrial Biography: Iron-Workers and Tool-makers* (Boston: Ticknor and Fields, 1864).

barrels? Cannon? Where are the lathes destined for? Where are their products headed? He mentions calipers, but what, if any, drawing and plans direct the arrangement? What is the fate of the patterns for these machines or their products? Are the devices held under patent? Most of the restructuring of objects and relations are products of the nineteenth century, ensconced between two industrial revolutions.

Fairchild hints toward this when he mentions Maudslay's "art of clarity and precision," perhaps sardonically, a line after we hear the "clunk-and-slide of the milling machine." This is well over a century after Maudslay's efforts, or those of Franz Reuleaux toward designing silent, frictionless machine tools. But then Fairchild recoils into the matryoshka-doll fantasy of young men "remembering."

If we take Fairchild, a machinist and the son of a machinist, seriously and refrain from analyzing his poem as (a Eurocentric) labor ideology, perhaps elegiac by deindustrialized 1998, we face something interesting. Such a thought-experiment requires heavily discounting the nineteenth-century history of self-acting tools, deskilling, and the displacement of control. But that the act of turning could feel the same and mean something quite different, with consequences in a cascading nexus of international political economy, should give us pause.

That dissonant denial suggests a more terrible beauty, a greater blindness in the manifold social life of craft and class, undead and constantly startled at awakening.

It is intimately bound up with selective forgetting that how we feel with objects, about objects, in making objects and in using objects, is practically always entwined with how we feel about living people.

That we fail to see it is one inheritance of drawing capital.

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