Displacement and Equilibrium: A Cultural History of Engineering in America Before Its "Golden Age"

A DISSERTATION
SUBMITTED TO THE FACULTY OF
UNIVERSITY OF MINNESOTA
BY

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IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY

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August 2012

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Introduction

At the beginning of the nineteenth century in the United States, as in Europe, the label "engineer" was reserved largely for military officers who specialized in the construction and operation of war machines and strategic defenses. By the end of that century in the United States, one hundred and twenty-six colleges—forty-six of which had been endowed by the federal government—graduated around two thousand non-military engineering students per year in specialized branches including civil, mechanical, mining, electrical, and chemical engineering, supplying the American labor market with what, by the time of the 1890 census, had become a politically-recognized sector of quasi-managerial technical experts.

In the decades following the American Civil War, even as the expectations about the parameters and responsibilities of engineering work were being codified, the presence of civil professionals calling themselves engineers was obvious. In the milieu of the first large-scale corporations and international expositions, men administering and designing urban and regional infrastructure projects and factories not only claimed a new and ambiguous engineering identity but also formed societies to debate the best ways to control membership and increase social leverage. Between the end of the American Civil War and the first World War, these societies discussed and presented (usually only within their own bodies) various competing codes of ethics, epistemic schemes and pedagogical philosophies, and opinions about the social and political power and responsibilities of engineers in industry, in government, and in, for lack of a better term, the field.

The multiplicity of competitive societies (especially given their nonexclusive membership), the lack of hierarchy or regulation of the societies, and the haphazardness with which their memberships devoted attention to their causes created a tumultuous churning of unfocused repetitive rehashings of arguments ranging from the political (what role do engineers as experts have in shaping government policy?) to the pedagogical (how well do or do not the tenants of a liberal education satisfy the needs of the young engineer?) to the existential (who is an engineer and what is it that makes him so?).

Documented attempts to answer these questions—at least those still in existence—range from transcripts of the cross-talking speeches delivered before meetings and cantankerous letters to the editors of trade magazines mundanely scattered amongst the details of local projects and field experiments in society periodicals to the ceremonial (and celebratory) addresses published in the proceedings of the conferences of societies' "great minds" planned to coincide with large political gatherings or at sites like international expositions.[1] The written, often published, fragments of these arguments that exist today take a variety of forms, including polemical addresses, authoritative documents (like policy tracts and collections of rules and creeds), and, perhaps most interestingly, value-laden histories of engineering.

These early histories of engineering often consisted of episodic biographies of great men and greater feats, relying on resemblance to trace the provenance of engineering not only to respectable early modern builders but to classical icons—baptizing posthumously the builders of every ancient lighthouse, aqueduct, road, and pyramid as an engineer. Hero tales, they typically situated men and machines in the context of the rise of science and the betterment of man, rarely treating the social and political contexts within which they existed as more than a matte backdrop to contrast with their unique brilliance or as an antagonistic anti-technological force full of primitives and petty bureaucrats.

By contrast, economic histories of Industrial Revolutions in Europe and America written at the same time rarely make note of the engineer, tending instead to feature either the political forces which directed capitalists to create and destroy or the capitalists who leveraged their intuition and innovation to shape political institutions. When historians did address early engineers (whether self-identified or claimed after the fact by the profession), they eulogized them as mythological figures—self-made and singularly-inspired inventors—and, more often, detailed the miraculousness of the machines they created.

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[1] The United States hosted 8 international expositions between the Centennial in 1876 and the opening of the Panama Canal in 1915.

As professional societies developed in the late nineteenth and early twentieth centuries, the histories written by their members became position statements, providing authoritative background for the political, pedagogical, and existential questions under debate. These histories of engineering (and, often, of engineering societies, colleges, or even firms) asserted that canal and railroad megaprojects, industrialization and the development of a mass production market system, and the increasingly public view of science as applicable to everyday life generated demand for a class of technological agent who, equipped with both the new scientific knowledge of nature and the artisanal mechanical sense appreciated in past centuries, could subdue nature, labor, and even man for the general betterment of the community and the individual. In these accounts, engineering arose organically as science made its way from the gentlemanly circles of Europe to the practical American man, as the builder and the blacksmith, the minter and the miner each in turn abandoned his noble but savage tools (the rule of thumb and other traditional work practices) for empirical ones (machines, mensurations, and manuals). When mentioned at all in these narratives, the colleges and universities that pre-existed engineering degree programs are featured as conservative institutions eventually overwhelmed by practical men and public outcry; bastions of the arcane (most obviously in their insistence on teaching dead languages), they gave way at first to physics and natural science and then, inevitably (and, in America, at the demand of the public), to practical education in chemistry, civil engineering, and the like.

Having achieved mass cultural recognition as a respectable professional class, today's American engineering societies do not produce histories as regularly. Reflective spaces (like "About Us" pages on society websites and industrial building lobby exhibits) and celebratory occasions (like historic preservation events and bridge anniversaries) borrow largely from the traditional historical mode established in the early twentieth century, though often the terms of the narrative are updated with more socially and environmentally sensitive rhetoric. Engineering in these casual contemporary accounts is a thing that always existed (even if it wasn't always called that); it's a mindset—creativity itself, or the organization and systematization of creativity

specially called design. The apparentness and centrality of engineering to civilization is evident in the use of the label engineer for any and all work.[2]

But while the society histories, or at least the rhetorical quality of these histories, still dominate the narratives produced by the professional engineering community, modern histories of engineering (often branded as "histories of technology" or even of "science and technology") are written largely from outside the engineering community and are critical of the great men, great machines, and grand enterprise approach. Dismissing the early biographies and economic histories as passé and denying contemporary public media as a-historical, modern treatments engage the society-produced histories, often indirectly, by introducing political, social, and physical details to question the motives of and motivations for professionalization itself and question the role of engineers as agents of the larger social good.

Ironically, these modern social (even rhetorical) histories, in their effort to critique the birth of a profession or the application of an engineering ethos throughout the twentieth century, have largely failed to question the underlying network of values which formed the conceptual nexus for late nineteenth century professionalized engineering—naturalizing professional engineering rather than recognizing it as one of any number of ways social institutions may have formed at the confluence of cultural forces. In part, this is because such a cultural analysis would require especial consideration of the centuries before professional engineering and, additionally, especial attention to the context where engineers were not; in short: a contextual history of engineering before engineering and without engineers.

Linkages to professional engineering in the late eighteenth and early nineteenth century, including thoughts about the nature of labor, class, political power, and nature, have been occasionally developed by contemporary historians to explore the professionalization of engineering in America in the late nineteenth century and the role of engineering and

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[2] Consider the rise in the term engineer as applied to business and lifestyle work functions, the pinnacle of which is, perhaps, the seventies application of the title "domestic engineer" to housewives.

technology in society in the twentieth century. More often, however, they have been either ignored or used, uncritically, to provide a framework for an engineering ethos to be subject to critique. In doing so, even histories critical of engineering as an essentially socially beneficial practice end up representing engineers and their epistemology as demanded by civilization and generated organically by scientific and technological innovation.

Such assumptions inherently restrict critical scholars' ability to question the image of the iconic engineering man, his role in the construction of technology and the social infrastructure which has been said to warrant his existence, and the values typically assigned to the technologies (especially machine labor) themselves. In addition, it makes natural certain unnatural assumptions about the primacy of science as a cultural force compelling institutional and social change.

The result is that these histories, while more appealing to our modern sensibility, are equally and unsatisfyingly restricted from making productive insights about the cultural values integral to formation of the modern cultural concept of engineering. That is because each of these histories presupposes the emergence of a professionalized and socially institutionalized engineering, not only rejecting most of the non-surviving experimentation of the century following the American Civil War (a subject which has been discussed at some length) but also neglecting to look at those contexts which, through their relegation or rejection of early engineering concepts (or through the simple lack of people we would identify as engineers), contributed in a logically negative way to the modern identity of engineers.

A contextual history of the period before engineering professionalization—which in America would arguably extend from the fortification of the colonies during the French and Indian War and the Revolution to the foundation of named social institutions before and after the Civil War—could serve as the environment for rich, culturally informed discussions about the relationship among ideas of work, class, nature, technology, and science at the inception of professional engineering, and could help reveal some of the underlying values which have been propagated through time unappreciated by engineering's various institutional forms. An

elaborate cultural contextual history would be less a single history than a nexus of cultural narratives; it would be an environment more than a work and would require more history, more cultural and rhetorical investigation, than any singularly motivated history itself would require.

A narrative of this nexus in which engineering arose afford insight regarding the connections between any number events—not just those which seem, in retrospect, linked to the formation of the field, but also those which seem to indicate the development of other structures which, if further developed, might have produced an altogether different political, economic, and technological body of practice.

From the details of these past narratives, understood in their social and political contexts, important questions can be asked about the past's eventual future. Consider, for example, a few of the several questions which arise organically in the discussion of industrial sites later in this study: How might have constructs of domestic spirituality in turn on the century New England informed early industrial labor practices? How might the implicit expert and social cultural infrastructures of tidewater craftsmen have informed military procurement and administrative practices? How did the idiosyncratic pedagogies of individual men influence, perhaps a generation later, seemingly unrelated decisions? And, in the case of each of these questions, what were the cultural catalytic factors which led to these observations? And that led from these situations to have subsequent broader impact? Largely: how do values expressed by individuals propagate through communities to inform seemingly unconnected events and institutions? And how do communities subtly sustain cultural values as those institutions persist?

While the answers to these questions connect quite readily to a broader discussion of the development of engineering identity and professionalization, even preliminary answers require a history not of engineering or engineers but of the concept of engineering in America as it is evidenced in contexts in which engineering and engineers are not only present but also absent. Rich questions like these require individual narratives, synthetic cultural observations, and an analysis of the artifacts (both material and rhetorical) through which the ley lines of values pass.

A complete rhetorical retelling of American narrative without presupposing the existence of engineering would require extensive and elaborate investigation into traditional and nontraditional sites and characters in an attempt to reconstruct the rich network of needs, norms, and values—a network which must recognize not only the political and social context *of* engineering and its products but also the political and social context *for* and the political and social context *around* engineering and its products. While it is clear that the shifting demands in (and of) the industrial workplace and the political and commercial improvement of the land had a formative influence on the American conception of the professional engineer, it is also apparent that those complex constructs, like the actors situated in them, were caught up in the shifting political, social, and economic conditions of the new nation, itself inextricably linked to its environment and to circumstance.

For a conservative start to such a project, choosing context immediately adjacent to the popular frames of reference affords the opportunity to rather quickly make connections back to the existing body of scholarship. Given the scale of the larger projects articulated here, and the scope of this document, selecting accessible and immediately recognizable cultural settings seems like an appropriate first step in the construction of a broader base. So, as the contemporary conception of the engineer—a professional who applies mathematic and scientific principles to design, construct, and oversee all manner of technologies from roads to mechanical devices to abstract processes—is an amalgamation of early modern military and craft roles and late modern conceptions of science, industry, and democracy, the chapters of this study will proceed as follows:

The chapter following this introduction discusses in more depth the tradition of constructing contextual or cultural histories like one attempted here, tracing inspiration for this approach to the mid-nineteenth century insights of Swiss historian Jakob Burckhardt. Considering, as a modern example, the work of Karl Polanyi and the contemporary methodological arguments made by scholars in the cultural study of technical communication (especially Bernadette Longo), a methodological approach is constructed around the modification of traditional historical approaches to foreground the cultural and contextual. Recognizing the motivations and background of the author of the history as essential to the work, this approach relies on

opportune questioning and rhetorical analysis at the juxtaposition of reconstructions of the past. The historical juxtapositions and questionings, then, are feature in the following chapters.

The second chapter is an account of the Continental Army during the American Revolutionary War and, more importantly, its incomplete disbanding during the subsequent Constitutional period. The army commanded by George Washington did not slip naturally into being the Army of the United States that we identify as a centuries old organization today. Rather, the Continental Army, a contingent body supported by state militias, was viewed by a significant body of the newly liberated American population as an essentially ad hoc organization, whose purpose had been achieved with the evacuation of British troops and which could serve little purposed in peacetime democratic society.

This chapter will suggest that those who advocated a persistent standing military relied on a variety of arguments, including the need for a cultivation of expertise in war and the construction and maintenance of war machines and fortifications. For a certain group of political influentials, in fact, this was the primary argument—surpassing the threat of imminent invasion or the ever popular complaint of hostilities with native tribes—and was executed politically by the rhetorical expansion of a pre-existing, publicly recognizable, and previously more narrowly construed military job class: the engineer.

Even In the decades before the War of 1812 (which arguably secured the influence of military advocates), the engineer became the justification for a federally funded center to educate a military elite, a contentious allocation in a society hyper-aware of the icons of royalty and stratocracy. And, in the decades following the war, through visible expert participation in state-located canal and harbor megaprojects ("internal improvements") culminating, perhaps, in the project to expand the national Capitol building, the engineer became the icon of acceptable military participation public life and, at the same time, became an icon of a certain expertise and of a set of goals often consociated with government.

The third chapter relates the development of educational institutions in the United States during the same period, extending to the early days of normalization for schools and colleges. For the first century of United States sovereignty, public education was a widely recognized and fiercely debated priority of state and local governments. Though often described as essential to any nation ruled by a mass electorate, issues of states' rights, of taxation and funding, and of public and private management plagued initiatives to develop extensive and accessible education for both children and adults. Idiosyncratic solutions to regional educational demands and preferences produced a plethora of systems, schemes, and organizations, which often appeared and disappeared from year to year as they accumulated or lost interest and funding.

This chapter will suggest that a number of the rigid boundaries that might be considered fundamental to modern education in the United States—including age stratification, tracking into scholarly and trade-oriented study, mandatory and accessible schooling (or even the desire to school)—did not begin to crystallize until the middle of the nineteenth century, at perhaps the crest of a fashionable demand for accessible scientific and mechanical popular education. After a brief survey of the variety of traditional and progressive institutional models that functioned to service demands of tradesmen and generally curious adults, the chapter will discuss two movements: the academy and the polytechnic. Academies, a form of secondary education (often displacing college), were simultaneously idiosyncratic and ubiquitous and, on paper, often seem a blend of the socially esteemed college tradition and scientific and "practical" education favored by an expanding American middle class quickly recognizing a new and diverse set of professions (beyond the traditional core of medicine, divinity, and the law). On the other hand, the polytechnic model, a more specialized term referring to an American hybrid of European educational traditions and championed by a few influential educational administrators, became the norm for organizing a diverse body of newer institutions of higher education attempting to establish credibility as schools of agriculture, engineering, and the practical disciplines.

The fourth chapter adds yet another layer to the story, describing the industrialization of the new American nation at the intersection of shifting global relationships and local identities. Simultaneously a nation of libertarians and of consumerists, markets and manufacturing in the

United States were highly sensitive to international political turmoil, domestic infighting, and the opportunistic exorcism of traditional ideas of class and labor. In the period between the American Revolution and the Civil War, a fundamentally new grammar of work, class, and commerce developed, locating (not just people but) citizens in an industrial landscape of manufactured power, standardization, and machine-assisted labor. Established as a plantation for Britain, America in the first half of the nineteenth century shed its agrarian exclusivity and established commercially competitive industries in nearly all relevant market sectors of the period.

This chapter suggests that the diversity of operations in manufacturing sites and sectors relied not only on economic factors, but on the interactions of key personalities and the evolving sense of democratic ideals proceeding from the revolution. After a discussion of the numerous government and private attempts to induce and inhibit manufacturing, two iconic settings of early industrial development are discussed: the textile mills at Lowell, MA and the armory at Harpers Ferry, VA (now WV). Wealthy Boston socialites did more than built prosperous mills on the Merrimack at Lowell; they, largely through their agents, built an entire community, a constructed environment that recreated all of the social and mundane routines of contemporary life at the rhythm of regularized factory work. Visitors to Lowell used their diverse frames of reference to critique not only the environment but a larger transformation of American attitudes about work and life. A look at the gradual industrialization of the armory at Harpers Ferry, however, provides an interesting comparison. At Harpers Ferry master craftsmen from the Potomac and Shenandoah river valleys resisted efforts by military overseers to introduce Yankee mechanical innovations and factory-style piecework labor practices. Taken together, these sites offer opportunity to witness early modern management roles as they co-develop with the engineering identity—roles that would later be identified as the application of engineering principles to work.

These three chapters present less an image of the engineer than an image of the settings with which late-nineteenth century Americans would come to associate engineers. By the 1880s, land grant universities, world's fairs, railroad mega-firms, and electric power would put a complex engineering identity in the realm of everyday. Before that time (really before the Civil War) the

idea of the engineer was amorphous. Distinct not only from terms like mechanic, craftsman, and artisan, but also from terms like manager, operator, foreman, and factor, it seemed to be simultaneously alienated from concepts of art, craft, skill, and trade and associated with ideals of useful, practical, and productive. Perhaps it is precisely because of this amorphousness that the shell of engineer was selectively imbued in the latter half of the century with intense industrial power and economic and social leverage.

This work seeks to identify the network values around which an idea of engineering and the engineer coalesced in the period before professionalization. As such, the conclusion attempts to employ the cultural and contextual narratives drawn in previous chapters to suggest features of the engineering concept immediately prior to professionalization, with the idea in mind that a fuller understanding of these features are essential to understanding the oft recounted "golden age" of engineering which would follow.

1 Using historical context to contextualize history: The ideology of cultural history

In his final novel *Das Glasperlenspiel*, Hermann Hesse employs an avatar, Swiss cultural historian Jakob Burckhardt, to debate the scientific nature of and the essentialness of order to the study of history.

> Every science is, among other things, a method of ordering, simplifying, making the indigestible digestible for the mind. We think we have recognized a few laws in history and try to apply them to our investigations of historical truth. Suppose an anatomist is dissecting a body. He does not confront wholly surprising discoveries. Rather, he finds beneath the epidermis a congeries of organs, muscles, tendons, and bones which generally conform to a pattern he has brought to his work. But if the anatomist sees nothing but his pattern, and ignores the unique, individual reality of the object, then…he is using mathematics on the least appropriate object. I have no quarrel with the student of history who brings to his work a touchingly childish, innocent faith in the power of our minds and our methods to order reality; but first and foremost he must respect the incomprehensible truth, reality, and uniqueness of events. … To study history means submitting to chaos and nevertheless retaining faith in order and meaning. (168–9)

While relating history as a science and recognizing the essential scientific impulse to classify, quantify, and reduce, Hesse questions the purposes and deployments of classification, quantification, and reduction. The anatomist, in his analogy, does not use expert knowledge to attend to the regularity of bones and organs in a cadaver. Rather, he uses his structured expectations as a tool to identify differences, uniquenesses, the "individual reality of the object." Historians, Hesse implies, recognize certain elements fundamental to historiography (e.g., human actors, motivations, sequence of events), but the relation of these elements themselves, he asserts, are not the object of history. In short: while accepting the structural or

scientific tools of a historian, Hesse is criticizing a vacant and method-motivated structural approach to history.

Jakob Burckhardt, the real-world counterpart of the character Hesse constructs, had made this argument nearly a century before the publication of *Das Glasperlenspiel*. Burckhardt was critical of a scientific positivist approach to history that relied on privileged sources to construct a purportedly objective narrative of the actions of, largely, influential men; the approached often represented by the adage "history is past politics and politics present history." Instead, cultural historians, like Burckhardt, beginning in the mid-nineteenth century, had begun asserting that historical value relies on any number of (or even, on every aspect of) cultural and social phenomena, including the personal narratives of the non-influential, the rhetoric of material and ephemeral objects, artistic expression, methods of and reactions to marginalization, and even the absence of expression or access to power.

Cultural histories do not strive to reduce history to dates and so-called "key" figures or events. Rather they attempt to represent or create a holistic cultural moment—a gestalt of the social, political, and cultural chaos that contextualizes the interaction of people in place and time.[3] At the same time, cultural historians recognize (as Hesse's Jacobus did in the passage above) that the complete construction of the gestalt is impossible, not simply for reasons relating to quantity and fidelity, but because a history, itself, is essentially produced within a cultural context different from that it takes as its subject—a context which carries its own inescapable biases and attentions. In Burckhardt's own words: "History is on every occasion the record of that which one age finds worthy of note in another."

Rejecting and released from the positivist fetishization of objectivity, cultural historians recognize that the motivation for producing a history is an essential component of constructing

[3] The title itself of Steven Shapin's recent collection is revealing on this point: *Never Pure: Historical Studies of Science as if It Was Produced by People with Bodies, Situated in Time, Space, Culture, and Society, and Struggling for Credibility and Authority.*

and relating history. Cultural histories, thus, often adopt tailored or limited motivations; they attempt to address the contributions of the mundane, the dispossessed, or the encultured voice in the creation of the dominant narrative or, more often, in questioning the dominant narrative. Ambitious cultural histories, on the other hand, intensely root in the idea that the values and contextual elements which shape events exist in the moment and in the minds of people who, as people, have personal understandings of their environment and community. Very often, they serve as clarions seeming to argumentatively reclaim the social and human in the face of reductionism and quantification.

In accepting a motivation for history, cultural historians also suggest that history has some non-objective social purpose. In societal use, the best of these works offer a compelling qualitative antidote to dehumanizing ends/means or policy motivated historiography, especially when it masquerades as scientifically objective.

For example, the Karl Polanyi's classic critique of market economics *The Great Transformation* begins with the unforgettable assertion that "Nineteenth-century civilization has collapsed." Writing from London during the Second World War, Polanyi questioned the source of the great collapse and reached the conclusion that the war was a result of a larger displacement of society from economic policies in that it was a conflict based on conflicting society-preserving movements of human communities to restore the social in economic policy. In other words, socialism and fascism were conflicting corrections made by situated societies in reaction to the displacement of societal concerns from the capitalist economic programs implemented during (but not intrinsic to) the large scale industrialization of the nineteenth century.

In order to make this claim, interestingly, Polanyi relies on societies, events, and cultural elements decades, even centuries, before the war. While not describing his work as a cultural history,[4] he describes the open-endedness of his approach as follows:

> [W]hat we are searching for is not a convincing sequence of outstanding events, but an explanation of their trend in terms of human institutions. We shall feel free to dwell on scenes of the past with the sole object of throwing light on matters of the present; we shall make detailed analyses of critical periods and almost completely disregard the connecting stretches of time; we shall encroach upon the field of several disciplines in pursuit of a single aim. (4)

In order to support and express his historical and cultural observation, Polanyi sheds the positive historical methodology and, over the course of his work, moves freely across time and place to describe thematically and rhetorically enlightening episodes using economic, sociological, textual, and, at times, theological methods, each of which he accepts as rooted in his current context. He then knits together conclusions drawn from these episodes and analyses to fulfill what he cites as the social objective of his history, to answer the "anxious question":

> The issue on which [fascism and socialism] divide is whether in the light of this knowledge the idea of freedom can be upheld or not; is freedom an empty word, a temptation, designed to ruin man and his works, or can man reassert his freedom in the face of that knowledge and strive for its fulfillment in society without lapsing into moral illusionism? (256)

Polanyi's work is a cultural history in that it is attentive to the themes and remnants of a situated past while being cognizant not only of the present environment in which it is being produced but also of the purpose for its production. This work will aim similarly.

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[4] In fact, Polanyi throws the label of history out altogether, perhaps as a means of avoiding critique from conservative (what have been described here as positivist) historians.

Motivation and methodology for a cultural history of American engineering

Cultural histories rely on rich contextual readings (or "thick description" as Clifford Geertz would say[5]) of elements of society often overlooked or dismissed as inconsequential by positivist historians. Polanyi rejected the bounds of economic analysis to include sociological, theological, and biological reasoning; Burckhardt suggested that art was a significant and relevant source of cultural information for contextualizing social and political events. A number of modern cultural historians (like Roger Chartier, Lynn Hunt, and Mona Ozouf)[6] have adopted methods which emphasize text and image as important, not just as a research medium, but as a situated rhetorical artifact.

The tools and knowledge I bring to this work are rooted in the scholarly study of workplace writing—especially the kinds of writing that take place in scientific and engineering workplaces—and in the pedagogy of teaching technical and professional writing to science and engineering students. Additionally several years of private consulting for engineering and technical writing firms have significantly informed my sense of the contemporary relationship between engineering colleges and pedagogy and the engineering workplace.

Recognizing this biographical information is essential to appreciating the construction of the history that follows. It has informed not only my selection of sources and my impulse to consider or question source materials, but has also given me a general framework of likely elements in industrial and educational settings—a framework which, though not inescapable, has influenced my classification or identification of themes, trends, or motivations.

One clear influence, from scholarly study, has been the recent application of a cultural history methodology to write the history of technical communication as a practice and as a discipline.

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[5] See, for instance, *The Interpretation of Cultures* for Geertz's full treatment of the subject.
[6] This list, I will readily admit, reflects my bias for studies of the French Revolution.

Bernadette Longo's *Spurious Coin*, which has been perhaps the most complete attempt at this project, traces the roots of the contemporary values assigned to technical writing to reveal that those values rely on institutionalized ideas of power and legitimacy derived from science and then applied to the management of human interests.

Longo's work is instructive as a model for my work in that I have made the following observations about her approach. It was only by first providing an explicit framework for the values of technical writing—an act which required codification and situational knowledge in the present on the part of the author herself—that could Longo go on to identify germane historical references. It was only by identifying and contextualizing historical references—an act which required empirical method and a recognition that present values and concepts are the only lens for articulating the pass—that could Longo go on to make assertions about the connections that informed technical writing at the confluence of diverse value systems. Finally, it was only by making assertions about these connections—an act which required the construction of a knowledge framework inescapably associated with the authors background and motivations for writing—that could Longo make productive social assertions about, in this case, the need to be critical of the application of scientific values to human endeavors and ways to humanize technical writing (and generally management) practices and scholarship. The cultural context of technical writing is not introduced as justification or artifice to aid an otherwise historical narrative in *Spurious Coin*; it is, instead, the object of study in the work and thereby a path to assertions about the underlying value system on which technical writing rests.

Contemporary assumptions about engineering practice are intimately associated with its claimed values, such as its creative or design-centeredness—the idea that engineering, a productive process, is essentially a neutral agent because it is not only a scientifically informed arbiter of the physical world but is eminently debatable (though only in ways which it reflexively authorizes). But they are also bound up in the unarticulated values with respect to which engineering was formed to conceptually embody, such as the confluence of conflicting values in which surrounded early American military agents—who functioned in the formative years of the republic simultaneously as legitimizers of democracy and as an essentially (and perhaps existentially) anti-democratic force.

The numerous epidictic attempts to define the role and status of engineering at the beginning of the twentieth century are, in this sense, a reaction to the settling of the framework of values for engineering, a social attempt by a community of practice to redefine power relationships and take control of their own destiny in a capitalist and democratic context.[7]

Edward Layton recognizes this in his *The Revolt of the Engineers*, a critique of the political role of engineering professionals in the American Progressive movement and a reinterpretation of the professional identity of engineers and their relationship to industry.[8] Layton's engineers, professional society members and company men of the early 1900s, are defined by their associations and position in industry. Their ideology is essentially tied to the tension between their pursuit of scientific and business professionalisms. For Layton, the engineer's power identity relied (or perhaps relies) on an ethos of science as a fundamental arbiter and on the engineer's position as scientifically imbued agents in the industrial workplace (and, as Layton goes on to describe, in the realm of early twentieth-century politics).

However, to set the stage for his treatment of the failed political, social, and professional "revolution" of the 1920s, Layton divides the "emergence of the engineering profession" into two stages. The first of these is a proto-professional stage largely covering the canal (and early rail) era up to but not including the civil war (1816–1850). The second, which Layton labels the "golden age for the application of science to American Industry," begins in 1880 after Reconstruction and ends at the beginning of his revolutionary period in 1920. Of the unnamed earlier period, Layton says little—and what he does say makes it clear that, for his study, the period is simply a proto-professional ether (2).

While any history, of course, has its limits, Layton's bifurcation of periods (one repeated by many historians of technology and engineering) produces the interesting effect of associating engineering with science in a way that, today, is culturally typical but, in the formative period

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[7] And Max Weber would perhaps add protestant to this list.
[8] See Layton Chapter 3 for the most direct discussion of this concept.

that he neglects, was novel. Specifically, in the case of *The Revolt*, by relying on only the post-Reconstruction period to discuss the Progressive movement, he begs the answer of several questions: If scientific logic is an intrinsic element of engineering, then how did it become so? Did a sense of engineering pre-exist this special application of scientific logic or is the application of logic itself engineering (i.e., how essential is society or even the individual actor to the concept of engineering)? Given the answers to those questions, what precise relationship do science and engineering have? How was engineering popularly conceived as being related to science? How did people come to define themselves as engineers not scientists?

Though these seem ready questions for further research, I would suggest that they are really illusions—questions created by construing today's sense of the cultural definitions of science and engineering over the past period.[9] They are similar to another, but perhaps more obviously problematic question that I am often asked by people to whom I describe this project: if there weren't engineers before the eighteenth century, who were the engineers before there were engineers? It's an understandable question. After all, walls were built before the eighteenth century; roads, bridges, sewers, and canals dotted the Roman world. It would be a trivial matter to parcel out the task knowledge we today associate with engineering to blacksmiths and architects, misusing Lewis Mumford's observations about our shift from wood and water to coal and iron, perhaps, and creating a convenient, cogent, and ever so tidy series of evolutionary intermediates on the path of progress. Answering that question in that manner, however, relies not just on the anachronistic assertion of contemporary values and episteme on the past, but on the philosophical position that such an assertion is legitimate.

As odd as it might seem to suggest in our self-proclaimed technological age, engineering as we know it is a relatively new concept. In fact, engineering to someone in Layton's "golden age"—also a self-proclaimed technological age—was a relatively new concept. In both cases, however, I would suggest that science (as some mass cultural and philosophical concept which itself was

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[9] Alternatively phrased: questions about the present's past or questions about the past which assume the past's future.

also new at one point and which has meant dramatically different things in different contexts) was less of a formative agent of the *practice* of engineering and more of an idea conveniently borrowed by engineering and borrowed from by engineering. The chicken and egg question here—do engineers employ the principles of science? or are the principles of science what make that set of professionals engineers?—thankfully, is not the right question to ask.

Rather, the questions which may lead us to a richer understanding of values which, over time, have informed our contemporary societal notional of engineering are questions less about engineering itself and more about the cultural system which engineering displaced. The society which gave rise to and has been transubstantiated into engineering practices today, in the American context at least, is a society grappling with the application of enlightenment and libertarian principles in a rich and diverse economic and social climate. It is a society in which the struggle to simultaneously empower and restrain is in the midst of reshaping classical notions of centuries old institutions and in which political power for its own sake is an anathema and notions of anarchy and collapse are in the process of being redefined.

In this sense, the somewhat simplistic statement that late eighteenth and early nineteenth century America was the crucible for the century that followed becomes a reasonable starting place for a discussion of how, in Layton's case, for example, Progressivism came to claim expertise as a legitimate rationale for political power and how the value system of the period rejected that claim. Likewise in my investigation into the cultural nexus surrounding the professionalization of engineering, the values of the larger culture (more so than what we contemporarily consider appropriate engineering values) are of immediate need of definition.

To this end, in the chapters that follow, I explore three contexts each of which contribute diversely to a sense of the cultural context and values of, around, and at the crystallization of an engineering concept. As articulated in the introduction, the first of these explores the military context of engineering, from which can be drawn important observations about the legitimization and institutionalization of coercion essential to republican power. The second explores the notion that specific kinds of learning are essential to professionalization,

questioning the assumption that an obvious (or at least single) educational pathway was available and formative to the development of an engineering identity. The third chapter discussed what today is considered a classical engineering setting in terms of its political and social contexts to suggest that productive observations can be made about the values displaced by the engineer by utilizing visitors' and participants' accounts rather than seeking out the engineer as a structural element.

In choosing these settings, I am assuming that institutions and individuals act within society to influence the development not only of the superficial processes of naming engineers, deciding what they know, and creating a context for their work, but also in the recognition, classification, and conceptualization of engineering as a profession and a discipline at large. I find this to be an acceptable assumption not just because of the overt occasions in which identifiable individuals played a part in the construction and regulation of institutions, but also because social institutions (the government included most especially in the antebellum period) served as the chrysalis of and, indeed, interface for the evolving values of the American Revolution which, popularly expressed, were a fundamental influence on the institutionalization of an early and uniquely American educational and professional infrastructure.

That is to say, the organization of people with diverse social, political, and economic interests is a fundamental reality of the American environment and that the assemblage of people for one purpose very often could be attributed other purposes and effects in retrospect. Engineering, as a concept and as a profession, can just as easily be construed in terms of its relationship to the military, to education, and to the factory as it has been to in terms of science, the government, and the natural environment. This fact is a common flourish of American rhetoric.[10] The multi-dimensional nature of engineering, and the occasion to describe engineering and its settings

[10] Consider Thomas King, the Know-Nothing Boston minister, railing against Catholicism as: "the ally of tyranny, the opponent of material prosperity, the foe of thrift, the enemy of the railroad, the caucus, and the school."

from the dimension that suits the purpose of the writer or speaker makes the need for a diverse set of speaker and writers all the more desirable.

In a liberal democracy, power is legitimated via the interaction of constituencies.[11] I would suggest that engineers, as much as they are anything, are an artifact of the radical political shift in the means of authorizing and legitimating control of the national habitat and the habits of its citizens. They are the commissioned agents of those attempting to influence material reality in this new value system, and the values they embody are (persistently) inextricable from that existential purpose.

[11] Whether through rational consensus or, as some like Chantal Mouffe have recently suggested, through a processes of sustained agonism.

2 National service and public work: Military education and civilian engineering

Before becoming a term associated with industry, building, and even work in general,[12] *engineer* was a military term. A cooption of the Latin-derived *engine* (literally the product of ingenuity, material or not), *engine'ers* were soldiers in France in the Late Middle Ages who were, for instance, trained to fire cannons. They were operators; the ones who handled the engines of war.[13]

By the latter half of the eighteenth century, a certain kind of educated non-military craftsman had begun to adopt the label as well. These were men who, with knowledge of mechanics and mathematics, were able to plan and oversee the construction of public works (typically functional structures pertaining to transportation such as roads, bridges, canals, lighthouses, water and sewer systems) In England, socially and politically connected men like John Smeaton used the label civil engineer as a clarification, so that they would not seem to be claiming fraudulently to have been military engineers and to liberate themselves from any of the baggage attached socially to military engineers.

In America prior to the revolution, however, there was neither large scale transportation infrastructure nor a continental army. The development of these (and other key) institutions and of national and regional identities was co-incident with the development of a profession of—even a concept of—engineering in America. The material and political culture of governance, labor, and civilized society that arose out of eighteenth century European enlightenment ideals and the debates surrounding (and constraints imposed by) violent revolution are therefore central to the American conception of engineering.

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[12] Consider labels like "domestic engineer."

[13] This root usage survives in modern English most closely, perhaps, in the case of the application of the term engineer to the operator who, in conjunction with a conductor (and brakemen), drives a train.

Likewise, existential arguments, which peaked in the conflicts of 1776 and 1812, were at the heart of public discourse in the tumultuous formative decades of the American republic. The period between the wars included not only the (unusual) constitution and reconstitution of governance by text, but also fluctuations in the centralization of power and in opinions regarding the maintenance and public presence of a potentially oppressive continental army. The core themes of arguments about the existence and nature of the American republic and about a standing army echoed in the development of public and professional society for more than a century after, feeding debates about the value of military education and the propriety of subsidiary the military expertise in civil endeavors.

Early modern France and the origins of military engineering

The word *engineer* itself can be traced back to French and English communiqués at the close of the War of Saint-Sardos in 1324. Documents surviving from the time refer to operators of (and those who would construct mounting systems for) contemporary military engines, including the first cast metal European battle cannons, as *engine'ers* (OED; Chaplais 223). By the mid-1330s, with the beginning of English and French militarization in advance of what would later be called the Hundred Years War, the term was being applied to not only the operators of but the to the creators of military machines and embattlements (Sumpton 167).

Despite ongoing reliance on war machines and the associated *ingenieurs*, the French army's institutionalized corps, the *Corps de Ingenieurs du Genie Militaire*, wasn't established until 1675 when special problems in prosecuting war with the Dutch demanded complicated engineering solutions. The French, in combination with the English, had invaded the Dutch United Provinces three years earlier with the intention of prosecuting a quick ground war. However, shifting alliances, which included the departure of the English and the entry (on the Dutch side) of the Spanish, and ingenious Dutch guerilla techniques (including perhaps the ultimate defensive engineering technique: controlled mass inundations of the countryside) cut off overland supply lines and forced the French to divide their army and fight across a system of highly fortified islands.

Engaged in a war of attrition that the French were no longer certain of winning, the demand for infrastructural and military engineering solutions and personnel caused army officials to set up special ad hoc schools for military engineering. The Dutch inundation made the construction of temporary yet high stability bridges of foremost concern. The initiative was headed by Prestre de Vauban who was not only a renowned military strategist and engineer,[14] but also a member of the French Academy of Sciences and public intellectual publishing works on forestry, husbandry, monetary policy, and colonization. Vauban's philosophical approach to military engineering (which relied heavily on what today would be labeled statistics, psychology, and physics) informed the practical field education of French army engineers—and arguably defined the appropriate knowledge for that class—until his death in 1707.[15]

After the war, and throughout the reign of Louis XIV, the army continued to educate engineers through training in the corps. Given the status role of government and military participation in France at the time, the corps training attracted the children of the prestigious among the French middle class as it was the only branch of the army in which offices were not reserved for titled nobility. Membership to the corps—the title of engineer—became an accessible symbol of prestige, and well recognized and politically connected families outside of the titled circles sent representative sons. Both Charles Coulomb, the son of a lawyer and later researcher electromagnetism, and Lazare Carnot, the son of a public official and later mathematician, were engineers of corps (Rae 76).

In peacetime, military engineers were often lent as technical assistants to local infrastructure projects. Though the French national government rarely oversaw the construction of roads, bridges, or canals, an elaborate program of diffuse infrastructure spending[16] meant that projects

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[14] Vauban had earlier devised an ordinance-dependent strategy for taking Maastricht, a central and heavily fortified citadel which, after the inundation, became essential to French supply lines to Utrecht.
[15] For a full—and recent—discussion of Vauban's works related to military engineering, see Ostwald.
[16] City streets were generally constructed at the expense and oversight of cities; national highways were constructed in short increments—often mile by mile—at the expense of the province; canals and turnpikes were mostly constructed and tolled by industrial and merchants associations.

were often starting, stopping, and being redone. That these projects were built largely by local sponsorship (and taxation), local labor, and local engineering talent meant, of course, that they were infrequently embarked upon (and even less frequently completed) and that those that were constructed were rarely designed with neighboring jurisdictions in mind—roads of similar capacity often did not connect at provincial boarders but came to abrupt halts miles apart; canal locks were not standard in width requiring, at certain points, cargo be off loaded on to smaller ships; etc.

In the mid-1600s, a national construction agenda was somewhat accelerated under the administration of Jean Baptiste Colbert who, first Controller-General of Finances and then Secretary of State and the Navy, leveraged corporate interests in trade privileges with French colonies to extort sponsorship of public works projects. Recognizing the chaos created by the execution of mass numbers of local projects without centralized guidance, Colbert made a habit of identifying effective engineers from around the country who had specific qualifications for projects and employing them again as work arose. The engineers Colbert employed were of significant influence in early civilian participation alongside military engineers from the corps, and the projects undertaken during Colbert's administration became the curriculum for the next century of engineers.

It was during Colbert's administration, for example that the Languedoc, now called the Canal du Midi, was planned and completed. This canal, which leveraged local waterways across the south of France to connect the Mediterranean Sea to the Atlantic Ocean, had been envisioned as early as Roman times but had never been attempted because of the elevation and lack of water. A marvel of engineering for its time, the construction of the canal, however, relied largely on local solutions to regular problems—locks, in places, were not sized to match those in others and water diversion channels constructed to solve flooding in one place created shortages in others.[17] Notably, Colbert's hierarchical economic control of the project had enabled the

[17] See Roland's book, one of the few available in English, for a complete history.

completion of an artifact which would become the symbol for arguments over political and technical control a century later when professionalized engineers would argue the need for managerial responsibility of public projects in France.

Such discussions were delayed, however, in 1715 when Louis XIV died and Philippe d'Orléans took regency of the French government. Orléans was a reformer—almost immediately upon taking power he moved the capital to Paris, retired censorship restrictions, ordered sweeping tax reforms, and opened up diplomatic communication with England, the Netherlands, and Russia. He was also a modernizer—ordering the reorganization of the officer corps of the French military and creating a parallel civilian institution, the *Corps des Ponts et Chaussées* to manage the construction of public works.[18]

Between the time a civilian corps was formed in 1716 and the American Revolution, the corps surveyed and constructed standardized maps of the whole of France and began the planning and construction of a national set of highways and canals. But, national planning began in earnest only under the leadership of Jean-Randolphe Perronet who, in the 1770s, made standardization the mission of the corps. Perronet seized upon the irregular systems that had been constructed over the previous century—the mismatching highways and canal locks—as a symptom of poor planning and the nonmathematical nature of previous engineering practices.

In addition to institutionalizing regular practices for infrastructure construction for the corps, he also institutionalized the training of corps engineers through the creation of a school: the *Ecole des Ponts et Chaussées*. The school, which exists today, initially had a considerable emphasis on practice. In fact, there were no instructors. Rather, students followed a reading curriculum and took turns preparing and delivering lessons to their peers in geometry, algebra, mechanics, and hydraulics. Their studies were supplemented by work on current surveying and construction projects. Over time, as enrollment (and the number of alumni) grew, instructors were hired and

[18] See Haggard Chs 5 and 9 and also Graber.

the curriculum, while still dominated by practicum, began to include more traditional, for the period, elements of higher education: recitation, etc. (Gillispie 81–99).

At the same time, the military corps was becoming progressively more intellectually elite. After being brought under the direct administration of the Ministry of War in 1743, highly critical oral entrance and exit examinations (an innovation of Vauban still in place decades after his death) were becoming more and more competitive and more and more based on high-level mathematics. The tests were unique for military establishments of the period as they gave no credit to a candidate's noble birth or ability to secure references.

Interestingly Janis Langins, a historian of French military engineering and engineering education, has noted regarding candidates' occasional attempts to influence examiners that "the attempt to influence the examiner, rather than the Minister or his officials [suggests] that a new class of *fonctionnaire*, best exemplified by the state engineers, with uniform and rational standards of recruitment was being created in the eighteenth century" (93–4). Langin's term is notable. The rise in the civil authority of engineers, beginning with military engineers, coincided not only with the devolution of power from the monarch in the long buildup to revolution, but with the functioning of engineers in civil environments and the growth of scientific discourse in contemporary society. The fact that military engineers, rather than members of the royal or landed elite, were administering examinations like those for the corps is perhaps an early sign of the transference of authority which would occur during the revolution.

Notably, military engineers were becoming agents of government work in other nontraditional ways as well. Between 1747 and 1750, the army and navy engineers completed an extensive topographic and hydrographic survey of the interior of France and its waters. Historian Josef Konvitz has asserted that the French army's topographic (and French navy's hydrographic) surveys of France, completed in three years during the reign of Louis XV, "[proved] by example, that such a vast enterprise could be undertaken and concluded successfully," a fact which was, prior to that time, not at all recognized as a forgone conclusion (Konvitz "The national…" 401). He has also asserted that the maps (as artifacts) and the process of map-making constructed for

this project shaped the arguments of revolutionaries and the policies and politics of revolutionary governments for the decades that followed (Konvitz "The nation-state…"). Military engineers, as makers of these maps, were thereby entering into the realm of social policy and political debate. Far from simply supplying data for the successful military action at home, they were also, intentionally or not, supplying information about population density, arability, and transportation infrastructure. In choosing to (and how to) present this information, they were participating in debates about the equitable distribution of resources to the French people. And they were doing it at the behest of the government, their employer.

In fact, decades of surveys and construction, increasing demand for modern urban facilities, and egalitarian mottos of various revolutionary bodies, led, by the end of the eighteenth century, to a second class of engineers. Not trained at the government school, these men had often worked with state engineers on engineering projects, had read the current periodicals, and were often more willing to engage (and negotiate with) commercial investors. The existence of a state sponsored venue for technical education, John Hubbel Weiss argues in his social history of French engineering education, functioned to divide civil engineers into two classes. An engineer attending one of the state institutions would have been referred to not just as an *ingénieur*, but as *ingénieur des mines* or *ingénieur des ponts et chausses*. Engineers who learned industrial or construction training on jobsites, regardless of his specialization, would have been referred to as *ingénieurs civils*. Weiss argues that the latter term was a diminutive one, indicating function but lacking the prestige of the terms associate with national power.

> Service to an absolutist monarchy during the century before the Revolution had even brought ennoblement to some of the more successful *Ponts et Chaussées* engineers. As Revolution and Empire infused the State with nationalism's beguiling thaumaturgy, *Polytechniciens* found their role as executors of the public mission an ever-growing source of prestige. (15)

Importantly, i*ngénieurs civils,* deprived of prestige as they were not associated with the state, were also spared centralized military training. In 1795, the *Directoire Exécutif*, the revolutionary

government of the first French Republic, made artillery training required curriculum at the government schools, including the newly formed, intellectually elite *École Polytechnique*. From that time until the requirement was removed by the Third Republic (some sixty years later), approximately half of the graduates of the state engineering schools went into army or navy service on graduation. By 1804, at the direction of Napoleon, students wore uniforms and slept in barracks (Weiss 15–6). The classes of civilian and military engineers had achieved, in the public eye, separation.

Military engineering and the American Revolution

Despite the competitive establishment of military engineering corps during the Hundred Years War, no equivalent to the French educational infrastructure for engineers (civilian or military) existed in England. British military engineers were trained unsystematically in a largely practical apprenticeship fashion. The first engineering-focused military academy in Britian, the Royal Military Academy at Woolwich, was often referred to as "the shop" because it was initially housed in an arsenal.

Renowned British public works engineers like John Metcalf, James Brindley, John Rennie, and Thomas Telford began as mechanics and ascended to notoriety after working on progressively larger projects—from shopwork and basic construction to the largest bridge, highway, and canal projects of the day (Simon 32). John Smeaton, perhaps the reference for most British public works engineers of the period, was, by all reports, the first person to refer to himself in print as a "civil engineer."[19] Like in the French usage, Smeaton used his term to describe himself not only

[19] The earliest print reference to this title may be the title page of a report from 1768 entitled "A Review of several Matters relative to the Forth and Clyde Navigation as now settled by Act of Parliament, with Observations on the Reports of Messrs. Brindley, Yeoman, and Golburne, by John Smeaton, Civil Engineer, and FRS [Fellow of the Royal Society]," in which Smeaton, largely, laments errors made by the builders of a canal that he had designed connecting the Forth and Clyde rivers. A reprint of this report (without the original graphic title page, but with the text of the title page, can be found in Smeaton's collected publications (Faden 1:337). Notably, the introduction to the first edition of this collection expresses quite clearly the sentiments that civil engineering developed as a concept 1760, that Smeaton was central to its development, and that continental Europe had been ahead of Britain in this respect (xxii).

as designer of bridges, canals, harbors, and lighthouses but also as a designer of mechanical apparatuses (including steam engines, water pumping systems, etc.) and as an experimenter and fellow of the Royal Society. In 1771, Smeaton organized the Society of Civil Engineers which admitted non-military members whose professions were mechanical or construction based. The organization had (and still has) a fixed number of members and a specified hierarchy between empowered members (engineers) and lesser members (craftsmen, etc. who work with or at the behest of engineers). While an association of such members at the time was somewhat innovative, the organization, by design it seems, never developed into more than a supper club.[20]

An extension of Britain, colonial America had almost no educational or social infrastructure for developing engineering talent, and, in fact, had little of the kinds of transportation infrastructure associated with engineers like Smeaton and Telford. Aside from rudimentary roads, built and maintained by various colonial agents or, more often, by traffic itself,[21] the infrastructure and industry that would eventually become the hallmark of New England were all but nonexistent. British mercantile policies rewarded only the production of raw materials, which, once shipped to the mothercountry, could be used to manufacture goods for sale back to the colonies. Making profit from the production of manufactured goods (like textiles) in the colonies was impossible; this left for American subjects only farming and less demanded trades like leatherworking, coopering, and smithing. The American colonies were, however, rich in natural resources long since depleted in Europe, especially wood. Lumberjacking, sawmilling, carpentry, and turning were large and specialized labor sectors by the time of the Revolution. And local craftsmen, farmers, and sailors (and often apprentices to these trades) made up the bulk of revolutionary forces.

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[20] For a thorough account of members and membership activities—including dinner menus—see Garth Watson's *The Smeatonians*.

[21] Brush clearage and rutting was part of the early American travel experience.

The skilled men of these trades, apparently, did not necessarily take immediately to military engineering. There was a persistent problem finding men equipped to work collaboratively at the pace demanded, and the types of structures to be constructed were ambitious and the workings of artillery foreign to most. Washington, throughout the campaign to oust British forces, lamented the lack of engineers and artillerymen (and the general lack of trained soldiers) in letters to congress. In July of 1775, for instance, he wrote:

> In a former part of my Letter I mentioned the want of Engineers. I can hardly express the Disappointment I have experienced on this Subject; the Skill of those we have being very imperfect and confined to the mere manual exercise of cannon, whereas the war in which we are engaged, requires a Knowledge comprehending the Duties of the Field and Fortifications. (Fitzpatrick 3:325)

This was not a problem only for Washington, of course. A month prior to the statement above, the Committee of Safety of Pennsylvania, which served largely as an executive government overseeing the defense of the state during the Revolution, wrote to Washington to request engineers to aid in the obstruction of the Delaware River. While it seems polite in today's parlance, Washington's reply was terse:

> I was this Evening honoured with yours of the 15 Inst, and It is with no small degree of pain that I am under the necessity of Informing you It is out of my power at this time to comply with the request made by your Honourable body. The many Important works carrying on for the defense of this place against which there is the highest probability of an Attack being made in a little time, will not allow me to spare from hence any person who has the least skill in the business of an Engineer nor have I but one on whose Judgment I would wish to depend in laying out any work of the least consequence. Congress well knows my wants in this Instance, and several of my late Letters to them, have pressed the appointment of Gentlemen qualified for this business… (Fitzpatrick 5:153–4)

At Washington's insistence in the summer of 1776, Rufus Putnam became the first chief engineer of the revolutionary army. He had been a millwright and a farmer and was a self-educated surveyor. Putnam, a veteran of the French and Indian war, had enlisted in a Massachusetts regiment immediately following the battle of Lexington and had early on been assigned work constructing fortifications. Putnam was identified for promotion by George Washington after the British evacuation of Boston. In two letters to Washington in September and October 1776, Putnam became the first to write out for Congressional approval a plan for the formation of an American engineering corps. Writing that "without a corps of engeneers [sic]…the works will never be properly executed nor don [sic] in a reasonable time," Putnam went on to recommend a rather large, perhaps unreasonably large, contingent of carpenters, masons, sappers, and miners to be directed by a chief engineer and accompanied by, interestingly, mathematics tutors (Walker 29–32).

Notably, in his own later account of the event, Putnam would suggest that he offered to step down as chief engineer and become an engineer in the line so that a more qualified man with more a formal education could be found to head up such a large organization. (Indeed in his September 1776 letter, he implies the same thing.) Interestingly, on each of the occasions in his memoirs when Putnam mentions his lack of schooling, he directs the reader to his correspondence where they may see his "ineptitude at grammar and errors in spelling" which, apparently, were a source of great embarrassment for him (Buell 233). Whether it is these problems which Putnam thought would disqualify him for the post is unclear. In either case, Putnam resigned his engineering commission to accept the command of regiment only a few months later when the Congress decided to reject his suggestion for the formation of a corps.

Writing to the Congress after Putnam's transfer, Washington described Putnam as follows: "altho' he is not a man of Scientific knowledge, he is indefatigable in business and possesses more practicable Knowledge in the Art of Engineering than any other we have in this Camp or Army" (Fitzpatrick 5:349). The contrast is interesting. Washington's words imply that the Congress would be more ready to recognize a "man of Scientific knowledge" as an engineer—or at least as a captain of engineers. On the other hand, Washington identifies with engineering some body of "practicable Knowledge" which, it seems, is independent of the scientific. Quite a

few questions could be asked reguarding what Washington ment by “Scientific,” i.e., was he referring essentially to mathematical ability? or also some sort of experimental or physical knowledge? Likewise, a better sense of Washington’s thoughts on the Congress members’ expectations and dispositions would help in a richer interpretation of a statement like this one. At this point, however, the dichotomy is interesting enough as it anticipates a tension that will arise between the “practical” and “scientific” positioning of engineering throughout this work.

No companion writings or references to deliberations regarding this event by members of the Congress appear in the *Journals of the Continental Congress*, a standard resource of primary sources of such deliberations, transactions, and speeches. While it is probable, of course, that that the Congress, which by mid-1776, was unable to make payroll for line infantry, simply rejected without consideration the grandiose plan for a corps of skilled auxiliaries. It is also possible that members of the Congress viewed Putnam as a placeholder—what was available in the absence of a trained military engineer. Perhaps they were relieved by Putnam’s resignation as, by that time, trained French engineers were on the scene.

By July of 1777, Louis Duportail, a lieutenant colonel in the French military engineering corps, had arrived in the United States and been made colonel and chief engineer of the army. It was common, at the time, for military men, especially from France but also from Prussia, Poland, and Austria, to come to the colonies to enlist as officers above their rank in Europe—a lieutenant colonel in France was at least a colonel in the colonies, given the low level of training and volunteer nature of the colonial army. Duportail, however, quickly found conditions in the army were less than satisfactory and, among his immediate demands, were promotion to brigadier general, a substantial raise, and the formation of a corps of engineers which he would head up. Within months of accepting a position in the army, Duportail had come to roughly the same conclusion as Putnam, only his plan for the corps was more elaborate and more expensive. Duportail, with a more fully formed French vision of military engineering to rely on, arguably, did a better job at selling Congress on the necessity of engineers to the revolutionary cause:

> If fortification is necessary in any Armies, it is peculiarly so in those, which like ours, from a deficiency in the practice of maneuvers cannot oppose any to those of the enemy—being necessitated therefore to receive him on their own ground, they ought always to be protected either by a natural or artificial Fortification (Walker 34)

And, no doubt, Duportail's educated background and foreign/expert record didn't hurt his argument. For soldiers of the corps, Duportail demanded higher wages than line soldiers (as they were to have special skills and to be the target of the enemy when laying mines, etc.), and, in line with upper middle class French ideals, he demanded that soldiers recruited from the line be able to able to read and write and "be intelligent persons of good character" (Walker 34).

Unlike Putnam, Duportail did not waver in expressing who should command the corps. Until the end of the hostilities, at which time he planned to return to France, he would command the engineers (who would be largely drawn from men of the line who prior to hostilities had been carpenters and masons), sappers and miners, and whatever artillerymen could be trained. Interestingly, Duportail also made assertions about the essential independence of these agents from other chains of command.

> The Companies of Sappers ought to be altogether under the Command of the Head Engineer—for if the Major Generals had a right to employ them as they pleased, each, from a desire to fortifying his Camp in his own way, would ask for Sappers and they would all be taken from the Engineers. Besides as such partial works do not enter into the general plan of the position they are for the most part useless, ill concerted, and sometimes even dangerous. (Walker 35)

In this excerpt, as in others, Duportail makes clear his position that military engineers (especially himself) possess a certain knowledge and skill, obtained from education, that can only be

misapplied when commanded by those without that skill (i.e., generals).[22] Notable too, in his discussion of the corps and later of corps activities, Duportail relies heavily on a system of labels more specific (and less prestigious) than engineer. More than does Washington, Duportail refers separately to artillerymen and engineers and refers to defensive fortification engineers as sappers and offensive fortification engineers (who were largely charged with deploying explosives to clear enemy positions) as miners. Arguably, the increased specificity of these terms is useful. However, the revolutionary army had very few engineers who could have been classified as one of these or the other. In part because of shortage and in part because of the lack of regimented roles passed on by formal education, soldier engineers served each of these roles as needed by the moment and by their commander. These terms do, however, function in Duportail's letters to distinguish engineers who have not been institutionally trained from those who have (largely his French colleagues).

Duportail's emphasis on educating military engineers is more tangibly apparent, however, in his briefly detailed plan for math tutors and "engineers" to instruct and read lectures on military topics to sappers and miners in their downtime (Walker 43). When Congress finally acted to establish a corps in May 1778, they included engineer training as part of the corps plan, though at the same time specifying a preference for immediately practical topics: "these companies to be instructed in the fabrication of field works, as far as relates to the manual and mechanical part…The commissioned officers to be skilled in the necessary branches of mathematics, the non-commissioned officers to write a good hand" (Walker 37). They would revisit this decision at the end of the war when the urgency of the hostilities was over, and this system of field education would become the counterpoint in discussions about the institutionalization of education and the creation of military academy.

[22] We will see this theme again of course, echoing through the centuries.

Civilian engineering as rationale for maintaining a military in peacetime

The institutional education of engineers that Duportail envisioned peacetime would afford would not come to pass until decades after the war. It was by no means assured, in fact, that the United States would have a standing army at all after the conflict with the British ended. Arguments recorded in the journal of the Continental Congress and in newspapers of the day indicate a suspicion that a standing army cannot necessarily be trusted not to harass the civilian population or to abstain from exercising (or being manipulated to exercise) political power through threat of force. A standing army would also cost money, money that would have to be raised by a federal establishment; whereas, an alternative network of state militias could be regulated to address local needs for defense.[23]

When the Congress, not surprisingly, sought Washington's input on the matter, Washington solicited the input of military subordinates. Washington's personal affects contain at least four letters (re-published in Walker's collection) from engineering officers Putnam, Gouvion, Pickering, and L'Enfant, each of whom offer an opinion (327–39). While, as Walker notes, Duportail's letter has been lost, summaries of his letter by Washington himself seem to indicate general consensus among the five engineers: in peacetime, several military engineers—Pickering comes in lowest, suggesting "as many as two engineers will probably be found necessary"—must be employed so that border fortifications can be constructed as demanded and maintained and so that, in the event of hostilities, engineers, whose education makes them laborious to recruit, will be ready to construct combat fortifications. Three of the four letters

[23] Perhaps the best digest of popular considerations regarding the maintenance of a standing army can be found in the nationally reprinted newspaper editorials that appeared during the establishment of the federal government in the late 1780s commonly referred to as the Federalist (and Anti-Federalist) Papers. While the authors of these papers, unknown at the time, have since been identified as prominent politicians and republicans of the period, their wide readership and their declared mission, to persuade the public to support or withhold support from the adoption of the Constitution, recommend them as an excellent barometer of public concern. Discussions of the concerns about maintaining standing army and the need for defense appear in Federalist Papers 24 and 25, but also in 8, 16, 29, 41, and 45 and in the Anti-Federalist writings of Brutus (especially tracts 9–11), Federal Farmer (especially 2 and 3), and Cato (especially 3 and 5).

printed also suggested the eventual formation of a school to train officers as well as engineers and artillerymen.

In May 1783, Washington enclosed his suggestions for maintaining peacetime military strength in a letter to Alexander Hamilton, who at that time was the chairman of the Committee on Peace Establishment.[24] Washington's recommendations illuminate the situation facing the new country. The United States was a loose confederacy with few small urban settlements, owing a massive debt, and possessing rich agricultural and natural resources but lagging behind European nations in agricultural and manufacturing industrialization. The Northern border of the country, a border with hostile Britain, was a mixture of latitude lines and midpoints of rivers and lakes and was, in places, disputed (i.e., present day Maine and northern Minnesota). To the West, beyond the borders traditionally ascribed to the thirteen colonies, the new nation possessed significant and largely unsurveyed territorial lands populated by Native Americans and, sparsely, by French settlers, mostly fur trappers.[25]

Washington suggested the maintenance of garrison forces at strategic points, including West Point in New York, to "awe the Indians, protect our Trade, prevent the encroachment of our neighbors…and guard us at least from surprises" (Walker 374). The cost of these troops, numbering approximately 2,600 for the entire country, could be defrayed, at least partially, by the troops themselves who would grow their own food and, in some instances, work in the manufacture of weapons and other military stores.

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[24] The entirety of this letter can be found at Fitzpatrick 36:374–98.

[25] French territory in North America had extended to the Appalachian Mountains until the portion east of the Mississippi River was conceded to Great Britain at the close of the French and Indian War in 1763. By the end of the Revolution, in fact, there were no French investitures on the continent—French possessions in Canada were also ceded to the British and the plains West the Mississippi were been ceded to Spain by the same treaty.

For military security and general cohesion, Washington also recommended the establishment of robust communication lines with garrisons in positions furthest north (i.e., closest to British Canada).

> altho' by the Treaty, half the Waters, and the free Navigation of the Lakes appertain to us, yet, in Case of a rupture with Great Britain we should in all probability, find little benefits from the Communications with our upper Posts, by the Lakes Erie and Ontario; as it is to be presumed, that the Naval superiority which they now have on those Waters, will be maintained. It follows as a Consequence then, that we should open new or improve the present half explored Communications with Detroit and other Posts on the Lakes, by the Waters of the Susquehannah, Potowmack, or James River, to the Ohio, from whence, with short Portages several Communications by Water may be opened with Lake Erie. (Walker 375–6)

While Washington goes on to suggest the establishment of fortified land routes between waterways (itself a task for military engineers), his recognition of the unlinked nature of inland waterways would later be seized on by the advocates of major civilian engineering projects: canal proponents in legislatures throughout the country.[26]

Washington, however, also recognized the limitations of capital and political will for the formation of a comprehensive military school. While suggesting that a military education institution, which could "keep alive and diffuse the knowledge of the Military Art" as well as maintain weapon stores, would be "highly expedient," he goes on to question the cost of such an investment while faced, at the same time, with a crushing war debt—in fact, in an earlier letter he suggests that the construction of a navy also be postponed until some schedule of debt

[26] Washington, of course, favored networking the Potomac and/or Susquehannah Rivers (in present day Virginia and Maryland). The canal which eventually came to serve the function he described here would be built across upstate New York: the Erie Canal.

service can be made. He also questions whether the American citizen, wary of a standing army that could be used to oppress the public, would permit such a development. Washington does, however, make exception for the training of engineers:

> Until a more perfect system of Education can be adopted, I would propose that Provision should be made at some Post or Posts where the principle Engineers and Artillerists shall be stationed, for instructing a certain number of young Gentlemen in the Theory of the Art of War, particularly in all those branches of service which belong to the Artillery and Engineering Departments. … And as this species of knowledge will render them much more accomplished and capable of performing the duties of Officers, even in the Infantry or any other Corps whatsoever, I conceive that appointments to vacancies in the Established Regiments, ought to be made from the candidates who shall have completed their course of Military Studies and Exercises. As it does in an essential manner qualify them for the duties of Garrisons, which will be the principal, if not only service in which our Troops can be employed in time of Peace and besides the Regiments of Infantry by this means will become in time a nursery from whence a number of Officers for Artillery and Engineering may be drawn on any great or sudden occasion. … [U]nless we intend to let the Science become extinct, and to depend entirely upon the Foreigners for their friendly aid, if ever we should again be involved in Hostility. For it must be understood, that a Corps of able Engineers and expert Artillerists cannot be raised in a day, nor made such by any exertions, in the same time, which it would take to form an excellent body of Infantry from a well regulated Militia. (396–8)

In this statement, Washington not only asserts the special nature of military engineers (who "cannot be raised in a day" the way infantry can) to justify their education, but, recognizing the opportunity an educated branch of service presents, suggests blending the engineer's education with the larger military science education of officers, thereby creating a pool from which both engineers and officers may be drawn in time of need. Additionally, he appeals to the security of the nation to justify his suggestion.

Leveraging the country's insecure position to be persuasive, Washington was referring to France when he suggested that failure to educate an engineer/officer class would be to "depend entirely upon the Foreigners for their friendly aid." While France had been both financial and military supporter in the war for independence from Britain, both Washington and the Congressional officials, at this point, had become wary of the ally, who was, by all accounts, on the verge of bankruptcy, facing riots at home (some by reformists, some over famine induced by crop failures that year), and preparing, it seemed, to once again assert control of its nobility (as was evidenced by a number of rather sudden war loyalty provisions, including the Segur Ordinance, which tightened nobility restrictions for those entering the army officer corps).

The report to Congress of Hamilton's committee investigating the matter looks to be written directly from Washington's letter. Hamilton suggested a small standing army for the various reasons Washington lists and the maintenance of an engineering corps as:

> officers of this corps require science and long preliminary study, and cannot be formed on an emergency; and as the neglect of this institution would always oblige the United States to have recourse to foreigners in time of war for a supply of officers in this essential branch—an inconvenience which it ought to be the object of every nation to avoid. (Walker 343)

Hamilton, in the same paragraph, goes on to note that such a corps will be indispensible in peacetime as well: fortifying and constructing frontier posts, harbors, etc. Hamilton's committee, however, did not take up Washington's suggestion for the formation of a school. Expressing a preference for practical training, the report contains the following statement:

> The committee are of the opinion that the benefit of such institutions [i.e., military academies] rarely compensates for the expense—that military knowledge is best acquired in service, that with respect to those branches of service which are of a more scientific nature, the professors proposed to be attached to the corps of Engineers, will produce substantially all the utility to be

> expected from academies—that at all events institutions of this kind can only be an object of future consideration… (Walker 344)

This hybrid of apprenticeship and on-site tutoring (in this case for mathematics), reinforced by Hamilton's committee, is a form that opponents of institutionalized civilian engineering education will come back numerous times over the centuries following the revolution. What is unclear about Hamilton's committee's suggestion is what apparatus would have been used to provide new engineers opportunities to acquire such knowledge "in service." Without a war to fight, there would have to have been some structure of drills, etc. to teach recruits techniques. Presumably superior officers would have been responsible for planning and evaluating such activities. Even in the absence of an institutional military school (and setting, for a moment, the math tutors aside) a form of schooling would have been being conducted in the corps akin to modern industrial apprenticeship courses.

In either case, the status quo prevailed. Congress, divided by support and opposition for a standing army at all, and the creation of an officer class especially, and in the midst of debate over revisions proposed to the Articles of Confederation, failed to respond. Duportail, eager to return to France, wrote one last plea for a standing army, a formal school, and a substantial corps of engineers, but Congress did not respond and Duportail left.[27]

Among other letters in support of a corps was one from Pierre L'Enfant. L'Enfant's letter contains the same points about readiness and fortifications as the others, but notably also describes the knowledge engineers should have (including, somewhat uniquely, mechanics, hydraulics, drawing, and natural-philosophy) and proposes a role in for the corps in peacetime: the construction of public works.

[27] The greater part of this letter can be read in Walker, 349–53.

> The duty of the said Corps shall be to attend to and have the direction of all the fortified places that of all military and civil building, the maintenance of the Roads bridges and Every Kind of work at the public charge, surveys of the several places Shall be by them made and properly drawn with a view to make out an atlas of the whole Continent ... (Walker 358)

> The Service which is to be Expected from such an Established corps, will prove a mine to Save more than the said third of Expences in any underta[king] whatsoever. Advantages which will turn to the immediate benefit of the United States by committing to the Said corps the Execution of all building underta[king] such as those of a Congress, who were Ever the Seat of his permanent residence is to be agreed upon will necessitate to have Erected proper building whose locale to Enforce the object of their destination are to be combinated in Such a manner as to give an idea of the greatness of the empire, as well as to Engrave in Every mind that Sense of respect due to a place which is the Seat of a Supreme Sovereignty… (Walker 363)

It is interesting, of course, that L'Enfant recommends the corps for the construction of not only roads but civic buildings. L'Enfant himself would plan the renovation of the New York City Hall which would serve as the seat for the first two sessions of the new Congress and, some years later, would be commissioned to plan both the capital city and the permanent house of Congress. The often discussed grandness of his plans for the city which would become the District of Columbia are anticipated in this letter, not just in his phrasing ("Seat of Supreme Sovereignty") but in his construal of the corps as, like the corps of France, the engineering arm of government and surveyor of the continent. L'Enfant's letter, of course, also failed to sway the Congress.

Within a decade, French King Louis XVI was executed, and the United States had defaulted on its debt to France (asserting that the debt was owed to the crown and not a revolutionary government), disregarded treaty obligations by securing trade agreements with Britain, and

entered into an undeclared naval war with France. These dramatic shifts in foreign relations occurred around the same time as several disastrous interior battles, including the Battle of Wabash, in which nearly a quarter of the US army was lost.[28] As Congress responded to each threat in turn, a peacetime army (and even more, a navy) accumulated. Officially, the corps of engineers, established as an emergency measure during the revolution, continued to muster and was instrumental in maintaining battlements, especially in western territories where conflict with Native Americans occupied military attention. As hostilities with France seemed more likely, additional regiments were added to the corps. When relations normalized with the French (with the accession of Napoleon), the corps was not reduced in size.

Despite the gradual growth of an establishment of military engineers, military advocates (like Washington and Jefferson) continued to lament the lack of institutional facilities for education. On several occasions when Washington received letters from foreign nationals requesting commission in the U.S. military—an idea to which Washington objected on principle—he routinely replied that he would favor the idea only "in those branches of the Military Science which relate to Engineering and Gunnery: for in those our Military establishment is defective, and men of known and acknowledged abilities with ample testimonials thereof, would be certainly encouraged" (Fitzpatrick 37:97).[29] Writing to then Secretary of War, James McHenry, in May 1799, Washington identified the deficiency once again:

> It is well known that the great advantage which the Armies of France have over those they contend with, lies in the Superiority with which their Artillery is served, and in the skill of their Engineers. Let me entreat, therefore, that the most prompt and pointed attention be given to the procuring, and instructing, men in these Sciences. Lamentable indeed must be our case, if we shall have to acquire the knowledge of these arts in the face of an enemy, when *that* Enemy

[28] On this point, see Guthman.
[29] Statements like this one can be found in a number of instances, made both to members of the government and to foreign nationals, in volumes 36 and 37 of Washington's papers.

> ought to experience our Skill in the exercise of them. I do not mean to *recommend* characters as instructors in these branches; but I will mention the names of some who have passed through my mind, and have been recalled to it. Du Portail, Lamoy, Serif, Rivardi, and Latrobe. The last of whom I know nothing of, but have been told that he has knowledge *in*, and professes to be well acquainted with, the principles of Engineering. I notice these as persons within your reach, in case nothing better can be done. It is necessary to be provident. Let us not have things to prepare, when they should be in use.
> (Fitzpatrick 37:207)

At the same time, Alexander Hamilton was writing back and forth with James McHenry regarding legislation for a suite of military academies, which would include an army college, an engineer's college, a navy college, and a "Fundamental" college which would either teach the basic principles that the others would apply or simply teach concepts that were common to each of the three curricula.[30]

Hamilton's school of Arillerists and Engineers would consist of "Two Professors of Mathematics, Two Professors of Geography and Natural Philosophy, One Professor of Chemistry, Two Architects, Three design and drawing Masters" (Syrett 24:308). Interestingly, Hamilton also suggested beginning the process of differentiation which would occur more naturally with the growth of the standing army: "the functions of the Engineers and Artillerists shall be separate and distinct; those of the former relating to the service of Artillery, those of the latter to fortification and other military constructions, and to the attack and defense of fortified places" (Syrett 24:312)

When the Congress in 1802 finally established a military academy at West Point, it allotted no more resources to the school than were already being offered to the hybrid training of

[30] Three letters regarding this exchange can be found in Hamilton's collected papers (Syrett 24:306–14).

engineers in the corps setting. Not surprisingly, curriculum in the early years of the institution was little different than the non-institutional training that corpsmen stationed at West Point had been receiving; recruits, however, were consolidated at the campus and the posts of several functioning war department officials were relocated to the site from New York and Philadelphia. Perhaps most notably, Lieutenant-Colonel Commandant Louis Tousard, an artillery inspector and author of a text on the French system, was charged with organizing the education of artillerists.[31] Tousard's textbook, *American Artillerist's Companion*, published in 1802, treated holistically not only the use of turn of the century engines of war but their fabrication, defense, and repair and the structures of troop organizations best suited for their effective deployment. Identifying the strengths and weaknesses of the French system and relating them to the American context, perhaps the most surprising aspect of the book was Tousard's emphasis on uniformity—as a traditional ideal of the enlightened military commander (xiv), in the procedural use of artillery (2:x), in their construction (2:277), material composition (2:527, 2:470), and in the consumables (i.e., gunpowder) they require (2:257, 2:612), as well as in the regimentation of corps to operate them (2:61); an emphasis that would come to fruition when, after the War of 1812, West Point graduates would gain control of the armory system of the United States.

By 1812, renewed hostilities with the British led Congress to specify (and endow) the development of a more comprehensive curriculum modeled after the French engineering and artillery schools. This initiative was headed at the time by the Army's Chief Engineer Joseph Gardner Swift, who was also the school's first graduate. Swift, busy preparing coastal fortifications in North Carolina, delegated the administration of the school to Alden Partridge. By 1815, hostilities had once again subsided, and Partridge's ideals of a well-rounded "citizen soldier" education began to take shape. Curricula at the school emphasized not only geography, tactics, and the military applications of natural science and mathematics, but also language, agriculture, and what would today be labeled civil engineering.

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[31] See the timeline in *The Centennial of…* 2:52.

Having just fought a conclusive war, what at the time was referred to as the "Second War of Independence," with the British on American soil, the maintenance of the new expanded military academy was not entirely sure. Arguments against the need for a standing army and the nature of military training occupied a significant part of the legislative agenda as a well-documented "Era of Good Feeling" descended over a largely non-partisan legislature and a citizenry who felt liberated at last from threats of war. Others, including Tennessee legislator Davy Crockett, a veteran of the Creek War and popular national figure, objected to the military academy as nonegalitarian and to its institutionalized educational form:

> It excludes a large portion of American youth from commissions in the Army, as none but graduates of that school receive commissions. [Crockett] also questions the utility of the institution, and asserts that it is better calculated to make dandies than soldiers. The institution costs the nation an immense sum, and it is certainly objectionable in principle. We passed through the war of the revolution and the war of 1812 without its aid, and we believe it might be safely dispensed with. (*Erie Gazette*)

In this passage taken from a newspaper editorial (floor debates of the House were not transcribed in 1830), Crockett highlights the major arguments: cost, necessity, equality, etc. His use of the term "dandy" reveals the underlying tone of classism and misogyny which would often accompany discussions of higher education in America. The word had become popular in the colonies by the end of the Revolutionary War when the song "Yankee Doodle," sung originally by British during the French and Indian War to mock colonial troops, was appropriated by brigades of the revolutionary army as a battle victory song.[32] Crockett is essentially

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[32] Incidentally, the Yankee Doodle song was written in June of 1758 by Dr. Richard Shuckburgh after watching the disheveled colonial soldiers who had mustered at Fort Crailo to join the British troops in fighting the French. Local lore suggests that Shuckburgh wrote the song while sitting on the edge of a well behind the Van Rensselaer home, which he was visiting for dinner. The lyrics to the song, popularly sung today as patriotic, mock the colonial troops' lack of social savvy: a doodle is a fool, a dandy is a man who puts on fanciful airs despite his low position, yankee doodle rides a pony rather than a proper horse, and,

[this note continues on the next page]

suggesting that the curriculum at West Point feminized poor and middle class boys and encouraged them to put on upper-class airs.

In an effort to advertise the possibilities for academy graduates in peacetime, discussions of the curriculum coming out of West Point more and more emphasized graduates' civilian engineering potential, though even this strategy was not uncontroversial. (George Cullum's Biographical Register of West Point graduates lists positions in rail or canal construction for the majority of first two hundred graduates.) The fact that many graduates of West Point often went on to private practice rather than military careers and were instrumental in the construction of railways and canals was by design. As Alden Partridge would later write:

> The constitution of the United States has invested the military defense of the country in the great body of people. … [E]very American citizen…is emphatically a citizen soldier, and it appears to me perfectly proper that he should be equally prepared by education to discharge correctly his duties in either capacity. If we intend to avoid a standing army, (that bane of a republic, and engine of oppression in the hands of despots,) our militia must be patronized and improved, and military information must be disseminated amongst the great mass of the people; when disposed with them, it is in safe hands, and will never be exhibited in practice, except in opposition to the enemies of the country. I am well aware there are amongst us many worthy individuals, who deem the cultivation of military science a sort of heresy, flattering themselves, and endeavoring to induce others to believe, that the time has now arrived, or is very near, when wars are to cease, and universal harmony prevail amongst mankind. But, my fellow citizens, be not deceived by the siren song of peace, when in reality there is no peace, except in a due and constant preparation for war. (271)

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being poor and rustic, ornaments his uniform with a simple feather and thinks it ostentatious (like the so-called macaroni, who were epicene and overly styled).

> Wars amongst nations do not arise because they understand how to conduct them skillfully and on scientific principles; but are induced by the evil propensities and dispositions of mankind. … War [by nations uneducated in scientific studies of military operations] becomes a far greater evil than it does under an improved and refined system, where battles are won more by skill and by hard fighting, and the laws of war are proportionally ameliorated. (273)

Partridge walks a fine line in these passages: he agrees that a standing army is corrosive to republican values yet criticizes those who would reject military science and military preparedness. His assertion, rather, is that military preparedness should be diffused among the people, such that in the event of an invasion, the whole citizenry would be prepared to resist. Additionally, Partridge asserts that the study of scientific military principles would make war more humane, more tolerable, and more rational.

While the curriculum pioneered by Partridge, one that provided military officers a productive peacetime outlet, became the key argument of West Point's benefactors, Partridge (apparently a martinet) was soon ousted in favor of another former graduate Sylvanus Thayer. Both Thayer and Partridge continued to develop models of holistic military and engineering curricula—Thayer at West Point, Partridge at a newly founded private institution the American Literary, Scientific, and Military Academy in Vermont. The Academy in Vermont, which is known today as Norwich University, was a private military academy and the first to offer a Reserve Officers Training program (branches of which today are organized as a federal corps as ROTC). While the curricula at West Point and Partridge's new Academy remained quite similar, Partridge became an outspoken critic of West Point and, in the decades that followed his ejection from the institution, he founded at least five other military academies and wrote scathing critiques of West Point under the Latinate pseudonym Americanus.

In modern histories of engineering education, West Point is often citied (along with the Rensselaer School and the Erie Canal) as the nation's first engineering school. West Point, itself, claims this title on its webpage (West Point). Education historian Terry Reynolds observes:

> West Point's peculiar status—a military academy that paid more attention to scientific, mathematical, and engineering education than to military education—was largely the result of the pressures of antebellum American society. A military academy in a republic that begrudged military expenditures, looked down on the profession of arms, and despised social and intellectual elitism had to do more than simply supply professional military officers to survive. (463)

And, in the online companion to an exhibit on the school entitled "West Point in the Making of America," the Smithsonian Institution describes the period between the schools foundation and the civil war with these words:

> West Pointers led many of the expeditions westward, explorations part military reconnaissance, part scientific exploration, part treasure hunt. They surveyed and mapped the land, gathered information, identified potentially valuable resources, collected specimens, and wrote reports. The military posts they established often became the nucleus of towns and cities.
>
> Whether as army officers or civilian engineers, West Pointers built America's roads and canals, bridges and railroads. They also transplanted major features of military organization to the new railroad corporations and pioneered mass production.
>
> In these activities and others, West Pointers helped lay the groundwork for America's economic development, intellectual growth, and territorial expansion—engineering, exploration, and war.

The Smithsonian's description of West Point is, perhaps, the fulfillment of Reynolds observation. The academy is described largely as a social agent. Even where its military function is mentioned, it is assigned a social value (as when military posts "became the nucleus of towns"). The engineering education mission of West Point is a convenient proxy for its military mission

and, by the twenty-first century when this statement is written, the military and engineering missions are almost entirely divorced. The separation is even indicated by the syntax of the concluding two lists: "economic development, intellectual growth, and territorial expansion—engineering, exploration, and war." The terms in these lists are paired—westward cartographic expeditions were typically described, at the time, as the hallmark of scientific investigation and constant territorial pushes westward into populated Native areas and eventually into Spanish colonial territory was accomplished largely by military power. These lists assign economic development to engineering, implying perhaps transportation networks, labor saving devices, etc. while neglecting to mention, as had been the justification largely at the time, the construction of fortifications and the deployment of artillery.

The estrangement of engineering from the military conceptually was likely supported by the kind of military action in which the antebellum United States was involved. In the conflicts of the half-century after the War of 1812 with Native tribes and with Mexico (and Texas secessionists), large scale defensive and offensive fortifications were seldom constructed. While at the same time the construction of canal megaprojects, and later rail networks, demand for qualified civilian engineers routinely outpaced supply.

Engineering union in sectionalist America

The economic oppression which isolated American industry from Europe had ended with the resolution of the War of 1812. By 1816, the Napoleonic wars in Europe had also ended, and American resources were again highly demanded by European markets. Cheap imports, easy credit, and the highly valued export market led to decades of alternating economic speculation and depression. However, industrial development in the country was confined to the coast and to points along navigable rivers where waterpower and ship traffic could be used. The cost of transporting a ton of goods 30 miles over American soil was as much as the cost of shipping the same goods across the Atlantic (Nettels).

At the same time, the country had expanded westward beyond the seemingly impenetrable boundary of the Appalachian Mountains. Thomas Jefferson, at the time of the purchase,

disclosed in a letter to Joseph Priestley his equivocal thoughts on the matter: "Whether we remain in on confederacy, or form into Atlantic and Mississippi confederacies, I believe not very important to the happiness of either part" (Foley 794). A decade after the purchase, other borders of the country were once again in flux—Spain had exchanged a portion of Florida for a portion of what today would be Louisiana; the remainder of the Florida territory, under Spanish rule but occupied largely by a mixture British and American citizens was in the process of rebelling to form their own republic; and the Anglo-American Convention of 1818 had resolved joint claims on the Red River Basin by ceding the British only those lands above the 42nd parallel (incorporating into the territorial system what today would be the northwest corner of Minnesota and the northeast corner of North Dakota). Also, it was clear that the Anglo-American Treaty was only the first phase of the resolution of northwestern land disputes. While the Monroe Doctrine had yet to be articulated in 1819, the impulse to envision the continent free from the British and Spanish (as it was now free from the French) was not out of hand. Without a means of networking the traditional thirteen colonies with the western territories, however, the future of such a union was ambiguous.

When DeWitt Clinton spoke to the New York State legislature about the construction of a canal which would connect the Hudson River at Albany to the Great Lake system, the expansion and unification of America was, not surprisingly, one of his themes.

> When the western canal is finished and a communication is formed between Lake Michigan and the Illinois River or between the Ohio and the water of Lake Erie, the greater part of the United States will form one vast island, susceptible of circumnavigation to the extent of many thousands of miles. The most distant parts of the confederacy will then be in a state of approximation, and the distinctions of eastern and western, of southern and northern interests, will be entirely prostrated. ("Legislature of New York" 56)

Clinton's appeal to national unity was persuasive in an America fresh from the War of 1812, recommitted to independence and nationalism. Nationalism, of course, was likely not what

persuaded legislators to endorse the canal proposal. A number of well researched books have been written on the economic and political maneuvering involved in the planning and construction of the canal and the administration of Clinton, who would shortly thereafter become Governor of New York.[33] Clinton, a former mayor of New York City, had become an early member of the board of commissioners assigned by the state of New York to investigate the route for a potential canal and an early advocate for constructing a canal that would run the length of the state to Lake Michigan.[34] Being such an innovative and extensive project, of course, the canal was controversial and the project had been on the table nearly ten years when the legislature finally approved a plan and allotted funds for construction only after political changes in Washington made it possible to obtain loans for a corporation founded to build the canal.[35]

While it would be convenient to reduce the construction of the canal to the appropriation of funding by the state, any discussion of a public megaproject like the Erie Canal requires the acknowledgement of the extensive system of public and private corporations, proxies, subcontractors, and capital agencies. Even in early America, legal proscriptions on the direct transfer of public money to private entities, protections intended to inhibit corruption, and capitalist advocacy for industrial deregulation (which includes the minimization of the government payroll or skilled workers) all contributed to the corporation system which facilitated the construction of the Erie Canal and which has evolved in various ways to facilitate the construction of subsequent public works in America.

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[33] See Cornog or Hanyan and Hanyan.

[34] The more popular proposal at the time had been the construction of a much shorter system of two canals: one to network the Hudson and closer Lake Ontario and another to bypass the falls at Niagara, connecting Lake Ontario and Lake Michigan.

[35] A measure which would have partially funded the canal was actually passed by the federal legislature in 1817, only to be vetoed by then President James Madison, whose veto message to Congress suggested that the bill deviated from the legislature's Constitutional mandate by an "inadmissible latitude of construction and reliance on insufficient precedents." Writing Albert Gallatin regarding the veto, Jefferson, past his initial objections regarding the canal, would lament not only the missed opportunity but also that the veto might "settle forever the meaning of this phrase ['to lay taxes to pay the debts and provide for the general welfare '], which, by a mere grammatical quibble, has countenanced the General Government in a claim of universal power" (Lipscomb 15:128).

The intricacies of this system, largely, did not (and still do not) enter into the public discourse on the role of the state in the construction of public works. Rather, in his speech previously mentioned, Clinton had the following to say about the role to the state:

> To be instrumental in producing so much good, by increasing the stock of human happiness—and by extending the empire of improvement, of knowledge, of refinement and of religion, is an ambition worthy of a free people. The most exalted reputation is that which arises from the dispensation of happiness to our fellow creatures, and that conduct is most acceptable to God which is most beneficial to man. … That this important pursuit is the foundation of wealth, power, and prosperity—that, it requires the energies of the mind as well as the labours of the body—that is demands the light of science to guide its progress, and the munificence of government to accelerate its movements, to extend its usefulness and to diffuse its blessings, are positions which cannot be contraverted. ("Legislature of New York" 56)

The mingling of the will of God and the will of the State is, in some ways a traditional device applied by monarchs throughout history. In other ways, though, it was of special appeal in an early America which seemed to demand such civic expression at every turn. Clinton's expressions of God's inherent pleasure with the acts of democrats and with the refinement of His creation were popular and recognizable concepts, as were his appeals to labor, science, and government.

Notably, Clinton does not refer to engineers or engineering in his speech. While specific occupational terms such as architect, builder, and surveyor were popularly used as both personal labels and to note categories of professionals, the complex term engineer, at this time, retained nebulous associations with military fortifications—especially as conflicts with Britain had reenergized popular reminiscence of the still recent Revolutionary War. As well, the term seems more often to have been used in the context of a specific job (as in: the engineer of the

Morris Canal) or, sparingly, to apply only to those notable and experienced builders (typically British and French talent that had been imported).

The Erie Canal, of course, was not the first canal constructed in the United States. Canals and river improvements along the Susquehanna and Schuylkill rivers have been alternately constructed and abandoned since 1790 in efforts by influential businessmen in Baltimore and Philadelphia each to secure for their city inland trade. Likewise short connections were made from the Connecticut, Potomac, and Delaware rivers to local waters to further trade routes and bypass navigation trouble spots.[36] The Erie Canal was, however, the first canal in the world of its scale. More than twice as long as the Languedoc, the canal built hundreds of years earlier in France to connect the Mediterranean and Atlantic Oceans, the path of the canal would, in a number of places, parallel navigable waters and connect the Hudson not to closer Lake Ontario, but to Lake Michigan. The Erie Canal was also unique in that its construction was managed by non-military American engineers (rather than experienced British or French engineers or engineers trained at West Point or in the army corps). In fact, the two New Yorkers—Benjamin Wright, a failed surveyor from Rome, and James Geddes, a pioneer who had set up a small salt operation in Syracuse—had little canal building experience at all when selected by Clinton to lead the initiative. Political appointees, Wright and Geddes soon became authorities on the topic in part by reading and in part by learning on the job.

The completion of the canal in 1825 was accompanied by a ceremonial parade of vessels from Lake Michigan to New Jersey's Sandy Hook, a peninsula extending into the waters where the Hudson Bay meets the Atlantic Ocean. At Sandy Hook, on the vessel *Seneca Chief*, then Governor Clinton poured a barrel of water from Lake Michigan into the Atlantic Ocean to celebrate what at the time was called the Marriage of Waters. The spiritual overtones of the ceremony and the accounts of the accomplishment that followed were no doubt influenced by the monumental task and by the Governor's disposition to such imagery. Carl Carmer's historical

[36] For an excellent book on the construction of early canals, including the Erie Canal, see Shaw.

narrative of the event (Chapter 20 of his *The Hudson*, the fifth book in the Rivers of America Series), illustrates the pervasiveness of the metaphor in New York City, where the parade would end. Describing the sympathetic parade of "landlubbers" through the streets to the battery, Carmer makes special note of trade groups taking up the metaphor for their displays.

> The tailors marched proudly, carrying out the bridal idea of the occasion with two large banners, on depicting Adam and Eve under a tree in the Garden of Eden, with the inscription "United We Are," and the other reading "I was naked and ye clothed me." Tiny white-clad Master Hatfield led the men of his father's trade, the hatters, bearing in his youthful arms a flag on which was printed a couplet:
>
> > Rocks and hills can't now restrain
> > Erie's Waters from the Main. (169)

Carried to its logical extent, the marriage metaphor positions the Governor, who called for the union and who presided over it, a sort of priest. Which, perhaps, makes the engineers in the background who actually constructed the linkage either God or, if God could be construed as the state of New York who financed the project, at least the hand of God. Renowned naturalist Samuel Latham Mitchell reinforced this idea in his speech which he accompanied with vials of waters from around the world.

> …he [Mitchell, referring to himself in third person,] would tell you how recently imparted influence of republicanization would henceforward cooperate with the sea's phosphorescence to render it luminous, and with its salinity to continue it wholesome; he would portray freedom pervading the billows and rolling with every wave to the shores, and trace its workings upon the compacted continents and scattered islands comprehending within its embrace. Had he the ability he would observe that this renovating and regenerating would rise, by exhalation into the atmosphere, and impart some of its qualities; that it would impregnate the clouds and descend in rains and dews; that it

> would enter the vegetables and animals which constitute the food of the human race; and that finally, the frame of man himself would be gradually so modified and mended by it, that tracts bordering on the Senegal, the Gambia, and the Congo, shall lay aside their ferocity and enjoy, as we do ourselves, Liberty, under the guidance of the Law. (Carmer 168)

With the completion of the Erie Canal, those waters contained by the lands of democracy had been released into the world's waters where, as Mitchell asserts, they will fertilize the world. The waters themselves, exposed to democratic values will be converted and become agents of liberty around the world—even most savage Africa. In Mitchell's speech it is mankind, or maybe democrat-kind, that has accomplished such a feat.

But the engineers who planned and oversaw the project were certainly recognized as well; if not as the articulators of global democratic insemination, as men who would affect the intercourse of nature and man at man's behest. Figures like Wright and Geddes, and like John Jervis, Nathan Roberts, and Canvass White, each of whom made careers from their work on the canal, are now the foundational names in the history of American civil engineering; the American Society of Civil Engineers, in fact, named Wright as the "Father of American Civil Engineering" in 1969 (Weingardt 4). When Thomas Jefferson, originally an opponent of the canal, received one of a number of honorary commendations from the canal corporation, he responded referring, if not to the engineers nominally, that the canal will "prove to mankind the superior wisdom of employing the resources of industry in works of improvement rather than destruction" (Jefferson, "Letter to…").

Originating in the revolutionary period, debates over the role of engineers in the defense and development of America and the rationalization of engineering works, like war and canal infrastructure, would become the core themes of the American industrial revolution. Moreover, the role of the engineer as *fonctionnaire* and as the skilled arm of the government would become more important in a democratic society and in a society in which the military is civilian led and restricted from taking police action. The infrastructure for educating an elite class of

engineers, however, would be firmly established in America only after government intervention to create an authorized system of engineering colleges after the Civil War.

3 The self-made engineer goes to school: Institutionalized education(s) for engineers

The corporations created to construct American canal and rail projects during the first half of the nineteenth century employed as engineers a certain class of technical man who, prepared by a rudimentary mathematical education and plenty of practice surveying and drafting, rarely had any formal training in the sciences or mechanical arts. While a significant number of graduates of West Point worked as engineers on these projects, there were only so many West Point graduates to go around, and so they made up only a small fraction of all the engineers employed to survey and construct canal and railways. And while it may have been advantageous to consult an expert French of British engineer when designing the overall layout of a project, the mundane mile-by-mile design tasks were rarely assigned to expensive and in-demand foreign talent. Instead, rail and canal engineers developed their methods by a process of learning on the site—a process akin to apprenticeship process that was also being practiced in the mechanical trades at the time.

The image of the engineer in the early decades of the nineteenth century—exemplified by men like Wright and Geddies—was that of a man who worked his way to such a position rather than getting a fancy education, of a self-made man whose competence came from common sense and a willingness to work hard. By the end of that century, however, the term would largely apply to graduates of three- to six-year college degree programs in nearly a dozen specialized fields represented by as many professional societies. The infrastructure for that system, over the course of the nineteenth century, was built upon the intersection of English, French, and German models of higher education with a chaotic spectrum of ephemeral private and public educational venues, as well as upon new social and political initiatives that expanded the role of general education (and scientific education) in everyday life.

Colleges at the turn of the century: National initiatives to broaden education and the conservative response of colleges

By the end of the eighteenth century, there were twenty-four established colleges in the United States, including ten non-sectarian colleges.[37] These schools were attended by fewer than 2,000 students and employed fewer than 100 instructors—the largest schools, Yale and Harvard, each enrolled around 200 students; the smallest, William and Mary, enrolled 53 students (Cubberly 104). While not regulated or associated in any official way, these schools had similar curricula based English university's Oxford model: classical and modern languages, English grammar and rhetoric, literature, history, geography, theology, philosophy, geometry, and logic. American universities, however, were slowly liberalizing their curricula: moving more toward elective-based degree programs and developing curricula in mathematics and natural philosophy. Nearly all American institutions had adopted courses in mathematics and natural philosophy (which often included elements of what would later be distinguished as "applied science" or "engineering" topics including hydraulics and mechanics) during the previous century.[38]

In 1708, the newly elected and controversial president of Harvard John Leverett appointed a non-faculty "tutor" in the sciences.[39] William and Mary, in 1712, was the first to establish a chaired professorship specifically for natural philosophy and mathematics. Occupying this chair at the time of the American Revolution was James Madison, who, in 1777, was made president of the university and who, as president, made several sweeping curricular adjustments including introducing a partially elective system of courses (which included an option for students to opt out of advanced levels of classical language and allowed students in other degree paths to take

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[37] These include the members of the Ivy League, excluding Cornell, (i.e., Harvard, Yale, Princeton, Dartmouth, Brown, Columbia, and the University of Pennsylvania), as well as William and Mary, the University of North Carolina (the first and at the time only state institution), and Queen's College (which is now the New Brunswick campus of Rutgers).

[38] Both Emmerson and Cubberly make this assertion in their descriptions of the period.

[39] John Leverett was Harvard's first non-clerical president and was elected after opposing former president Cotton Mather proposal to require students to swear a loyalty oath which, among other things, would have required they vow the evidentiary superiority of the Bible. His tenure is described in Ch. 6 of Morison's history of the school.

math and natural philosophy as desired) and ending the professorships of humanity and of divinity—both of which had been tied intimately to English traditional sources (McGivern 19).[40]

Like James Madison, other political and philosophical leaders in the formative period after the revolution worked to construct (or reconstruct) linkages between higher education and national and industrial concerns, often by making bold statements about state educational missions with universities in mind. John Adams wrote into the Massachusetts constitution of 1780 that it was the function of that state to "to encourage private societies and public institutions, rewards and immunities for the promotion of agriculture, arts, sciences, commerce, trades, manufactures, and a natural history of the country." Later, in 1818, the Charter of the University of Virginia would employ similar wording attributable to Thomas Jefferson. These statements would uniquely bind democracy and education, not just through the ideal of an educated citizenry—one that would be able to make effective democratic decisions—but also though the ideal of an educated workforce, one that could sustain an effective economy given the lack of labor and vast resources available on the American continent.

Leveraging these republican ideals, advocacy for educational institutions associated with the federal government appeared periodically in political debate and in the popular media. West Point, as has been mentioned, became a federally funded military school in 1802 but was not fully endowed until the 1820s. Proposals for a national non-military university, however, began appearing in Congress as early as 1787 after the publication of editorials by Philadelphia doctor Benjamin Rush.[41] Rush's letters, published in both specialized and popular venues like *American Museum* and the *Federal Gazette*, articulated a need and a plan for a university which would prepare graduates of state institutions for prominent national positions in government and in

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[40] While not the stated purpose of his paper, the relevant excerpt from the university's charter illustrating how these requirements were related to the school's founding by English writ is captured in Ewing.

[41] Rush's advocacy and the debate leading up to Congressional vote on the National University bill have been described by, among others, Castel. (Also, for an excellent, if antiquated, summary of Rush's work and influences, see Good.) As Castel and others have noted, Rush's plan for a university resembling France's National Academy was likely shaped (or at least was predated) by a plan by the Chevalier Quesney de Beaurepaire to establish a network of such schools in the country. This plan, however, did not share the publicity of Rush's letters, which were reprinted in newspapers up and down the coast.

industry. In perhaps his most widely read article, printed following the Constitutional Convention failed to draft specific provisions for a national institution, Rush articulates the need for such an institution.

> "Your government cannot be executed. It is too extensive for a republic. It is contrary to the habits of the people," say the enemies of the Constitution of the United States. However opposite to the opinions and wishes of a majority of the citizens of the United States these declarations and predictions may be, the latter will certainly be verified, unless the people are prepared for our new forms of government by an education adapted to the new and peculiar situation of our country. To effect this great and necessary work, let one of the first acts of the new Congress be, to establish within the district to be allotted for them, a federal university, into which the youth of the United States shall be received, after they have finished their studies, and taken their degrees in the colleges of their respective states.

Rush, in proposing a national university, is appealing for a national unifying force—a sort of government graduate school, where the best of each state's higher education system could come to be groomed for public service. Later in the article, Rush suggests briefly that, by thirty years after the creation of the college, it should become a requirement for non-elected government positions. At the university, those of diverse background would come together for a common experience, a common education in the ongoing American Revolution.[42]

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[42] Just as it became common in communist political rhetoric of the twentieth century to refer to the ongoing revolution, texts from the decades after the American Revolution often employ the same device: the war with Britain may be over, but the Revolution is a continuing project. Another, and more frequently anthologized, of Rush's articles on education, "Address to the people of the United States," actually begins with a similar statement. "There is nothing more common, than to confound the terms of American revolution with those of the late American war. The American war is over; but this is far from being the case with the American revolution." This article is reprinted in Good (198).

To this end, Rush's university would teach not only government, but ten other subjects: history, agriculture, "principles and practice of manufactures," "the history, principles, objects, and channels of commerce," mathematics (but only those portions "necessary to the division of property, to finance, and to the…practice of war"), natural philosophy (but, once again, only those parts "which admit of an application to agriculture, manufactures, commerce and war"), natural history (which is again qualified by an anecdote about how such knowledge can be useful in trade), philology, the modern languages of German and French, and athletics (again, qualified as those exercises useful for promoting health, etc.).

In opposition to the Oxford traditional curriculum still espoused by American educational institutes of the day, Rush's list does not include classical language and does include, high on the list, agriculture, manufactures, and commerce. Notable as well, terms which might seem to align with, at least the American version of, from the Oxford curriculum (i.e., mathematics, natural philosophy, natural history) are qualified: only those things which are useful from each is selected for the new curriculum, specially tailored for American needs. Rush's elaboration on the term philology (which he defines as rhetoric, criticism, construction, and pronunciation) further evidences the practical, scientific, and political foci of his curriculum:

> Instruction in [philology] will become the more necessary in America, as our intercourse must soon cease with the bar, the stage and the pulpits of Great Britain from whence we received our knowledge of the pronunciation of the English language. Even modern English books should cease to be the models of style in the United States. The present is the age of simplicity of writing in America. [Various complex and florid styles] are all equally unnatural, and should not be admitted into our country. The cultivation and perfection of our language becomes a matter of consequence, when viewed in another light. It will probably be spoken by more people, in the course of two or three centuries, than ever spoke any one language, at one time, since the creation of the world.

Rush's assertion that a new study of American English must evolve has obvious political overtones in an America recently free from British rule. His further assertion, however, is that American English presents an opportunity for the development (indeed "perfection") of a simple direct language, a language which will not only act in to enhance democracy but join citizens of the new continents.

Recognizing the arguments against the university, Rush in one part of his article addresses those who would insist on paying the national debt first; in another, he speaks to those who would argue state primacy over the federal system. Rush also addresses the generally anti-education, anti-elite, even anti-intellectual arguments by drawing a comparison to European models.

> While the business of education in Europe consists in lectures upon the ruins of Palmyra, and the antiquities of Herculaneum, or in disputes about Hebrew points, Greek particles, or the accent and quantity of the Roman language, the youth of America will be employed in acquiring those branches of knowledge, which will increase the conveniences of life, lessen human misery, improve our country, promote population, exalt the human understanding, and establish domestic, social and political happiness.

While most writers of the period (mostly after Rush) would argue for an American University on the grounds that Britain, France, and German each have equivalent institutions, Rush uses European universities for an altogether different rhetorical point—he uses them as a foil, to highlight how the education he is proposing is practical education, with practical desirable benefits. At the heart of Rush's argument for a national university is not the inherent value of intellectual pursuits, it is the utility of an institute higher education.

By 1790, the proposal had gained the support of a number of prominent government figures including George Washington, who charged Congress with improving national unity and civic understanding through education either by "affording aids to Seminaries of Learning already established, by the institution of a national University, or by any other expedients" (Twohig

4:547).[43] Despite Washington's advocacy, however, a number of bills—some directly establishing a university, others indirectly aimed at establishing corporations to act on the government's behest—were defeated by opponents claiming fiscal conservatism.

During Washington's presidency and in the years after his death in 1799, however, at least a dozen books and pamphlets were circulated containing elaborate plans and proposals for a national institution. These tracts—many by national figures including Noah Webster, Samuel Knox, and E. I. du Pont de Nemours—articulated variations of the French Academy model heralded by Rush's initial plans.[44] They largely failed to gain Congressional attention, however, until 1806 when diplomat and notable intellect Joel Barlow produced a pamphlet arguing for the unique opportunity of America to become a cultural and educational paradise.

Entitled *Prospectus of a National Institution*, Barlow prescribes a comprehensive national institution, like one envisioned by the Napoleonic reformations to the French system of academic schooling and government service, but in an American democratic setting. Including schools of mines, roads and bridges, medicine, veterinary science, and general science and supported by a conservatory of useful arts and manufactures, a museum of fine arts, a national library, and an observatory.[45] Barlow's proposal (likely because of the influential nature of Barlow himself) received the backing of Thomas Jefferson, then in his second term as president, as well as Pennsylvania Senator George Logan, who, an anti-war Quaker at the time of the quasi-war with France, commanded a block of Senate votes. [46]

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[43] Washington would go on to advocate a National University throughout his presidency and after as a private citizen, instructing the planners of the capital city to allot space for the school in what would today be West Potomac Park (specifically the area occupied by the western half of the Lincoln Memorial's reflecting pool) and, at one point, even offering his own land grant for the institution.
[44] For a survey of these writings and many more, see Hansen.
[45] Barlow's short prospectus in which each of these items is mentioned is included in the references.
[46] For a biography of Barlow well-referenced to primary sources, see Todd. Of the few contemporary biographies of Burlow, only Ford's addresses his participation in the debate over a national university.

At Jefferson's behest, the Senate took up the measure to establish a university, not as a regular bill, but first as an amendment to the Constitution. Why Jefferson chose such an approach on the matter remains ambiguous—James Madison, Jefferson's Secretary of State, had been among the writers of the Constitution at the Philadelphia convention that argued that a provision for a national university be omitted from the text of the document on the grounds that it was clearly within the purview of the Congress, which was charged with constructing internal improvements and providing for the general welfare of the citizenry.[47]

The amendment, of course, failed to make it out of the Senate for ratification. And the amendment process lent credence to arguments against subsequent legislation; states' rights oppositionists could now cite the process to question the sincerity of those asserting that the ambiguous phrase "internal improvements" could refer to a social institution such as a University and were therefore within the enumerated powers of the legislature. Educational historian George Emmerson, however, also points to the advocacy of a dozen or more existing universities to lobby for the legislative defeat of the amendment establishing a government funded competitor (135).

The fight for a comprehensive national university was lost by the time of War of 1812. Though reintroduced several times by science and education minded presidents including John Quincy Adams and, even, Woodrow Wilson, Congress each time dismissed the idea as outside the purview of the federal government and as unnecessarily or unfairly competitive with the existing educational infrastructure (Castel 295). Despite any work on the part of existing universities to preserve their industry, members of the existing higher education infrastructure did little to address calls like Rush's for practical education. By the mid-1820s, the discussion around the proper role of a university (practical or intellectual) and around university curriculum (classical or flexible and elective) became intense enough that several universities commissioned

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[47] Grouping a national educational intuition in with other engineered works as an "internal improvement" (the same way one would refer to the reconstruction of a natural river into a navigable one) is, no doubt, a rhetorically interesting concept which, unfortunately, would require more extensive knowledge of the private communications of the Philadelphia Constitutional Convention.

studies of their curricular approaches and their role in the community. The most famous of these studies was that of a conservative Yale commission which, in 1828, produced a report arguing the benefits of a rigid classical curriculum including the mastery of Latin and Greek, which were described famously as the only studies that "could provide the necessary disciplines and furniture of the mind" (15)[48]

Supplementing "self-made": Popular organizations and media as sources of scientific and mechanical education

Of course, the sentiments expressed in the Yale Report were by no means the sole operating principles of all institutions of higher education in the United States. Outside of the elite universities, scientific, arts, and trade organizations were being established in each of the major cities. After the revolution, the Royal Society of Arts, which had first been established in colonial New York but relocated to Philadelphia, became the source of a variety of more specialized organizations (some of which persist to this day). The American Academy of Arts and Sciences, the American Botanical Society, and the American Academy of Natural Science were all created during the period of debate over the chartering of a national university. In addition, medical schools (both independent and associated with American colleges) were founded throughout New England and the mid-Atlantic in the decades surrounding the turn of the century. These schools required extensive coursework in biology and chemistry, as well as practical laboratories, which at the time were unique in American educational settings (Emmerson 135–6).

At the same time, mechanics institutes or lyceums, venues of popular adult education, often on industrial and mechanical topics, were routinely created and dismantled in industrial cities

[48] The Yale Report of 1828 has, since its first publication, been a highly discussed document in academic literature. For an interesting and recent "rereading" of the report (accompanied by a digest of the history and the twentieth century discussion and a nice bibliography), see Pak.

across the country.[49] Perhaps the most persistent of these was Josiah Holbrook's institute in Boston, Massachusetts, which became a supplier of apparatuses and museum curiosities for institutes all over the country. Holbrook defined the role of the lyceum broadly, not only as the main organ of adult education in "useful knowledge," but also as an outlet for teacher education, a supplement for youth (especially those finishing common schools but unable to afford further education), a partner for (or manager of) libraries and curio museums, a compiler of town history and of local agricultural, geographic, and geological information. Holbrook also made sweeping claims about the ability of lyceums (and generally adult education venues) to improve public discourse and even general conversation which, once supplied with nobler topics, would naturally abandon gossip (Holbrook 26–34).

Founded largely through philanthropic contributions, lyceums (and more specifically targeted mechanics' institutes) hosted libraries, museums, and sometimes workshops and offered courses in industrial and trade topics ranging from craftwork to commerce. Lyceums and institutes were the public outlet for scientific demonstrations, for introduction of trade techniques to local businessmen and craftsmen, and, in some places, for the continuing education of women in homely topics, including composition. The institutes also served as venues for traveling lecturers; in fact, most venues devolved into lecture houses only rather quickly after their establishment. Popular lectures on science were given in most every town either by locally gentlemen experts or visiting lecturers on traveling circuits. Records of large prominent host institutions, like the Franklin Institute and the early Massachusetts Institute of Technology, indicate that admission to lectures was purchased and attendance, in many cities, was high. Lectures, and especially subscription lecture series, were advertised not only as an opportunity to witness curiosities and broaden general insight into the natural world, but also as an opportunity to improve skills and employment opportunities (Hyman 259–63).

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[49] Lyceum, perhaps, is a broader term than mechanics' institute. Lyceums in America hosted public lectures on political and philosophical topics and even entertainment programs as well as acting as industrial education outlets for scientific and mechanical topics. Though, certainly industrial education was a major component of their mission. For an extensive and current discussion of the lyceum movement in America, see Ray.

Universities participated in lyceum outreach by supplying lecturers; additionally, members of university faculties were often key members of local philosophical societies and science institutes. In fact, these societies often succeeded where university forays into the sciences were met with mixed success, in part because they were more attended by public subscription and simply were constituted by larger bodies of members (including local businessmen and manufacturers, who increasingly an important source of funding). The University of Pennsylvania, for example, had America's first independent department of Natural Science in 1816 with five faculty members, but it failed to attract students or financial support and was dissolved when the Franklin Institute was established in the same city in 1824.

While the lyceum lecture system had a definite impact on the public knowledge and discourse—new scientific thought quickly became a hallmark of the learned class[50]—it likely did little to contribute directly to the development of a professional class of engineers.[51] Engineers profiled in Charles Stuart's 1871 *Lives and Works of Civil and Military Engineers* either attended West Point or succeeded through a combination of apprenticeship, exposure to foreign engineering feats, and self-study.[52] The lending libraries and museums supported by institutes, of course, were likely a source of reference material for those who were engaged in self study, though it seems that textbooks, if not equipment, were easily obtainable, especially by the middle of the century, to those of means. [53] Certainly texts in French were available; French texts were used

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[50] Again, see Ray here or any book on American nineteenth century oratorical culture (e.g.,, Clark and Halloran).

[51] There are a few exceptions to this of course. Certain prominent and prolific institutions like the Franklin Institute in Philadelphia had remarkably active research and invention certifying bodies. This organization is discussed more in the final chapter.

[52] This is one of those persisting assertions made by all engineering history texts that could probably never be quantified. Stuart's book of profiles, for example, leans heavily on the engineers who worked on, were apprenticed on, and had derivative connection to the Erie Canal and, even for those with West Point educations, makes assertions of each man's self-education and apprenticeship. Modern works, like James Kip Finch's 1960s *Story of Engineering*, on the other hand, often identify the Erie Canal *itself* as an engineering school (257–300). Suffice it to say that, with the exception of those engineers who had come from military careers at West Point, the idea of education outside of practical apprenticeship never enters into biographical descriptions.

[53] Palmer Riketts, historian of Rensselaer Polytechnic, arguably the nation's first engineering school, quotes Amos Eaton, that schools first professor: "Our country is inundated with wild schemes of learning;

[this note continues on the next page]

at West Point and a number of Stuart's profiled engineers—those whose class afforded them private schooling especially—relied on French texts to self-study engineering principles. English texts written in America—those that were not translations of French texts or simply remedial arithmetics and grammars—reveal something about the disposition of their authors' to the trades.

Kelt and Frost's widely circulated *Mechanic's Textbook*, for example, contains a discussion of entrance into and continuing education for those in the mechanical trade. Largely consisting of numerical tables, the later portion of the book, which the title page makes clear is the work of Frost rather than Kelt, is subtitled: "To which is added, valuable hints to the young mechanic on the choice of a profession; misdirection of industry; intellectual cultivation, and the studies and morals of the mechanic, etc., etc."

In this section, Frost lament's the status of the mechanical trades as "uneducated." Frost's complaint that parents' desire for their sons to enter "learned" occupations (as become doctors, lawyers, or clergymen) rather than become mechanics is both illogical and un-American. Frost points out that collectively merchants, mechanics, and farmers have more money than do doctors, lawyers, and clergymen, that men make acquaintances based on similar tastes and interests not professions, and finally that it is possible to find examples of low-regarded members of the traditional professions that rank below the regard of most mechanics. More interestingly, however, Frost claims that "in a country such as ours, such a claim of superior respectability on behalf of any profession is preposterous" (181) and that any disparagement of mechanics, as a class, would apply equally to the average tradesman as well as to Nathaniel Bowditch (a mariner), Roger Sherman (a shoemaker), Benjamin Franklin (a printer), and George Washington (a surveyor) (184).

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while the speculating book-sellers are sending their harpie-like peddlers to rob our youth of the last fragments of common sense" (62).

On the other hand, Frost asserts that the decision to become a mechanic, if logically reached, should be based on the "fitness [of a man] for undertaking it" (180). Only those who have a natural temperament for the work, he implies, should take it up. And any who do take up the work should take it up in earnest. It is important that a mechanic be a master of his trade if, among other things, he will be able to "superintend with intelligence and authority the workmen under his care" (186). In order to reach a level of mastery, Frost suggests finishing apprenticeship and cultivating the mind at any opportunity—specifically via science and literature. To this end, he suggests attending or subscribing to a lending library, attending public science lectures, and seeking out and making friends of those engaged in scientific experimentation.

> By making himself master of those principles of science which are most intimately connected with his trade, the mechanic, while he is satisfying a liberal curiosity, may possibly be approaching some brilliant discovery, which will speedily conduct him to fortune and fame; and if the lighter reading, generally termed literature, promises no such result, it affords him the most dignified and innocent means of amusement, and preserves the vigour and increases the brightness of his intellect. (189)

> Lorenzo de Medicis by commerce raised his family to princely rank—they were the merchant kings of their age. The American mechanic has no occasion to seek any advancement of this sort, for every voter in our country is something greater than a king; by virtue of the elective franchise he is a maker of kings (198).

In this statement, Frost is challenging an unarticulated premise: that learning not directly associated with practical outcomes is elitist. Instead, Frost rejects the idea of elitism in a democratic society entirely, suggesting that mental cultivation does not function to elevate someone above their trade but, to make one happy and successful in his trade and, as he later points out, to prepare him for the call of political office. In this way, Kelt and Frost's text is

exemplary of texts written by and for American tradesmen—while not rejecting formal education specific to mechanics (none yet existed to reject), it advocates social and personal means of self-development: lectures, reading, social intercourse with the learned and other trades-people, and democratic participation.

Academies: Publicly-supported commercial institutions that educate for "living"

Historians of education, especially contemporary followers of Dewey like Theodore Sizer, have argued that movements for mass education (especially regarding literacy and basic math), which would later become compulsory primary and, eventually secondary, education, grew out of the revolutionary commitment of citizens of the United States to a democratic form government. This is exhibited, for instance, in the texts of state constitutions which adopt various plans for districting and mandating the provision of remedial educational infrastructure, even for the more sparsely populated areas of rural states.[54]

Students who wished to (and could afford to) acquire education beyond basic literacy and arithmetic had a few options. If they lived in reasonable size town or city, especially in New England,[55] they could attended a Latin grammar school—a locally funded school controlled, typically, by a locally elected board which offered a classical curriculum.[56] In addition to these schools, however, were a host of private alternatives that presented themselves as educational options for students in less populated areas or those seeking a sectarian or vocational education. While many of these alternatives were the ad hoc construction of solitary itinerant

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[54] For the most part, these plans consisted of mandating enabled bodies (i.e., cities, counties, townships, etc.) provide such as they see fit. Systems for overseeing such education didn't develop until later. See Cremin for a thorough discussion of the evolution of common schools.

[55] Reasonably dense in the case of the Massachusetts Bay Colony, for example, would be an area which could attract the subscription the 100 families required for a charter (Eberling).

[56] The curriculum of these schools could be described as preparatory. They taught Latin vigorously, as well as the rudiments of logic, geometry, classical literature. Students, thus, were introduced to the Oxford curriculum before attending a university.

educators, others were elaborate private institutions, some (but certainly not all) of which restricted entry, some of which boarded resident students, and many of which were state chartered and at least partially state funded. These latter intuitions, typically referred to as academies,[57] came and went throughout the colonial and antebellum American periods and existed alongside the Latin grammar schools, and later alongside public high schools, as alternative education venues well into the late 1800s when state offered public high school was compelled and they were absorbed into the public system, privatized entirely, or closed due to lack of funding.[58,59]

Largely unregulated and reliant on a mixture of subscription and public assistance, they were subject to the turmoil of local opinion, periodic financial crisis, and competition. As such, academies of the antebellum period rarely advertised exclusive admission and traditional Oxford-preparatory curricula.[60] The diversity of academies is perhaps their unifying feature. In the muddle of early American education, academies were the commercial expression of local demands. Coastal New England academies offered courses in navigation and marine trades; rural academies offered agricultural courses; Franklin's academy in Philadelphia, before its conversion into a university, offered an extensive system of accounting and finance courses. Also, academies throughout the nation offered instruction in basic sciences and mechanics.

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[57] The use term 'academy' is a classical reference, of course, but in this case was likely spurred by Milton's usage of the term in his *Of Education* which education scholars often point to as the initial model for academy education. The term was used so ubiquitously and inconsistently in the eighteenth and nineteenth century, though, that it can hardly be said to have a strong connection back to Milton's essay. For more on this connection, and for excerpts from Milton, see Sizer (especially Ch 1 and Introduction n6).

[58] Several pre-revolutionary academies also exist in the form of private universities today (e.g., Benjamin Franklin's Philadelphia academy is now the University of Pennsylvania, Francis Alison's Free School is now the University of Delaware, the Augusta Academy is now Washington and Lee University).

[59] It's worth noting that those colonial academies exiting into the 1800s were funded out of charter obligations. States in the new nation inherited the contractual requirements which had been established by the colonial and royal government in the century before. This was made clear in the Supreme Court decision following the state of New Hampshire's attempted to intervene in the governance of Dartmouth College (*Dartmouth College v Woodward)*. This decision, ironically, paved the way for the establishment of the contractual system used by states to create independent, publicly-funded, private corporations, not just for education but also for the construction of public works (e.g. canals).

[60] Which, it might be argued is the hallmark of those academies which have persisted into the present as private schools (e.g. Philips Andover and Philips Exeter).

However, academies were not vocational schools. Courses at the Philadelphia Academy, for instance, were entirely classroom and textbook based and were described by administrators and promoters of the school as preparing students for the breadth of practical experiences of American life, rather than for use in immediate occupation (Sizer 31). Rather, academies often justified practical course topics not as vocational but in almost the opposite way: as education for living. At the Topsfield Academy, in Massachusetts, students learned skills for "mental discipline, moral culture, and practical life" (Perley 16). At Philips Andover Academy, students learned "the great end and real business of living." Years later at the Barre Academy students would be securing "the means of securing a sound, practical education, for the business of life."[61]

Academies, perhaps, were separated as a class of institutions from itinerate schools by the commercial savvy of their administration. Competitive advertisements for academies litter the pages of publications in the new country, and appeals for public funding occupy volumes of early state legislative agendas. Both rely routinely on American themes of industriousness and democratic participation.[62] Writing at the turn of the century, Philadelphia doctor and public figure Benjamin Rush suggests that among the responsibilities of the education "business" is the homogenization of American citizens, especially in Pennsylvania, where "citizens are composed of the natives of so many different kingdoms of Europe" whose diverse traditions and habits create conflict (6–7). After making several observations about the nature of the conflicts that arise in heterogeneous communities, Rush goes on to state:

> From the observations that have been made it is plain, that I consider it is possible to convert men into republican machines. This must be done, if we expect them to perform their parts properly, in the great machine of the

[61] Sizer quotes these latter two mottos from Andover and Barre (as well as others like these) from catalogues and advertisements throughout his introduction to his collection of primary sources cited herein.

[62] The marketing efforts and government petitions of both academies and colleges are described in Church and Sedlak.

> government of the state. That republic is sophisticated with monarchy of aristocracy that does not revolve upon the wills of the people, and these must be fitted to each other by means of education before they can be made to produce regularity and unison in government (14).

Rush's commentary illustrates the position of education in the new republic. While going on to assert that modern commerce requires more sophistication (in language and in finance) which can only be brought through education, he comes back each time to this idea of the unity of the educated man as an element of a larger system, a mechanical system. Even if academies could not be called vocational schools, as instruments of education they were still fulfilling a vocational function: they trained citizens for educated participation in society. In fact, this was many academies' declared purpose. Philips Andover Academy, for instance, contained as late as 1852 a statement in its mission: "to furnish the youth of [this] vicinity…the means of securing a sound, practical education, for the business of life" (Sizer 5).

It is tempting to see in the rise of academies as an upstream phenomenon, creating the demand for the later development of scientific and technical university programs. However, academies did not necessarily function to feed students into the growing higher education system. Rather, the backgrounds of students admitted to academies were often the same as those accepted into four year colleges—a combination of common school, perhaps grammar school, private tutoring, self study, etc. By the late 1820s, when Americans were perhaps at the height of anti-elitist sentiment, a strong and populated academy system was, in fact, a competitive threat to existing colleges. This is best illustrated, perhaps, in the 1828 Yale Report which casually dismisses academies as inferior:

> What is the characteristic difference between a college and an academy? Not that the former teaches more branches than the latter. There are many academies in the country, whose scheme of studies, at least on paper, is more various than that of the colleges. But while an academy teaches a little of every thing, the college, by directing its efforts to one uniform course, aims at doing

> its work with greater precision, and economy of time; just as the merchant who deals in a single class of commodities, or a manufacturer who produces but one kind of fabrics, executes his business more perfectly, then he whose attention and skill are divided among a multitude of objects (24–25).

The not so subtle qualifying phrase "at least on paper" is the signal, perhaps, of an open secret: academies advertised impressive plans of instruction, but were often staffed by few teachers of limited background and often had few resources to carry out the diverse programs promised. As Sizer notes, in his introduction to a collection of primary texts on education in the period, academies' reliance on textbooks and recitation freed instructors from the need to know the subject of study and allowed the teacher/student ratio of classes to climb to numbers which would be thought obscene today (28–30).[63]

It is unclear how many of the "self-taught" engineers of the canal era attended academies, but it is certainly likely many did, especially those from New England or New York, from urban areas, or from wealthy families. Of the engineers Stuart profiles, only one (White) was reported as attending an academy. (Of course, half of the engineers in the book were reported as having attended West Point, which itself was called the United States Military *Academy*.) At the beginning of several biographies, however, a lack of means was given as a reason for a lack of formal, presumably academy, education.

It is also unclear how many academies purported to educate students for careers as engineers. While unlikely to brand themselves as vocational schools, academies certainly advertised courses in surveying, in mechanical philosophy, and chemical properties, as well as in natural philosophy (which would have included, in some form, much of the physics that engineering

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[63] Also interesting in this passage is the Yale committee's application of manufacturing and commercial metaphors to education. Metaphors like these, which either objectify students as commodities or privilege them as consumers, exist throughout the pedagogical literature surrounding technical and quasi-vocational education from its inception to the present. These metaphors will become a reoccurring theme in the next chapter, which treats industrialization.

educators later in the century would include in specialized curricula.) Several of the institutes formed by former West Point administrators and graduates (e.g. the Gardner Lyceum in Maine and Aldrich's Academy in Connecticut), none of which survived the nineteenth century, certainly taught topics which would have, even at that time, attracted the label engineering.

The polytechnic institute: The pedagogy of antebellum technical education begins to converge

In the unregulated (indeed chaotic) environment of educational options detailed so far in this chapter, the foundation of a non-sectarian, scientific school in upstate New York by a wealthy landowner and occasional political figure did not likely draw much attention.

The Rensselaer School was just such a school, and Stephen Van Rensselaer III was just such a figure. The last in a long line of Dutch estate owners and, one of the wealthiest men in the country at the time,[64] Van Rensselaer's associations were notable. His maternal grandfather (Philip Livingston) signed the Declaration of Independence. His first wife was a daughter of a renowned Revolutionary War general (Philip Schuyler). And his second wife, taken after the death of his first, was the daughter of William Paterson, one of New Jersey's first senators, the state's second governor, and, by the time of his daughter's marriage to Van Rensselaer, an associate justice of Supreme Court.

In his youth a congressman and serious candidate for governor of New York, Van Rensselaer's apparent reluctance to accept a military commission (foisted on him by political rivals who wanted to keep him out of the elective pool) and his later ineptitude at leading a military incursion into British territory during the War of 1812 sufficiently affected his political image assuring that he would never be elected to statewide office. Instead, he became a popular

[64] In fact, recent analysis by Fortune Magazine comparing historical figures' wealth with national GDP suggests Van Rensselaer was the tenth richest American of all time. Van Rensselaer benefits from the method of computing this statistic, of course, as his fortune predated the American industrial revolution ("The richest Americans").

political appointee, first to membership of the committee overseeing the construction of the Erie Canal, over which he would preside for nearly half of the life of the committee,[65] and later to the directorship of the state's first agricultural board.[66]

Between public service positions and military service, Van Rensselaer went against the land speculation trend of the era, administering the division of Rensselaerwyck (his family estate) into floating-rate perpetual leases which functioned, in the short term, to the general betterment of the county economy.[67] He also deployed considerably resources, additionally, funding libraries, museums, and, most notably, the school at Troy which would bear his name: first called just the Rensselaer School, and eventually, to indicate its connection to the French school model, Rensselaer Polytechnic Institute.[68]

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[65] Notably, his work locating portions of the Erie Canal extended beyond his participation on the commission to actually conducting the geological and topographical surveys of the region through which a portion of the canal would pass.

[66] For a limited biographical sketch of the life and lifestyle of Van Rensselaer, see McClave. However, for a fascinating contemporary commentary on his political life and public perception, see Barnard's *A Discourse on the Life, Services and Character of Stephen Van Rensselaer*. Published in the spring of 1839—Van Rensselaer had died in January of that year—Barnard's book is part biography and part eulogy, and contains a number of insightful and interesting comments about the role of Van Rensselaer as landlord, as public servant, and as proponent of education.

[67] Van Rensselaer's feudal lease arrangements governing the nearly half-million acre New York estate are largely credited for the later upheaval in the farm industry in New York. Under these agreements, rent fluctuated with the price of wheat and renters were given incentives (including the casual neglect of rent collection) for improving their property, which, at the time, appeased farmers who, while not able to purchase their land, were able to operate it under benevolent conditions. When, upon Van Rensselaer's death, however, it was disclosed that his testament specified that his creditors be paid by collecting past rents and fees from tenants, farmers revolted, refusing to pay rents. This revolt led to a decade of political turmoil involving, at various points, the use of state militia troops to enforce payment, secret election deals to empower farmers, a supreme court enforcing finer points of contract law, violent harassment of officials by farmers disguised as Indians, and eventually, and amendment to the state constitution outlawing the practice of feudal leasing. Eventually, however, Stephen Van Rensselaer IV (son of the elder Van Rensselaer) agreed to sell off the estate piecemeal to tenant farmers to make good on the debts owed. According to Charles McCurdy's book on the decade (published in 2001), it is possible to still find homes in Albany the ownership of which requires some nominal annual rents "to some remote assignee of Stephen Van Rensselaer" (336).

[68] The school persists to the present day, of course, as Rensselaer Polytechnic Institute (RPI).

By all historical accounts, the formation of the school was marked by a letter from Van Rensselaer to the Reverend Samuel Blatchford of Lansingburgh, NY stating, in part:

> I have established a school at the north end of Troy, in Rensselaer County, in the building usually called the Old Bank Place, for the purpose of instructing persons, who may choose to apply themselves, in the application of science to the common purposes of life. My principle object is to qualify teachers for instructing the sons and daughters of farmers and mechanics, by lectures or otherwise, in the application of experimental chemistry, philosophy, and natural history, to agriculture, domestic economy, the arts, and manufactures. (Van Rensselaer)

The context of this letter, however, is seldom addressed. In his biographical eulogy of Van Rensselaer, Daniel Barnard notes that this letter, written in the fall of 1824, was preceded immediately by Van Rensselaer's support of a summer-long lecture tour, by Amos Eaton, with whom Van Rensselaer had worked surveying sites for the Erie Canal, and a "competent number of Assistants" employed to "traverse the State, on or near the route of the Erie Canal, with sufficient apparatus, specimens and the like, and deliver, in all the principle villages and towns where an audience of businessmen, or others, could be gathered, familiar Lectures, accompanied with experiments and illustrations, on Chemistry, Natural Philosophy, and some or all of the branches of Natural History" (77). Whether this tour was promotional (preceding Van Rensselaer's announcement of the academy in an attempt to recruit a first cohort of students) or whether the success of this tour influenced Van Rensselaer's perception of the feasibility of a school it is unclear. What is clear, though, is that the letter above was written not two months after the close of this tour and that Amos Eaton would be employed as the head instructor from the opening day of the school.

Based on the text of Van Rensselaer's letter, it is often casually remarked that the mission of the Rensselear School was to educate "the sons and daughters of farmers and mechanics"—Daniel Howe's recent installment in the Oxford History of the United States series, in fact, makes this

claim (552). A careful reading of the passage, however, reveals that Van Rensselaer's "object" was to "qualify teachers for instructing the sons and daughters …," not necessarily to instruct the sons and daughters themselves or to instruct them in farming or mechanics per se. This phrasing is interesting in line with Barnard's reminiscence that Van Rensselaer frequently made attempts to educate his tenants by sending around schoolmasters "of very slender qualifications, for want of better" (78).

Whether Van Rensselaer's early educational initiatives were out of philanthropy or feudal duty (or perhaps self-interest, as education in agricultural methods might encourage his tenants to make improvements on his holdings), Barnard attributes Van Rensselaer's foundation of the school, at least in part, to his dissatisfaction with available tutors. Within a few years of the school's opening, as a scheme to raise enrollment and, possibly, attract state funding, Van Rensselaer had offered the counties of New York tuition waivers for students of their selection who would promise to return home after graduation and teach. By 1830, graduates of the Rensselaer School were teaching in common schools and academies throughout New York and were notable presences in teaching seminaries across the country.[69] In a preface to an 1831 printing of the new Constitution of the School Association of Rensselaer County, the Rensselaer School and its able graduates are credited with inspiring the inclusion of "experimental instruction" in common schools across the state. Despite growing recognition, by the mid-1830s, the school was no longer emphasizing teacher education. It is unclear whether the drive to qualify teachers simply diminished over time as other pursuits took the foreground or whether, lacking support from the state legislature, it was consciously abandoned.[70]

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[69] Seminaries, academies for women that nominally emphasized teacher training, have been well researched as novel academic venues for women in the early nineteenth century. According to the School Association of Rensselaer County, Rensselaer graduates taught at the seminaries in Ipswich, MA; Troy, NY; Columbia, SC; and Sparta, GA (3).

[70] Or it may have just been assumed that a certain portion of graduates would go on to teach just as others would go into other professions. In the 1820s, the process of becoming a teacher was hardly a formal one. While a variety of academies dedicated to the purpose existed (especially, it seems, in North Carolina and Pennsylvania and especially by the middle of the century), the general custom was that

[this note continues on the next page]

Additionally of interest in the letter quote above are the topics and applications listed for study by Van Rensselaer. Topics such as navigation, manufacture, commerce, or agriculture, which might today seem innately vocational or "applied" (or, perhaps, in the language of the day "useful"), were routinely used by academies as cases for recitations (in the education of math, geometry, etc.). Van Rensselaer's stated intention, to educate for "the application of science to the common purposes of life," seems to depart from this tradition, treating subjects such as these as fields of study in their own right. [71]

As such, early educational methods at the Rensselaer School were unorthodox. Students did not participate in the lecture, recitation, and disputation pattern common to the time. Rather, they took turns preparing and performing for each other laboratory experiments under the supervision of faculty. Likewise, students were examined at regular periods by evaluators for whom they would perform and rationalize experiments of their choosing. Students also made regular trips to local worksites (farms, mills, tanneries, etc.) returning to the laboratory after to describe and test their observations about the methods used at those sites. Finally, students were obliged to get exercise not by "degrading contortions called gymnastics" which "detract from the dignity of deportment which becomes a man of science" but by surveying land, collecting animal, plant, and mineral specimens, and experimental gardening. (Ricketts Ch 4; "degrading contortions…" pg 60).

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anyone could teach a level of schooling they had successfully completed—especially if they had completed the level above as well. The earliest states didn't begin licensing teachers until the 1890s. And then education from a renowned academy or college more than qualified a man or woman to teach. See Lucas, especially 6–18.

[71] Such pedagogical position might seem like a lot to read into one line the letter, especially as Eaton was likely the pedagogical force behind Van Rensselaer's designs. Ironically if the language was directly inspired by Eaton, then it seems safest to interpret it as significant rather than the idle arrangement of words. Whether or not the phrasing was inspired directly or indirectly by Eaton, interestingly, it matches phrasing found in the mission of London's Royal Institute in 1800.

There is no question that Amos Eaton, the school's first principle instructor, influenced these educational practices.[72] By the end of his career, Eaton, a lawyer by education, was renowned throughout the state as not only an educator but also as a surveyor, a geologist, and, most especially, a botanist.[73] His renown came not only from speaking engagements and his role at the Rensselaer School, but from various published works, from reference treatises on regional flora to guides for rural teachers and practitioners. His first work, a 32-page manual on surveying published in 1800 (when he was 17) was fully entitled: *Art without Science: or the Art of Surveying Unshackled with the Terms and Science of Mathematics: Designed for Farmers' Boys*. In this manual he claimed to "simple story of the practice" without distraction from the "speculative principles" or mathematics. "The cloister" he went on to assert "begins to surrender to the field where things, not words, are studied" (1). The title and these quotes from the introduction of Eaton's work clearly indicate his bias toward the period's tropes of practical education and useful art, which, he seems to assert, are achievable free from the imposition of higher-order pursuits (like mathematics and language). Reconstructing Eaton's pedagogy from the latter quote, the roots of what he would come to call an "experimental" pedagogy[74] can be seen: students learn from doing or from observing, rather than from reading and reciting.

Throughout Eaton's writings before and during his tenure at Rensselaer, it is easy to find statements like these: emphasizing the practical over the pure, the applied over the scholarly, dismissing complex constructs and granular knowledge in favor of the tools and general themes immediately applicable to the vocations. While a modern reader might be tempted to recognize

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[72] In fact, he may have even influenced the actual wording of the texts mentioned so far. Edward Stevens has suggested as much in his book on the rise of technological education in the early nineteenth century *The Grammar of the Machine* (151).

[73] Law was an early career for Eaton. Imprisoned for forgery from 1802 until 1815, when he was pardoned by Governor DeWitt Clinton, Eaton did not practice law again after. For a biography of Eaton, see McAllister (regarding his imprisonment and pardons, see pages 71, 132, and 155 respectively.)

[74] Eaton doesn't use the work pedagogy per se. Rather, he talks about experimental learning, experimental method of teaching, or experimental school or classroom. Maybe a misleading (or easily misinterpreted) term, "experimental" in this case does not indicate the pedagogy itself was an experiment, rather that the learning/teaching taking place relied on the conduction of experiments.

Eaton's tone as anti-intellectual, Eaton was, at the same time as these publications, pursuing an elaborate research agenda—documenting the flora and geology of the Hudson River valley, conducting chemical and horticultural experiments, etc. His seemingly anti-intellectual didactic voice did not match his lifelong commitment to the Baconian ideals of scientists of the time.[75] It is perhaps more enlightening, then, to consider samples in Eaton's writing for teachers (rather than students), like his *Chemical Instructor* which was published in 1822 and republished throughout his tenure of service at the Rensselaer School.

Like his earlier surveying work, the full title of his chemistry text—*Chemical Instructor: Presenting a Familiar Method of Teaching the Chemical Principles and Operations of the Most Practical Utility to Farmers, Mechanics, Housekeepers and Physicians; and Most Interesting to Clergymen and Lawyers. Intended for Academies and the Popular Classroom*—reveals something of Eaton's disposition.

> …I have undertaken to present the science in a manner, which shall render it accessible to all academies, and to all other public schools…also to popular assemblies, where lectures are given. I have endeavored to bring down the sublime science of chemistry within the reach of the laboring agriculturalist, the industrious mechanics and the frugal housekeeper. But in doing this, I hope I have not degraded the science by low or vulgar descriptions; though I have everywhere aimed at a familiarity in manner which must necessarily sink below that style which is always desirable. (5)

In this passage, taken from the book's introduction, we get a different sense of Eaton's appreciation for the "sublime science" and its relationship to the vocations. And throughout the work that follows, Eaton suggests a program of accommodation: introducing elemental

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[75] A later chapter of this dissertation discusses the themes of science and research in more depth. McAllister, however, is a great source for information about the scientific purists of Eaton. Also, though I have not been able to obtain a copy, Van Klooster's biography, published by the American Chemical Society, is apparently focused on Eaton's life as a chemist.

substances in their environmentally common rather than elementally pure states, glossing over the specifics of, what today would be called, oxidative states in favor of the common agricultural and industrial properties of substances, etc. It might be suggested, in fact, that method of demonstration and hands on experimental work advocated by Eaton to replace recitation were, for him, the ultimate forms of accommodation.

Eaton explains his pedagogical disposition most directly, perhaps, in an 1828 address to the Buffalo School Association, published shortly thereafter as a pamphlet entitled *A System of Education Proposed for the Improvement of Common Schools.* In the pamphlet, Eaton first articulates his "experimental" pedagogy dialogically—answering a half dozen questions which he, presumably, would anticipate from an audience of educators—and then in the form of a short essay. Eaton reveals first the deficiencies he finds in the monitorial system (the common program for vocational education at the time which, according to Eaton, encouraged students to form habits without any foundation in science) and with the arrangement of topics based on maturity of the student which, he suggests, insufficiently emphasizes sense and memory in early years and judgment in later years.[76] Then, accompanied by details of the facilities and faculties required to execute an experimental curriculum, Eaton then goes on to state that:

> I would adopt the modern improvements in science, and give them a practical direction to the concerns of life. I would also introduce those facilities in aid of classic studies, which experience has justified. (5)

The balance and practical application expressed in this statement are the hallmark of the Rensselaer School's curriculum in the 1830s and 1840s. While Palmer C. Ricketts, historian of Rensselaer, offers perhaps the most nuanced review of annual changes to coursework and evaluation practices at the college, a variety of other treatments, most of which are based on Ricketts's text and visits to RPI's archives, offer different perspectives on the period. Emmerson

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[76] Further detailing this point, Eaton suggests the study of named things (flowers, animals, etc) and history at an early age and then grammar and rhetoric at a later age. He advises against fiction at any age. (5)

uses curricular content to argue for the status of Rensselaer, which he contrasts with West Point, the Gardner Lyceum in Maine, the Franklin Institute, and even the French *Ecolé Polytechnique* in his history of engineering education. Edward Stevens, on the other hand, dedicates a chapter of his history of early American technical literacy to the school. Entitled "A precedent for technological education," this chapter relies on annual catalogues and teaching and administrative documents found in the RPI archives to detail the evolution of the Rensselaer School's curriculum from one of general and pedagogical scientific education to a more specialized, and eventually polytechnic style, curriculum.

The Rensselaer School was renamed the Rensselaer Institute in the 1833 rewritten by-laws. These by laws also clarified the administration of the curriculum at that point: dividing the institute into two departments (experimental and classical) and elaborating on the teaching responsibilities of each for the winter (16 week) and summer (24 week) terms.

In the winter, the experimental department was charged with teaching "Practical Mathematics, particularly Mensureation with models, Land Surveying and Engineering, Astronomical measurements and calculations, particularly as applied to navigation."[77] It is notable that Land surveying and Engineering are presented together as one item in the list. This is indicative of the transportation and public works orientation of the term engineering in the region and period immediately following the completion of the Erie Canal. When the Rensselaer Institute would finally offer its first one year degrees in engineering a few years later in 1835, they would be degrees in Civil Engineering, not engineering in general.

[77] The wording, capitalization, and punctuation have been quoted correctly here. I assume that, in this list, Astronomical measurements with its following text is the last list item and that a conjunction is absent or unnecessary in the phraseology of the day. The alternative, of course, would be to read the sentence such that engineering, astronomical measurements and calculations were grouped and simply lacked a serial comma. Which would alter the meaning of the modifier that ends the sentence and thereby the scope of engineering education expressed in the charter significantly from my interpretation in the text. Notably, the pattern of capitalization supports the reading I assert in the body of this paper.

In addition to these responsibilities, the experimental department in winter was also in charge of preparing and evaluating students' extemporaneous speeches. The by-laws specify students give five such speeches per week, one on each of the following topics: "Rhetoric, Logic, Etymology, Physical Geography, deduced from Geology, and Civil Geography, deduced from History." [78] Notably, composition, etymology, and modern languages, if any were selected for the term, were taught by the Classics department during the same term, as was mechanics.

In the summer, when outdoor work in upstate New York is more plausible, the experimental department taught botany, zoology, geology, "Mechanical Philosophy and Chemistry, with practical applications." The classical department, at the same time, would teach, among other things, mechanics, land surveying, extemporaneous speaking, book keeping, botany and geology.

Though no justification or further elucidation of these topics occurs in the by-laws, both Ricketts and Stevens rely on archived annual catalogs to describe a variety of activities, field trips, indoor and outdoor laboratories, and oral testing schemes. While both descriptions (and a perusal of the few digitized documents put online by RPI's archives) leave a modern reader with the feeling that the week by week curricula was created somewhat on the fly, the practical rooting of topics and hands on experiential approach (a form of which would be advocated ardently in the following century by American educational pragmatists) seems to be the unifying factor.

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[78] I don't think that the intent as was written in the by-laws was for each student to give five speeches per week for each of the 16 weeks of the term. First, that would be overwhelming, especially when the topics of the speeches are prescribed as they were. But, more because of the phrasing of the sentence preceding the instruction, which opens with the phrase: "The remainder of the Term shall be occupied." While no specific period was mentioned for the topics quoted in the previous paragraph, (e.g., "Practical Mathematics, …), this paragraph of the by-laws seems to indicate that there is some natural time when that would stop and the speaking portion of the semester would begin. (Or perhaps the weeks of speaking would be spread throughout or depend on weather conditions as some other instructions in the document do.)

In 1833, after one year's attendance to this program, a student was awarded a "Bachelor of Arts in Rensselaer School" which, according to the by-laws, is "intended to imply that he has been a successful learner in said school in the application of science to the arts." Then, after three years of productive employment, or after another year of coursework, students were awarded a similarly labeled Master of Arts. Notably, it is specified in the by-laws that students should not use the abbreviations BA or MA, but should use the full title.[79]

While this style of awarding Latin degrees might make Rensselaer under Eaton seem more like a college than an academy or a mechanics institute, the traditional colleges of the time probably didn't see it that way. Though many colleges, including Harvard, Yale, and the University of Pennsylvania, had, by the 1830s, employed at least one faculty member in natural philosophy, the separate scientific programs and schools, which would become a feature of high-end universities in the mid-1800s, had yet to be created. The Lawrence Scientific School at Harvard was founded in coordination with a bequest in 1847. The Yale Scientific School, renamed the Sheffield school in 1860, was founded out of the several professorships in natural philosophy and chemistry in 1847; a faculty member in civil engineering was added to this school in 1852.[80] Neither of these schools, however, granted degrees in engineering until considerably later. The Rensselaer Institute, however, granted its first 40-week degrees in Civil Engineering in 1835 and, after reorganization, its first 3-year Civil Engineering degrees in 1853.

The Rensselaer Institute's shift in 1835 to granting a degree in Civil Engineering and a Bachelors of Natural Science (CE and BNS) was organized in part with education and engineering advocates at the state legislature in Albany.[81] A notice issued promoting the first year's degree claims, in

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[79] I assume this would be abbreviated BARS and MARS, though I've seen it written different ways Ricketts, for example, writes "A.B. (r.s.)," which may have been the convention. The by-laws themselves articulate the bachelors designation as BA, rather than AB, however.

[80] The first chair of engineering in a British University was in Glasgow in 1840, where was "denied use of lecture rooms by his colleges, who disapproved of the development" (Emmerson 140 note).

[81] Historians of Rensselaer, including Ricketts and Rezneck, cite 1835 NY legislation which enabled the formation of a mathematics department at Rensselaer as the beginning of the program in Civil Engineering at the Institute. While I have yet to find any information beyond the text of the legislation, I

[this note continues on the next page]

great detail, a twenty-five topic course of study, including not only surveying, sighting, soils, and fluid flow, but also chemistry, mathematics, composition, and speech (Eaton "Notice…").

That first year, four students were awarded the degree CE. Two years later, ten were accepted into the same curriculum. While all 10 matriculated, Rezneck quotes the reservations of one student's evaluator, who advised the student to read "good authors, in order to supply the defects of his literature." The evaluator goes on, however, to suggest this to be a typical problem for students at the school and wonders "whether this deficiency can be remedied in any other way than to require higher literary qualifications for admission to the Institute" (Rezneck 46). If these students were, indeed, among the first students in America to be awarded degrees in engineering, then it appears that complaints about engineering students "literary qualifications" (in this case, likely a proxy for written and oral communication skills) are as old as engineering education itself! (As is the idea that students should have learned to write before entering an engineering program.)

Enrollment was suitable, according to subsequent bulletins, not only for "young men who have pursued a classical course, so far as to be fitter for college, and who are yet too young" but also for those who, having "finished a regular course of classical education" (i.e., college) desire a practical education, or even "practical men" who desired an education to match their profession (Rezneck 74).[82] The unique course in engineering attracted students from all over—while most were from New York or New England, by the late 1840s, the school boasted students from all states and even Latin and South American counties.

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would assume that the legislation was proposed to the legislature *by* administrators of the school (likely Amos Eaton, who seemed to be at the root of any initiative)—i.e., that the legislature did not act by itself, surprising the Institute. In either case, the legislation received an appropriation from the state General Assembly (for equipment, etc.) which likely did expedite the development of the degree program.

[82] Notably, Rezneck quotes circulars which seem to appeal to agriculturalists and engineers equally. This is interesting, as the school rarely appears in histories of Agricultural education except when they assert, as does the 1909 Cyclopedia of American Agriculture, that no "agricultural instruction seems ever to have been given by the Institute" (4:388).

It was only after the deaths of Stephen Van Rensselaer in 1839 and Amos Eaton in 1842 necessitated it that the Institute finally received significant state funding. From 1846 onward, the Rensselaer Institute, then under the leadership of George Cook, filed annual reports to apply for funding from the New York State Literature Fund. These reports, copies of which are archived at RPI, have enabled historians of Rensselaer to document the curriculum and financial and enrollment statistics of the latter half of the nineteenth century—a period beginning with the drastic reorganization of the Institute and ending with the professionalization of engineering and engineering education.

The 1847 appointment of Benjamin Franklin Greene as senior professor was a turning point for the Rensselaer Institute. Historians of Rensselaer (like Ricketts and Rezneck) and of engineering education (like Emmerson, Rae, and even Wickenden) attribute to Greene the "modernization" of both the institute and the curriculum. The tenure of Greene, as Rezneck puts is, marked "the end of improvisation, however ambitious, and the initiation of a systematic program and policy of growth" (78). Greene, who had conducted a tour of French and German engineering programs, imposed a polytechnic model on the school—even printing the name of the school to be Rensselaer Polytechnic Institute, though the name change would not be officially sanctioned by the state until 1861.[83] Between his appointment in 1847 and 1853, the course requirements for a degree at the Institute grew from one year to three.[84] Departments representing fields of study were organized at the college, separating the teaching of mathematics and physics from chemistry and geology from mineralogy, botany, and zoology (Rezneck 79). By 1850, reports produced by the Institute for the state were earning the school a larger share of the Literature Fund, a share more akin to that received by colleges than by academies or institutes (Rezneck 83).

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[83] In the 1847 catalogue, the school was further described as "a Polytechnic School for the application of Mathematics, Physics, Chemistry, and Natural History, to Civil Engineering, the Arts and Manufactures, and Agriculture" (Rezneck 78).

[84] More specifically, students enrolled in 1850 graduated in 1853. So, while students pursuing their second year masters did graduate in 1851, there was no class of 1852.

An 1855 bulletin published for "the citizens of Troy" contains, perhaps, the most complete account of Greene's influences and plans for the Rensselaer Institute. In this bulletin, Greene describes the recent reorganization of the Institute as well as the programs of education at a number of French and German polytechnics. He goes on to articulate the mission of the new Rensselaer school, in terms of the "true idea of a polytechnic institute" (32). According to Greene, true polytechnic institutes aim to educate six classes of "Scientific Technist":

1. *Architects*, who "Design and Superintend the Construction of *Edifices*";
2. *Civil Engineers*, who "Design[] and Construct[]…Common Roads; Railways; Bridges; Tunnels; Canals; Docks; River and Harbor Improvements; Lighthouses; the Supply and Distribution of Water for Towns, Sanitary, Agricultural, and Manufacturing purposes"
3. *Mining Engineers*, which include both mining and metallurgy
4. *Mechanists*, who are "also sometimes called Mechanical Engineers" and who "Design[] and Superintend[]…the Construction of the Steam Engine, Hydraulic, and other Machine Motors"
5. *Technologists*, "whose functions embrace those professional duties incident to the Establishment and Superintendence of Works for Higher Manufactures and Physical Arts; such, for example, as Potteries, Porcelain and Glass Works; Manufactories of the various Textile Fabrics, Printed Fabrics, Ornamental Metal Work, etc."
6. *Technical Chemists*, which include both "those engaged in Chemical Manufacture" and "those engaged in Manufactures dependent on Chemistry—such as Bleaching, Dyeing, Printing on Textile Fabrics, etc." (32)

In this list, for the first time, three fields of engineering—civil, mining, and mechanical—are clearly evident. Architecture heads the list, and indeed heads almost any treatment by Greene who seemed to favor it.[85] Interestingly, items five and six anticipate educational programs which, in some contexts, would be called engineering today: not only applied chemists but

[85] At the time, there were no schools for architecture in the United States. A school of architecture was finally established at MIT in 1865, another at the University of Illinois in 1867.

chemical engineers would certainly identify with number six, and number five predicts regional manufactures programs like the textile engineering program at North Carolina State or the ceramic engineering program (recently absorbed into the materials science program) at Rutgers.

For 1855, of course, this is an ambitious list, especially for a school that, until 1850, had only offered a one year degree in either natural sciences or civil engineering. Greene readily admits in the text of the bulletin that this list is a goal ("object" is the word he uses); that through growth in enrollment and local and state support, the Institute could grow to be a fully realized polytechnic institute.

After this list, Greene notes the absence of a few, perhaps expected, classes: Forestry, which he deems "naturally limited to the wants of a few countries"[86]; Agriculture, which he dismisses as having "peculiar requirements" which lend such programs to distinct agricultural schools; and Commerce, which he suggests is a perfectly appropriate addition to a large and thriving polytechnic institution (33).

Green also articulates a curricular program which foreshadows the modern building block style engineering curriculum. In describing the "true" polytechnic institute, he suggests that such institutes:

> divide the system of instruction…into three parts;—first, the *Preparatory Course*, embracing all those studies necessary to matriculation in the institution; secondly, the *General Course*, constituting the foundation in general science and literature, on which, as a common basis, are erected the subsequent courses; and thirdly, the *Technical Courses*, which include all those special teachings, more or less peculiar to the objects of the institution. (33)

[86] Though not, it seems, in the United States or, more specifically, in upstate New York. There were certainly lumber operations in the region, but perhaps the abundance of timber made the restorative expertise of foresters unnecessary.

The intent of preparatory course, as articulated by Greene in the remainder of the bulletin, was remediation. The diversity of students entering the Institute, in part due to the lack of standardized secondary education which would come later in the century, warranted a year of remedial math, language, composition, etc. While most engineering programs today attempt to ensure these faculties in their incoming students by adopting entry requirements, some state universities especially still contain remedial colleges which function as a first year experience for students labeled deficient.

The general course and technical course that Greene notes are akin to the underclass and upperclass division of courses in today's engineering programs. While in the last few decades a number of sites have experimented with mixing math, English, and science requirements in with the "technical" curriculum of engineering courses, students at engineering colleges in the United States today spend largely their first year taking surveys of physical and biological sciences, a progression of applied mathematics, composition, and any humanities requirements that are demanded by the university as a whole (not usually the specific engineering program). Then, in their last two years, they take their engineering coursework.

With this new three year program of study, which would not long after become a four year program, the Institute was arguably investing as much time in a student as any traditional college in the country. And, while the pattern of student co-teaching, lecture, fieldwork, and weekly extemporaneous speech had been a workable model, even in the new curricular regime, as the school grew, the participation of students in the preparation of class material tapered off and role of evaluator of student work, formerly the purview of the instructor, was delegated to hired *répétiteurs* who, typically former graduates of the Institute, would hear students' speeches and provide evaluations. By 1860, however, the employment of *répétiteurs* had ended, as had the practice of weekly speeches (Ricketts 96–7).

While not aligning the Institute with traditional colleges per se, Greene makes the point that the Institute was now more on par with colleges than with the system of academies, mechanics

institutes, lyceums, seminaries, etc. by describing the role of the polytechnic in the German education system. To do so, he offers the following table: (37)

Humanistic Schools.		Technical Schools.	
Three-fold system.	Four-fold system.	Three-fold system.	Four-fold system.
1. Elementary School.	1. Elementary School.	1. Elementary School.	1. Elementary School.
2. Gymnasium.	2. Gymnasium.	2. Techn. Middle School.	2. Real School.
	3. Lyceum.		3. Higher Trade School.
3. University.	4. University.	3. Techn. High School.*	4. Techn. High School.

* Generic of synonymic for Polytechnic School, Institute, etc.

Of course, "German" in 1850 was no clear concept in itself. While the confederated portions of Prussia, Austria, and Hanover during the previous decades had undergone significant industrialization campaigns, which included the creation of an extended system of public education for the growing middle class, portions of Austria (and today Hungary) which were outside of the confederation, and certain free cities within the Germanic region at large, were developing entirely separate systems of education based on various local traditions dating to the Reformation and before.[87] This table is a dramatically tidied up version of education in the Confederation at the time, but serves the rhetorical purpose of balancing technical and humanistic schools—asserting the dominance of the polytechnic (described as a technical high school in the table) over trade schools (which presumably, in America, would link up to academies, lyceums, and mechanics institutes) while also freeing polytechnics from direct comparison to universities, which appear in a separate column.

[87] For key insight into secondary education in Prussia, Austria, and Germany, in the eighteenth and nineteenth centuries especially, see Russell, which is not only one of the few works in English from the period but is also widely available through reprint.

Greene's capstone statement for this discussion articulates the special nature of "true" polytechnics—not comparable directly with universities yet sibling, enabling technical/industrial education rather than humanistic.

> A true idea of the Polytechnic Institute is, therefore, that of *a series of Special Schools* for the complete educational training of Architects, Civil Engineers, Mining Engineers, and other Scientific Technists,—all united under a common organization,—all alike aiming at the realization not only of exact and extended scientific culture, but of the utmost practical skill in the applications of science to the pursuits of active life. The name Polytechnic Institute—Institute of many Arts—becomes etymologically significant when thus applied,—alike of the plurality, the nature, and the importance of its objects. (38; italics are original)

Polytechnics institutes are just that: "institutes of many arts," where each school (today we might say discipline) is subordinated to a common organization designed to facilitate the dissemination of a scientific culture into the realm of practice. Just as universities extend the humanistic culture into the genteel life (of the lawyer, the divine, the gentry), polytechnic institutes extend the scientific culture into the trades, into the workplace, into the commercial system, and into the (agricultural) field.

Greene's idea of a "true" polytechnic is neither a copy of the scientifically grounded French model (represented by the *Ecolé Polytechnique*) nor a copy of the industrially grounded German model (represented by the *Karlsruhes* located throughout the Confederation in Baden, Munich, Berlin, etc.).[88] Instead it was a synthesis of the two, a unique model which would become the unfulfilled mission of Rensselaer as it expanded over the following century.

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[88] The French version, perhaps, of an industrially grounded polytech would be the *Ecolé Centrale* in Paris, which was founded in 1829 by private industrial investments in an expression of dissatisfaction with graduates of the *Ecolé Polytechnique*, who, according to the complaint, received too much theoretical

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Greene's articulation of the new mission for Rensselaer, which he would call Rensselaer Polytechnic Institute even before that name was legally formalized in 1861, was not made in isolation, however. Around the time of Rensselaer's transformation (and certainly by the time Greene's tract was published), both established colleges and states were entering into the fray of scientific and technical education, including education for engineers. Many of these initiatives, also inspired by French and German education, used the name polytechnic as well.

The Polytechnic College of Pennsylvania, formed in 1853 by chemist and doctor Alfred Kennedy, was, according to its first recruiting efforts "designed to supply a great want in American Education to wit: Thorough collegiate training for the practice of Mine Engineering, Civil Engineering, Mechnical Engineeing, Analytical and Industrial Chemistry, Metallurgy, and Architecture" ("Advertisement").[89] At the school's second commencement in 1857, it apparently awarded degrees in civil and mechanical engineering and applied chemistry ("Second Commencement") and, by the mid-1860s, was surpassed only by RPI in the number of civil engineers it graduated.[90]

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education (including too much math) and who were more likely to enter government service (Weiss 21–5).

[89] Few texts even note the existence of this school today, even though it absorbed, in 1865, the East Pennsylvania Agricultural School ("Commencement…") and was apparently the first, among the many attempts nationally and especially in Philadelphia, to establish a "full-fledged architectural school" in 1860 (Cohen 140). At the same time, however, the school doesn't appear in the histories of engineering education (with the exception of McGivern) and even failed to appear in analytical documents of the period! (Cohen notes that the seemingly comprehensive reports issued by the national Commissioner of Education throughout the 1870s fail to list the school.) The college failed to acquire land grant support after the 1862 federal act (discussed in the next section) and, after decades of downsizing, closed in 1886 when its founder died. Notably, the annual report of the US Commissioner of Education had erroneously listed the college as closed 5 years earlier in 1881. For the only real source of information on this school, see McGivern's "Polytechnic College of Pennsylvania: A forgotten college."

[90] Philadelphia, at the time, was a center of commerce, industry, and education, with institutions like the Franklin Institute and the University of Pennsylvania which, in 1852 established a Department of Mines, Arts, and Manufactures that would a decade later include a school Agriculture as well. This department was never fully staffed—appointments to the architecture and civil engineering positions, especially, often went unfilled or suffered from mid-term attrition—and the University was able to stabilize its program only in the early 1870s when it was converted to a Department of Science, which required

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In New York City, the term polytechnic was extended to several academies educating younger men for scientific careers and for college. In 1854, a group of local business men established the Brooklyn Collegiate and Polytechnic Institute, a school for young men (most were between nine and seventeen) offering courses, but not degrees, in industrial, mechanical, and college preparatory topics. By 1891, the mission of the institution had grown so broad (they had started actually granting degrees to older students in the mid-1870s) that the school was split into two, both of which exist today: a lower school, which is now the country day school Poly Prep, and Brooklyn Polytechnic which, would become the Polytechnic Institute of New York after its acquisition of New York University's School of Engineering in 1973 and, after a further realignment with New York University in 2008, is currently called the Polytechnic Institute of New York University.

The polytechnic idea took hold most firmly, perhaps, in the Midwest, where institutions were new and traditional systems of education on the east coast held little sway. A recent dissertation by Iowa State University's Paul Keith Nienkamp details the development of engineering education at the Michigan Agricultural College, the University of Wisconsin–Madison, the Iowa Agricultural College, and the University of Nebraska–Lincoln with a special eye to the way professional associations interacted with engineering education efforts at midwestern schools. While many midwestern schools were established after the late nineteenth century federal land grants, schools like the University of Michigan–Ann Arbor attempted (unsuccessfully) to offer courses in civil engineering as early as the 1840s (58–9).

The University of Michigan is a notable example because it underwent an extensive reorganization in 1850 (only a little more than a decade after its establishment) leading to the adoption of some features of the German educational model that had, in part, inspired Greene at Rensselaer. University President Henry Tappan, who had, like Greene, visited Prussian polytechnics, articulated the role of industry and the university and his vision of polytechnic

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students complete a two year (largely humanistic) preparatory course prior to admission (Cheyney 263 and 311–12).

education in a rural state in 1853 in a speech before the State Agricultural Society of Michigan, an organization which, at the time, was lobbying for the formation of a second (some argued replacement) institution, exclusively dedicated to agriculture. To Tappan, a polytechnic recognizes agriculture, mechanics, manufacture, and commerce as divinely and intimately bound together—to study one and neglect another is to limit all.

> The mechanic arts and husbandry have gone on together, hand in hand, and together they have subdued the earth and made it what we see it today. … [S]ee how the world has advanced by the united efforts of the mechanic arts and husbandry! Industry, God's great and glorious minister on earth, by these two, has renewed the face of the earth. How wonderful, how glorious this universal and ceaseless industry which fills the earth with good things! (171)

For Tappan, the plow (his ancient ancestor of the steam engine) is not simply an artifact of human ingenuity. It is divine inspiration delivered to the agriculturalist by God but through by the hands of the mechanic. The surplus created by the mechanization of the farm stimulates manufacture which, with further assistance from the mechanic, is able to output new and better luxury goods for enhancing civilization. Commerce, of course, is stimulated in turn.

In this system, each field not only benefits from developments in the other, it is dependent on the other for its existence. Without commerce, manufacturers would have no purpose for producing, no way to distribute their product. Likewise, without manufacture or commerce, there would be no need for farmers to produce food beyond subsistence, as no system would exist to distribute it, or produce raw material crops (like cotton) at all, as there would be no means to refine it into goods. Without the mechanic, farming, manufacture, and commerce would each lack the improvements which the mechanic brings (plows and reapers, looms and dye tanks, mints and steamships). And without farmers, of course, practically everyone who is not a farmer would starve.

While Tappan sells this system to the agriculturalist audience as a balanced system and a sacred system—handed down as a means by which man performs his divine duty, improving upon the earth—he does not fail to note how central and special the role of agriculture is as a first mover. In fact, the system set forth in Tappan's speech could be seen as entirely agrocentric; each element is derived from and responsive to the farm, more dependent on the farm than the farm is on it. Without commerce, manufacture, mechanics, the farmer would still survive. Not only would the farmer survive, but he would not necessarily be reduced to a "primitive" form,[91] as only the mechanical implements of farming are exogenous to the farmer himself. (Crop rotation, for example, originated with the farmer; it was not due to the intervention of the mechanic.) Without the farmer, however, no man would survive (or, perhaps, no other industry would survive, as the men of those industries would turn to farming to sustain their biological needs).

Tappan's purpose in constructing this agro-centric system, however, is to make the point that the growth of industries (individually and as a whole) are dependent on the "association" of the men of these trades. To elucidate what he means by "association," Tappan begins with the example of a railroad, which "might possibly be made by each man making a piece of it though his own lands" but which, were it constructed in such a way, would be either dysfunctional or at least "most expensive." The solution to this problem, of course, is corporation: "Since, then, we are mutually dependent, and have a common interest in view, it becomes necessary to combine our capital and labor by the formation of a railroad company." (179).

This first example, however, is merely a metaphor for his real point, which follows as his second example:

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[91] In Tappan's words: "Such was the condition of the savage tribes who once possessed these regions [i.e. Michigan]. The savage retains the world as he finds it, because he is destitute of knowledge and education. He has not the industry of thought, and therefore he has not the industry of the hand." (183).

> Again, improvements in agriculture, more or less, would unquestionably be made by each man on his own farm conducting solitary experiments. But who does not perceive how much more rapidly these improvements must advance by association, where the results of individual experiment are communicated to all; where principles and methods are discussed; where information collected from every part of the world is widely diffused, and where public institutions are established for agricultural education? There are a thousand such examples of the same nature…It is association, enlightened, confidential, and generous association, which carries on the great improvements of the world. God has made us so dependent upon each other, that we cannot work alone and be successful—we must combine our means and efforts. (179)

The productive (indeed, divine) goal of association warrants an organization dedicated to facilitating association, facilitating the collection and dissemination of knowledge; for Tappan, this structure is the university, more specifically the university in a form deliberately agro-centric and polytechnic. While the "combin[ation] of means and efforts," Tappan goes on to note, could occur under despotism,[92] the "noblest and most benign association is the free association of enlightened men…inspired by a love of the true, the beautiful, and the good." This kind of association, Tappan asserts, is the "highest representation of Divinity on Earth, showing us knowledge and goodness, clothed with irresistible authority and might" (180). Tappan thus connects the mission of the agro-centric, polytechnic university back to liberty and the ideals of the revolution.

Notably, earlier in the speech, Tappan also ties the lack of support for the university to sectionalism, once again the popular evil of the time, especially in the midwest where conflicts between older eastern states constantly threatened to disrupt the settlement and development

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[92] On this point, Tappan provides some colorful commentary. Asserting that despotism was the means by which means were combined to produce ancient works like the pyramids, modern works like the Louvre and the Vatican, and, in its most fanatical state, even modern empires like the Turks and, currently, the Mormons.

of the new territories (176). The spirit of sectionalism, Tappan asserts, is not only at the root of movements to establish a number of small (locally active) schools rather than one (central but more powerful) university in Michigan. But, more importantly, the spirit of sectionalism is the root of movements to privilege one form of industry over the other, and, at the university, one form of education over the other.

Making this connection, Tappan is then able to make an acceptable request of the "Men of Michigan," a phrase he repeats emphatically nearing the end of his speech; he does not ask them to endorse a centralized comprehensive university education, but rather to overcome sectionalism (by which, at the end of his speech, he means bias against education in general and non-agricultural education initiatives specifically).

> Those nations which give the greatest attention to science, literature and the arts are the very nations where the mechanic arts, agriculture and manufactures are carried to the highest perfection. Would you perfect the industry of a people, then perfect their system of education. And when we perfect their system of education we refer to education in all its parts and degrees:— education of the highest forms to make philosophers and men of science to do that higher work, which necessarily belongs to a class exclusively devoted to thought, observation and experiment; and education for the working classes, so that work and thought may go on together according to the laws of our being, and the constitution of the world in which we live. (185)

A university president and political activist on matters of education, Tappan was well aware of debates in state houses and Congress about state and federal investiture in higher education. His speech before the agriculturalist "Men of Michigan" foreshadows the academic sectionalism which coming federal support of education would soon exacerbate.

4 Manufacturing and the American System: Agriculture, industrialization, and the control of work

1776 was not only the year the American Continental Congress declared independence from England; it was also the year that James Watt first publicly demonstrated a commercially available condensing steam engine and the year that Adam Smith's *Wealth of Nations* was published. Independence from mercantile rule, a source of inexpensive and mobile mechanical power, and a philosophy of economy reliant on "natural liberty" and an "invisible hand" (which would, in the coming decades, be called market capitalism)—these were the driving forces of an American Industrial Revolution which would stabilize the newly formed American state.

Having undergone in the preceding centuries drastic changes in agricultural practices and metallurgy and a political revolution, England undertook in the eighteenth century to extend its mercantile project, grooming the economy of the American colonies as a stimulant for the factories of Birmingham, Derby, and Cromford. By 1783, the American colonies would be politically independent, but with none of the manufacturing infrastructure of the mother country and without the administrative strength to direct the continental economy.

The American industrial revolution that followed was a product of Americans interaction with their former colonial masters, of the immigrants welcomed by the sparsely populated new nation, and of the personalities and personal ideologies of key political and popular figures, more than it was about the "classes and masses" acting uniformly in a new democracy.[93] The establishment of the American nation and the American and British industrial revolutions, as they occurred together, cannot be separated, making the American engineer, the concept of

[93] This is Maurice Ashley's phrase. Ashley, in his authoritative work *England in the Seventeenth Century*, asserts that the outcome of the Glorious Revolution had only as much to do with "the classes and the masses," typical objects of study for historians in the 1960s, as it did to do with the particular personalities of parliamentarians and coincidences of moment.

whom arises from this milieu, a product of the liberalism, progressivism, and populism of the American Revolution and the capitalism and mechanical monism of the industrial revolution.[94]

The idea of the American engineer, in the century that followed, would root itself in multiple traditions—the inventor, the soldier, the tradesman, the planter—each of which would bear a relationship to the land and the machine colored by the roles those elements played in the birth and development of the new nation.

Industrial production in Britain and her plantations

The industrialization of Britain was well underway by 1776 when the American Revolution nominally began. The agricultural cycle on manor farms in Britain had been moving throughout the eighteenth century from dogmatic adherence to the old triennial rotation, which alternated cereal plantings with periods of soil-restoring fallowing, to an assortment of mixed crop cycles, many of which substituted fallow periods with nitrogen-fixing fodder crops (like clover, legumes, and turnips) or, by the end of the century, with industrial crops (like sugar beets, flax, hemp, and rape oilseed). The cyclical availability of fodder crops, and the diversity of crops and of growing calendars adopted, affected husbandry, popular diet, land use, and industry. More fodder crops meant not only nitrogen replenished soils, but also more manure fertilizer; it meant support for more livestock, which in turn could be used in labor (plowing, milling, etc.) or for food or goods (textiles, leather goods, chemical products, etc.); it also meant the repurposing of remaining spaces dedicated to common grazing and the redefinition of the relationship between herders and farmers and between tenants and landlords.[95]

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[94] Neil York has argued something similar in his book *Mechanical Metamorphosis*. His character, the inventor in America rather than the engineer, he associates intimately with both the ideals of greater convenience and mobility and the liberation from mundane labor (as mills, farming, and factory work were being revolutionized) as well as with the liberation of the nation from foreign rule and dependence on foreign economies.

[95] This is not to say that new agricultural practices were the cause these changes. The enclosure of common land had begun as early at the fifteenth century when, after the Black Death, labor scarcities

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Coincident with these changes in agriculture was a century of mechanical innovation which led to the widespread availability of new agricultural and manufacturing tools. Plows superficially tipped with iron rims in the eighteenth century were replaced first with reshaped mouldboards of Chinese design (the first of which were imported by the Dutch then copied) and then by iron covered and single casting designs. Additionally, mechanical sowers and harrowers were first implemented to replace manual tillage and broadcast sowing, improving the reliability of planting. These mechanical innovations, as well as countless others, each served to improve crop yield and reduced manual labor.

The industrial revolution in Britain, however, was arguably a textile revolution. Before the eighteenth century, textile production was a cottage industry—merchants purchased raw materials and delivered them to networks of artisans who, in their homes using looms and spinning wheels, produced thread, cloth, and eventually finished goods for those same merchants to sell. By the end of the eighteenth century, the cottage industry was waning in favor of a factory system in which workers gathered in large mills and factories and worked in supervised conditions and in tandem with animal and mechanical power, to feed, operate, tended to complex machines.[96] Compared to the cottage system, the factory system provided industrialists the ability to operationally regulate quality through machining, supervision, and testing. Supervision and mechanization also enabled industrialists to better estimate the time and volume of production and to regulate labor supply and competition for workers. Where merchants in the cottage system were threatened by artisans who might attempt to profit off of their trade directly, in the factory system workers could be supervised and compensated

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made the production of wool more profitable than tenant rents. The breakdown of the feudal system in the ensuing years and the the agricultural transformation in the eighteenth and nineteenth centuries in Britain is well documented in histories of modern agriculture. For a detailed explanation of agricultural practices, see Chapter 8 of Mazoyer and Roudart. For a more typical event driven account, see Curtler.

[96] Most of these machines were developed and first implemented in the 1740-1760s. Lewis Paul and John Wyatt's first mill in Birmingham used donkeys to power rolling machines. Later additions of carding machines, water frames, and spinning mules, as well as the application of ever more efficient steam engines, made the process even more machine-centered.

according to supervisory reports which might contain anything judged relevant, from observations about an employee's rate of production to his or her character.[97]

The modern mechanically assisted agriculture and the factory system were enabled not only by tools and mechanical innovations, but by new sources of power and inexpensive and available iron. For at least 3000 years, iron smelting in Britain relied on charcoal produced by logging and burning the trees of local forests. Forests were not just a source of game and timber; without charcoal made from trees, iron tools, weapons, and building materials could not be produced. Monarchs and land holders in Britain, beginning in the Middle Ages, kept strict account of the usage and regeneration of forests and forest resources, often protecting forests from over-hunting and overcutting and from the periodic demand to clearcut forests to provide for the imminent needs of war or to provide arable lands.[98]

By the 1500s, however, scarcity of wood (and its related high price) became a common theme in political, civil, and military discourses. Shortages that, in the sixteenth century, were economic (based on land owners withholding timber) and local (mainly surrounding cities and industrial and coastal areas), by the eighteenth century were chronic and of serious concern for the navy, for the ship-dependent merchant classes, and for citizens of ever more urban settlements who suffered most from the inflated prices of wood and iron products, including wood for heating.[99]

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[97] For a discussion of cottage industry, see Sella. The transition from cottage industry to factory system was by no means a sudden one. It took place over more than a century and occurred, by most modern accounts, in increments. Not only did population shift from home to factory gradually, but the cottage practice evolved considerably in the latter half of the eighteenth century in imitation of, or perhaps reaction to, practices of the factory. Regions of coordinated cottage outfits which functioned as distributed factories, for instance, have been labeled proto-factories. See Mendels, for example.

[98] Statements concerning the governance of forests were among the first written British laws; in fact, guidelines on access to forestry were written into the Magna Carta (Williams 134). But the early sustainable forestry movement reached its peak, perhaps, in the mid 1600s with John Evelyn's *Sylva, or A Discourse of Forest Trees*, in which Evelyn advocated the planting of tree plantations in support of the navy. At the same time in France, Jean-Baptiste Colbert was doing just that at Tronçais (Braudel 238, 240).

[99] While the prices of goods in general tripled between 1500 and 1650, the price of firewood over the same period increased eightfold. Over the same period as well, the population of London increased sevenfold, from 50,000 to around 350,000 (Wiebe 375).

Throughout the reigns of Elizabeth I and James I (1558–1649), endless government commissions investigated the issue; most ended in the creation of further logging prohibitions and schemes for achieving more favorable rates on importing lumber from Norway.[100]

The alternative to expensive wood, for heating homes and most industrial processes at least, was coal. By the mid-seventeenth century, coalfields in Edinburgh, Newcastle, Sheffield, and Swansea supplied urban and coastal populations with the alternative fuel. While comparatively less expensive than burning wood, coal had drawbacks; the fossilized remains of plant and animal matter, coal contains a variety of volatile noxious impurities which, when burned, are released into the air, making coal unusable for heating exposed chemically-sensitive processes like brewing or smelting.[101] These processes continued to rely on wood-based charcoal.[102]

Non-mechanical mining techniques and the mass quantities of scarce wood required for smelting factored into the cost of iron in the seventeenth century. By the mid-eighteenth century, however, the production of charcoal from trees was supplemented by the development of coke: coal pyrolyzed to remove impurities.[103] Additionally the application of steam engines to

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[100] Notably, Michael Williams, among other forestry and historical economics scholars, have recently the traditional account of a Britain besieged by shortfall suggesting that lumber shortages in London did not necessarily reflect problems throughout the isles and that special interest groups interested in preserving titled land and profiting economically off of lumber importation influenced not only cutting legislation but public opinion (170).

[101] Beer brewed over coal, for instance, would acquire a sulfurous taste and smell. Likewise, iron produced in such a way would be weakened by impurities. Throughout the seventeenth century, however the English Parliament incentivized patents for a coal-based iron smelting system; see Section 9 of Volume 2 of Scott's *The Constitution and Finances of the English, Scottish, and Irish Joint-Stock Companies to 1720*. Coal was readily accepted for home heating (Williams 184), however, filling homes all over Britain with ammonia and sulfur gasses until Benjamin Thompson (better known at the time as Count Rumford) invented the smoke-redirecting fireplace until the 1790s.

[102] Charcoal, produced when plant or animal matter is pyrolyzed—that is burned in a low oxygen environment (such as in an earth covered kiln)—has a similar hydrocarbon composition without the same noxious impurities. Interestingly, the world charcoal, literally "turn to coal," implies this connection. (The OED suggests that associating the word *char* with burning is relatively modern. The prefix here *chare-* refers to transmogrification.)

[103] Though coke was first produced in Britain in the mid-seventeenth century, there is no record of its use in iron furnaces until Abraham Darby began using it as a substitute for charcoal in his furnaces at Shropshire in 1709. It's worth mentioning that the Chinese, from whom Europe first acquired other

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the ventilation and drainage of mines allowed access to ever deeper mineral deposits. By the end of the eighteenth century, millions of tons of coal were being extracted from mines in Britain, coked, and used to run furnaces and steam engines to produce iron and other industrial products and to heat buildings (Williams 184). These changes not only lowered the cost of iron but diverted at least some of the demand for wood.[104,105]

The tool and animal based reduction of demand for agricultural labor, the production of comparatively cheap iron using coke (rather than wood), and the relatively cheap and clean mechanical power that new coke-fed steam engines produced allowed industrialists in central Britain to build ever larger outfits, at first simply centralizing local cottage workers for work, and then eventually creating whole living communities centered around industrial sites. By the end of the eighteenth century, the population of Britain was growing, more citizens than ever were moving leaving agrarian settlements for industrial and urban communities, labor roles were changing, and activists both in factories and outside were organizing.

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incendiaries like gun powder, were making coke near what is today Wuhai as early as 800. See, for instance, Chapter 2 of McNeil.

[104] It's worth mentioning that coal mines themselves require quite a lot of wood to build and maintain. The use of coal to replace wood as a fuel source, while a net positive in terms of the amount of wood that could be conserved, required significant outlays of wood for the structure of the mine. The British public of course complained about what they perceived to be the egregious use of wood resources when even timber for residential building was restricted. Georg Agricola recognized this complaint about mines in several places in his 1556 treatise *De Re Metallica* saying of opponents of mines: "Also they argue that the woods and groves are cut down, for there is need of an endless amount of wood for timbers, machines, and the smelting of metals" (8).

[105] A little later, the potash industry, which in Britain relied on burning hardwood trees, would be almost entirely replaced by one producing soda ash from sea plants. Potash, which is used in the production of glass and soap and in the dying process, is also used as a fertilizer for potassium depleted soil. Potassium depletion in a fodder-based crop rotation system becomes a problem as the cycle emphasizes the restoration of nitrogen to the system encouraging the farmer, who no longer fallows, to exhaust the potassium in the soil. While soda ash is equally capable of contributing to the production processes of soap and glass and the dying processes, it does not function similarly to potash as a chemical fertilizer. Without a potash industry, British farmers in the early 1800s became dependent on Canadian production, which was later a source of bargaining in Canadian efforts to secure favorable (i.e., non-mercantile) trade agreements with the mother country.

At the time of the American Revolution, none of the century's industrializing trends had been exported to the colonies. In fact, mercantilist laws governing the colonies explicitly forbid the importation of British industrial machinery (including steam engines), required government permits for the establishment of mines and factories, forbid or imposed stiff tariffs on the exportation of grain and finished products to Britain (as well as, in some cases, to other colonies), and regulated exports to foreign countries and other colonies, including the West Indies. On the other hand, the American colonies were an economic engine for Britain: supplying British textile mills with raw cotton and wool (as well as supplying the British public with tobacco and sugar) and consuming British manufactured goods.

Thirty-five hundred miles away, the trade of raw materials, the manufacturing of goods from those materials, and the economic means by which materials (and consumers and producers) entered the marketplace became the mechanism by which London exerted control on the American colonies.

British mercantile policies extended beyond what could be produced and exported to control who profited off of the carriage goods. The motivation for these policies was clearly articulated in what is probably the first explicit shipping ordinance in 1645: "taking into consideration, that nothing more enricheth this Kingdome than commerce, whereby the navigation thereof is much increased…and therefore ought to be incouraged." [106] A response to Dutch trade supremacy, the ordinance gave one English company exclusive rights for carting whale oil and fish products from Greenland to England where they could be legally exported—essentially forcing the Dutch to accept an English company as a middleman. After a comparable ordinance was passed in 1648, restricting Turkish imports similarly on behalf of the Levant Company, the floodgates

[106] While this legislation is referred to in both McClellan (8) and in Bucholz and Key (250) simply as "the Ordinance of 1645," this is not a reference to the more often noted "Self-denying" Ordinance passed in the spring of 1645, which allowed for the reorganization (without prejudice) of control of the army. Rather, it is an ordinance passed a month later under the title: "An Ordinance prohibiting the Importation of Whale-Oyle, Fin or Gills, but by Ships set forth from hence, and by English Subjects." The full text of this ordinance can be found on the website of the British Parliament's primary history project (May 1645…).

opened, and, by 1650, the Parliament was busy fighting over petitions from competing corporations for the privatization of trade routes (Israel 308–11).

A generalized form of these acts was not passed until 1660 when, after the Restoration of Charles II, a variety of legislative acts, especially passed during the Commonwealth period of the English civil war, were revoked.[107] The Navigation Act of 1660 was Parliament's response to a political opportunity to construct a comprehensive plan for carriage and colonial trade. According to this act, not only did the ships need to be registered by English corporations, but the ships' crews needed to be largely English as well,[108] and certain goods (listed in the act) had to travel to London before they could be exported to foreign markets or even other colonies (including the various British Caribbean colonies). According to arguments of the time, the mercantile system enriched a specific subset of the merchant class or Britain who, in turn, enriched the average British citizen as, to use an anachronism, their wealth trickled down. Practically, of course, the relatively small percentage of wealth which did trickle down was more than offset by the expense of maintaining the security of colonies and the infrastructure for accessing them.[109]

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[107] A similar coordinating act was actually first attempted in 1651 (in the midst of the civil war) by the Rump Parliament. With some noticeable differences, this act served as the template for the one described here.

[108] This was not a problem for colonial Americans, they were English. After the revolution, this portion of the act became more significant.

[109] Historians from the early twentieth century, including Fisher in his authoritative *The Struggle for American Independence*, provide endless, though somewhat opaque, details regarding the economic backwardness of early mercantile policy (49–54). Late nineteenth century American public figure and historian George Bancroft, in his *History of the United States*, on the other hand, provides a variety of anecdotes, including one apparently derived from the Grenville Papers about an annual income of £2000 which cost the British government nearly £8000 to collect. Richard Middleton, in his history of colonial America, hypothesized that discrepancies of the eighteenth century like those noted by Bancroft were indicative of the fact that "the system was being increasingly managed for the benefit of special interests…in contrast to the seventeenth century when the aim had been to strengthen the kingdom as a whole" (215). Notably Joyce Appleby has suggested that special interests were at the root of seventeenth century policies as well (in *Economic Thought…*).

These rules applied to the American colonies in the 1660s, but the free inter-colony trade on the American continent (and the proximity of Dutch and Spanish colonies) made the illegal export of tobacco, cotton, and other enumerated goods a trivial task. By 1670s, however, the Dutch had lost their colonial holdings on the North American continent (the areas around the North and South rivers—now the Hudson and Delaware rivers—largely as New York, New Jersey, and the Delmarva Peninsula) and the list of enumerated goods had begun to grow to include goods like molasses which forced American colonists to forgo inexpensive French sugar in favor of marked up English products.

By 1750, when the list of enumerated goods included almost anything produced by the colonies for export, Parliament added iron to the list of regulated trade goods, effectively legislating a ban, not on the production of iron bars, but on the finishing of iron goods in the colonies.[110] The goal of the legislation was not to make the colonies reliant on British iron, but to secure for England a stable supply (free from dependence on Sweden) and prevent colonies from manufacturing goods. Colonies were allowed to produce iron bars, but they then had to be shipped to London where they could be converted into finished goods. Iron to be used locally (including iron for structures and for shipbuilding and iron molded in place as for farm implements) also had to be shipped to London where it would simply be shipped back, unmodified, at an inflated price.

American colonists, of course, protested this cumbersome and expensive regulation. For the most part, they simply ignored the act, using unstamped iron locally as they saw fit largely free from any penalty—British forces in the colonies, of course, were not numerous enough to

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[110] Given the problems the British had meeting their own iron demand, the Parliament had allowed the colonies to exploit their rich supply of timber and surface metals to produce iron since the settlement of Virginia and Massachusetts in the 1600s. The ironworks at Saugus, MA, for example, employed almost a hundred workers in the latter half of the seventeenth, supplying New England with iron for ship building, farming, fishing, and construction. Arthur Binings writes extensively about the manufacture and regulation of iron from colonial America (especially Pennsylvania) through the eighteenth century. See Hartley for a treatment of the Saugus works specifically. An overview (or more accurately a timeline) of colonial mining and metalworking operations can be found in Bishop, Chapter 17.

enforce the law and local officials made little effort to do so. There was also an address for legislative relief: an unsigned petition to Parliament to abandon the act[111] which offers six "Reasons against a General Prohibition of the Iron Manufacture in His Majesty's Plantations." These reasons call attention to the extremity of the hardship that would be peripherally imposed by the measure (especially on farming and shipbuilding) and to the scarcity of labor in the colonies (which causes little unnecessary ironwork to be done). The six complaints humanize the production issue, equating enlightenment concepts of human liberties with work. Consider the following two points:

> 2. To forbid his Majesty's Subjects the making any Sort of Iron Wares, when its for their own Necessary Use, and not for Exportation, seems to bear hard on the common Rights and Liberties of Mankind; especially, when the Ore is what their own Soil yields, and what is found but in small Quantities comparatively in the Mother Kingdom.
>
> 3. If such a Prohibition be thought just to prevent the Plantations from interfering with the IronWorkers in the Kingdom, all other Tradesman may expect, in their Turns, to be forbid Working at their respective Callings. For, by the same Reason, the People may be forbid making Cheese or Cyder, for fear of prejudicing the Manufactures in Cheshire and Herefordshire.
> ("Reasons against…" 56)

[111] The petition described here was republished in the 1892 annual report of the American Historical Association. It was found archived shortly before, apparently, in the Bodleian Library at Oxford (fol. 666:178) alongside several writings related to the argument. A number of such petitions exist on behalf of colonial interests and have been reprinted in a variety of histories and on several government and university sponsored primary resource websites. It seems the general consensus of these websites that petitions like these were common and, while the colonists had no representatives in Parliament, would reach the floor through publication and lobby. Their authenticity to the period would be of interest to this analysis, and that seems to not be doubted by the American Historical Association of 1892 at least or by several state and university American history primary resource archives.

These points rely on a right to work—especially to work, within the confines of the bounty of nature, to produce goods on one's own behalf. In these expressions, ironworking is akin to farming, and the men involved are identified intimately with not only their position in the hierarchy of governance, but with their position in the network of production (not only "Subjects" but "Tradesm[e]n"). The complaints are qualified, however; they recognize the right of the English government to control commerce, or at least, to control the supply of goods to extra-colonial markets (be they foreign or English).

American dissatisfaction with the Navigation Acts and other taxation arrangements was expressed throughout the colonial period. When not nominally based on security or libertarian issues, insurrections and political movements often relied on complaints about the remote administration of land speculation, taxation, and the inequitable enforcement of smuggling and trade laws.[112] Violence, mob protests, and parapolitical colonial organizations became a feature of the American colonies only in the last decade before the revolution, however. The Stamp Act of 1765, which required that published or official documents be produced on paper that had been imported from London (and stamped accordingly), and the Townshend Acts of 1767, which functioned indirectly taxing paper, paint, glass, and tea through export tariff, both were met with violent street protests and coordinated resistance by assemblies of men purporting to be colonial officials (the Stamp Act Congress in the cause of the former and via the Massachusetts Circular Letter in the case of the later).[113]

Notes taken by Caesar Rodney, a Delaware delegate to the Stamp Act Congress, suggest that the bulk of the debate that occurred at the New York meeting revolved around the nature of the stamp as a vehicle of tax. The Congress came to consensus on few things, but, in Rodney's notes, seemed to agree that direct (they called it internal) taxation by the affixation of a stamp was illegitimate, while indirect (external) taxation by levying a duty on the finished good itself

[112] For examples, see Charles McLean Andrews's *Narratives of the Insurrections*.
[113] Peter Thomas's book on the Townshend Act is a particularly detailed reference on these points.

would not be out of line with practice.[114] But when the Townshend Acts, which followed the repeal of the Stamp Act, replaced the direct levy with an indirect one, the colonists protesting in the streets failed to appreciate the distinction.[115]

Perhaps the watershed of violent response to mercantile policy came after British application of the 1773 Tea Act, an act which levied a global tax on tea in place of a requirement that all tea pass through London. While the act actually lowered the price of tea in the colonies, its branding as a tax (and by smugglers whose business was disrupted by the legislation as an oppressive tax) lead to protests in coastal cities throughout America, including an assault on a tea laden East India Company ship in Boston harbor in which a considerable amount of property was destroyed.[116]

In an effort to quell the appetite for insurrection, the British followed the Boston Tea Party with a series of legislative acts aimed at punishing the residents of the Massachusetts colony en masse. Now typically referred to as the "coercive acts" or "intolerable acts," they closed the port of Boston, seized control of the colonial government of Massachusetts, and made affordances for a new organized contingent of royal militia who had been redeployed to occupy the colony.[117] These new political repressions provided the fodder necessary for revolutionaries

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[114] Rodney's diary of the Congress is archived at Rowan University's Frank H. Stewart Special Collections Room in Glassboro, New Jersey. It is apparently the only surviving written record of the Congress save, presumably, the declaration produced by the body.

[115] John Dickinson's *Letters from a Farmer in Pennsylvania*, a widely circulated pamphlet in the wake of the Townshend Acts, groups the Townshend and Stamp Acts as co-illegitimate asserting, in Letter Two, that "All before, are calculate to regulate trade, and preserve or promote a mutually beneficial intercourse between the several constituent parts of the empire...Never did the British Parliament, till the period above mentioned think of imposing duties in America, FOR THE PURPOSE OF RAISING A REVENUE." Dickinson, a wealthy Delaware planter was committed to repairing the relationship with England and famously refused to sign the Declaration of Independence, though subsequently he was a delegate to the 1787 Constitutional Convention and President, at different times, of both Delaware and Pennsylvania under the Confederation.

[116] Now a museum, the Old South Meeting House in Boston has an extensive exhibit dedicated to the Tea Party.

[117] Five separate pieces of Parliamentary legislation, the acts are the root of many of the nominal reasons for rebellion and the root of several clauses in the later written Articles of Confederation and

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to successfully recruit the forces that would participate in the first battle of the war in Concord, Massachusetts less than a year later.

The constitution of agrarian republic

Dissatisfaction stemming from increasingly intrusive mercantile legislation and taxation was a key driver of participation in the Revolution.[118] In the battles of the American Revolution, citizens of the new republic asserted their economic freedom: farmers rejected the limitation of markets, speculators rejected the administration of land, merchants rejected the imposition of navigation and contractual tariffs, tradesmen at large rejected the taxation of raw materials and the prohibition of manufactures, and consumer at large rejected the economic manipulation of goods and services by a distant and seemingly self-interested authority.

The continental publications of the 1770s are suffused with calls to buy exclusively American made goods (homespun clothes, etc.) and to forgo what could not be obtained through local patronage. At the same time were rife reports of economic collaborators (tax collectors, merchants subscribing to British goods, etc.) resigning out of intimidation. Busy arranging supplies and financing for a quickly assembled continental army, however, continental authorities made few plans for creating sustainable environment of production.

Constitution. The Quartering Act, for example, required that Massachusetts colonists provide military housing though taxes or real property—though not in their own houses as has often been misconstrued. The Jurisdictional Act (or the Administration of Justice Act) made the trial of a royal official (government or military) subject to change of venue at royal whim, effectively preventing local witnesses from testifying in court cases against soldiers which might suddenly be moved to the Carolinas or even to London or Bombay. The sort of paternalist punishment tone of the acts can be seen most clearly, perhaps, in the often overlooked Quebec Act which is unique in the group as it does not apply to the Massachusetts colony, but rather bestows a variety of favors upon (the colony's well behaved sibling) Quebec—the right to speak French, the right of Catholics to hold positions in the colonial government, etc. For a book length treatment of the Acts and colonial response, see Ammerman.

[118] Of the "train of abuses and usurpations" listed in the Declaration of Independence, arguably half of them refer to economic regulatory issues. Some of these, of course, are catchall statements or procedural complaints (like "He has forbidden his Governors to pass Laws of immediate and pressing importance, unless suspended in their operation till his Assent should be obtained…"), while others are more directly on the target of taxation and industrial/agricultural regulation (like, "He has erected a multitude of New Offices, and sent hither swarms of Officers to harass our people, and eat out their subsistence").

Looking within the continent, America would finish the war with an agrarian cottage economy on which patriotic Americans could subsist. From a global perspective, however, the pre-industrial environment (and staggering debt) the new nation inherited on succession made prospects for its survival dismal. At the close of the war in 1783, the newly formed United States became an economic orphan—a massive, inefficient producer of raw materials largely reliant on European import markets and British finished goods and unable to take advantage of ready foreign markets, like those in the West Indies, because of political alienation.[119] To make matters worse, the negotiations following the war took place during a particularly volatile period in British governance; four heads of government sat during the treaty's construction. Because of this, economic policies of the Parliament varied wildly from protectionism to William Pitt's proposal that the Navigation Acts be repealed altogether.[120]

It was John Lord Sheffield rather than Pitt, however, who articulated the position upon which Parliament would eventually settle. Sheffield's "Observations on American Commerce"[121] was frank in its assessment of British leverage and American disorganization. Asserting that the confederated form of government adopted by the Americans could never so organize the states as to resist a flood of British manufactured goods,[122] Sheffield argued not only to preserve the

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[119] No longer British citizens, Americans began to feel the full effect of the Navigation Acts which prohibited non-British ships from bringing goods for trade to the British West Indies, among other places, effectively allowing moderated staple trade with the islands while robbing American merchants of the opportunity to seek market profits. Notably, trade expeditions outside of the Atlantic sphere began in this period—trade throughout the Mediterranean grew and, in 1784, a group of wealthy New York and Philadelphia merchants (including Robert Morris) commissioned the first American trade expedition to China.

[120] Toth presents a brief sketch of the twists and turns of trade with respect to the islands during this period.

[121] Though tangential to our purposes, it is worth noting that a significant controversy exists regarding the authorship of the "Observations." There is considerable evidence that the tract was written (or at least informed by) Silas Deane, a former member of the Continental Congress who became a disgraced ex-patriot when accused of embezzling (by over-expensing) on a diplomatic trip to France. If this is the case, then it could be argued that the economic turmoil which eventually would precipitate the War of 1812 be linked to what today would be identified as a common discretionary abuse. (See Minchinton.)

[122] He was right of course. The third clause of the Articles of Confederation states: "The said States hereby severally enter into a firm league of friendship with each other, for their common defense, the security of their liberties, and their mutual and general welfare, binding themselves to assist each other, against all

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Navigation Acts but to encourage (through rebates) merchants to take fuller advantage of exclusionary shipping and protectionist practices; the only benefit to maintaining distant colonies like those of the West Indies is in the "monopoly of their consumption and the carriage of their produce." In other words, colonies like the West Indian Islands are only worth maintaining insofar as mercantile profit can be maximized—monopolizing both the transport and use of raw materials and the sale of finished goods back to the population (and charging for everything).

In December of that same year, Thomas Paine responded to Sheffield's "Observations" in a ubiquitously published pamphlet.[123] Paine, indignant, called for unity among the colonies, who, as predicted by Sheffield, had been unable to coordinate their tariffs in a sensible way to avoid the onslaught of British merchants. Paine's warning—"while we have no national system of commerce, the British will govern our trade by their own laws and proclamations as they please"—became a central point of discussion when the Constitutional Convention met a few years later in Philadelphia.[124]

By the time of the convention, public pessimism had grown to unprecedented heights. State legislatures, taking advantage of their independence, had begun taxing and printing unbacked

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force offered to, or attacks made upon them, or any of them, on account of religion, sovereignty, trade, or any other pretense whatever." This is somewhat of a normative statement—no specific boundaries are given the phrase "general welfare," no interpretation is included of what qualifies as an "attack" or as legitimate "assist[ance]." Functionally, this ambiguity served to free states from any responsibility to each other or to the un-empowered continental government. This problematic feature of the Articles would pass on in 1787 into the Constitution, ironically in the eighth section of the first article (where the powers of Congress are enumerated) where it would serve the opposite rhetorical function—to enable the expansion of the continental government.

[123] Entitled "A Supernumerary Crisis. To the People of America.," this pamphlet XIIIB—the sixteenth and last pamphlet—of those collectively referred to as *The American Crisis*. Reprints abound, most seem to reprint this letter in the space of a couple pages.

[124] For the sake of precision, it should be noted that this specific quote is actually one of Paine's rhetorical characterizations of Sheffield's tract. It is clear, however, that, while Paine finds that the expression of the argument by a British official offensive, he does not question the validity of it. In fact, admitting the argument (though without ever phrasing it as directly), he uses it to build a case for greater colonial organization and cooperation. This quote has been used for its conciseness.

paper money, enacting land reforms, and generally pursuing the popular whim without regard to union or consequence. Popular publications printed side by side letters from bankrupt farmers, tracts of Thomas Paine's *American Crisis*, position papers on federalization, profiles of the savagery of pioneers, and letters from statesmen pleading the limitations of the legislature to the citizenry. The first editions of the *American Museum*, which had begun only months before the Philadelphia convention, included an article by William Barton advocating centralized trade authority, an article by Benjamin Franklin asserting that American life was not as bad as the media and gossiping citizens made it out to be, and a reprint of the 1765 compact issued by merchants of Philadelphia declaring that they would not buy imported British goods (perhaps in advocacy of a similar course or perhaps out of reminiscence for the days when such cooperation could be expected). One unsigned editorial, enumerating the "Causes of a country's growing rich," reacted to the American economy and to the American/British trade relationship by advocating not only the transformation of that relationship into an equitable one[125] but also the development of American agriculture, industry, and land[126] and the patriotic restraint of American citizens.[127]

In his history of early America *Empire of Liberty*, Gordon Wood interestingly describes the reactions of those who we would today call founding fathers, to post-war chaos as follows:

> [B]y the 1780s many leaders had come to realize that the Revolution had unleashed social and political forces that they had not anticipated and that the 'excesses of democracy' threatened the very essence of their republican revolution. The behavior of the state legislatures, in the despairing words of

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[125] Reason five commends free trade. Reason four commends the equitable carriage of goods (on American ships just as on British ships).

[126] Reason one and two refer to the importance of both subsistence and export agriculture and industry. Reason states "improvement of the land, encouragement of agriculture, and thereby increasing the number of people, without which any country, however blessed by nature, must continue poor."

[127] Reasons ten and twelve address this concern directly. Twelve is especially clear, using emphatic capital letters: "a disposition of the people of a country to WEAR THEIR OWN MANUFACTURES, and import as few incitements to luxury, either in clothes, furniture, food, or drink, as they can conveniently live without."

> Madison, had called "into question the fundamental principle of republican Government, that the majority who rule in such governments are the safest Guardians both of the Public Good and private rights."[128]

Wood's quote from Madison's letter is accompanied in his text by, among others, New Jersey Governor William Livingston's oft-noted observation that the American people "do not exhibit the virtue that is necessary to support a republican government"[129] and a quote from Philadelphia Doctor Benjamin Rush's timely article in the *Pennsylvania Gazette*:

> The rights of mankind are simple…They require no learning to unfold them. They are better felt, than explained. Hence in matters that relate to liberty, the mechanic and the philosopher, the farmer and the scholar, are all upon a footing. But the case is widely different with respect to government. It is a complicated science, and requires abilities and knowledge of a variety of other subjects, to understand it. (Rush "To the Freeman…")

Madison, Livingston, Rush and others[130] seemed to have reservations about the election of tradesmen and those without a classical education or, more to the point, those without significant leisure. Interestingly, Adam Smith, the English economist whose *Wealth of Nations* was published only a decade before, makes a similar point about the management of industrialized civilization:

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[128] Quoted from page 19 of Wood. His quote of Madison, can be found in several places including Ravove's edited collection of Madison's writings, page 75.

[129] Wood refers the quote to Sedgwick's 1833 biography of Livingston—which at 500 pages is probably the most extensive treatment of the man. Sedgwick, who draws the quote from a February 1787 letter to Elijah Clarke, provides significantly more context which supports the assertion that Livingston's was concerned about the "iniquity" of the American people and the divine retribution that may be coming.

[130] The collection of letters and articles leading up the ratification of the Constitution edited by Kaminski, et al is useful on this point. Of the 23 volumes of primary texts published so far in this 30 volume set, initial comments on the need for the Constitution (vols 13 and 14) and texts regarding ratification especially in the mid-Atlantic states (vols 20 and 21) are brimming with discussions of the kind of man suited for office and appropriate and democratic ways of encouraging gentlemanly governance.

> In a civilized state…there is little variety in the occupations of the greater part of the individuals [but] almost infinite variety in those of the whole society. These varied occupations present an almost infinite variety of objects to the contemplation of those few, who, being attached to no particular occupation themselves, have leisure and inclination to examine the occupations of other people.[131]

Though this excerpt is short, Smith's assumptions can be easily detected: the worker in Smith's world, who performs one of an infinite variety of tasks, cannot possibly appreciate the industrial system as a whole. The requirement of a detached leisure-wielding class of governors, for Smith, arises from the ultra-specialized division of labor that marks the "civilized state."

Equally apparent from their letters is that Madison, Livingston, Rush, etc. were not afraid of rabble-rousers and the unruly mob; they were afraid of the mob electing the rabble-rouser to a state legislature where he would then have power akin to gentlemen who "belonged" in government—as in the case of Isaac Sears, who had been a member of the New York Sons of Liberty and was elected to the New York legislature promising to oust British loyalists from the state.[132] A surviving Yale student play from the time expressed a similar concern, though more pointedly; when one of the characters fears that the mob of citizens is no longer deferential to the legislature, he is sent a threatening anonymous note to keep his unpopular opinion silent to which responds: "I must confess, this is something very singular, that a person must be

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[131] This quote is from Smith's essay on education and institutions can be found in Book V, Part III, Article II.
[132] Sears is perhaps most notable because he was later exposed for having bought up deflated war veterans' pay vouchers and using them to speculate on the seized property of the exiled "loyalists" (Maier 234).

cautioned against speaking his sentiments upon any political point in a free state—but sir, we have a new set of folk lately come upon the stage." [133]

Political office in the late eighteenth century, descending from the English tradition at least, was largely not considered an occupation in and of itself; rather, it was the duty of the educated gentleman whom fate, the state, or the people called to service.[134] Under colonial governance, the legislatures of each colony were filled with such gentlemen; they were often liberally educated[135] and could claim a profession (specifically law, medicine, clergy, or military) or significant holdings (a plantation or other form of property like a fleet of ships). Washington or Jefferson like other southern politicians were planters; Adams and Hamilton, like many northern politicians, were lawyers.

After the revolution, however, state legislatures were filled with a "new set of folk": farmers (who advocated printing money to ease debts and forestalling land auctions), merchants (who advocated withholding currency and taxing land in order to lower tariffs), and tradesmen (who advocated raising protectionist tariffs and breaking commercial trade monopolies). Social and fraternal organizations, not new to the colonies, became political lobbies and rally points for candidates seeking office. Some of these organizations, typically identifying with the Revolution itself rather than an economic sector or social movement (like temperance, abolition, etc.), advocated their platforms in the guise of legislative restraint, national unity, or responsible electing.

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[133] Relevant portions of the play, and a description of its circumstances, can be found in the eighth chapter of Grasso's book on American eighteenth century public discourse. The play itself, unpublished, can be found in the Yale Archives associated with the Class of 1786 Miscellaneous Manuscripts 6,15.
[134] Political appointees in contemporary US executive departments still "serve at the pleasure of the President." Popular political discourse around military service and political appointment rely on the anthropomorphism "your country needs you."
[135] Noah Webster, in his essay "On the education of youth in America," asserts that a liberal education is the path to genteel participation in society as it "disqualifies a man for business" (Webster 93).

The Society of Cincinnati, for example, was incorporated in 1783 to, in part, "promote and cherish, between the respective states, that union and national honor, so essentially necessary to their happiness, and the future dignity of the American empire" ("The Society…").[136] Formed in the wake of peace with Britain, the Society's member role included American and French veterans of the Continental Army, most of whom were owed significant sums by the US government. The society's first president, George Washington, was at the time referred to by some as the "Cincinnatus of the West" as he had been a planter, led the Revolutionary Army and then, in a well-choreographed bit of political theatre, resigned his commission at Annapolis and returned to farming.[137] The inclusion of some—and the exclusion of other—prominent politicians, a number of unofficially declared federalist proposals, and its hereditary plan for growth made the society a center of controversy.

Having just fought a war for independence from a government that was dominated by hereditary control and classist private organizations and that wielded its military to police the colonies, an exclusive military organization in which only members first born sons became members (and in which the politically powerful and agreeable could become guest members) seemed an anathema. Worse yet, the Society, which quickly decentralized into local lodges, often failed to publicly speak with a uniform voice and contained amongst its ranks a variety of political conservatives, including some who advocated making Washington into a sort of emperor of the Americas. Washington's acceptance of a leadership position in the organization, in fact, was often questioned—Cincinnatus, after all returned to his farm after relinquishing power, he did not become an extra-governmental advocate or leader of a veterans association.

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[136] The society was named after Lucius Quinctius Cincinnatus, the Roman patrician who, when Rome was threatened by the Sabines, left his farm to accept a six month dictatorship and who, upon the defeat of the Sabines only two weeks later, promptly relinquished his control over the empire to return to his fields The story can be found in a number of histories. See Livy's history of Rome *Ab Urbe Condita Libri*, Book iii. Or Dionysius of Halicarnassus's *Roman Antiquities*.

[137] Unlike Washington, Cincinnatus had become a laboring farmer and had become so out of necessity after having been impoverished by a retributive fine imposed by the same Senate who would later ask for his service.

This irony did not go unnoticed, of course; publicly and privately the society had critics. South Carolina Judge Aedanus Burk (before his decline into mental illness) made rather public accusations about the Cincinnati's plan for an American nobility; members of the organization, he suggested, within a few generations of intermarriage would seize control and establish a monarchy (Hünemörder 145). The Massachusetts state legislature established a committee to investigate the organization; the committee found the society inappropriate and dangerous to democracy.

Most political commentators and politicians outside of the society, however, were less afraid of the society and more scornful. Benjamin Franklin, for example, in a 1784 letter to his daughter criticized the Society for all of the reasons noted above as well as for its use of the bald eagle as a symbol. To the latter point, Franklin laments the choice of the eagle—a bird that has a generally cowardly demeanor and that survives by stealing the food of weaker birds and which, therefore, "is, therefore, by no means, a proper emblem for the brave and honest Cincinnati of America, who have driven all the kingbirds from our country; though exactly fit for that order of knights, which the French call, *chevaliers d'industrie*." The French expression *chevaliers d'industrie*, literally knight or industry, was an old slur. Traditionally the phrase referred to men of power (soldiers or government agents) who made their living opportunistically, by exploiting whatever advantage they had over others. But by the latter half of the eighteenth century, the term was already being as a pun to identify men of economic means who exploited poor laborers or monopolized consumers.[138]

Franklin's pun about industrialists was only a small part of a casual letter to his daughter, but, taken in the context of his and certain colleague commentators of the day, it's revealing. The vacuum of national coordination in the new United States was accompanied by a vacuum of aristocracy. Both of these, of course, were a response to popular demands of the citizens of the

[138] The fruition of this usage would come when Thomas Carlyle would title Chapter 4, Book 4 of his *Past and Present* "Captains of Industry." Carlyle's captains would be a refutation of the exploitative label, of course.

Revolution. But many of the political elites and magazine writers of the time were on the watch for the rise of an empowered class, which is perhaps the reason the Cincinnati received so much attention and were the brunt of so many conspiracy theories.[139]

The Constitution of 1787 was, at once, an expression of political will to organize and promote an American economy and an attempt to counterbalance the voice of the mob. By dividing power between the states and a continental government, between the deliberative voices reflecting local interests and continental-wide leadership, and between the capricious voices of the "new set of folk" and the more qualified voice of the gentry,[140] various interests acted in tension rather than coordination, distributing the potential power of landholders, of farmers, of political elites, and of the population at large. Under the new Constitution, the Congress was given (exclusive to the states) the power not only to regulate tariffs but to print a single nation currency, establish a postal system, and regulate weights and measures. More broadly, the Constitution also gave Congress the authority to regulate interstate commerce (effectively creating a national free trade zone) and authority to control the use and distribution of public lands.

The Constitution, though written in a secret session, was not written in a vacuum. The public may not have known about the workings of the Convention cloistered in the Pennsylvania State House, but the delegates were well aware of the angst-ridden city public. In the Philadelphia air the months surrounding the Constitutional Convention were debates about the future of the

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[139] The fear of a rising aristocracy can be seen not only in popular publications of the time but also in seminal government documents. The assignment of title was notably absent from the powers of the Congress of the Confederation, and the Federal and State governments were expressly prohibited from assigning title by the Constitution (Article 1, Sections 9 and 10). While government officials were also prohibited from accepting title from foreign governments by these clauses, citizens were not. Though a thirteenth constitutional amendment (signed by several states but never ratified) to prohibit citizens from accepting titles was actively discussed late as 1812.

[140] As to this latter point, until the mid-1890s, member of the US Senate were appointed to their terms by the legislatures of the respective states rather than being directly elected. They were thus most often elder statesmen of the states, who, many at the Philadelphia Convention thought, would gentrify the legislature, giving it not only a veneer of respectability but also preventing the lower legislative house, elected by the population at large, from taking rash actions.

new American nation. Credit markets in the city had begun to tighten for merchants as household debt reached all time post-war highs. American currencies were scarce and fluctuated wildly as states horded notes, minted new specie, and reassigned measures and values at will.

The pages of *American Magazine* were filled with reminders of the economic agreements made by states entering the Revolution and suggested remedies for personal debt. A cautionary sermon by "A Farmer," entitled "Cause of, and cure for, hard times," depicts how the household of an honest farmer, gone wild with spending on imported fineries when taken over by women and an educated son, could be brought back to right by selling off imported good and returning to traditional self-sufficiency by reliance on agricultural homespun ("Cause of, and cure for, hard times"). An article by Ben Franklin, in the same volume, attached a similar optimism to America's farms and fisheries. With a surplus of foodstuffs, timber, and fibers, Franklin's article asserts, there can be no problem with the American economy. Agriculture and not fineries, suggests Franklin, is the source of wealth in America (Franklin 7).

The position articulated in Franklin's article and in other articles that relate economic growth almost exclusively to agriculture had been, in decades prior, articulated in a preliminary (and notably quantitative) way by the physiocrats, a group of French philosophers now sometimes labeled the first political economists. Notable physiocrats, including Richard Cantillon and François Quesnay, argued for a model of the national (mainly French) economy that relied on a circular flow of goods and services in which the land alone could contribute to economic growth.[141] The land, according to Quesnay, is the only thing that produces more than the work put into it; a national economy, then, can only grow as it is supplemented by the bounty of

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[141] Cantillon, in *Essai Sur La Nature Du Commerce En Général* (*Essay on the Nature of Trade in General*) supplemented concepts from William Petty's decades older *Verbum Sapienti* and *Political Arithmetic*—namely the quantifications of the "velocity" of money and ideals of rent and *vadere sicut vult* (or as Cantillon would call it *laissez-faire*)—with an economic structure based on circular trade between laborers, artisans, entrepreneurs, farmers, and property owners. Circulated from 1730 (though not published until 1755), Cantillon's *Essai* first assigned the name entrepreneurs to the class of non-agricultural businessmen who capitalize on the work of artisans rather than the land.

nature. Quesnay's model of an economy, expressed in his *Tableau Économique*, relies on the division of participants into three classes—proprietary, productive, and sterile—or: those who own and improve the land, those who cultivate it (*fermiers*, literally farmers), and those who consume. Included in this last sterile consumer category are artisans and merchants who consume raw materials in order to produce products for reconsumption. In Quesnay's model, the natural value—that which is intrinsic to products that are not directly agricultural (i.e., finished non-food products)—bears no surplus; it is simply the value of the raw agricultural product and the subsistence of the artisan; it is food, degraded by the investment of sterile labor and waste, to take a form that satisfies variety of function.[142]

To put it somewhat anachronistically, Quesnay's model associates wealth with tangible goods and computes value based on the material composition of goods and the subsistence of the worker (without considering later human-based classical concepts like psychological demand for a product or the transference of worth of the skill of an artisan). Even the term physiocracy itself rather projects this idea—implying the laws of nature (rather than human or social) governance of the economy.

The privilege that the physiocratic model assigns agriculture has several interesting ramifications, not the least of which is an anti-mercantile and anti-industrial economic policy; if agricultural products are the primary source of wealth for a nation, then industrialization encourages the production of a low value product at the expense of a high value product and mercantile industrialization encourages the diminishing export (rather than full consumption) of those low value products. To a certain extent, the physiocrats, native to France, were responding to France's international position: France's colonies in the Caribbean and Southeast

[142] Perhaps the best (and certainly briefest) summary of physiocratic doctrine is Pierre Samuel du Pont de Nemours's *On the Origins and Progress of a New Science*, published in 1767 at what was probably the peak of physiocratic discussion (before family scandal attached to one prominent member of the movement, before Voltaire made the physiocrats his political enemy, before Adam Smith produced his alternative and more methodologically mature *Wealth of Nations*, and before the Reign of Terror weeded out the few remaining professors).

Asia did not produce finished goods for export directly to international markets, they produced agricultural products. Not in surplus, finished goods were exported from France at the expense of consumption at home. Food was practically the nation's only abundant product.

The details of the new American nation's economy were different—and the political climate was certainly different—but the balance sheet was similar: tremendous amounts of food and raw agricultural products could be (and, in some regions were being) produced and there were no subservient markets in which to offload finished goods. American statesmen, like Franklin, who appreciated the writings of the physiocrats, however, were attentive not just to similarities between the French and American conditions but to the similarities between the British and American economies as well.

Prior to the Revolution, while agitating for political recognition in Britain, Franklin had syllogistically summarized his own version the physiocratic doctrine in private correspondence with Scottish social and legal philosopher Henry Home, Lord Kames. All goods and services, writes Franklin, "have their values estimated by the proportion of food consumed while we are employed in procuring them" such that a "small people, with large territory, may subsist on the productions of nature with no other labor…[from which will arise] a *great increase* of vegetable and animal food, and of materials for clothing. The superfluity of these is wealth." Continuing his deduction based on this physiocratic definition of wealth, Franklin asserts that "*[m]anufactures* are only *another shape* into which so much provisions and subsistence are turned" and that the natural value a finished good can be calculated simply by considering the amount of raw material and subsistence (Ketcham 227).[143]

To illustrate equitable trade in this system, Franklin provides a few examples, including the example of a half shilling worth of flax transformed by nineteen and half shillings worth of

[143] This letter can be found in its entirety in a collection of Franklin's letters edited by Ketcham. Italics throughout that work presumably indicate various stress markings by my by Franklin's hand. His letters, of course, were not typed; but Franklin's penned words were often emphasized graphically—by underlining and the like—rather than by capitalization as was a contemporary custom.

subsistence goods consumed by the artisan into twenty shillings worth of lace. The lace example, Franklin's last in the passage, is particularly interesting because he uses it to point out the potential for inequity in the trading of manufactured goods.

> Thus the advantage of having manufactures in a country does not consist, as is commonly supposed, in their highly advancing the value of rough materials, of which they are formed…[but that they] may be more easily carried to a foreign market; and, by their means, our traders may more easily cheat strangers. Few, where it is not made, are judges of the value of lace. The importer may demand forty, and perhaps get thirty, shillings for that which cost him but twenty. (Ketcham 228–9)

The natural value of lace (which included the labor going into making it) was fixed to the value of the agricultural products consumed. The merchant selling lace for more than its natural value Franklin brands a cheater. Franklin's cheated strangers have little agency: they are not demanding consumers willing to weigh the value of lace and decide its worth; they are simply ignorant of the process of making lace and therefore unable to calculate the fair value accurately enough to recognize that they are being cheated.

Far from the observations made by the editorialist of "Causes of a country's growing rich," whose article, as mentioned, would appear next to Franklin's decades later, Franklin concludes his letter observing precisely three ways for a nation to acquire wealth:

> The first is by *war*, as the Romans did, in plundering their conquered neighbors. This is *robbery*. The second by *commerce*, which is generally *cheating*. The third by *agriculture*, the only *honest way*, wherein man receives a real increase of the seed thrown into the ground, in a kind of continual miracle, wrought by the hand of God in his favor, as a reward for his innocent life and his virtuous industry. (Ketcham 229)

Agriculture is not simply the best way to sustain an economy—it is the "only *honest way*." It is the only way that is virtuous, because, as man interacts with the soil, he relies on the divine "hand of God" that creates new life with each season in more bounty in American than anywhere else. While Franklin's route to these conclusions may have been exposure to the ideas of Quesnay and the physiocrats, in rare articles for the public on the subject of economy, his position played more simply as a preference for agrarian development than economic theory—a position which seemed to align with Washington and Jefferson and with a variety of pseudonymous authors.

The idea of America as ideally (and idyllically) agrarian had been well established, in fact, in the popular mind not only in America but in Britain and France as well. From the accounts of the earliest colonists, comments on the fertility of the soil and the richness of flora and fauna had always been included in accounts of the New World. Perhaps the most widely circulated snapshot of American life contemporary with the time of independence was J. Hector St. John de Crèvecoeur's *Letters from an American Farmer*. While not an expressly political document, Crèvecoeur's treatment, published in the last years of the revolution in both English and French, addressed the would be European traveler entering America to find "fair cities, substantial villages, extensive fields, and immense country filled with decent houses, good roads, orchards, meadows, and bridges" but, at the same time, "no aristocratical families, no courts, no kings, no bishops, no ecclesiastical dominion, no invisible power giving to a few a very visible one, no great manufactures employing thousands, no great refinements of luxury" (48–9). This dichotomy, furthered in the rest of his letters, illustrates how, to Crèvecoeur, the idea of manufacturing was as much an anathema to the American ideal of independence and productive labor as were aristocracy and papacy.

Throughout *Letters*, Crèvecoeur endeavors to use Americans' industrious connection to the land to explain novel features of American society. For example, he asserts that the various European immigrants who come to America and take up the land naturalize as Americans because of their experience with the land. German and English farmers in America become American farmers, he explains, as they work American soil and as it yields fruit according to their labor and technique not their national origin (57). Equally, the "fury of making Proselytes" is

unknown in an agrarian American in which the "seasons call for [men's] attention" (64–5).[144] Describing a Sunday Protestant service, Crèvecoeur depicts the congregation and parson dressed alike in "neat homespun"—notably the parson, in Crèvecoeur's scene, is also a farmer and as such is not dependent upon the community.[145] The farm cycle replaces the rhythms of European sectarianism, soothing religious frictions as it does inherited European nationalist tensions. The land itself acts as an equalizer for industrious immigrants of all backgrounds.

In fact, the land is even the agent that normalizes the outcast and the non-industrious immigrant. Pushed ever westward, put out of society and off of "improved" land, the citizen outcast from the cultural refinement and democratic participation of coastal America becomes the pioneer—a baser creature, a hunter, who through communion with nature is eventually civilized as he becomes a caretaker and then an improver of the land, creating the new American interior (58–61).[146] For Crèvecoeur, industriousness with the land is itself the hallmark of Americans, whom he describes as "animated with the spirit of an industry which is unfettered and unrestrained, because each person works for himself" (50).

Franklin's physiocratic editorials and Crèvecoeur's pastoral scene, however, were in no way as authoritative a statement as the comprehensive agrarian philosophizing of Thomas Jefferson. In his compendium *Notes on the State of Virginia*, published and expanded continuously between 1781 and 1787, Jefferson sets aside only two (sizable) paragraphs for to treat "[t]he present state of manufactures, commerce, interior and exterior trade" (290–1). In these two paragraphs, Jefferson articulates a forceful and moral agrarian position.

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[144] This is actually quite a long and interesting passage. Crèvecoeur takes the reader on a stroll through a fictional American town populated by Catholics, Lutherans, Quakers, etc. none of whom know each other's religious preferences—to the extent that the religions intermarry, even, and that progressive generations become ever less attached to specific principles of any specific religion.

[145] Later, when addressing tax and tithe, Crèvecoeur goes on to note that ministers do receive a small salary that is accumulated voluntarily, unlike in Europe where portions of farm products are "claimed, either by a despotic prince, a rich abbot, or a mighty lord" (55–6).

[146] In fact, Crèvecoeur makes quite archetypical comments about the proximity of men to woods and wilderness and how their savagery (the American version of which is pioneerism) diminishes as the land is improved. See also 67–8.

In an early statement of American exceptionalism, Jefferson asserts that, though "the political oeconomists of Europe have established it as a principle that every state should endeavour to manufacture for itself," America should not enter into manufacturing. Transferring the logic of Europe to America, Jefferson first argues, is flawed because the natural conditions of America are different. America has "an immensity of land" to be improved and husbanded, whereas in Europe the land is crowded and bound up by the legacy cultivation and feudalism.[147]

Jefferson's further argument, however, is more interesting. Given the excess of unimproved open land, he asks: "Is it best then that all our citizens should be employed in its [the land's] improvement, or that one half should be called off from that to exercise manufactures and handicraft arts for the other?" Jefferson bases his answer to this rhetorical question (the former option, of course) on the divine role of man as husband of the earth:

> Those who labour in the earth are the chosen people of God, if ever he had a chosen people, whose breasts he has made his peculiar deposit for substantial and genuine virtue. It is the focus in which he keeps alive that sacred fire, which otherwise might escape from the face of the earth. Corruption of morals in the mass of cultivators is a phænomenon of which no age nor nation has furnished an example. It is the mark set on those, who not looking up to heaven, to their own soil and industry, as does the husbandman, for their subsistence, depend for it on the casualties and caprice of customers. Dependence begets subservience and venality, suffocates the gem of virtue, and prepares fit tools for the designs of ambition. This, the natural progress and consequence of the arts, has sometimes perhaps been retarded by accidental circumstance: but,

[147] The term husband is used less in connection with agriculture, perhaps, today than in the eighteenth century; though we still use the term husbandry, the word has acquired a somewhat arcane tone. The passages of Jefferson that follow rely on the term as it was used at the time: not only the head of household but also a farmer. The term, at the time, typically did not extend to other natural industries (e.g., forestry, fishing, or mining), but in England did sometimes extend to cover ship tenders. The OED provides information on the usage of the term as both male head of house and farmer back to circa 1200.

> generally speaking, the proportion which the aggregate of the other classes of citizens bears in any state to that of husbandmen, is the proportion of its unsound to its healthy parts, and is a good-enough barometer whereby to measure its degree of corruption
> (290–1).

By the end of the eighteenth century, Jefferson's readers would likely recognize the basis of his commentary; as industrial and political revolutions gained steam, so did Romantic depictions the natural world (and man's role in it) and pastoral images of the cultivator exercising righteously (rather than offensively) the dominion over the earth awarded him by God on the sixth day of creation. The political quantitative observation which Jefferson adds to the pastoral position, however, is reminiscent of the physiocratic argument for agrarian economy. The corruption of a nation, Jefferson is asserting here, is directly related to the proportion of its members who are not engaged in cultivation. In their dependence on customers, manufacturers and artisans are corrupted. They are subservient and venal and "fit tools for the designs of ambition" and, therefore, poor candidates for democratic citizenship.[148]

Regarding political economy, Jefferson goes on to dismiss the potential profits lost by engaging, if not in manufacturing, at least in shipping by suggesting that the losses incurred from transportation across the Atlantic "will be made up in happiness and permanence of government." America will be a happier in more stable place by keeping manufacturers and merchants out, by establishing a reverse mercantile relationship with the traders of the world, effectively making America, as Jefferson would write later in a letter to GK van Hogendorp,[149]

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[148] It's notable that, in the remainder of the passage Jefferson exempts building tradesmen (specifically carpenters, masons, and smiths) who, unlike other manufacturers, are "wanting in husbandry" (291).
[149] Hogendorp was a Dutch statesman who would eventually become Prime Minister of the newly independent Netherlands. The exchange referred to here, interestingly, occurred when Hogendorp, still a student in Berlin, wrote to Jefferson with questions about his political philosophy and the American Revolution. For the full letter, see Boyd's *Papers of Thomas Jefferson* (8:633).

"with respect to Europe precisely on the footing of China."[150] In his final sentences, Jefferson constructs an analogy relating the effects of urban factory mobs on governance to those of sores on the body. "It is the manners and spirits of a people which preserve a republic in vigour," Jefferson concludes. "A degeneracy in these is a canker which soon eats to the heart of its laws and constitution" (291).

Jefferson, however, was in Paris during the 1787 Constitutional Convention and Washington, with whom Jefferson often exchanged sympathetic letters, seemed bound by his role as president of the convention (or possibly by his own sense of image) to remain largely apolitical during the debates on the subject of encouraging manufactures. Other ideologues (not all agrarians but anti-federalists as well) were also absent from the convention. John Adams was in London; Patrick Henry declined attendance; Richard Henry Lee and Samuel Adams were not selected by their respective states; no one from Rhode Island attended.[151] Of the more than fifty delegates who did attend the Convention, only a dozen derived their income from agriculture.[152]

The rest were largely merchants (chief among these Robert Morris) or speculators in land or securities[153] and Philadelphia, the fortuitously central city of the Convention was awash in early

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[150] Notably, the exchange quoted here took place in 1785, well in advance of the wars between Britain and China which marked the middle decades of the 1800s.

[151] Rhode Island, the smallest state, was perhaps the most anti-federalist state and the state to withhold approval of Constitution longest, finally signing only after editorials suggested dividing the state at the Narragansett to expand Connecticut and Massachusetts.

[152] This is not to say they were or weren't farmers, per se. Jacob Broom owned a small farm in Wilmington, Delaware but, despite almost perfect attendance, was largely silent in surviving minutes of the convention. William Few had been born poor and had acquired after distinguished military service a small farm in Georgia, but rarely attended the Convention splitting his time between Philadelphia and Augusta, then the capital of Georgia. On the other hand, nearly all of the delegates from Virginia and North and South Carolina owned large slave operated plantations (e.g., Blair, Butler, both Pickneys, and Washington himself).

[153] Almost all wealthy men, the delegates could often be construed as falling into more than one category, of course. Though, some like Franklin, Mifflin, and McHenry had exclusively public service and military careers. There were also professionals: at least were two physicians (Hugh Williamson and James

[this note continues on the next page]

industrial development and manufacturing lobbyists. A multipart report entitled "On American manufactures" appeared on the pages of the *American Museum* in the months before the convention. With all the trappings of a political argument, the author of piece[154] declares his love of country, sets up a straw agriculturalist opposition, and dispenses with it in favor of encouraging manufactures.

To his opposition's desire that Americans should be "almost wholly occupied in cultivation of the land," he leverages the American value of equal worth in the face of inheritance and the Protestant work ethic replying "we cannot all be cultivators of the land, because every father has it not in his power to give every one of his sons a tract of land, but every father may have it in his power to have his son taught a trade. If, then, trades and manufactures were encouraged," he goes on, "every father might places his son, somehow or other, in an eligible way of procuring a decent living, by which he would become a useful member of the community" (17). An overly agricultural economy, the author argues, can only lead to low citizen productivity, idleness, and the impoverishment of society—all anti-puritan, anti-American ideals. A man who cannot afford enough eastern land to provide his children farm work will either raise an idle family (who will not contribute to the economy, who not having worked fully will be inept in political participation, or worse who will become delinquent, alcoholic, etc.) or will move west where, after spending years finding, buying, and improving a remote tract will produce only for subsistence being "at such a great distance from places of trade and commerce, that he would spend almost the whole produce of his plantation, were he to bring it to market" (17). Underproduction will be the only resort of the pioneer farmer and, as cities will never establish themselves in the west without manufacturing centers, the population will degrade until, meeting the classic fear of the new nation, there is no basis for society at all.

McClurg) and a few were trained as lawyers, including Rufus King, William Houstoun, and president of Columbia University William Samuel Johnson.

[154] The article is signed simply: "A plain but real friend to America," and contains a note on the second page that the essay was written in Maryland.

On the other hand, the farmer who is not willing to move west to provide land to his excess children, the author sets up alternatively, apprentices them into bookkeeping, after which they get positions as clerks, secure letters of credit, and eventually import goods to sell. In 1787, of course America was importing almost all manufactured goods, but imports—as well as credit, of course—in this narrative (as in the advice from A Farmer discussed above) are a symbol of vice in the author's argument. And so what happens to the farmer's son turned trader? He is unable to fetch a high enough price to repay his loans selling goods only to farmers' wives and daughters and "becomes a bankrupt, and an injury, instead of a benefit to society."

Interestingly, though not in so many words, the author decries this latter problem as an essential problem of the agrarian economy advocated by the physiocrat-inspired American. Excess farm labor where land is all improved can do nothing but turn to idleness or speculation. Likewise skilled laborers whose labor sectors are kept undeveloped (like those in America who would be mechanics) can do nothing but turn to idleness or speculation.

> We are all like to become merchants. Hence this branch is wholly overdone, and in a most ruinous state; the country is full of goods, and our money all gone. What alternative? Is it not clear and evident that we cannot all be merchants? If, then, American manufactures were countenanced and encouraged, this need not be the case. (19)

The author's argument, designed to appeal to agriculturalists, is not for diverting some farm labor to become mechanics and manufacturers (terms which he does not dwell on and, in fact, seems to use interchangeably only to vary his voice, to get by them faster). The author's argument, rather, relies on finding useful—rather than socially or economically corruptive—employment for the surplus labor that cannot be absorbed by agriculture, in which he includes not only farmer's children but the poor and those landless skilled immigrants who daily were arriving in the country who, without manufacturing employment in the east, found no

alternative but to "wonder in the woods and wilds of the back country, to live like Indians, and to be useless to our government" (20).[155]

This argument, which appeals to the American puritan values of productive labor and contribution and non-idleness, dominates the arrangement of the article but is reinforced subtly by a second argument, based on similarly American ideals of personal liberty and equality. This secondary argument seeps into the article as small comments are made about workers who, desirous of being mechanics, are instead forced to poverty, about immigrants with economic skill made to live like savages, and about the undemocratic social privilege assigned to farmers under the current economic regime.

Alexander Hamilton would make similar points nearly five years later when, as Secretary of the Treasury, he would submit to the new Congress a *Report on Manufactures.* In it, Hamilton would advocate moderate tariffs combined with subsidies to nurture infant manufacturing in America. Taking cues from the century earlier writings of French Finance Controller Jean-Baptiste Colbert, Hamilton would resist Adam Smith's arguments for free trade and national specialization the same way Smith, in his *Wealth of Nations* resisted the physiocrats definitions of wealth. Hamilton's position, that a favorable trade relationship with Britain was essential to stable American markets in the short term and that American industries had to be incubated and assisted until they could compete with British ones in the long term, eventually seeped into national legislation ushering in a new era of investment in local production, diversified economy, and internal improvement and setting up the conflicts which would dominate the first sixty years of the nation's new government: Federalist against Democratic-Republican (and later to

[155] This was a familiar argument at the time, of course. Manufactures had long been advocated even in the face of opposition from colonial governance in urban populations in the north. A series of reports from the 1750's Society for Encouraging Industry and Employing the Poor detail some of the schemes for incentivizing cloth production as well as the interactions of Philadelphia and Boston merchants who, it seems, periodically shared advice on heading such programs. See, for example, "Report of the Committee to the Society…."

be republican against democrat), industry against agriculture, urban against rural, north against south.

Manufacture and the American System (of economy)

From the time Hamilton's *Report on Manufactures* was written to the completion of the Erie Canal, the population of the United States more than doubled and the population of largest city tripled.[156] The American economy in 1780 was largely agricultural—supporting less cottage industry than subsistence required and fewer professional workers (with the exception of ministers perhaps) per capita than any European country. But by 1820, organized manufactures employed a recognizable fraction of the population; urban dwellers, still the minority, were a recognizable class of citizen; and agricultural land was beginning a noticeable shift westward.

In response to Hamilton's report in 1791, Congress had done what it often does when confronting controversial legislation—split the question. Tariffs, of course, were popular with Federalists and Democratic-Republicans alike, and so Hamilton's modest tariffs (designed to offer modest protection to industry without angering on the British) were accepted, but his incentives to industry (his "essential complement" to low tariffs) were rejected.[157] The fact that the Democratic-Republicans would have, given their way, imposed *higher* tariffs than Hamilton's plan proposed (without any incentives, of course) led many Federalists (who were either unaware of or insensitive to the portions of Hamilton's plan not adopted) to view Hamilton as a traitor. But Hamilton continued to promote manufactures in the absence of direct subsidies by taking advantage of the fortuitous and singular moment—the founding of a new government—

[156] While the largest city in the United States though the 1770s was Philadelphia, New York, the basis for these figures, had eclipsed Philadelphia by the time the war for independence was over. The largest city in North America, however, remained Mexico City, which was larger than the top four US cities—New York, Philadelphia, Baltimore, and Boston—combined.

[157] Both broad incentives and specific requests for patronage were eventually eliminated from consideration. The notes of the first several sessions of Congress are filled with propositions from businessmen and industrialists who promised returns on assistance. Debates, however, were short lived and supplicants always denied.

to enroll Dutch investment in national bonds. Through the construction of a national debt, and a national banking system reliant on that debt, Hamilton acquired the subtle power to direct government financial backing and provided an outlet to improvement projects and to the whim of the people for domestic refinements.

Hamilton saw no conflict between agricultural and manufacturing labor. And under the administrations of the first two American Presidents (Washington and Adams, both Federalists) he was able to make his arguments known. In his *Report,* he readily admitted that labor shortages were likely a feature of the American economy for the foreseeable future. Rather, Hamilton advocating importing skilled immigrants to fill manufacturing role naturally supported by the American continent but for which no labor could be spared. He also favored enrolling women and children in the ranks of those contributing to the household economy; factory work in rural centers and urbanizations would provide women and children an opportunity to escape idleness and make money for their families without having to resort to men's labor. Additionally, he branded American manufactures as a national security issue, pointing out the likelihood that trade relations, even in an America that avoids entangling alliances, were be unpredictable and that to rely on another nation for essential goods weakened America's diplomatic position. This message was taken up in earnest in the latter years of the Adams administration, when hostilities between American and French ships seemed to foreshadow war.

By 1801, however, Jefferson was president, the pro-bank, pro-industry Federalists had been divided by conflicts between Adams and Hamilton, and roundabout subsidies and tariffs had done little to encourage more than the production of basic leathergoods, homespun clothes, artisan metalgoods, and building materials made off and on throughout the colonial period.[158]

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[158] It's perhaps notable Samuel Slater, often credited with the foundation of the New England mill system, left Britain (despite an embargo on textile experts emigrating) and established a mill in Pawtucket, Rhode Island in the mid-1790s. The Rhode Island mill—and others like it in Paterson and Newark, New Jersey, in Beverly, Massachusetts, and in Philadelphia—were minor operations, however, compared to the mill towns of Lowell and Lawrence that would begin operation a few decades later.

Probably in view of the closeness of the election, [159] Jefferson's first inaugural address was deprecating: he asked to be pardoned in advance for mistakes he would surely make; he employed unifying metaphors—the federal government was, for instance, portrayed as a ship in which the crew (the president and legislature) would be mutually reliant; and, for the bulk of the address, he relied on a recitation of, what he perceived to be, the "essential principles of our Government." Included amongst these principles were not only concepts of personal liberty and republicanism (many phrased with the Constitution in mind), but also the duty of government to act thriftily that "labor may be lightly burthened," to pay down the debt as a means of improving national credit, and to act in the "encouragement of agriculture, and of commerce as its handmaid" (*Inaugural Addresses…* 1:21). The prioritization of agriculture in his address, of course, was symbolic more than directive. Without direct stimulation, the national economy had remained agricultural.

Months later in his annual address to congress, Jefferson would expand this thought urging the Congress to take a laissez faire approach to "[a]griculture, manufactures, commerce, and navigation," which he deemed "the four pillars of our prosperity," as they are "the most thriving when left most free to individual enterprise" (Jefferson. "First Annual…"). He extended this laissez faire approach to westward expansion, promoting a variety of policies that would extend agricultural settlement of the in the interior of Pennsylvania as well as what are today West Virginia, Ohio, and Kentucky, including advocating the repeal of an excise tax on distillates, which had been a hallmark of Hamilton's influence in the Washington administration.[160]

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[159] He had won the office only by the House or Representatives breaking an electoral tie between himself and Aaron Burr, and the tiebreaking process had gone on for several days and several ballots.

[160] What we might today identify as a sin tax, Hamilton's tax on spirits disadvantaged agricultural production in the west where farmers typically distilled grains into durable and easily transportable alcohol products. Western farmers had a problem: they could not sell their products locally because, without urban centers, local demand rose little above subsistence, and they couldn't ship most products to larger eastern markets because, without mature infrastructure, crops would spoil before arriving or simply cost too much to transport. Hamilton's idea was to tax spirits in order to discourage premature westward expansion of agriculture at the same time paying first the national debt and then for improvements to the lands and waters of the east to increase access to the west. Reaction to the excise,

[this note continues on the next page]

However, representing Jefferson's term as a roll back for industrial support in favor of agricultural production would be an error. Supported occasionally by British immigrants who (acting against British law) brought with them trade secrets of the cloth mills of the home country, textile mills opened and closed throughout the first decade of the 1800s. And, as the population of the country grew, the urban population grew disproportionately.[161] The new immigrants to cities opened small time operations leatherworking, metalworking, and tailoring, producing typically the most high demand and easily produced finished goods.

Jefferson's successful election to a second term, the acquisition of the Louisiana territory, the death of Alexander Hamilton (and subsequent flight westward and later scheming of his killer Aaron Burr) changed the political landscape in America. Burr had established in the New York Tammany Society a center for political operations in support of the Democratic-Republican Party, and New York City had grown to its largest size yet—and was growing.[162] New pressures on Democrats to fund navigation improvements (including early plans for a canal connecting the Hudson with the Great Lakes) and to provide support for urban economic initiatives influenced many House Democratic-Republican discussions of the legislation and litigation of western lands.

City growth prior to and throughout the first term of the Jefferson administration was enabled by the exportation of agricultural surplus (less to Europe than to the proximate islands) and by

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of course, was the rebellion of interior farmers, especially in Pennsylvania where the largest riots (collectively referred to now as the Whiskey Rebellion) attracted the attention of the national militia. The western rebels were put down by the administration of the man who had led the rebellion against the British not twenty years prior. Washington's (and the federalists') justification was that a government constituted by the people was substantively different than one imposed upon the people. The suppression set a president for national policing in the face of insurrection—rather than the exclusion of speech or assembly—which would be used throughout the first half of the nineteenth century in the run up to the Civil War.

[161] In 1790, fewer than a quarter of a million people (out of 4 million) lived in towns over 2,500. By 1825, when the population of the country had nearly tripled, the population of urban dwellers had increased fivefold (A Chandler 17).

[162] New York wouldn't become the largest city in the world for another 100 years when, in 1925, its population would expand to nearly 8 million and pass the population of London (T Chandler).

the domestic demands of an ever more materialistic American culture. Merchants in cities acquired finished and luxury products—either by importing on credit or procuring through speculating on risky intercontinental trade expeditions—and then sold those products locally to buyers who would carry a certain percentage of them inland to sell them to buyers who would sell some and carry others further inland. The growth of Philadelphia, New York, and Baltimore was based on ever larger catchments of consumer farm households.[163]

With the renewal of hostilities between Britain and France in 1805, however, American trade with Europe and its colonies attracted more political attention than ever—the British threatened to declare war on any nation violating their embargo of France and began routinely searching American ships at sea (often seizing American crewman under the pretense that they were British defectors) and the French threatened to declare war on anyone giving in to British demands. In 1806 and again in 1807, expressing concern about being drawn into the conflict, the Democratic-Republicans of the Congress, at the request of Thomas Jefferson, passed two sweeping acts[164] prohibiting nearly all American international trade. Throughout Jefferson's second term, these acts were amended to broaden executive control of trade, in a largely unsuccessful attempt to stamp out illegal trade through Canada,[165] at sea, and by proxies, and, later, even rewritten to target, more specifically, the countries involved in the European conflict.

The embargo, once instituted, was grossly unpopular. Urban merchants were driven to bankruptcy, ships rotted in dockyards, agricultural over production sent prices plummeting while land speculation drove farm prices higher, and the general lack of domestic goods enticed

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[163] These are the large mid-Atlantic cities of the time, of course. For other large cities of the period, this model of growth is less applicable; consider Boston, with its established shipping and fishing satellites (like Salem and Gloucester), or southern cities like Charleston and New Orleans where plantation economies made the export of agricultural commodities to Europe and the importation of slaves from Africa more significant trade .

[164] The Nonimportation Act (2 Stat. 379) and the more comprehensive "Embargo laid on Ships and Vessels in the Ports and Harbours of the United States" (2 Stat. 451), respectively. A number of amendments occured, most notably 2 Stat. 453 in 1808.

[165] Especially in the Champlain Valley. See Muller.

smugglers.[166] Later renowned poet William Cullen Bryant, then in his teens, detailed the situation in Boston, where sailors' "starving children cry in vain for bread" and farmers "sink to poverty and woe" facing rotting crops and unpaid debts and taxes (4–5) and where the citizens of America, he asserts, are no better off than those of Italy or Austria under Bonaparte's arm because the citizens of America are indirectly oppressed by Bonaparte and Britain through the reaction of their own ruler (namely Jefferson).[167]

The failure of the non-intercourse policy has specific ties to the development of military, infrastructure, and industrial engineering and the formalized education of engineers. Neither the declared intention of the embargo (to keep America out of war) nor Jefferson's likely secondary goal (to construct a self-sufficient national agricultural economy)[168] were realized. The War of 1812 would begin over issues related to the embargo a few years into the presidency of James Monroe—Jefferson's secretary of state and co-crafter of the non-intercourse scheme. The War of 1812, as has been discussed in previous chapters, is an early turning point for the establishment of education for military engineers at West Point and for engineering leadership in infrastructure developments of the 1820s and 30s.

Perhaps more germane to a study of the development of industry, however, is that the lack of mercantile and agricultural work and the demand for finished goods (especially textiles and metalgoods) drove the establishment of new manufacturing facilities. By his eighth (and final)

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[166] A dedicated (if dated) treatment of the embargo and its effects can be found in Jennings.

[167] The fruit of Bryant's poem is perhaps more recognizable in standard histories today. Bryant's reference to the embargo as a Terrapin led to a often reprinted political cartoon in which the coat of a man carrying a barrel toward an illicit looking rowboat is caught by a large turtle.

[168] This does not seem to have been Jefferson's declared purpose at any point, but is often insinuated (or even taken for granted as true) by critics and friends of his policies alike. John Bristed, popular critic of everything, referred in his *America and Her Resources* to the embargo as Jefferson's "great agricultural scheme" (37). John Lambert, in his popular account of his travels through the United States and Canada, wrote that the common feeling in New England was that the embargo was designed to so devastate the New England shipping and commercial sectors that the region would convert to farming and America at large, without trade, would revert to a "Chinese nation" (65, 366).

annual message to Congress in 1808, Jefferson would not only acknowledge the stimulation of manufactures but claim it, if reluctantly, as a positive outcome of the embargo.

> The suspension of our foreign commerce, produced by the injustice of the belligerent powers, and the consequent losses and sacrifices of our citizens, are subjects of just concern. The situation, into which we have thus been forced, has impelled us to apply a portion of our industry and capital to internal manufactures and improvements. The extent of this conversion is daily increasing, and little doubt remains that the establishments formed and forming will—under the auspices of cheaper materials and subsistence, the freedom of labor from taxation with us, and of protecting duties and prohibitions—become permanent. (Jefferson, "Eighth annual…")

Jefferson's language is hedged regarding the embargo, which by this time was long unpopular and apparently late in its life as moves to repeal it had begun to win favor even with administration loyalists. Perhaps making what political capital he could of a bad situation, Jefferson describes the embargo not as a failed policy but as thrust upon citizens by "belligerent powers" and accepts the rise of domestic (and extra-cottage) manufacturing as a reality of the situation.

In later years, in personal correspondences, Jefferson would even credit the embargo with serving the national interest, developing a domestic manufactures sector to accompany agriculture and further make America free from foreign influence. Responding to a letter written at the conclusion of the war with Britain in 1816, Jefferson would tell Benjamin Austin, who had noted that Jefferson's old speeches were routinely relied on by opponents of manufacturing, the following:

> You tell me I am quoted by those who wish to continue our dependence on England for manufactures. There was a time when I might have been so quoted with more candor, but within the thirty years which have since elapsed, how are

> circumstances changed! We were then in peace. Our independent place among nations was acknowledged...We have experienced what we did not then believe, that there exists both profligacy and power enough to exclude us from the field of interchange with other nations: that to be independent for the comforts of life we must fabricate them ourselves. We must now place the manufacturer by the side of the agriculturist… [E]xperience has taught me that manufactures are now as necessary to our independence as to our comfort. (Peterson 1407)

Looking beyond the striking statements in this excerpt, even the phrasing suggests Jefferson's change in opinion; e.g., describing agrarians as "those who wish to continue our dependence on England" rather than with any of the positive economic and physiocratic phrases of his writings decades earlier.

The growth in manufactures in the first two decades of the 1800s were due in part to the knowledge of immigrant mechanics, in part to the embargo, but perhaps most of all to the continued demand for goods through a war with, formerly, the chief supplier of those goods. Less than thirty years after the Treaty of Paris and the conclusion of the American Revolution, the new nation was at war with Britain again. The similarities between the two conflicts were not lost—British goods were shunned as they had been in the first war; homespun cloths and citizen and municipal promotion of manufacturing became a badge of patriotism; Americans even called the war the Second War for Independence, insinuating that economic independence had not been achieved by the conclusion of the first war.

Throughout his first term, Madison would continue Jefferson's and the Democratic-Republican line of accepting industrial growth as a necessary by product of non-intercourse, though trade had opened up again when the embargo had been restricted by Congress to British and French trade only (making it almost entirely unenforceable). However, Madison and his treasury secretary Albert Gallatin seemed to recognize the necessity of American industrialization. It had become apparent by Madison's second year in office that war was imminent, and plans for

military production and fortifications, addressed by Jefferson with some resistance from the Congress were given the full push.

In the face of shortage and dependence on foreign finished goods, Americans had once again made homespun the symbol or patriotism. Unlike the homespun movement of the 1770s, however, the movement of the embargo era inspired not only a return to cottage production but also inspired a class of capital investors—unable to attend to trade and with access to new manufacturing techniques via recently immigrated machinists—to invest in high-density, automated, and often residential production operations. In 1803, there were four cotton mills in the United States; a year after the embargo in 1810, there were 226 (Wright 17). And, while several of the few original mills were at a competitive disadvantage, having been sited prior to new mechanical considerations or having relied traditionally on nearby ship construction and trade,[169] Samuel Slater's original mill in Pawtucket, Rhode Island, which had been established in 1792, expanded, by 1808, from twenty-two spindles to about nine hundred (*Relf's Philadelphia Gazette*).

In 1810, like Hamilton had twenty years earlier, Albert Gallatin wrote a *Report on Manufactures* for Congress.[170]

> A great American capital has been acquired during the last twenty years; and the injurious violations of the neutral commerce of the United States, by forcing

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[169] John Cabot's mill in Beverly, MA was an example in both regards. A horse (rather than water) powered mill, it closed when local shipping traffic could no longer be monopolized by the influential owner. See Hoisington for a full account.

[170] Gallatin, another of the largely forgotten founders, was a well know government figure and an opponent of Alexander Hamilton. He was not only Madison's treasury secretary but had been the treasury secretary for Jefferson as well. (In fact, his 15 year tenure in the position still holds the record for occupants of the office.) Notably, years earlier, Gallatin had also been the negotiator who calmed the Pennsylvania insurgents of the Whiskey Rebellion before Washington and the army arrived. His omission from this chapter is necessitated by brevity, but his role in the development of financing schemes for industrial self-sufficiency should not be underestimated. For an academic treatment of Gallatin's extensive influence and vision, see Kuppenheimer. Henry Adams wrote likely the most read biography of Gallatin, but for a recent (and well footnoted) biography see Dungan.

> industry and capital into other channels, have broken inveterate habits, and given a general impulse, to which must be ascribed the great increase of manufactures during the two last years.[171]

Gallatin's metaphor is a poetic articulation of the turning point in the American economy—the swollen waters of capital accumulated since the revolution breaking out of their "inveterate" paths and flowing into the new "channels" of industry which, once carved, will not be blocked up. He had no way of knowing it at the time of the *Report*, of course, but in the decade following the expansion of industry would only accelerate, the channels widen. Madison, at once, served to promote and limit the conversion of the American economy—pursuing trade equality into war and yet continually describing the limitations on industrial expansion[172] and advocating the improvement of national navigation and infrastructure while blocking measures taken by Congress to that effect.[173]

With the Federalists crippled by scandal divisions within their own party, formerly unified factions of the Democratic-Republicans splintered nominating two candidates in the election of 1812. While Madison won reelection off the votes of southern states' and, importantly, Pennsylvania's electoral colleges, DeWitt Clinton's nomination as a dissenting Democratic-Republican (under the Federalist label) was a sign that the New York political machine had moved away from Madison's camp and that New England and the Mid-Atlantic at large were united in their opposition to war and trade infringement. The Federalists would make one last

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[171] The entire report can be found in the 1832 Congressional publication of the second volume of the *Finance* edition of *American State Papers*, pages 425–31.

[172] In his 1815 address to Congress, Madison would accept basic manufactures but refuse to support full on incentivization claiming "experience teaches that so many circumstances must concur in introducing and maturing manufacturing establishments, especially of the more complicated kinds, that a country may remain long without them, although sufficiently advanced and in some respects even peculiarly fitted for carrying them on with success" (Madison "Seventh Annual…").

[173] In 1817, Madison would veto a large scale federal public works bill claiming that it was outside of the powers of Congress as enumerated in the Constitution, suggesting that Congress might resubmit such a bill after amending the Constitution accordingly, an act he no doubt recognized as a political impossibility (Madison "Veto Message").

stand at Hartford where their caucus would produce demands for Constitutional amendments favoring trade actions, limiting war powers, and addressing the power of the southern voting block and would threaten succession. Their conference, however, would be ill-timed—coinciding with the end of the war, the Federalists (and New England merchants) would be portrayed as unpatriotic (even treasonous) and un-American.

The so-called "Era of Good Feeling" that was inaugurated by the dismantling of the party system and the clear election (and uncontested reelection) of James Monroe, however, was less a victory of agrarian and southern interests over mercantile and northern interests than it was an acceptance of agriculture and commerce (and in a related way manufacture) as mutually supporting economic pillars. The most cohesive plan, perhaps, to come out of the legislature during Monroe's tenure was Henry Clay's so called "American Way" or American System in which industry, trade, and agriculture alike could be stimulated by a system of tariffs, a national bank, and subsidies for internal improvements.[174]

While the former two points of these plan were implemented soon after their introduction into the Congress, federal support for infrastructure developments were harder fought. By the 1820s, investment in large scale internal improvements was no longer a fringe idea. With the formulation of the first trust style businesses centered around various insurance schemes and the securitization of farm mortgages, canals and highway projects became natural alternatives to speculation on ever more distant lands and the ever more conservative returns brought by shipping.[175] But Monroe, himself a public advocate of internal improvements, maintained Madison's position when pressed by legislation that the Constitution should first be amended before any federal monies were allotted to the construction of canals or highways. Though a variety of minor harbor clearance and charting expeditions were funded in the early years of his

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[174] Perhaps the neatest articulation of Clay's doctrine can be found in his Senate floor speeches from February 1832, which have been collected and featured on the US Senate website as a "classic" (35 page) Senate speech (United States Senate "Classic…")

[175] For an excellent discussion on trends in investment (both quantitative trends and social trends) see Haeger.

presidency, when a funding bill was passed for the Cumberland Road in 1822, Monroe vetoed it. His resistance to federal spending on improvements, however, lasted only a few years, and by 1824, when Monroe had personally invested in several joint stock corporations (most notably the corporation organized to construct the Chesapeake and Delaware Canal), he relented, signing off on the first comprehensive improvements bill distributing millions of federal dollars among underfunded state and private improvement projects.

Political oscillations like this one were the hallmark of the 1820s. In fact, while superficially the "Era of Good Feeling" was a non-partisan period of economic and industrial growth and national expansion, closer examination reveals the post-war decade as one of contradictions where the rhetorics of *laissez faire* and internal improvement served as tools to connect those with access and means to those seeking to secure political control. Perhaps the prime example of the beneficiaries of this new economic political regime is the New England association of plutocrats, simply named Boston Associates.

Formed at the onset of the war as an association of major merchant families (including the Lowells, Cabots, Appletons, Gores, Gorhams, and other Massachusetts notables), Boston Associates pioneered venture investing in manufacturing, acquiring expert foreign knowledge to set up cutting edge technological operations and then building whole settlements around water-powered mills, settlements that would not only employ but house and supply board for a new class of middle and lower class male and female workers.

Boston Associates was also the premier networked organization. Employing Daniel Webster—largely bankrolling his expensive lifestyle, Webster was always on the verge of financial ruin—Boston Associates gained access to, after Webster's various campaigns, the House and Senate and the Supreme Court and, perhaps most importantly, a commission set up by the national legislature to pay claims to merchants who suffered losses during the brief conflict with the

Spanish in 1820 over Western Florida.[176] Webster's position in the Congress allowed him to shape tariff laws to the whim of Boston Associates. He also succeeded, at the Associates's instigation, in introducing legislation for a uniform bankruptcy code, limiting liability for stockholders of corporations on the liquidation of an enterprise, and legislation for patient reform, expanding infringement litigation significantly and increasing patent holders rights to extend and modify claims.

It was in the first half of the 1820s, however, that Webster's connections in the Spanish Claims Commission (established by the Adams-Onis treaty but unfunded for decades) earned the Associates and their proxies likely a million dollars in federal money to satisfy not only claims of real losses (equipment, trade goods, etc.) but of lost opportunity due to real losses compounded over the years. A similar episode occurred ten years later when a commission was set up to pay claims to merchants affected by French conflicts.

Historians Carl Prince and Seth Taylor, recounting Webster's involvement in the commissions on behalf of the Associates, identify the claims commissions as an "unprecedented American underwriting of private commercial losses" (298). They go on to note that the monies distributed went largely not to merchants but the merchants' insurers, and that this stimulus of New England underwriters provided the venture capital for the explosion of manufacturing in the 1820s and especially 1830s. In this way, write Prince and Taylor, the Boston plutocrats drew a "sometimes unaware federal establishment into their partnership" while simultaneously advocating *laissez faire* by rejecting taxes on corporations and the regulation of working conditions.

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[176] There are lots of biographies of Daniel Webster, who was a Federalist in Hamiltonian fashion and an aristophile, as well a drinker and a spender. Bartlett, if dated, is probably the most thoroughly connected to primary sources throughout. Somewhat a hallmark of late seventies popular American biography, Bartlett interestingly divides Webster into conflicting personalities—Godlike and Black—the real Webster to be somewhere in between. For a more recent biography, Remini, also well noted and indexed, focuses somewhat more on Webster's oratorical skills than his designs on society and power. Webster's connections to Boston Associates are well document in his own papers, of course (See Wiltse and Moser, eds) and were recognized quite publically at the time by colleagues in the legislature, (for some interesting accusations and conflicts see Stanwood, especially Ch 5.)

Clay's American System differed from Hamilton's suggestions in his *Report on Manufactures* in that he advocated the investment of tariff monies into the physical infrastructure of America (rivers, canals, harbors, roads, etc.) rather than the industrial infrastructure (like the incentives for manufactures advocated by Hamilton). Perversely, in the face of a new plan and the destruction of the Federalist agenda, three decades after Hamilton's report, it was the combination of immigrant know-how, an expanded labor sector including women and children, tariffs, and subsidies (if indirect) to stimulate manufacturing that induced the mass industrialization that would make the mills of New England second only to those of Britain.

The socialization of labor (and the labor-ization of society)

Between 1823 and 1834, the associated owners of the mills of Lowell, Massachusetts[177] converted a mile-long wooded bend in the Merrimack River[178] amidst farm villages into an industrial encampment rivaling any outside of England. Named after Francis Cabot Lowell, organizer of the Boston Associates who had died several years prior, Lowell was a system of canals, mills, boarding houses, dining halls, and churches, the location of each of which had been carefully planned to take full advantage of the availability of water power.

The first canal, the Pawtucket, was named after the 30 feet of rapids and falls which had been the landmark for citing the northern boundary of the Massachusetts Bay Colony[179] and made the site an ideal source of water powered milling. The less than two mile canal diverted water flowing into the falls along a roundabout southern course emptying into the Concord River just

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[177] Much of the information in this section comes from a visit to the various mill museums, waterpower structures, and libraries managed by the National Park Service in Lowell, Massachusetts.

[178] The area had been a central fishing ground and pilgrimage site of the Pennacook Indians in early colonial times.

[179] The falls became a landmark in 1740 when the boundaries of Massachusetts and New Hampshire were clarified by the English government such that the northern border of Massachusetts ran exactly three miles north of the Merrimack river (following its snakelike curves) until Pawtucket falls at which point the boundary ran in a straight line west (###cite act of parl###). It's also worth noting that it is no coincidence that the name of these falls and of the site in Rhode Island where Samuel Slater built his first mill are the same; the name Pawtucket is derived from the Algonquin term for the site of falling water.

before it joined the Merrimack and had been commissioned in 1796 by a corporation of Newburyport shipping merchants to improve navigation on the Merrimack and access to Southern New Hampshire agriculture and timber.

By the 1820s, the Pawtucket Canal had fallen into disrepair and a much more significant southward canal, the Middlesex canal, had been constructed diverting the little remaining traffic to Boston. The Boston associates, who had already successfully constructed and operated a profitable, though not expandable, mill at Waltham, easily acquired the Pawtucket Canal and surrounding acreage through stock purchase. The canal and the river formed the foci of the planned development of Lowell, to which were added another four miles of internal canals and river improvements (including an underground water tunnel) over the next twelve years, further diverting energy from the falls to run seven (by 1848 ten) fully integrated textile mills.

The textile mills of Lowell were integrated in the sense that each mill could produce fabric from raw cotton—carding, spinning, dressing, and weaving it in house. As the first such mill had been built by the Associates in Waltham in 1815, the integrated system of textile production came to be known as the Waltham-Lowell System. Interestingly, the term Waltham-Lowell System, at least as was used at the time, tended to include not just the integrated mechanical processes and the assignment and management of work on the shop floor, but a variety of social labor practices as well, including methods for selecting, compensating, and boarding of workers.

Agrarian writers and politicians (and Madison and pre-1812-Jefferson) were right in their assertions that America did not have the labor force to make efficient use of the fertile American countryside and to produce manufactures. Their writings, however, seldom acknowledged women as independent laborers, treating the domestic (cottage) manufacturing complex as a system where a male farmer produced goods for market and, after some

refinement by his wife, for consumption.[180] Single women, in New England especially, had few work outlets that offered livable wages, and farm families, especially those producing monocultures, often found it difficult to barter for goods sufficient to feed and clothe children to the new social expectations. Additionally, single sons of farmers (especially sons from families with several children) often went west to pioneer or join western militias, leaving in most northern states, a gender imbalance. In this environment, the mills at Lowell found a ready labor force: young single women often referred to as "mill girls" but termed by the Associates management "operatives."

In fact, the term "mill girls," notably, captures not only the gender of the workers but also the age and, to a certain extent, social position. The ideal operative was young, though not necessarily younger than some boys apprenticed to trades at the time and single. The town of Lowell itself was structured to accommodate just this labor source and in a respectable way. Dormitories were constructed adjacent to mills to provide local shelter to girls who came to work from all over the region. Housemaids, often widows, were hired (partially out of a deduction from the girls wages) to supervise the girls and provide them constructive moral advice. A system of mill and church bells notified girls when it was time to work, to eat, to sleep, and to pray. Work was six days a week and church attendance, for most operatives, was mandatory. Temperance and physical fitness were also asserted, and free time activities were often prescribed or, in the case of card games, prohibited. Girls were to come to Lowell, make money for their families or savings, maintain their respectability, and then, at a suitable age, leave the factory with a fortified character to take up a suitable life as a New England wife, mother, etc.

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[180] The same should not be inferred about writers in opposition. Hamilton and others frequently included discussions of women as laborers in his tracts. Washington, who, if assigned a side, would have to be lumped in with Jefferson, once wrote to Lafayette on the subject: "Though I would not force the introduction of manufactures…to the prejudice of agriculture, yet I conceive much might be done in that way by women, children, and others, without taking one really necessary hand from tilling the earth" (Sparks 9:464).

The bells, overseers, and rules of the factory, in this sense, were a model for young girls to take with them on leaving Lowell, a model for them to construct a life after the factory. One of these girls, Lucy Larcom, came to work in Lowell's Boot mill in 1834 at the age of eleven. At the age of sixty-five, a nationally recognized poet, Larcom wrote an "outline" of her childhood entitled *A New England Girlhood*. In her memoir, her experiences at the Boot Mill in Lowell are recounted romantically—portraying rebelliousness and the millwork as simultaneously an arduous and civilizing influence on her life. Larcom, toward the end of her chapter on mill life, writes about her "distaste" for the crowded living conditions and for the confinement away from the woods and fields of the town and (as excerpted below) for the noise of the machines.

> In the sweet June weather I would lean far out the window, and try not to hear the unceasing clash of sound inside. Looking away into the hills, my whole stifled being would cry out "O, that I had wings!" … I discovered, too, that I could so accustom myself to the noise that it became like a silence to me. And I defied the machinery to make me its slave. Its incessant discords could not down the music of my thoughts if I would let them fly high enough. (182–3)

The latter portion of this expression—her poetic description of rising above the noise and challenging the mechanical system—can be found excerpted in a display inside the working spinning room of the Boot Mill Museum in Lowell. What is not found in the museum exhibit, however, is the resolution that follows immediately:

> There is nothing more miserable than to lose the feeling of our own distinctiveness, since that is our only clue to the Purpose behind us and the End before us. But when we have discovered that human beings are not a mere "mass," but an orderly Whole, of which we are a part, it is all so different!
>
> This we working girls might have learned from the webs of cloth we saw woven around us. Every little thread must take its place as warp or woof, and keep in it steadily. Left to itself, it would only be a loose, useless filament. Trying to

> wander in an independent or a disconnected way among the other threads, it would make of the whole web an inextricable snarl. Yet each little thread must be as firmly spun as if it were the only one, or the result would be a worthless fabric. (184)

This is Larcom's epiphany: in accepting the factory as a natural environment, she constructs her existential metaphor around work. Her desire for solitude, her resistance to the intrusive noise of the machine, and her longing for fresh air become simply tangential to the elements of the factory, in particular the cotton threads, which express as well (or perhaps best) a social philosophy. Decades after Larcom would leave Lowell, English social theorist Harriet Martineau, after touring of factories across America, would write: "[a] steady employer has it in his power to do more for the morals of the society about him than the clergy themselves" (138). In this way Martineau, as would many other writers, connects the bells, machines, social structures, noises, and rules of the overseers—the things that constructed Larcom's childhood at Lowell—to those implements used to administrate religion for centuries.

Vivid accounts of Lowell, and more often the girls of Lowell and their society and purity, were captured by visitors throughout 30s. [181] From America and abroad, familiar or not with squalid English manufacturing towns like Manchester, endless factory tours produced what even now seem endless accounts of the town. Largely these accounts gravitate toward similar themes: the integration of the natural and the stunningly unnatural (while the visitors are shocked by the scale of Lowell, they never fail to notice the flowers in the mill windows and the grassy central commons); the integration of work and society (most accounts describe not only the work done in the mills but boarding, churches, and social activities); and the independence and purity of the mill girls (while visitors remark on the potential danger of the imbalanced environment,

[181] Interestingly, perhaps America's most renowned visitor Alexis de Tocqueville, in Boston in 1834, never visited Lowell. His visit to (and disgust with) Manchester, England some time earlier perhaps was enough to keep him out of the American mill town, though many contemporary travelers made comparisons of the two favorable to Lowell.

most follow their expressions of trepidation with familial metaphors about girls, overseers, and house matrons).

One of the American south's more colorful federal Representatives Davy Crockett visited Lowell around the same time Larcom arrived at the Boot Mill. Southern and western politicians walked a political tightrope with their constituency who simultaneously favored an urban northern market for their grain and cotton but were against the tariffs and trade regulations that protected the growth of northern industry at the expensive of their export relationships. The American south had plenty of places to sell its cotton without Lowell, and tariffs like the one in 1828 labeled "Tariff of Abominations" forced the south to pay high prices for foreign manufactured goods (when northern manufactures could not yet supply them) while at the same time reducing foreign demand for American cotton. [182]

In a widely published report of his 1834 visit to New England and the Mid-Atlantic states, Crockett wrote less about the economics of factory system itself, however, and more about the labor environment he found, possibly responding to the suspicious of his constituency about the potential moral hazard of setting up a machine town of young girls.

> Next morning I rose early, and started for Lowell in a fine carriage, with three gentlemen who had agreed to accompany me. I had heard so much of this place that I longed to see it; not because I had heard of the "mile of gals"…but [because] I wanted to see the power of the machinery, wielded by the keenest calculations of human skill; I wanted to see how it was that these northerners could buy our cotton, and carry it home, manufacture it, bring it back, and sell it for half nothing; and in the meantime be well to live, and make money besides. (91) …

[182] Crockett was on an anti-Jackson tour of New England and the mid-Atlantic. And, as Jackson had visited Lowell a year earlier and had since made less trouble for the Associates (perhaps because the Bank of the United States decommissioning controversy had already abated at that point), Crockett was compelled politically to follow up and, perhaps, was also compelled politically to produce a glowingly positive report.

> Not one [of the operatives] expressed herself as tired of her employment, or oppressed with work: all talked well, and looked healthy…Here were thousands, useful to others, and enjoying all the blessings of freedom, with the prospect before them of future comfort and respectability: and however we, who only hear of them, may call their houses workshops and prisons, I assure my neighbors there is every enjoyment of life realized by these persons, and there can be but few who are not happy. (92)

Beyond this excerpt, Crockett contextualizes his assessment of the girls' welfare with details of their environment and of the alternative environments in which they might be found—the family farm, the city, pioneering. From these, Crockett draws his conclusion that Lowell is a place of opportunity for these girls rather than a prison, where they may invest work today and draw on that investment "future comfort and respectability." In fact, the only possible injustice that Crockett notes was that "they kept the prettiest [girls] inside, and put the homely ones on the outside rows" (92)

Leaving Lowell, Crockett expresses his "regret that more…southern and western men do not [visit], as it would help much to do away with their prejudices against these manufactories" and, in parting, presents a two page table of statistics, which he calls a "statement" that is "complied from authentic sources," regarding the factories in and around Lowell, Lawrence, and Danvers. In the rows of this tabular statement are a title row of corporations followed by body rows which report amounts of consumed raw materials (wool, cotton, coal, charcoal, etc. in tons, bales, etc.), amounts of fabric (quantity and type) produced, and numbers of spindles, looms, females, and males employed. The placement of the mill girls, for which Crockett had expressed affection, among the mechanisms and resources of the factory suggests the elemental role that labor played in the machine process of the factory, a fact that that Crockett took away from his visit and a fact that other visitors (especially those familiar with English mill towns) would struggle to express, if not overtly, in their writings.

For example, French economist Michel Chevalier, a Saint-Simonian and free trader, visited Lowell on a French government sponsored tour of the Americas in 1834. In an anthology of letters on his experiences, he writes of an account supposedly given him by "[a]n American, well acquainted with the character of his countrymen" that Lowell, rather than the War of 1812, was New England's answer to British tyranny, that New Englanders, who had been against the war but whose patriotism was beyond reproachable, had established Lowell to attack the English not where they were dominant and invulnerable—the sea—but rather where they were dominant but vulnerable—cotton manufactures (Chevalier Letter XI). Running with this mythology of the town's purpose, Chevalier observes that Lowell, as a settlement, has been constructed, unlike those of Europe, not "by some demi-god, a son of Jupiter, or by some hero of the Trojan war, or by the genius of Alexander or a Caesar, or by some saint, attracting crowds of miracles, or by the whim of some great sovereign…. It was neither a pious foundation, not an asylum for fugitives, not a military post." Rather Lowell is unique in that it was constructed by a citizen speculator, an economic footsoldier.

Chevalier closes his Letter XI written on arriving at Lowell expressing concern. While the settlement appears, in stark relief to English urban factory settlements like Manchester, clean and morally pure, he questions that appearance: "Does this brilliant glare hide the misery and suffering of operatives, and those degrading vices, engendered by poverty in manufacturing towns, drunkenness and prostitution, popular sedition hanging over the heads of the rich by a frail thread, which an ordinary accident, and slight imprudence, or a breath of the bad passion, would snap asunder?"

In Letter XII, he answers his questions definitively: Lowell is not like the factory towns of England. He notes that, not only are workers at Lowell paid higher wages, but the quality of the community, as supervised by the manufacturers themselves, makes their experience dramatically different. While Chevalier notes this approach with interest, he suggests it would not be transferable to France, where young girls would not tolerate distance from their families. Referring to the Yankee farm girls as "double-distilled English," Chevalier asserts that the Protestant education and ridged community expectations contribute to the girls' "coldness of domestic relations, a more or less complete absence of a full and free expression of the stronger

feelings of the soul" and an accustomization to "show[ing] more respect for the feelings of others" (Chevalier Letter XII). He goes on:

> Nobody in this country, then, is surprised to see the daughters of rural proprietors, after having received a tolerable education, quit their native village and their parents, take up their residence 50 or 100 miles off, in a town where they have no acquaintance, and pass two or three years in this state of isolation and independence; they are under the safeguard of the public faith. All this presupposes an extreme reserve of manners, a vigilant, inexorable, and rigid public opinion, and it must be acknowledged, that, under this rigorous system, there is a sombre hue, an air of listlessness, thrown over society; (Letter XII)

While not exclusively, it is primarily the nexus of supervision and Protestant socialization that makes Lowell possible (as it would not be in France, where young Catholic girls, he suggests elsewhere, would not have the discipline) and that makes possible the purity of Lowell's laborers. Chevalier, in an ironic flourish given his reliance on Protestantism to explain the town's functioning, compares Lowell to a Spanish convent and the girls to nuns who "instead of working sacred hearts, spin and weave cotton" (Letter XII). To visitors like Crockett and Chevalier, Lowell is at once a public work and an act of private enterprise; its operatives are parts of a machine process or celebrants of the religion of manufacture—or threads in a cloth to Larcom—and young women whose attestable virtue is essential to the acceptance of the enterprise.

The 1830s was not only a decade of expansion for Lowell, it was also a harbinger of the town's long decline. By constructing an elaborate damming and pooling system at the top of the falls, waterpower been made reasonably secure year round. Getting goods to Boston for export during the winter freeze, though, had been difficult over land routes (and impossible on the regional canal system which was shallow and still). To secure a year round path to their shipping hub in Boston, the Associates built one of the first permanent rail lines on the coast to connect the mills to the Charles River, complete with the first rail lift bridge on the continent and granite

bedding, which was later found inferior to wooden ties and warranted the rail be rebuilt when it was expanded four years later. At the same time, however, the waterpower systems of the mills were being made obsolete by ever more reliable steam engines.[183] By the mid-1840s, the mills at Lowell would be described, especially by foreign visitors familiar with the mechanical apparatuses of English mills, as underpowered or quaint.

Also during the 1830s a variety of labor disputes punctuated Lowell's carefully crafted wholesome labor environment. Wage walkouts and protests at one mill or another, always followed by purges and paternalistic concessions, were an annual feature of the town.[184] After one labor dispute, William Austin, supervisory agent of the Lawrence Manufacturing Company, went so far as to amend the operating rules for the mill to include a paragraph clarifying the genial relationship between labor and management.

> Persons in the employ of the Company will reflect, that it is their voluntary agreement to serve, and consequent mutual relations of the parties, which render it proper on their part to conform to regulations of that warrant the Agent in promulgating rules for their observance, and which govern him as well as themselves. They will perceive that where objects are to be obtained, by the united efforts and labor of many individuals, that some must direct and many be

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[183] Engineering historian Palmer Ricketts had made the argument that America's lack of steam technology was eventually beneficial, however, as legacy equipment never existed to slow implementation of efficient equipment when it became available in the 1830s. In 1803, when inefficient and dangerous engines were being employed throughout Britain, there were six only steam-engines in the US: one at the Schuyler copper-mine on the Passaic River North of Newark, NJ, "one at the Philadelphia water works, one…at the Manhattan waterworks, one in Roosevelt's saw mill in New York, and quite a small one used by Oliver Evans to grind plaster of paris in Philadelphia." All of these had been imported from Britain (74). Ricketts, interestingly, also suggests that the first steam-engine built in America was built in 1772 by Christopher Colles for "a distillery in Philadelphia," though he goes on to describe this engine as "very defective" (74).

[184] The Senate commissioned in July of 1910 a "complete report on the condition of woman and child wage-earners in the United States." The 19 volumes of this report contain, in addition to the current state of labor, a significant history of women and child labor statistic, practices, and conditions, attempts at organization, and legal enactments. Volume 10, regarding organization, treats the strikes at Lowell in the 1830s on pages 27–33, referencing media and personal accounts of the time.

> directed. That their religious and political opinions need not however be influenced, nor their personal independence, or self respect, or conscious equality lost sight of or abandoned… They may apply with confidence to the Agent for advice, and such aid and counsel as he can afford them will be cheerfully granted, especially for those who may be far from their parents and friends. It remains to encourage and cherish mutual respect, kindness and conciliation towards each other, and that peculiar instances of industrious and honest merit be rewarded, and which the Agent will reciprocate and aspire to accomplish. ("General Regulations…")

Ambiguous and good-feeling as it may sound, this portion of a policy statement establishes the role of management in labor and a management-favorable tone for confrontations with respect to those roles. Operatives work in the mill of their own volition, it specifies up front, and as such they accept the right of management to make the rules which they (and the management) must abide. The primacy of rules for management is framed as a concession or at least and equalizing, but given that it is the manager (given an authoritative name: Agent) that makes the rules—and that labor (given a generic name: Persons) has no part—it is a hollow concession. Next, the operatives are told what they should take away from observations made in the work environment. Without sacrificing equality or liberty, they must recognize that the goal of the management is their goal, though it is finally made clear that, in exchange for their fidelity (and given that they have given up the usual character-constructing familial ties to work at the mill), they have permission to seek the authoritative advice of their managers on subjects beyond their work. In all instances, however, operatives are charged with recognizing the social hierarchy established at the mill.

Perhaps the specifics of the statement and its tone are less interesting than the effects of inscribing such a statement at all. A paragraph in the operating regulations for the mill, the amicable work environment described in the statement becomes an official policy apart from the whims of the manager; actions of the laborers can then be justifiably construed in these terms. As amicable as the expression seems on the surface, as a policy document it functions to authorize management, setting the script for debates about performance, behavior, and what is

appropriate in the workplace. Workers—who have accepted the script, in its own words, by "their voluntary agreement to serve"—cannot accuse a manager of being arbitrary if that manager can articulate his actions in the terminology of the policy. Written by management, the script offers token affections to workers in exchange for their full (even overfull and exceptionally industrious) commitment to work.

While the servile terms and protestations of equality in this policy statement might seem curious, in the context of the Revolution (only a few generations old) and re-revolution (as the War of 1812 was often considered), the still pervasive rhetoric of egalitarian and libertarian social structures and the hierarchy of the mill were at odds. It's not surprising that labor actions at the birth of unionization in America[185] relied on colonial analogies (aggressive managers were often pejoratively referred to as Tories[186]) and on metaphorical or even direct assertions that working conditions in factories were akin to those on slave plantations.

By the time the abolitionist Quaker poet John Greenleaf Whittier wrote his essay *The Stranger in Lowell* in 1845, the protestant Yankee mill girls had been replaced by Irish immigrant women, and a new wave of French Canadian immigrants was starting to dominate the town's western quarter. Whittier, a native of the area (born in Haverhill, buried in Amesbury), found Lowell's success suspect; he questioned the motives of the investors who by the 40s had become distant from the day to day operation of the mills and whose influence, Whittier felt, propped up the slave economy of the South for the sake of cheap cotton. As though a stranger approaching the city, Whittier describes it as follows:

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[185] While organized local movements did exist in the 1820s and 30s, it wasn't until the 1870s that the Knights of Labor, founded in Philadelphia to organize industrial workers, began exerting influence on a large scale.

[186] For example, see the Resolution issued by the strikers of 1834 printed (or reprinted) in the pro-labor newspaper *The Man*, specifically the verse portion(!) the last verse of which reads: "Yet I value not the feeble threats/Of Tories in disguise,/While the flag of Independence/O'er our noble nation flies" ("Issued by…"). Notably, the image was fed early on by Kirk Boott a manager who was an English immigrant and by all accounts particularly harsh.

> *This, then, is Lowell—a city springing up, like the enchanted palaces of the Arabian tales, as it were in a single night—stretching far and wide its chaos of brick masonry and painted shingles, filling the angle of the confluence of the Concord and the Merrimac with the sights and sounds of trade and industry*. Marvelously here have art and labor wrought their modern miracles. I can scarcely realize the fact that a few years ago these rivers, now tamed and subdued to the purposes of man and charmed into slavish subjection to the wizard of mechanism, rolled unchecked towards the ocean…and rippled down their falls in the wild freedom of Nature. *A stranger, in view of all this wonderful change, feels himself, as it were, thrust forward into a new century;* he seems treading on the outer circle of the millennium of steam engines and cotton mills. Work is here the patron saint. Everything bears his image and superscription. Here is no place for that respectable class of citizens called gentlemen, and their much vilified brethren, familiarly known as loafers. Over the gateways of this new world Manchester glares the inscription, "Work, or die" (Whittier).[187]

Unlike the descriptions of the environment above, Whittier in this excerpt (and throughout his essay) dwells on the work camp nature of the town and on the vulgarity of the natural world harnessed for utilitarianism (i.e., the tamed rivers of this excerpt, but more directly in an extended discussion of the lack of shade trees on the town streets which appears later in the essay but is not excerpted here). As Chevalier had a decade before, Whittier expresses the structures (physical and social) of Lowell in religious terms.

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[187] The two italicized sentences are (at the time this was written) featured on a placard in the National Park Service's Boot Mill Museum Exhibit in Lowell. (An ellipsis notes the omission of the sentence in between, and the existence or content of remainder of the paragraph is not indicated.) Presumably the exhibitors were attempting to take advantage of Whittier's eloquent evocation of the novelty and foreignness of the manufacturing town without marring the exhibit with his grim message. Given the content of this note, it's worth noting that the ellipsis in this excerpt represents the omission of a lengthy phrase referring to Merrimack's source in the White Mountains of New Hampshire.

> [Those engaged in the manufactures] adopt Carlyle's apostrophe of "Divine labor, noble, ever fruitful—the grand, sole miracle of man;" for this is indeed a city consecrated to thrift—dedicated, every square rod of it, to the divinity of work; the gospel of industry preached daily and hourly from some thirty temples, each huger than the Milan Cathedral or the Temple of Jeddo, the Mosque of St. Sophia or the Chinese pagoda of a hundred bells; its mighty sermons uttered by steam and water-power; its music the everlasting jar of mechanism and the organ-swell of many waters; scattering the cotton and woolen leaves of its evangel from the wings of steamboats and rail-cars throughout the land; its thousand priests and its thousands of priestesses ministering around their spinning-jenny and powerloom altars, or thronging the long, unshaded streets in the level light of sunset. After all, it may well be questioned whether this gospel, according to Poor Richard's Almanac, is precisely calculated for the redemption of humanity. Labor, graduated to man's simple wants, necessities, and unperverted tastes, is doubtless well; but all beyond this is weariness to flesh and spirit. Every web which falls from these restless looms has a history more or less connected with sin and suffering, beginning with slavery and ending with overwork and premature death (Whittier).

Chevalier's steepled factories are Whittier's imposing temples, wonders of the world;[188] Chevalier's Spanish nuns are Whittier's thousands of priestesses. While Chevalier's girls spin cotton rather than sacred hearts, Whittier's priestesses minister at powerloom alters until sunset when they flood into the evening streets. Whittier uses the momentum from this extended metaphor to make a singular point: labor attuned to the basic need of man is worthwhile, but the labor at Lowell is gratuitous labor and it benefits from (and therefore feeds

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[188] The Temple of Jeddo, included in Whittier's list of impressive temples of the world, was a massive centuries old Buddhist temple which was reported by the New York Times to have been destroyed by an arsonist protesting its conversion to a Shinto temple. The destruction of the temple happened in 1874, some 30 years after this essay. See "Burning of…."

the existence of) sin and suffering, in the form of physical and spiritual degradation of workers and most starkly in the form of southern slavery. To advocate abolition, Whittier makes the same linkages between the factory work system and slavery that labor leaders had been making at intervals since the foundation of Lowell.

Lowell's reliance on Southern cotton, of course, became a problem when, fifteen years after Whittier's essay, the South succeeded from the Union. Perhaps the final ante-bellum commentary on Lowell, at least the last widely circulated account of Lowell operating at full capacity, was made by Anthony Trollope in his account of his travels across North America.[189] Like earlier visitors, Trollope was impressed by the apparent quality of the life the mill workers enjoyed and makes favorable comparisons between Lowell and Manchester, England.[190] At the same time, however, he notes Lowell's size (approximately 40,000) and the sizes of other even smaller mill towns in the area (e.g., Lawrence) and questions whether such rigidly run manufacturing operations could be run at larger sizes.[191] In fact, the size of Lowell had been rigidly controlled by the Associates for some years. There was only so much water power to go around (a fact that would soon make the mills at Lowell uncompetitive compared to steam and water installations like those at Fall River) and the land in the city was wholly owned by the corporations to prevent competition. The largest British mill towns (Manchester and Leeds) could expand and contract as demanded because any serious commercial interest could set up shop and lure away workers and materials. While this led to the labor practices lamented in the comparisons made by visitors to Lowell (prostitution, drunkenness, malnutrition, squalor, and, the favorite, textile workers who could not afford clothes), it also led to lower corporate overheads and larger profits. Considering this, Trollope would draw the following conclusion:

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[189] Chapter 17 of Trollope's tour through North America is dedicated to Cambridge and Lowell. The two seem to be in the same chapter more due to their proximity to Boston than for any relationship between the two. In fact, the first sentence of the chapter establishes this relationship, describing the two cities as "[t]he two places of most general interest in the vicinity of Boston" (240).

[190] Not to be confused with Manchester, New Hampshire further up the Merrimack, which had become by 1860 a mill town roughly half the size of Lowell.

[191] In fact, he notes that Chicago, which was not a mill town and had only been growing for 10 years, was already had a population of well over 100,000 by 1860.

> [I]t seems to me that as New England takes her place in the world as a great manufacturing country—which place she undoubtedly will take sooner or later—she must abandon the hot-house method of providing for her operatives with which she has commenced her work. … That it should under its present system have been made in any degree profitable reflects great credit on the managers; but the profit does not reach an amount which in America can be considered remunerative. … When New England employs millions in her factories instead of thousands—the hands employed at Lowell, when the mills are at full work, are about 11,000—she must cease to provide for them their beds and meals, their church-going proprieties and orderly modes of life. (249–50)[192]

Visiting America at the beginning of a civil war, the pessimism of Trollop's statement shouldn't be overestimated. His observation about the scale of Lowell (and his assertion that the activities at Lowell could not be scaled to the levels of the major industrial concerns in the Britain without inviting similar problems) are realistic and rely on a maturing international conceptualization of political economy and the possibilities of machine-aided manufacturing. Interestingly, Trollop praises Lowell not for its output or for its operatives' purity, but for its managers savvy and for its conceptualizers' legacy: the acceptance of manufacture as a legitimate economic sector by agrarian neighbors.

> The tone which she will have given will not altogether lose its influence. Employment in a factory is now considered reputable by a farmer and his children, and this idea will remain. Factory work is regarded as more respectable than domestic service, and this prestige will no wear itself altogether out. Those now employed have a strong concept of dignity of their own social position, and their successors will inherit much of this, even though

[192] The precise figures he goes on to cite—derived from profits between 7 and 12 percent prior to the beginning of the Civil War—he suggests were not attractive to American investors.

> they may find themselves excluded from the advantages of the present Utopia. (250)

In the excerpt above, Trollop anticipates the rise of less paternalistic (and really less labor favoring) form of manufacturing in America and credits Lowell for clearing the way for that rise. The positive image of the factory worker that the small-scale (faux-manufacturing) environment at Lowell helped to create among the farm communities and political caucuses of New England and throughout America, Trollope suggests, would facilitate the acceptance of large-scale manufacturing, the practices of which would be more akin to those of Manchester than Lowell. Factory work, once established as an upstanding form of work, would remain so even as the nature of factory work changed, and the new laborers—generations removed from those at Lowell—would take part in the social credentials established by idealized experiment.

Mechanics, machinists, armorers, engineers, and managing an American System of manufactures

The Boston Associates's manufacturing initiative at Lowell and to a lesser extent later initiatives at Lawrence and Manchester, New Hampshire have received significant attention by historians and critics of industrialization, labor, and more general antebellum American studies. Lowell is one icon of early American industrialization, a site where work and living were integrated comprehensively, where the economic interests met environmental, social, and political conditions (the Merrimack, the structure of family farming, the demand created by the embargo, etc.) and applied a mechanical and paternal approach to capitalize it. Discussions of Lowell dwell on its natural environment and siting, on the economics of its founders and its material production, on the mechanical innovations involved in construction and operation of the mills, on the lives and practices of mill managers and house managers and especially the operatives—the girls working on the factory floor.

Less has been said, however, about the male workers at Lowell—the canal and waterpower engineers and the mechanics who tended the mill's machines.[193,194] From accounting and the causal use of labels to describe workers, these two classes seem not only separate from each other but also separate from the management structure of the mill town. The 1804 construction of the twenty-seven mile Middlesex Canal, which connected the Merrimack to Boston decades before the town of Lowell was constructed and assigned that name by the Associates, had been planned and directed by English canal engineer William Weston and American Revolutionary War engineer Loammi Baldwin.[195] Since that time, the term "engineer" had been assigned to canal managers by the Proprietors of Locks and Canals on the Merrimack River Corporation as well as by its successor the Boston Associates's incorporated Merrimack Manufacturing Company.

The purview of these engineers rested largely outside of the mills themselves however. Charged with supplying the mills with a consistent rate of water power, the canals about town, the locks, damns, spillways, and pools, and even the mills' wet mechanisms were their responsibility. But the mechanical systems which translated that power into work on the floor were the responsibility of the mill mechanics, as were the workings of the tended machines themselves. Mechanics not only worked throughout each of the mills repairing machines, but they designed and constructed new and innovating milling machines in a machine shop located on a triangular

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[193] As to this latter group, they are often claimed today by those attempting to write the history of mechanical engineering, but I have yet to see even those making mechanical innovations called anything but mechanics in the papers of the Associates and the diaries of mill managers. The American Society of Mechanical Engineers's list of engineering landmarks, notably, includes as number 107 the "Lowell Power Canal System and Gatehouse" emphasizing especially the 1847 portions of the system but excluding (by omission) the mechanical systems of the factories driven by the channeled water, many components of which still exist. On the other hand, their list also includes as number 30 the Wilkinson Mill (Samuel Slater's 1810 mill) which, according the ASME website relied on a named list of "trained machinists." Whether the term engineer is consciously absent from the description is debatable but notable ("ASME Landmarks").

[194] Though, a book on the waterpower and canal systems was just published recently. See Malone.

[195] See Mary Stetson Clarke for a local scholar's book-length treatment of the canal. A more dated account, which offers more concrete details about the construction, however, is Roberts.

parcel with limited water power access between the Appleton and Lowell (now called Market) mills.

The first overseer of the machine shop was Paul Moody, the mechanic who had collaborated with the Boston Associates to build their first mill at Waltham from Francis Cabot Lowell's memories and sketches of his visit to Manchester. While at the shop, Moody developed the system of leather belting used to transmit mechanical power to machines on the floor from the waterpower infrastructure throughout the mill. Within a few years of its construction, the machine shop at Lowell became an exporter of machines to mills throughout the region and, with the construction of the rail line to Lowell, began exporting railway equipment after George Washington Whistler became its director in 1835. By 1838, the shop had produced more dozens steam engines and locomotives and direction of the shop had again changed hands—a young British rail and canal engineer and Whistler's apprentice, James B. Francis, unified the management and the mission of the canal engineers and mill mechanics, directing both to work on the conversion of mills to hydraulic turbines and to produce such turbines and the machine tools to create them for commercial sale.[196]

While machine shops employing mechanics like the one at Lowell had begun appearing throughout New England,[197] the Lowell machine shop is an interesting site because of the distinctions between mechanics and engineers it implicitly supplies. In the accounts of the associates Paul Moody is persistently referred to as a mechanic or, sometimes in retrospect, a machinist. Whistler and Francis, on the other hand, presumably because of their connection to

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[196] Whistler went on to work on railways in Russia. Francis stayed on at Lowell locally improving its waterpower infrastructure by overseeing the subterranean feeder canals under Moody Street and building the reputation of the machine shop nationally by offering its and his services for consultation on projects like New York's Quaker Bridge Dam and the dam at Minnesota's Saint Anthony Falls.

[197] Worcester, which was also networked to Boston by rail, had by 1830 several such shops and largely supplied factories in Rhode Island. Machine shops and mills, including the Washburn-Moen company (which began producing extruded barbed wire in 1831) and the Whitin Machine Works (which would become one of the largest cotton picking and processing machine producers in the world) would by the Civil War surpass Lowell's prominence in milling machinery (though not power and machining tools). For a recent treatment see the Worcester Historical Museum's *Landscape of Industry*.

rail and canal work, are identified as engineers (as had been Weston and Baldwin years earlier). A somewhat anachronistic socio-professional distinction between mechanical and civil engineers seems readily available but unfulfilling considering the extensive mechanical (in addition to structural) work done by canal engineers supplying power to the mills. On the other hand, George Emmerson, in his often sited history of engineering education, suggests that the title engineer arose with popular recognition of higher education venues for engineers. Emmerson would identify Paul Moody as a proto-engineer, one who "did not make a profession of engineering as it was then understood…but fell rather into the category of craftsman—millwrights or mechanics—or simply 'inventors'" (109). However Francis had begun working on a railroad at 14 and had no formal education and Baldwin's education, a 1785 degree from Harvard, would have hardly fallen in Emmerson's regime of advancing engineering schools.

Perhaps the easiest way to explain the usage of the term engineer for certain functions in the mill and shop was that the term was inherited from Weston (who was an engineer because he was English) and Baldwin (who was an engineer because he had been so in the military before any form of academy existed). Whistler, who had gone to West Point, perhaps doubly secured the title by working with locomotives a field of work in which the term is readily applied to anyone building or operating a steam engine.

It's not a surprise, perhaps, that historical discussions of engineers in early industrializing America, the aim of which is often to recount a path to professionalization, rarely refer to Lowell. Even the Lowell National Historical Park Handbook, after a detailed timeline of events, summarizes the antebellum history of the shop at Lowell not as an early engineering triumph and not with Francis or Whistler, but by declaring that "Paul Moody helped train the first generation of master mechanics. Out of these and others' efforts to emulate British textile technology came the machine tool industry on which other industries were founded" (140). In this summary, Lowell participates not in an engineering revolution in American industry, but its master mechanics contribute by producing machine tools for the industrialization of America.

Lowell is only one iconic American industrial birthplace, however. And discussions about engineering and industrialization rely less on Lowell than they do on discussions of the growth of railroad corporations and conversion of armories to machine manufacturing.[198] In these sites, conveniently, the contribution of men labeled engineers to early techniques of administration help form the functional distinctions between engineers and mechanics.[199]

Perhaps the most significant academic construal of engineering and modern management as innovation of railroad corporations is Alfred Chandler's 1977 Pulitzer Prize-winning *The Visible Hand*, which not only suggests that management arose as a function of the demand for management created by the economic efficiency and necessity of coordinated enterprises but goes further to connect this phenomenon to the separation of the new technical class of managers from owners and to the reification of the management hierarchy as the source of power in business.[200] In Chandler's narrative, the large degree of capital and coordination required to construct and operate large scale railroads necessitated not only oversight by a class of managers but the conscious hierarchical organization of that class, and it was only by such experimentation with alternative organizations (in addition to traditional considerations like the procurement of raw materials, the assignment of wages) that railroads were made profitable. At first, management regimes that simply kept a railway company in business could be called successful. By the time of the Civil War however, calling management successful required ever more astounding feats of production and consolidation—nearly 9,000 miles of track were laid in the five traditionally northwestern states between 1850 and 1860 and it was becoming common

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[198] Notably absent from discussions of industrialization, of course, are large agricultural plantations which, existing mainly in the South, did not develop business practices similar to those mention in this section, in part because of the influence of slave labor and in part because of the nature of agricultural economy. For an interesting treatment to which many parallels may be drawn, see Scarborough.

[199] The intention is not to gloss over the wide body of pre-1830 focused histories that locate the genesis of American engineering in the revolution, in the canal construction era, or even diversely in pioneering, smithing, craftwork, etc. This observation, as is suggested by the sentence, pertains to discussions of engineering with respect to industrialization.

[200] This statement is, of course, refers to the work of the whole book. For reference, however, Chandler's seven propositions are articulated concisely in his introduction (6–10).

for rail companies to invest at a network level network not only by owning track but by owning the mines and mills networked by that track.[201]

This is a rich context to discuss the rise of a technical/pseudo-managerial class of engineers. Issues that could be explored include: the social, political, and physical differences between rail and earlier canal construction and how they inform the evolution of the concept of the engineer; how political conceptions of land use, taxation, and economic libertarianism in the context of a constitutional republic constructed and constrained the environment in which rail corporations grew; how financing schemes after the close of the Second Bank of the United States and leading up the European revolutions of 1848 (the so-called Springtime of Nations) contributed to a centralization of international corporations in New York which enabling the simultaneous construction and construction through unpopulated and under-populated regions and thereby changed the nature of rail design and labor; how the reliance on steam engines and other mechanical innovations prompted a bifurcation of technical and managerial expertise; and how the application of mechanical considerations to the desire to avoid catastrophic accidents and to construct a reliable delivery system equalized men and machines in the management process. As rich as this context is, however, the delocalized and diversely invested rail corporations provide little tangible connection to the highly local and rather singularly directed environment at Lowell.

On the other hand, similarly rich discussions surround the early implementation of machine processes in America's original armories, Springfield and Harpers Ferry. These sites are examples not only of early industrialization but are places where direct government interests (the production of small weapons) rather than indirect interests (taxes on profits) made industrialization a clear priority of the authoritative national government.

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[201] The period between in the Civil War and the turn of the century, of course, would dwarf this. By 1900, the United States would contain a quarter of a million of *active* rail miles and the consolidation of corporations would create some of the richest businessmen in history.

The weapons used to fight the American Revolution were either the British weapons that had diffused over the continent during the French and Indian War or had been captured on raids of British supply lines or from surrendering British troops, individually crafted (often long barreled) rifles made by local smiths, or, toward the end of the war, muskets purchased from the French. At the end of the conflict and with no vision of a standing army or federalized military supply system, domestic weapon production returned to the craft model and family-based craftsmen, largely in Pennsylvania and Connecticut, supplied arms to fill orders at depots at Philadelphia and Carlisle, Pennsylvania, at West Point, New York, at Springfield, Massachusetts, and at New London, Virginia.[202]

Federal contracting for the production of weapons had a number of problems, however, not the least of which was quality control and, by the 1790s when rising tensions with the French made the import of weapons, especially small arms, politically difficult and expensive, Washington, as President, was given authority by Congress to site "three or four arsenals with magazines" at which the President would have the power to appointment supervisors.[203] The depot at Springfield, a noncontentious choice and a site advocated by Secretary of War Henry Knox, was immediately converted to produce weapons. Not without some controversy, and though the magazines at West Point, Carlisle, and New London were still maintained by the government and meager federal appropriations would have enabled the upgrade of all three, Washington chose a new site Harpers Ferry, Virginia for a second armory, justifying the location by its proximity to established federal district, access to waterpower from the Potomac, and its distance inland, where it would be less subject to attack.[204] Thus with two armories rather than three or four, the direct production of weapons by the federal government began.

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[202] For an account of gun making and the family craft system in colonial and antebellum America, see Kauffman. For more on the arms contracting system see Deyrup (especially 55–67).
[203] See Statutes at Large 1:352.
[204] Himself a wealthy Virginia planter, it's no surprise that the land purchased by government for the armory benefited several of Washington's personal associates. This fact, the distance of Harpers Ferry from populated areas and from raw materials, and the apparent financial maneuvering of Washington's
[this note continues on the next page]

Despite the quick conversion of the Springfield site (musket production began in 1795), growing concern over an imminent war with France led the government in the late 1790s to continue to issue contracts for weapons. Of the contracts issued, at least two notable vendors, Eli Whitney and Simeon North, undertook the machine production of weapons in such a way that parts were uniform—in other words, parts of one weapon could be fitted into another of the same model by soldiers who were trained to file, fit, and repair weapons. Both were vocal advocates not only for the production of uniform weapons but for more stringent requirements in government contracts (to their competitive advantage).

Whitney's commitment to and execution of an interchangeable parts manufacturing doctrine, though still a dominant story in grade school history books, has long been an issue of contention.[205] Even a cursory reading of Whitney's correspondences makes it clear that his sudden shift in 1798 from agricultural implements (i.e., the cotton gin) to armaments was a function of desperation after several courts failed to provide his inventions patient protection. Retooling his facilities and a staff of semi-skilled craftsmen (none of whom were gunsmiths), Whitney over promised and under delivered until, a decade later, the balance of the contract was finally canceled.

Despite Whitney's public claims to innovative methods, the armory at Springfield, converted around the same time as Whitney's factory, in short order began out producing Whitney using a hybrid of traditional methods and ever more divided production practices. Whitney's production practices relied on the division of labor, templates, and rudimentary machine tools, in part, because of the low skill of his workforce and, in part, because model Charleville rifles were supplied with the government advance. These considerations and information about Honoré Blanc's musket workshop in France, which Thomas Jefferson had visited and discussed

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associate Tobias Lear led some to suggest Washington chose to site for personal reasons. Interestingly, even a Department of War surveyor declared the site unfit for construction. See Smith's "George Wasington…"for an account.

[205] See Woodbury for an excellent account.

with Whitney, probably afforded his first batch of "uniform" weapons delivered to the government.[206]

Whitney was not alone in the claim to interchangeable parts, of course. The heirs of Simeon North, a Connecticut contractor running an operation similar to Whitney's (though perhaps with more quality control), assert that he first applied the system of interchangeable parts to gun making. The argument for North relies largely on an 1813 a government contract written at his own instigation that somewhat irregularly requires that the weapons produced would contain interchangeable parts—literally "[t]he parts of these pistols are to correspond so exactly that any limb of one pistol may be fitted to any other pistol of [all those produced]." Interestingly, North's later contracts specified the interchangeability of lock specifically.[207]

The Harpers Ferry armory, unlike the one at Springfield, took longer to get up and running. Final approval and the appointment of a superintendent for the armory only came, after much back and forth in the War Department, in 1798. And even then the construction of the facility was delayed first by the inaction of the Virginia legislature, whose approval was needed for the founding of the site, and then by the inept and corrupt construction management of the armory's first paymaster John Mackey, who hired friends and unskilled causal labor rather than engineers to construct the short canal which would power the machine works.[208] Real work at Harpers Ferry only began after Samuel Annin, the paymaster appointed to replace Mackey, secured use of the soldiers stationed at the armory to finish the canal in 1801.

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[206] Tests on Whitney muskets at the Smithsonian Institute have suggested that, in fact, significant alterations would have been made to fit pieces.

[207] See the biographical "memoir" written seemingly by a descendent Ralph North, especially page 32 and Chapter 4. For a recent history which considers the economics of North's production model, see Diana Muir, especially Chapter 10 titled "Machines that make machines".

[208] For a narrative account, see Smith's *Harpers Ferry* pages 38-48. Not only the construction of the canal but the construction of the buildings was complicated by Mackey's and Secretary of War McHenry's political allegiances. The result, notably, was that Benjamin Latrobe, who was to design the armory, was denied the opportunity and that the canal, which could have been completed in short order by the engineer who designed and constructed the dam, was the source of much delay.

By the time the armory at Harpers Ferry was up and running, tensions with the French had eased and Thomas Jefferson and Albert Gallatin's plans to curtail government expenditures were in full swing. As a result, for almost the first years of operation, Harpers Ferry functioned as little more than an open workshop where the skilled craftsmen recruited to make weapons could come and work the way they always had. At first, this involved individually crafting individually exceptional arms with parts largely less interchangeable then those produced by private contractors and with little concern for the rapidity of production. Workers came and went by hour and by day: workers often left midday to tend to outside business interests returning to the shop later to finish work; more experienced craftsmen often finished their monthly quotas early so as to take free weeks away from the shop.

Mackey and Annin as paymasters and construction supervisors were charged with facilities, maintaining stores, and hiring and paying workers. However, most skilled workers, including many of the gunsmiths referred to in letters as "armorers," were recruited and supervised by the armory's first superintendent, the reserved Joseph Perkin. Perkin, an English gunsmith and Moravian had immigrated to America shortly before the revolution and, after making guns in private enterprises supplying the continental army, had opened his own shop in Philadelphia, becoming connected enough to secure an appointment as the superintendent of the New London, Virginia magazine and, upon its closure, the new armory at Harpers Ferry.

The first armorers at Harpers Ferry had been recruited largely from the closed depot in New London, Virginia and from the southeast Pennsylvania and Delaware valley. Beginning work without a production facility, no machinery, and no water power—features which the craftsmen had not been accustomed to anyway—Perkin and the craftsmen fell into a regular routine: weapons were brought from depots for modification and repair, responsibilities were doled out, and craftsmen went about completing them as they saw fit given the time allotted.

Early on, as a measure of efficiency and as the first new weapons were made, Perkin requested craftsmen produce components of the weapons largely along lines informed by the craft process, thereby dividing labor into several steps—locks, the most intricate part of the musket

requiring several fitted metal parts, were made by some craftsmen and were then fitted to components made by other craftsmen, namely stocks, which required woodworking, and barrels, which required extensive forging and boring.[209] This trivial application of the division of labor largely conformed to the way a gunsmith working on his own might divide up the work of production.

As a superintendent, Perkin, who had been himself a gunsmith, largely functioned as the orchestrator of a large craftwork venue—supervising, assuring quality, and collaborating with Annin to keep workers supplied with raw materials for work and wages for living. The result of this reciprocity of deference was a largely harmonious work environment, despite the conditions of the plant, and high quality, but strikingly low volume and resource intensive, product. By 1806, production at Harpers Ferry was less than half of that at Springfield given the workforce and federal oversight, anticipating the war with the British that would come six years later began soliciting reform of the leisurely work environment.

This culture of reciprocal deference and the problems ensuing from the various top down attempts to regulate work at the armory are described expertly in historian of technology Merritt Roe Smith's 1977 *Harpers Ferry Armory and the New Technology: The Challenge of Change.* Relying on war department records and the archives of the Springfield Armory—many of Harpers Ferry's records were destroyed during the Civil War—Smith details the conversion of the armory from a craft shop to an internationally recognized site of machine-based mass production, highlighting the political and cultural frictions previously neglected by accounts of armory industrialization.[210]

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[209] Hence the expression, lock, stock, and barrel, to indicate the whole of something. Notably Harpers Ferry produced few muskets in the years leading up to the War of 1812, focusing instead on a newly designed short barreled rifle. See Smith, *Harpers Ferry*, 52–57.

[210] Given availability of his exhaustive survey of these authoritative documents (many of which are not easily accessible even at the sites), the narrative of the development of Harpers Ferry in the following several paragraphs relies largely on Smith's selection of documents and his recount of their contents.

[this note continues on the next page]

With Perkin's death in late 1806, Colonial James Stubblefield, a political unknown, was named the armory's new superintendent. Nearly six months in arriving to assume his position at Harpers Ferry—he stopped first to tour Virginia's state arsenal as he had little experience with such large-scale operations—and finding Annin, whose years of federal service granted him seniority, managing the facility in his absence, Stubblefield acquired influence slowly. He nominally began an aggressive building plan that was largely at the War Department's instigation, and, as had been the case under the previous superintendent, Annin took charge of the construction.

At the same time, Stubblefield had a hard time recruiting armorers—Harpers Ferry was remote and experienced gunsmiths were often reluctant to give up their own practices to move their families into a flood and fever prone and society isolated backwater to take a job at a factory. Recognizing the high quotas set out by the government and short labor (especially given the recently enlarged facilities)—and still operating under the principle of reciprocal deference—Stubblefield and workers agreed to ever more specialized labor roles. Lock making was divided into a dozen or more smaller jobs; locks were made up of several small interacting pieces, each of which could be molded, cut, and filed separately before being fit together. For barrel making, successive functions developed; one armorer would forge, another temper, another bore, etc.

With these new job delineations, a pattern of increasingly divided labor, production at Harpers Ferry began its long migration away from the craft tradition toward the contemporary methods of early mass production. Despite increased production, the labor at Harpers Ferry was still largely unmechanized, however, relying on hand tools and the larger equipment typical to any

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Where possible, especially in the case of government reports but less so in the case of boxed and archived private papers, reports have been retrieved for first hand reading. In no cases, however, did that reading elicit further relevant information beyond, perhaps, a sense of tone which reading documents first hand typically provides.

blacksmith or gunsmith's shop.[211] The armory remained largely unmechanized through the War of 1812, after which skilled labor, released en mass from private industry, once again became available.

The War of 1812 had an impact on the political organization of the administration for war in Washington and, in turn, on production at the armories. The back and forth nature of the conflict was as attributable to, in today's parlance, underdevelopment of the supply chain as it was to anything else.[212] By the end of the war, an inordinate number of artillery pieces and personal weapons had been damaged—some critically and some in ways that rendered them repairable. At the front, however, despite the rich opportunity to salvage parts, few repairs could be made to a weapon if part of it had been damaged—pieces of one rifle, musket, pistol, etc. simply did not conform to the parts of another enough for battlefield repair.

A supervisory position, the Commissary General of Ordinance, had been created early in the war and Colonel Decius Wadsworth, a military engineer who had been (briefly) a superintendent of West Point appointed to the position, had been charged with inspecting weapons for deficiencies. When, at the end of the conflict, the position was converted into the Ordinance Department, Wadsworth took over direct supervision of armory production from the Secretary of War and made the production of uniform weapons a priority. Under the control of Wadsworth and his assistant Colonel George Bomford, one of the many West Point engineers staffing the department, the armories began work on a process of uniform production that would eventually normalize work at the armories and at private weapon-making factories.

While Wadsworth was senior enough not to be a product of the post-1802 Military Academy at West Point, he had been at the school when Tousard's holistic manual *American Artillerist's*

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[211] Smith, throughout his *Harpers Ferry*, details the increase in division of labor, often comparing the precise numbers of jobs at Harpers Ferry and other sites like Springfield and Whitney's factory. These counts come largely from payroll information.

[212] Hitsman offers a detailed military history of the war. The Henry Adams account is, of course, the more colorful analysis.

Companion was becoming a standard text. Bomford, who had been educated at West Point under Tousard's regime, was familiar with the book's call for standardization in operations and in equipment. Descriptions of the arsenals of France before standardization in the *Companion* eerily resemble the pre-1816 Harpers Ferry.

> Every arsenal had its particular proportions, which seemed to belong to different sovereigns, or intended for different purposes. The officers employed [at armories] transmitted them from father to son, and, on removing from one arsenal to another, the artificer found himself almost a raw hand, and could but imperfectly observe the regulations which were prescribed to him. … The nature of the materials was not opposed to the introduction of a uniform system…nor was it a want of information, but rather owing to that blind fatality which renders mankind the slaves of prejudice and custom, and, a stubborn adherence to their own opinions, no one being willing to give up any part of his pretentions. (227–8)

A view of Harpers Ferry thus preconceived, along with experience in military inspections, provides potential context for the priorities of Wadsworth and Bomford and their initial interactions both armories. In this context, also, Simone North's 1813 contract, in which uniformity was voluntarily conceded as a concession to satisfactory fulfillment, does not seem out of place.

Wadsworth and Bomford's first notable administrative act was to arrange a meeting with Stubblefield, Springfield eRoswell Lee, and Eli Whitney to agree upon uniform specifications for a new musket with standardized components. This meeting coincided not only with the retirement of Samuel Annin, but also with the reorganization of authority at the armories; functioning more like a military than a civil service installation, a deep hierarchy made the superintendent position superior to the paymaster and to the long unoccupied master armorer position, the duties of which were closer to what Stubblefield had performed in the past. Stubblefield wasted no time in further integrating himself personally into the economic

framework of the community by asking the Ordinance administration to recommend for appointment Armistead Beckham, his brother-in-law, as master armorer.

It was more than a decade before Stubblefield and Beckham were forced into retirement in 1829.[213] During that decade, Monroe's era of good feeling, Lee's Springfield Armory gradually introduced more accurate and more multi-operation machine tools and, at the request of the Ordinance Department, shared those tools and often the expertise of armorers with Harpers Ferry.[214] On the other hand, Smith portrays Stubblefield as the absentee superintendant; taken with the affairs of his wife's several brothers, together a dominant business force in the region, he left the management of the day to day concerns (including supply contracts, labor concerns, etc.) to his wife's brother and master armorer Armistead Beckham. Ever sensitive to the regional situation and to his social place in the community, the trickle of labor innovations and mechanization from Springfield were mitigated to the satisfaction of the armorers with the most social capital. In fact, the lack of progress toward Bomford's ever-articulated goal of weapons with interchangeable parts, outside of wartime, was less noxious than his anti-Jackson politicking before the election of 1828, which attracted enough attention to make Stubblefield's "retirement" unavoidable.[215]

Stubblefield's successor was Thomas Dunn a Democrat and Marylander who had superintended the iron works at Antietam. Dunn's sternness was quickly recognized by the staff of the armory: he immediately changed work roles and fired the workers he perceived to be problems. His reputation as a martinet was secured by his revival of the "yellow book," a collection of before unenforced rules, which had been set up by Roswell Lee several years earlier when he had actually come down from Springfield to act as temporary superintendant of Harpers Ferry

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[213] Smith provides an excellent and rich discussion of the conflicted actions of Stubblefield in the period after the War before his resignation in 1829, and the more outrageous acts of Beckham in the same period. See *Harpers Ferry*, latter half of Chapter 5 and Chapter 6.

[214] Between 1816 and 1829, more than 25 armorers were transferred from Springfield to Harpers Ferry in an effort to diffuse innovative practices. Few stayed in Harpers Ferry long. (See Smith 138 a summary.)

[215] Virginia still had public balloting in 1828; votes cast by citizens were recorded for public record, leading, at Harpers Ferry anyway, to retaliation and coercion.

during a federal investigation into Stubblefield's corruption. Upon Stubblefield's return he had shelved the rules, and their revival by the new superintendant seemed to have earned him no friends at the plant.

A late nineteenth century colloquial history by resident historian Joseph Barry,[216] which notably details Stubblefield as an honorable but persecuted gentleman, describes Dunn's short tenure as follows:

> His was a melancholy history. He was a strict disciplinarian and, indeed, he is represented as having been a martinet. The severity of his rules offended several of the workmen, and he paid with his life a heavy penalty for his harshness. A young man named Ebenezer Cox, [who had been discharged in the interim between attendants, came to apply for his old position at which point] Colonel Dunn who, with violent language, refused to be appeased and displayed great vindictiveness by threatening with expulsion from the armory works any employe who should shelter the offender in his house. Cox's brother-in-law, with whom he boarded, was obliged to refuse him entertainment, and it appeared as if Colonel Dunn was determined by all means to force Cox to leave his native town. Thus "driven to the wall" the desperate man armed himself with a carbine and presented himself at the office of the superintendent, about noon, on the 30th day of January, 1830. What conversation took place is unknown, but in a few minutes, a report of fire arms was heard. People rushed to Colonel Dunn's office and were met by his wife who, with loud lamentations, informed them that her husband was murdered. (26–7)

[216] Barry's short historical narrative of Harpers Ferry is eccentric. Its apparent, however, that, writing in his old age himself, he is at least relating the local lore (be they tall tales) told by "the octogenarians" who lived through the experiences recounted.

While Smith's recount of the event, formed from impressions of his personality take from letters and from the testimony of the investigators, is undoubtedly more favorable to Dunn, both seem to identify Dunn's murder as an iconic event at Harpers Ferry—a moment which would set the threshold of workers' potential response to management. Cox, Smith asserts, became a local folk hero, whose name would come up frequently as a threat to managers stepping out of line (*Harpers Ferry* 256). The folk quality of Barry's retelling is highlighted by the continuation of the story (passages not reproduced here) in which Dunn's already consumed rice dinner, spilled from his stomach, remained on the floor perfectly white and unstained by blood and in which the day of Dunn's burial was the coldest day ever, not just for Harpers Ferry, but at that latitude (presumably in North America).

Not wanting to chance a repeat incident, the Ordinance Department appointed an eminently respectable wealthy Virginia general and visible Jackson supporter, George Rust, as Dunn's successor. A large plantation owner with no knowledge of metalworking, Rust was an absentee superintendent. Though, before disappearing to his home and business, he succeeded in having Beckham removed as master armorer and replaced with Benjamin Moor. In a paper prepared for an earlier conference on Decorative Arts at Delaware's Winterthur, Smith quotes Moor's description of the facilities on arriving: "there are customs and habits so interwoven with the very fibers of things as in some respects to be almost hopelessly remitless." He also quotes a craftsman's opinion of Moor: "[he is] nothing more than a theorist, with his head crammed full of whims, Yankee notions and useless machinery" ("From craftsman…" 125).

In fact, from the time of Stubblefield's collaboration with Roswell Lee, workers resistance to changes in their work process had often taken this form—innovations, especially mechanical, were trivialized and treated with suspicion of anterior motives and as a symbol of effeminacy. Smith places the root of this attitude in the specific personalities of a few senior and "tradition-bound" artisans who associated "laborsaving machinery with visionary schemes and charlatanism" and who saw the economic motive for the transformation as morally improper; in the familial apprenticeship system which was degraded with the ever more divided labor process; and resistance to outside authority and expertise (especially from "Yankees") which

transferred from "resentment of the man" to "denigration of his machines" ("From craftsman…" 126).[217]

The last stand, perhaps, made by armorers against the imposition of machinery on the shop was in 1841 when then superintendant Major Henry Craig, an active ordinance officer rather than, as previous superintendents had been, a former military man, prohibited drunkenness, casual entry and exit to the facility, and the throngs of non-armory visitors and enforced a ten hour workday for piece-rate workers and daily workers alike. Piecework armorers, of course, objected to the enforced work day, arguing that it was an unfair imposition on them as their pay depended on their level of production not their hours at the worksite. Armorers accused Craig of bringing military discipline to the site, and the icon of their dissatisfaction became a clock that he had mounted above the entrance to the main workshop.[218] In Smith's words

> [T]he clock reinforced already irritated feelings about the pernicious influence of outsiders—particularly military men—at Harpers Ferry. Moreover its ineluctable cadence served to emphasize the rigorous discipline, regularity, and specialization so often associated with the coming of the machine. In this sense, the clock not only kept time but also symbolically deprived armorers of the satisfaction of traditional craftwork. Every minute had to be accounted for, and each accounting fostered further discontent. (271)

In March of 1842, the workforce of Harpers Ferry struck, chartered a boat, and sailed down the Potomac to Washington where they presented their concerns to then President Tyler. Promising

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[217] The armors' resistance might anachronistically be associated with modern conceptions of anti-intellectualism. In fact, the mockery of men like Moor resemble the derogation of West Point by southern politicians who opposed its development into an education institution described in Chapter 3 and the criticisms made by so called practical mechanics of early civilian institutionalized engineering education at Rensselaer described in Chapter 4. Themes of masculinity seem to play a central role in these criticisms. For a further discussion of this point, though centered in a later period, see Ruth Oldenziel's *Making Technology Masculine*.

[218] See Barry, page 30, and Smith *Harpers Ferry,* page 271.

no retaliation if they returned to work, Tyler dismissed them saying, by all accounts "go home and hammer out your own salvation."[219] The clock and the ten hour work day stayed. By 1846, a significant percentage of the workforce had turned over and most of the practices at Springfield had been implemented at Harpers Ferry. British envoys touring the facility in the 1850s would write in their report that workers at Harpers Ferry, like Springfield, seemed eager to adopt new, labor saving technologies. Though it's unlikely the sentiment had changed so dramatically, the fact that the British witnessed workers using the machines at all was a testament to the military's direct contribution to discipline at the plant.

The persistent titles armorer, master armorer, and superintendant at Harpers Ferry hide the transformation that those roles underwent in the fifty years between the site's construction and the integration directly into the military hierarchy which arguably achieved most closely the goals of administrations since before the 1812 conflict. The labor and production shortages and gradual division of labor, the off-site development and importation of machines and machine processes, and finally the transformation (or enforcement) of express workplace policies contributed to armorers' migration from craftsmen to machinists.[220] At the same time, the gradual evolution of military, military engineer, and West Point specific, backgrounds of superintendants (and of the overseers in Washington) had implications in the way work was managed and the way workmen were articulated as part of the work process—creative, skilled, expert, or as machine operators.

If the visit by British officials was, retrospectively, the climax of the industrial revolution mythology of Harpers Ferry, then the events following can only be described as anti-climatic—John Brown's failed abolitionist raid in 1859 and the destruction of the armory a few years later

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[219] Barry repeats this.

[220] It should be noted that John Hall's rifle works, which shared the site and funding of the Harpers Ferry armory, has not been discussed here. While John Hall and the various armory superintendants had antagonistic relationships, the rifle works was an innovative and largely separate operation that, less attached to the politics of the local community, was instead stifled by politics of the nearby capital. Smith's treatment is excellent; see Chapters 7 and 8. A more focused work that reproduces significant portions of Hall's archived letters and provides more context is Huntington.

at the hands of its own complement of soldiers to stop the works from falling into Confederate hands. Ironically, however, John Brown's raid, to which the armory succumbed, mirrors the Springfield Armory's successful resistance to the forces of Daniel Shay's rebellion during America's earlier crisis of union. Likewise, the burning of the indefensible armory was largely purposeless as many of machines, surviving the destruction, were moved to Richmond where—at the armory toured by Stubblefield half a century earlier—they were used to produce weapons for the Confederacy. Enough of the process of weapon production had been embedded in the machines that they could be operated outside of the specially constructed armory by interchangeable machinist workers.

Perhaps the most wide-reaching effect of developing manufacturing processes at the armories was the impact they had on private manufacturing facilities, which often hired armory workers or paid consultants expert in the "armory method." This impact has been described by historians of technology like David Hounshell, who have suggested that production practices diffused throughout the continent influencing New England clockmakers, the production of agricultural implements like the McCormick reaper, Singer sewing cabinets (while not, he notes with curiosity, to the sewing machines themselves), and eventually Ford and GM automobiles. In his *From the American System to Mass Production*, Hounshell assert how the application of special-purpose machine tools to the production line diffused through armory machinists from industry to industry and how, by the 1900s, the diversification and flexibility of these tools was essential to meet market demands for inexpensive yet varied product selection. Hounshell, of course, relies largely on tracing diffusion from the Springfield Armory. While not excluding the influence of Harpers Ferry, the lack of skilled migration away from the southern site (excepting Springfield armorers who had transferred in, of course) and the lack of local manufacturing peerage hinder discussions of its influence on the manufacturing sector.

Modern researchers rarely find an evolutionary interchangeability. Outside of the mythological accounts of Eli Whitney's factory and propagandic glorification of the armory system, socially obstructed or mechanically failed implementations of production machinery are just as common as examples of industrial facilities where overseers choose to stop short of more integrated machine practices for the simple capitalistic reason that they would be gratuitous. Robert

Howard, former curator for engineer at the Hagley Museum, had argued that the private arms production industry was never as interested in interchangeability or excess mechanization for its own sake the way the armory system was, noting that industrial concerns whose client base were individual purchasers would have reaped no benefit from producing guns with interchangeable parts for consumers who were likely on buying one weapon and, therefore, did not need to invest in the machine precision to make parts match (Howard 634–48). In this way, the armory system, though self-interested, also acted as an exceptional research works producing technological innovations; a public service akin to what the federal government would nearly a century later call "pure" or "basic" methodological development.

While the impetus to develop interchangeable parts at the armories, however, cannot be exclusively pinned on the influence of West Point training on those setting the establishment's priorities, there are apparent connections. The uniformity ethos of Tousard, if not articulated by Bomford directly, certainly resembles his view of local expertise and the independence exerted by comprehensive craftsmen. Describing similar French craftsmen, Tousard attributed resistance to mass production methods to craftsmen's "prejudice and custom, and, a stubborn adherence to their own opinions, no one being willing to give up any part of his pretentions" (228).

Though certainly less contrived, on a macroscopic level the communication and management infrastructure of the military outside of West Point was no less intricate. The national military administration was criticized by many elected representatives in Washington and in the states for its prosecution of the War of 1812. Facing renewed reservations about supporting military spending at the close of the conflict, reports and justifications were written by Monroe's Secretaries of War and the Treasury (John C. Calhoun and William Crawford) to detail War Department expenditures and accomplishments.

Unable to predict the whims of the elected (and mercurial) House committees and finding the impoverished information structure unable to support constant demands for the tracking of money and personnel, Calhoun charged Major General Winfield Scott with compiling a single

reporting procedure that would continuously collect and keep any information that might be requested by Congress. This process, articulated in published "Regulations" in 1821 and revised in 1825, detailed not only an elaborate hierarchical scheme for command and control of the nation's army and its resources, but established intricate procedures for the regular collection and reporting of information. These reports not only detailed budgets, expenditures, personnel reports, equipment allocations, provisioning, egress, the consumption and waste of food and fuel, etc., they also established in a material way recourse or responsibility for the actions represented in the document and for the quality of the control and observation of those actions—they established accountability.

The prominence of accountability through paperwork, seemingly of little importance to many of the accountability-resistant managers of Harpers Ferry, is more apparent in the context of the rail industry. While Chandler's analysis of railroad corporations in *The Visible Hand* led him to conclude deterministically that "unprecedented organizational efforts" were demanded by new technologies (94), he admitted that once the general structures suggested by the technology were "uncovered," that managers, left to their own human devices, began to extend the natural rationales that warranted their positions, creating elaborate systems of individual worker management that went beyond what was necessary to keep the trains running safely and on time.[221,222] The complex accounting schemes developed by the railroad corporations to track men and machines required recording details of work and that that recording often became purpose-independent work in and of itself, requiring details in excess of what could be productively used.

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[221] Interestingly, in Charles O'Connell has suggested that many of these management practices were first implemented by West Point graduates who consulted as civil engineers for early rail lines! Chandler explicitly rejects the influence of the army (see, for example, 95), as have, on separate occasions, historians of business Harold Livesay and Thomas Cochran who suggest that railroad companies evaluated and discarded military management structures, each, notably, without addressing what influence those evaluations might have had on constructing their management models.

[222] He editorially makes this point at places throughout the work. Speaking of personnel accounting, for instance, he describes management techniques that "went beyond mere necessity" (120). In another place, he describes the same system from another angle suggesting that workers "felt and often remarked that the eyes of the company were always on them through the books" (268).

Similarly, Craig's imposition of a ten hour workday for pieceworkers who worked on quotas and the "yellow book" rule requiring, what today might be called, time charging or tracking or details which likely could not be processed into productive modifications of the work environment, were evidence of this documentation ethos. Like the prioritization of interchangeability, parallels can be drawn between the valuation of documentation at the armories and at West Point where, by 1830, Thayer had constructed a regime of highly hierarchical chains of command and where multiple signed paper reports were required for everything from course attendance to cafeteria orders.[223]

The prioritization of interchangeability and hierarchical and report-based administration, however, do not fully account for the ways that machines were actually created or entered into or influenced the system. Machinists at Springfield and Harpers Ferry and at private factories like Whitney's and North's conceptualized, constructed, and lobbied for the tools which would enable the development of the mass production workflow. Thomas Blanchard's "machine for turning irregular forms" and his "machine for turning gunstocks" were considerable innovations in machining, though their implementation at the armories was slow.[224] John Hall, whose rifle works was associated with and at times integrated into the armory at Harpers Ferry, conceived of not only fabrication machines but of a unique breech-loading rifle, and then how lamented unproductive work demands (largely low quotas) that kept his ultra-equipped facility from testing the economy of its true productive capacity. Government officials corresponding with Hall, however, assured him that economy was less their concern than was the experiment of producing and introducing the unique weapons.[225]

Blanchard and Hall, machinists and, in a peripheral way, armorers, were, in conjunction with these machines also identified as inventors. Just as craftsmen armorers had became machine process and interchangeable part producing armorers in the half century of modernization,

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[223] See *Regulations of the…*.
[224] The former of these patents survives; the latter was destroyed by fire. A biographical sketch of Blanchard, however, written by colleague Asa Waters, details the development of the devices.
[225] See Huntington, especially pages 190–210.

machinist inventors, who in Blanchard and Halls case, at least, operated on well recognized Yankee ingenuity, became the tool of hierarchical management's process development initiatives.

The subtle roleplay of men like Bomford, Stubblefield, Lee, Craig, and even Cox cannot be removed from their contextual associations with the inventor (Blanchard, Hall, even Whitney) and his inventions (largely the machines) which enable the process of not only dividing labor but of specialization. To say that gunsmiths prior to 1800 were craftsmen is not to say they were isolated forgers and artisans. As historian of technology Polly Anne Earl has noted, the image of the lone craftsman at his bench is as problematic.

> Far from being proprietors of simple firms, many master craftsmen, especially in cities, were masters not of their crafts, but of the business skills necessary to survive in the bewilderingly complex world of colonial trade and finance. They were organizers and managers who had to deal with rapidly fluctuating currencies, to contract for labor and supplies, to oversee what was sometimes considerable specialization and subdivision of productive processes, and to arrange transportation, insurance, and sale of the finished product. (308)

The labor recruited for the armory system was highly skilled, capable of not only skilled craftwork but experienced in the management of the work process and of the social connections required to make the process profitable. The local and federal supervisors of the armories, to different degrees, used the products of inventors to construct a process in which armorers were asked to resign their complex expertise for the sake of the little articulated, abstract, and unconventional goals of uniformity and productivity.

The armorers' context is where the situation at Harpers Ferry is materially different from the situation at Lowell. In the physical chronology of New England, Lowell was preceded by Slater's mill in Rhode Island and certain of the Associates's earlier mill in Waltham. But in the social chronology of New England—in the timeline of what people recognized as typical of work and

the way people felt about the place of work in their lives—Lowell rose out of the nothingness like, to borrow Whittier's phrase, "the enchanted palaces of the Arabian tales."

The typical new operative in the Lowell mills of the 1830s was the young daughter (or perhaps wife) of an agricultural family, unfamiliar with work outside of the home and without ideas of her own expertise or expectations of professional deference. The artillerists at Springfield and the other armories were craftsmen, many of whom had not only worked in weapon production under a previous work arrangement and had perceptions of their own value and skill as craftsmen.

This is not to assert that the operatives at Lowell did not develop a sense of themselves as something like a skilled workers or craftsmen, only to suggest that they likely did not enter the factory for the first time with the expectations that they should have some control over their work environment and so the factory environment functionally informed their development of their expertise. While in Lowell the factory was perceived as preexisting its operatives, in Harpers Ferry the non-mechanized craftsman preexisted a divided and machine-based production process and the conversion of workers from extra-skilled to specifically skilled—or from craftsman to specialized laborer, a process that would later be labeled deskilling—played out violently.

Engineers are facilitators of specialization

That specialization proceeds from the availability of machines has been a common theme in histories of the nineteenth-century.[226] Even contemporary writers, in the midst of the mass political upheaval surrounding them, were wont to recognize mechanical innovations as a source rather than an outlet of events and social changes. Thomas Carlyle's expansive claim, in an 1829 *Edinburgh Review* editorial "Sign of the Times," for a "Mechanical Age" included not

[226] Deyrup, for example, states this directly on page 92. It could be argued that this concept is fundamental to Hounshell's and Chandler's works as well.

only the ubiquity of machines to replace natural and traditional methods of living but the application of the machine ethic to social practices and to the perception of the universe itself.

Adam Smith's 1776 treatise had simply given the industrial application of the machine ethic a set of convenient labels and relationships. Of course, the division of labor was not first envisioned or recognized in 1776. Nearly all human societies have employed functional forms of specialization since the hunter-gatherer societies of the Paleolithic era.[227] Classicist Moses Finley discusses extensively examples of divisions of production and service labor in the ancient world in his book *The Ancient Economy*. These examples include, interestingly, not only the trivial division of labor along what would be today called trade or industry lines (blacksmiths, woodworkers, domestic servants, etc.) but also within the production process, as is evidenced in the following excerpt from Xenophon's *Education of Cyrus*.

> Just as the various trades are most highly developed in large cities, in the same way food at the palace is prepared in a far superior manner. In small towns the same man makes couches, doors, ploughs and tables, and often he even builds houses, and still he is thankful if only he can find enough work to support himself. And it is impossible for a man of many trades to do all of them well. In large cities, however, because many make demands on each trade, one alone is enough to support a man, and often less than one: for instance one man makes shoes for men, another for women, there are places even where one man earns a living just by mending shoes, another by cutting them out, another just by sewing the uppers together, while there is another who performs none of these operations but assembles the parts, Of necessity, he who pursues a very specialized task will do it best. (book 8, ch 2, 4–6; as quoted by Finely, 135)

[227] On this point, see Kelly.

Two things are interesting about this passage. Xenophon not only identifies that it is the scale of a settlement or city as a primary factor in determining the degree of economic specialization, but also asserts that workers engaged in highly specialized labor will "do it best."

This is one of the key points made in 1776 by Adam Smith in *The Wealth of Nations*. Using the example of the manufacture of pins, Smith illustrates how routinization of tasks and assignment of tasks to narrowly skilled workers improves production. Smith's anecdote about producing pins was likely inspired by Henri-Louis Duhamel du Monceau's l'*Art de l'Epinglier (The Art of the Pin Maker)*, published fifteen years earlier in France and describing, without as much apparatus, how pin production had reached its zenith through the artful combination of machines and divided work. Unlike Monceau, Smith's emphasis is less on the division of work *tasks* as it is on the division of work *assignments*—which he refers to as the "division of labour." Monceau, however, was interested in production efficiency gained by a worker cutting a number of pins and then rolling that number rather than cutting and rolling each in turn; while, Smith described the production efficiency gained in having one worker exclusively cut and another worker exclusively roll.

The division of labor, according to Smith, offers a number of benefits. Like Xenophon millennia earlier, Smith notes that the worker who does only one task and does it frequently becomes more adept at performing that task than he would become at doing a number of tasks in turn. Additionally, he notes the time saved by workers who, performing one task, do not have to switch tools, work stations, etc. and the time saved by the use of machines to replace certain precision or strength requiring tasks. Unlike Xenophon, however, who was simply describing the habits of an economic system, Smith asserts in the first chapter of *The Wealth of Nations* that these principles can be combined to increase production quantity.

> The great increase in the quantity of work, which, in consequence of the division of labour, the same number of people are capable of performing, is owing to three different circumstances: first, to the increase of dexterity in every particular workman; secondly, to the saving of time, which is commonly lost in

> passing from one species of work to another; and, lastly, to the invention of a great number of machines which facilitate and abridge labour, and enable one man to do the work of many. (1:10)

In 1832, Charles Babbage, another Englishman and an early writer on the concept of programmable machines for computation, extended this observation to suggest that the specialization induced by the division of labor itself could be leveraged by the industrialist to stratify the work place and cut labor costs.

> That the master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill or of force, can purchase exactly that precise quantity of both which is necessary for each process; whereas, if the whole work were executed by one workman, that person must possess sufficient skill to perform the most difficult, and sufficient strength to execute the most laborious, of operations into which the art is divided. (137–8)

Simply put, by differentiating tasks and assigning tasks requiring varying skill and strength to workers suited to those tasks, the manufacturer can limit the need for highly skilled craftsmen and limit the time that highly skilled craftsmen are employed in less skilled labor. Babbage's dehumanizing phrase—"can purchase exactly that precise quantity of both [i.e., skill and force]"—is indicative of the transaction being made. The mass production system works at peak efficiency when machines and labor (interchangeably) have specialized capacities. The laborer who possesses multiple specialties may taint the process by exerting his or her uncalled for expertise—an act which might have catastrophic consequences given the rigidity of machine elements in the process. Alternatively, the over skilled worker may malfunction socially—demanding higher wages or resisting work conditions, like the armorers at Harpers Ferry—thereby dampening the efficiency of the production system.

The application of a mechanical philosophy to the workplace was not only made by those versed in machine processes or who used the language of the machine. On tour in the early nineteenth century, English sociologist Harriett Martineau described the interaction of work and social roles in America, noting the ramifications of the factory system. Martineau identifies American mechanics as a "comfortable" social class, who, like English mechanics, "have the fewest base and narrow interests [as] they are brought into sufficient contact with the realities of existence without being hardened by the excess of toil and care" (60).[228]

In fact, Martineau, throughout her analytical tour, aligns social categories with workplace roles, assigning properties to classes based on the nature of the work they do and suggesting that specialization's influence in industrial society is different than it had been in pre-industrial societies. In American society, she observes, the tradesman and the professional, though separate classes, are no more or less respectable because of the work they do. The bricklayer, she suggests, even "criticizes, and sometimes corrects, his lawyer's composition" (61). In this way, specialization and democratic socialization are complementary: the former relies on a recognition of roles and a sense of reliance on the work of others; the latter recognizes the inherent equality of members participating in a functioning system.

Following this logic, Martineau dismisses American unionization movements as antidemocratic and, thereby, stifling to America's startling capacity for innovation, which she suggests was reliant not only on egalitarianism (62) but on the social acceptance of industrial risk—"A man who makes haste to be famous or rich by means of new inventions, may injure his own fortune or credit, but is usually a benefactor to society, by furnishing a new idea on which another may work with more success" (137). To this point, Martineau identifies the factory as a reinforcer of egalitarian work relations and a producer of the safe social setting for risk taking, as a symbiont. Factories and industrial shops are the social incubators of innovations, where skilled mechanics

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[228] In fact, she identifies American mechanics as the "most favoured class," citing their only a single deficiency: unequal knowledge of science and their art, not do to lacking infrastructure—"schools, lyceums, libraries, are open to them"—but due to the lack of adept staff for that infrastructure—"instruction imparted there is not so good as they deserve" (60).

can experiment with techniques and cooperate as they would not in a cottage style economy. The factory model, for Martineau, becomes a model for all participatory decision making in a democratic society. As Larcom's woven threads became an expression for social collectivism, Martineau's "steady employer" becomes the social role setter that "has it in his power to do more for the morals of the society about him than the clergy themselves" (138).

The social professionalization of a class of mechanical engineers in America was occurring in the mid-1800s, well in advance of the foundation of the American Society of Mechanical Engineers in 1880 (after, as might be expected, Civil Engineers in 1852 and interestingly Mining Engineers in 1871).[229] Already social structures were developing that recognized the new class of professionals as central to industry, commerce, and, as the railroad expanded and coal mining made steel ever cheaper, even agriculture. By the 1853 meeting of the Michigan Agricultural Society, in fact, University of Michigan President Henry Tappan would include the rise of the engineer in his recitation of the mythology of the progress of man:

> At the beginning the same man was the thinker, the agriculturalist, the mechanic. In the growth of society, in the advance of civilization, a separation into classes becomes necessary. A division of labor is the palpable sign of progress and perfection. Thus the useful and fine arts, thus commerce, government and religion, all came to have their representative working men. And then too as science and philosophy advanced, they came of necessity to have their representative working men also. (185)

By the close of the Civil War, certainly, the ubiquity of the engineer as facilitator of society in all its forms (work, shelter, transportation, food, water, security, etc.) would be widely recognized. The military application of the term would become one (a lesser one, in fact) of a number of applications. An 1865 commencement announcement for the Polytechnic College of

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[229] The British Institution of Mechanical Engineers was founded, notably, in 1847.

Pennsylvania would not only make clear the relationship between the military and non-military engineer but also connect the non-military engineer to their soon assumed role of organizing and adding value to work: “Already the military engineer has been sent to the rear. The mine engineer, the civil engineer, and the mechanical engineer were now at the front directing the innumerable army of productive labor” (“Commencement…”).

5 Identification and the identity of engineering: From useful art to applied science

The preceding chapters have been concerned with, more than anything else, identifying values, personalities, and contexts which contributed to a cultural idea of engineering and engineering work. It's easy to use contemporary values to assess artifacts of the past, identifying precursors or assigning levels of conceptual evolution, and then to attribute these observations *en mass* to a people or a period. In some ways, though, it is harder to let go of ideas like levels and preordained structures and, accepting the chaos of a complex, ever fluctuating society of individual minds, motivations, and moments, accept revelations from any and every context, assessing the conflicting messages of the whole and being critical without being reductive.

My interests, motivations, and experiences prior to and during the process of constructing this history have played a crucial role in what appears here and what observations have been made. Based on these, I would suggest that a careful reading of the period between the American Revolution and the Civil War suggests that a variety of values and ideas clustered around icons (projects, people, events, etc.) that were labeled as or associated with engineering. And, it was the assignment (or not) of the label to those icons by which associated values got packaged and subsequently reiterated and refined through the reuse.

The way to expose these values, then, or to question the inclusion or rejection of values over time, would be to ask questions about the social construction of engineering as a culturally identifiable practice. In other words, ideas of engineering and of engineers were organically formed in the social environment of this period through repeated instantiation: a certain class of actions and people were labeled locally and in socially relevant ways as engineering and engineers, and the extrapolation and interpolation of the repeated communicative deployment of those labels (combined with the dispositions of actors to collaborate) produced a cultural commonplace that could be relied on and, in fact, would become a featured cultural theme in the development of transportation, work, and community life in the late nineteenth century—what Layton called the engineer's golden age.

The label set (engineering, engineer, etc.) certainly made its entrance into American (and indeed European) society through military use. To say, however, that the engineer is essentially a military agent is to miss the point: the military in the political and social context of life in the centuries before American independence is a complex cultural force with composite properties. What is interesting, however, is how this complex cultural force interacted with competitive cultural forces like the movement for American independence; how late eighteenth century European and colonial militarism, in the context of a new political order, recreated itself by reorganizing its values, priorities, and institutions and was reassigned rhetorical meaning by the society of that order.

I see it, perhaps, as most closely akin to the following physical system. Militarism introduced into a novel solution of unstable democratic and libertarian ideals dissipates and then crystallizes in a new form which combines elements of the solute and the solvent. In such a system one precipitate substance, namely engineering, appears to have shed some of the constituent elements of militarism which were involved in its production. But those shed constituent values do not simply disappear. Unless extracted they remain ever present in the cultural solution surrounding engineering and—this is where this chemical metaphor is interesting—they remain in constant communication with engineering, a certain fraction of which is always dissociating, pulled off by the recognition of the old structure, wavering back and forth between the old militarism and the new techno-republican composite.

This is how equilibrium works. In order to stabilize the product, the shed values must be recognized in the cultural milieu and consciously (and conscientiously) extracted.

But I would argue that in a cultural system, unlike a physical one, byproduct values—values which are declared by the dominant cultural voice unwanted (for, what is pollution to a chemist but the chemicals in an environment which have been declared unwanted)—cannot be scrubbed, even by the most deliberate or violent purge. Not only because ideas from the hearts and minds of people cannot be expunged, but because a knowing of these values is essential to

the human need to contextualize and identify. That is why it is important to posit the influence of these values, necessarily unaccounted for by the dominant narrative.

The soldier, by virtue of cultural and institutional situation, is in a selectively liberated position. The violent and anti-social functions of a soldier are protected as acceptable by their situation in or affiliation with a variety of institutions that operate as havens in society for behavior which, at large, is rejected (not just the military and designated conflicts but, in the eighteenth century, nationalism; in the medieval period, perhaps, Christendom; etc.) The military engineer, in this context, is a legitimized agent of situational control; works constructed by military engineers attempt to reframe the environment in which armies meet, both literally (by reshapping the land with walls and ditches) and figuratively (by introducing options for use of alternative fighting spaces and techniques—adding a vertical dimension to war with catapults and an intra-bodily dimension with poison gas, etc.) Off the battlefield,[230] military engines—cannons, walls, etc.—are also an agent of social control in a cultural context where the military functions to empower the ruling agency of a state to collect taxes, suppress rebellion, and largely exert psychological dominion over a population. Unlike the foot soldier, the military engineer's products (e.g., the fortified wall) can be estranged from the engineer for use, and the engineer's direct actions (e.g., construction of the fortified wall) is often not synchronous with his action's fullest impact.

It would be tempting, then, to discuss the civilian engineer as a being extracted from the military context in the eighteen hundreds. I would suggest, however, it is that situation of the engineer in the identifiably military context that changes (not the engineer who emerges from the military). This is more than a semantic distinction. It is not like governments in the eighteenth and nineteenth centuries suddenly realized that functions performed by military specialists could be transported into the public realm. Rather, with changes in mass social involvement in government, libertarianism, perhaps the general wake of the Enlightenment, the identifiably

[230] If your rhetoric permits an "off" the battlefield…

military context of government power in certain civic domains fell away from the ideals of engineering and, released from that niche, the concept was opened for reinterpretation and privatization.

With debates in America over the desirability of a standing army, engineers became the instantiation of the trained military man; a shell protecting an officer class for, depending on whose period point of view you take, the protection of the short-sighted public or the preservation of an institution of social and political elitism which, in the case of political collapse, would be ready to resume control. At the same time, they became the iconic example of the military man acting in public—not just by virtue of their training, but in that their operations were, in earlier contexts, quasi-military anyway. Interestingly, during the canal building period especially, their employment was largely private and, in larger examples, state rather than federal. The military power structure, through the engineer, became sensitive to the public whim and the economy of "internal improvements."

It is not surprising, considering this context and the open nature of the idea of engineering, that a variety of institutions would begin adopting the label for their own purposes. Approaching the engineer not as he is imposed but as he is constructed, institutionalized educational venues were not following or deviating from a script, rather they were creating pedagogies to recreate an end product, the nature of which was debatable. That said, education in nineteenth-century America[231] was essentially commercial. Without questioning (or needing to) the motives of educators and investors, the reliance of the school, academy, lecture circuit, library, etc. on public patronage and on paid attendance is evident in maelstrom of institution openings, closings, reorganizations, and program bulletins.[232] And the more secure a school was financially, the more it could focus its resources on the invisible economies of knowledge and prestige trading. The label engineer was an obvious opportunity in this environment. With open expectations—some schools offered engineering certifications at the completing of a short

[231] Some may argue that this observation is not limited to the nineteenth century.
[232] Schools advertised as much than as for-profit universities do now!

course in surveying—and growing industrial and public recognition of the term, those matriculating with engineering designations of various kinds acquired a variety of backgrounds and experiences. If one accepts that education is formative, the impact of the experiences that these men had must have shaped their identity; or, perhaps, that is why so many academy-educated engineers identified as "self-made."

In either case, as the notion of the engineer, fluid, over the century came to be assigned roles in the public and industrialists' mind that align rhetorically as much as tangibly. It's often remarked today, though seldom in universities, that engineering, now sub-parceled itself, is a diverse enough enterprise that the term is strained. This is explained away in modern academic settings by referencing design as a process that unifies engineers; in modern professional settings by setting up engineering as the fulfillment of science;[233] and, notably, even in Layton's golden age, as it was in noted engineer William Fairbairn's autobiography:

> …and thus we arrive at the interesting and certainly little known fact, that an engineer is not necessarily a person who has to do with engines, but anyone who seeks in his mind, who sets his mental powers in action, in order to discover or devise some means of succeeding in a difficult task he may have to perform (4).

Certainly an all-encompassing cultural construct that! Each of these explanations, however, subordinates the ethos of that ambiguous engineering concept of the early nineteenth century. The label engineer was not chosen at random by factors and state and government officials. But they were also not concerned with the economic naming of engineers in the same way educational venues were. The unifying feature among engineers of the nineteenth century, it seems, was the operative ability to influence the environment they were charged to control—be

[233] My favorite recent example of this is the "What is engineering" tab of www.discoverengineering.org, constructed by the National Engineers Week Foundation an educational outreach arm of a number of large corporate engineering employers.

it dunes identified by the coastal commission as receding in a strategically or commercially important channel or the arrangement of laborers and labor-saving devices on a shop floor.

In completing the set of terms, out of ease of resemblance (after all, the engineers work was suffuse with numbers), and to achieve the cultural status assigned it at the time, the engineer's work was deemed scientific. Both the educational venue, where science was decades ahead of engineering in being assigned a public cannon, and the industrial setting, where factors' economic class made science a liberal pursuit and a status icon, used engineers as a mechanism to show off their enterprises as enlightened projects rather than base economic engines. It is science, not exploitation, to ask workers to perform body- and mind-straining functions in atypical work environments. It is the engineer, applier of science and controller of the environment (of which cogs and workers were equal parts), who makes this possible.

Articulating engineering in this way, the upper class engineer functions on behalf of its cultural superior, the noble science. The parallels are almost too easy to draw. The engineer accepts the physical implications of work, deemed scientific for his cultural benefit, and disrobing the material implications of their work the scientific gentry remain clean and pure in a knowledge-centric culture. Engineers retain their military properties in this sense, the class who accepts the morally consequential items and brings them into the shelter of amorality where they can be developed and propagated. Science, pure, in turn offers its blessing, replacing religion and nationalism when unobserved, and quickly retreating to safety on those punctuated occasions when the society rises up in furor.

It was the veneer of egalitarianism that accompanied early American republicanism that was catalytic for this arrangement. Alexis de Tocqueville implied just this in 1835 in the tenth chapter of *Democracy in America*, which is titled "Why the Americans are more addicted to practical than to theoretical science."

> Equality begets in man a desire of judging of everything for himself: it gives him, in all things, a taste for the tangible and the real, a contempt for tradition and for forms. …
>
> Those who cultivate the sciences amongst a democratic people are always afraid of losing their way in visionary speculation. They mistrust systems; they adhere closely to facts, and study facts with their own senses. As they do not easily defer to the mere name of any fellow-man, they are never inclined to rest upon any man's authority but on the contrary, they are unremitting in their efforts to find out the weaker points of their neighbors' doctrine. Scientific precedents have little weight with them; they are never long detained by the subtlety of the schools, nor ready to accept big words for sterling coin; they penetrate, as far as they can, into the principal parts of the subject which occupies them, and they like to expound them in the vulgar tounge. Scientific pursuits then follow a freer and safer course, but a less lofty one. (47–8)

By dividing science into three parts—theoretical principles which are remote from application, "general truths" which are theory but can be applied to practical ends, and applications or methods of application—Tocqueville is able to implicate what he considers American democratic values in a bias for the "applied" and for, what would come to be identified as the engineering side of the science/engineering relationship. Tocqueville goes on to locate the individual actor in his interpretive system:

> Permanent agitation of a democracy makes each man commit to actions that will advance him lest he be pulled down by others. With no aristocratic leisurely class, there is no one to maintain theory... In aristocratic ages, science is more particularly called upon to furnish gratification to the mind; in democracies, to the body. (52)

He makes similar observations about the arts. In an economy with a limited high-end consumer base (of aristocrats) and with a large permanent base of lesser consumers who are largely assured persistently modest resources, artisans are required to manufacture few goods at consistently higher quality to maintain their clients' expectations. While, in a democracy, the constant floating of fortunes create shifting markets where individual citizens grow richer and poorer somewhat independent of each other and, involving acquisition as a status marker, are always seeking to purchase goods above their station at the lowest cost possible.

In a democratic system, real mobility and the system of desire and social signification surrounding mobility effect the composition and reliability of consumer markets such that the values of manufactured goods vary much more and economies of scale become reasonable models of production. In an economy of large scale production, it is Tocqueville's assertion, the craftsman who can lend the appearance of quality to a mediocre product is more successful than one who produces a quality product which is prohibitively expensive to the masses—imitation of quality rather than quality itself becomes the substance of art.

Tocqueville justifies this observation with examples from both the "useful arts" and the "fine arts." The production of low quality, low price watches, which by the 1830s had already become pervasive enough to subvert the market for high quality expensive watches, diminishes the infrastructure for producing and maintaining superior watches. Imitation diamonds (which in 1830 were likely glass and thallium composites), if perfected, will ruin the market for genuine diamonds. Paintings, manufactured to indulge mass interest in particular themes or style, discourage the production of (and obstruct the marketability of) unique works of committed and truly inspired artists (55–60).[234]

[234] In an unpublished note included in Eduardo Nolla's recent expanded edition of the book, Tocqueville, commenting on the vulgar commercial fiction industry that churns out imperfect but new fiction, writes "Americans don't have literature, but they do have books."

On a literal level, Tocqueville uses these examples to illustrate how mass acceptance of affected quality feeds back into the market value of and production method of commodities in unexpected and destructive ways. The mediocrity of practice required for large scale production, Tocqueville implies, has a deleterious effect on the skill of the craftsman, who operate below their ability, and on the infrastructure of art, as new craftsmen are allowed to enter the labor market without being asked to evidence their ability to produce quality items but on the sole provision that they can produce at the rate required to meet demand.

As Tocqueville is writing in the 1830s, industrialization is in its infancy. Far removed from the societal disaster of Manchester, the American industrialization movement, benefiting from space, natural power, bountiful resources, and a flexible commercial environment would achieve a balance of social and environmental control which would imprint intractably on the landscape of the North. The engineer would be the lynchpin functionary—the connection between the factor, the manager, the worker, and the physical world.

This is perhaps why academic discussions of engineering professionalism have been so appealing and so urgent in the recent century, and why discussions amongst professionalizing engineers were so fraught in the late eighteen hundreds. Insensitive to the cultural position of engineers in the industrial setting, discussions of industrial middle levels have, for the major portion of the twentieth century, tended to answer questions of professionalization by assessing a group's closeness to or distance from the practices of law and medicine as ideal professional communities, on the grounds that both operate in the middle class pay scale, both undergo institutionalized forms of professional education.[235]

There are a variety of quite significant problems, beyond the aforementioned, even, that complicate the comparison: industrial middle-level employees do not own the property that leads to production, they often have the goal of rising (and often do rise) into upper-levels, and

[235] See Parsons or Marshall.

they are subject to production market forces in a different way than independent professionals.[236] These observations link middle-level engineers more closely to upper- and lower-level industrial employees than to largely independent professional agents like those who practice medicine and the law. At the same time, occupational sociologies Robert Zussman points out:

> Unlike small shopkeepers and independent farmers, [engineers] are not victims of rationalized, bureaucratic enterprise but instead owe their very existence to it. Unlike entrepreneurs, they are neither heroic nor villainous representatives of economic individualism but 'team players' and 'organization men.' And unlike industrial workers, they have not been seen as a potential base for opposition to the modern social order so much as acquiescent participants in it.

This acquiescent role, I would argue, has not been passive or imposed, but was an active condition for the pursuit of engineering—an essential feature of the labeling of the early nineteenth century and a hallmark, not only of the engineer's military origin but of the devolution of centralized power in American society which led state agencies and commercial enterprise to structure in such a way as required quasi-military power brokers. As the term was available and akin, the engineer came to be.

Aside from the status quo, the immediate implication of this transference and crystallization, in the decades that would follow the hardening of the engineering identity is reactionary criticism of the engineer's purposive suspension. It's, perhaps, not a coincidence that Thorstein Veblen was Layton's declared inspiration. It was Veblen's position, writing during the rise of the Progressive era, that engineers "have continued to be employees of the captains of industry, that is to say, of the captains of finance, whose work it has been to commercialize the knowledge and abilities of the industrial experts and turn them to account [only] for their own gain…not to the extent of their ability; or to the limit set by material circumstances; or by the

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[236] See Mills or Braverman.

needs of the community" (61). Veblen expressed a middle road for the expert class searching for a critique of the capitalist system in which they were implicated but which, unlike Marx, they wanted to reform rather than tear down.

The debate is reminiscent of voting rights arguments during the period of national formation a century earlier. Along with their insistence that the citizens of the new American nation would be no more at the behest of or the interest of a monarch, the founders, outspoken politicos, and attendees of congresses and conventions were equally suspicious of the mob, the demos in democracy. The solutions: representative democracy, checks and balances, and limited voting rights (which persisted until the Civil War) mirror the industrial arguments for control by an expert class. The tools of that moment seem to become the tools of Veblen and the Progressives.

For Veblen the keystone of crisis in the engineered industrial environment was not the capitalists' control over the engineer, however, it was the, perhaps inevitable, absenteeism of the capitalist. The economically invested executive had been displaced by a parasitic machinery of bankers, accountants, and investors leaving him, without industrial or financial engagement, "an idle wheel in the economic mechanism, serving only to take up some of the lubricant" (66).

> In effect, the progressive advance of this industrial system toward an all-inclusive mechanical balance of interlocking processes appears to be approaching a critical pass, beyond which it will no longer be practicable to leave its control in the hands of businessmen working at cross purposes for private gain, or to entrust its continued administration to others than suitably trained technological experts, production engineers without commercial interest. (58)

> Technology—the state of the industrial arts—which takes effect in this mechanical industry is in an eminent sense a joint stock of knowledge and experience held in common by the civilized peoples. It requires the use of

> trained and instructed workmen—born, bred, trained, and instructed at the cost of the people at large. So also it requires with a continually more exacting insistence, a corps of highly trained and specially gifted experts, of divers and various kinds. These, too, are born, bred, and trained at the cost of the community at large and they draw their requisite special knowledge from the community's joint stock of accumulated experience. These expert men, technologists, engineers, or whatever name may best suit them, make up the indispensable General Staff of the industrial system; and without their immediate and unremitting guidance and correction the industrial system will not work….The material welfare of the community is unreservedly bound up with the due working of this industrial system, and therefore with its unreserved control by the engineers, who alone are competent to manage it. To do their work as it should be done these men of the industrial general staff must have a free hand, unhampered by commercial considerations and reservations; for the production of the goods and services needed by the community they neither need nor are they in any degree benefited by any supervision or interference from the side of the owners. Yet the absentee owners, now represented, in effect, by the syndicated investment bankers, continue to control the industrial experts and limit their discretion, arbitrarily, for their own commercial gain, regardless of the needs of the community. (69–70)

Veblen's engineers have functioned, on behalf of the capitalist, to reconstruct the physical environment and means of production, a process which included regulating the craftsmen—not only through the development of machining and mass production but through the development of social engineering mechanisms for controlling work (movement studies, graduated performance pay, aptitude testing, etc.) For Veblen, this was an indicator that engineers, his trusted party, should seize control of the system, bringing to it their deliberate rationale and concept of efficiency.

This position attracted, it can be argued, was formative to the movement identified as progressivism. A critical article published in the *Stevens Institute Indicator*, a well-recognized academic engineering quarterly, put it so:

> Remember that the existence of civilization as we know it, and to a large degree its advancement, depend upon transportation and intercommunication, which are fundamentally engineering industries. Are the engineers then to allow those important political and civic activities which cling around civilized life to fall under the sole direction of others?
> (Jackson 28–9)

The intellectual front of the Progressive movement, however, can be exposed only by understanding the values and displacements of the century prior. The displacement from the military shelter of the engineer, the evocation of the engineering label as a faculty for action on the part of the empowered, and finally aristocracy displaced by technocracy.

Lucy Larcom, working in the mills at Lowell, is ironically liberated not by freeing herself from the machine but by freeing the machine from herself—by becoming one with the fabric. Larcom assents to that unification as a way of finding fulfillment. If the cataclysmic wars that highlighted the early decades of the twentieth century are viewed, as Polanyi suggests, as survival response by a society displaced by economism, then an understanding of the grand facilitator of that project in the century prior is as essential to the preservation of mankind as anything.

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