Drawing Machines: Image and Industry in Early America

Drawing Machines: Image and Industry in Early America

A dissertation presented

by

Elizabeth Bacon

to

The Department of History of Art and Architecture

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

in the subject of

History of Art and Architecture

Harvard University

Cambridge, Massachusetts

April 2017

Dissertation Advisor: Jennifer L. Roberts Elizabeth Bacon

Drawing Machines: Image and Industry in Early America

ABSTRACT

Although early modern authors frequently used mechanical analogies to describe the operations of both the human mind and body, by the turn of the nineteenth century the term "mechanical" had acquired a new set of associations. Whereas pre-industrial machines had extended and amplified the forms and effects of bodily exertion, the new sources of power and principles of motion that drove industrialization cast the machine, not as an analog or extension of the body, but as its antithesis. This dissertation examines the ways in which the growing breach between bodily and industrial mechanics was bridged by an alternate form of manual labor—that is drawing. Through a series of four case studies on writing, military drawing, patents, and portraiture, the project consider the ways in which graphic practice came to replace the forms of embodied knowledge that had long governed practices of construction and manufacture. It examines the ways in which both artistic creativity and agency were reinvented through their interaction with the processes of both mechanization and industrialization, while also demonstrating the importance of the artist's body as a continued source of productive power in a context where production was increasingly driven by machines. Bringing together objects from both the fine and the mechanical arts, the dissertation explores the interdependence of representation and industrialization as a broad cultural phenomenon, with repercussions well beyond the walls of the manufactory. The resulting account describes a vibrant visual and material culture largely overlooked by the history of American art, but essential to understanding the origins of industrial capitalism and the subsequent estrangement of body and machine that has come to define the modern industrial paradigm.

TABLE OF CONTENTS

ACKNOWLEDGMENTS

I must begin by thanking my advisor, Jennifer L. Roberts: first, for the seemingly innocent question she asked in my third year of design school, “Have you ever considered pursuing a PhD?” and second, for her unflagging energy, interest, and support ever since I made that fateful leap into academia. I also want to thank the members of my dissertation committee. Ewa Lajer-Burcharth’s critical eye and mind have helped shape this project since its inception, while Wendy Bellion and Sarah Lewis’s more recent contributions have proved invaluable in setting the project on its future course. And although he is not a member of my committee, Timothy Hyde’s on-going support and good counsel have been essential in shaping the course of my academic career.

This dissertation would have been impossible without the expertise of the many librarians, archivists, and curators upon whom I have called in the course of my research. In particular, I want to thank Olivier Azzola at the École Polytechnique, Suzanne Christoff and her staff in special collections and archives at the West Point Library, Marlana Cook of the West Point Museum; Anne Lhuillier at the Musée des Beaux Arts Dijon, and Alex Mazzitelli at the New York Historical Society for efforts that went above and beyond the call of duty.

The project would have been equally impossible without the generous financial support provided by fellowships from the American Council of Learned Societies and the Luce Foundation, the American Antiquarian Society, the McNeil Center for Early American Studies, and Harvard University. The McNeil Center and the American Antiquarian Society were particularly important for the rich intellectual communities they provided. I would particularly like to thank Dan Richter at the McNeil Center and Paul Erickson, formerly of the American

Antiquarian Society, for their able leadership and the strong *esprit de corps* they fostered amongst the various fellowship classes to which I belonged. And, of course, I want to thank the other fellows at both these institutions—individuals whose work I continue to find inspiring and from whom I have learned so much.

In a similar vein, I would like to thank the two writing groups in which I have had the privilege to participate over the last several years. To Layla Bermeo, Jennifer Chuong, Ruthie Dibble, and Miri Kim, I would like to say how much I look forward to our meetings and seeing your fine and funny faces appear on my computer screen each month. Your comments never fail to provide new avenues for investigation, new perspectives on old material, and new energy for a piece of writing that has gone stale. To Margaretta Lovell and her Berkeley Americanists' Group, I want to offer my thanks for providing this displaced East Coaster with a warm scholarly community when I moved to the Bay Area in 2014. My work has benefited as much from your good sense as your senses of humor, and I cannot thank you enough for both your insightful commentary and your collegiality over the course of this project's development.

There are, of course, many others who have provided invaluable support, be it reading paper abstracts or chapter drafts, consulting on fellowship proposals and job applications, or simply providing a sympathetic ear as I sought to navigate the often puzzling world that is academia. To Maggie Cao, Caitlin Henningsen, Adam Jasienski, Whitney Martinko, Read McFaddin, Don James McLaughlin, Christen Mucher, David Pullins, Raisa Rexer, and Taylor Walsh, especially, I want to offer my gratitude for your intelligence, your friendship, and your sage advice. I also have to thank the many friends both far and near who have offered their sofas and their spare beds for my use on the many research trips that were necessary to the development of this project. Your warm hospitality is, in many ways, the raw material from

which this dissertation has been made.

However, my greatest thanks are due to my family. This work would not have come about were it not for the ravages my mother’s red pen has wrought across decades of writing projects, nor for the many spontaneous field trips into the American past ginned up by my father over the course of my childhood. To Martin and Cheryl Bacon, you have inspired my intellectual curiosity and supported my every endeavor. I owe you a debt I can never repay. Likewise, to Rebecca Bacon, your determination, grit, and self-possession are characteristics I can only hope to emulate. I will be counting on your excellent example and your cheerful friendship for another thirty years, at least. And finally, to Chris Eager, I offer my gratitude for your unfailing patience, your persistent good humor, and your constant support. Any success I have had is due to your willingness to approach our life together as an adventure—a never-ending set of twists and turns that you are always willing to take in stride. Now, we have a new set of adventures before us, and I can only say how grateful I am that you will be my partner in their pursuit.

For Ruth L. Brooks

LIST OF ILLUSTRATIONS

Chapter 4

INTRODUCTION

Following the end of British colonial rule in 1775, the United States embarked upon a relatively rapid course of mechanization and industrial expansion, one that came to fundamentally transform the role of embodied knowledge within the sphere of manufacturing. On one hand, mechanization gradually shifted manufacturing from a reliance on manual labor to a dependence on automated machinery, drastically altering the means of production. Industrialization, in turn, aggregated both manual and mechanized production into large-scale factories, reorganizing manufacture into discrete procedures that could be individually rationalized, routinized, and replicated. Although not identical, these two forces frequently worked in tandem, such that traditional forms of artisanal production were put under pressure from two directions at once. Machines came to displace certain manual skills from the sphere of manufacturing entirely, while other forms of physical labor were adapted and redeployed within emergent systems of industrialized assembly.

Within this context, mechanical drawing emerged as a unique form of technical expertise—one that called upon the kind of manual dexterity and material sensitivities that had long characterized artisanal knowledge, but one that also transformed such knowledge into two-dimensional abstractions more amenable to American industry's emergent systems of mass production. Used with growing regularity and sophistication in the first decades of the nineteenth-century, mechanical drawings became an essential binding agent of early industrial capitalism, transferring action between designer, administrator and worker and thus facilitating the division of labor that characterized the first stages of industrialization.[1] Important developments in the practice of projective geometry permitted the invention and representation of ever more complex mechanisms, while the circulation of technical illustrations in foreign journals like *The Repertory of Arts and Manufactures* (founded 1792) and the emergence of domestic publications such as the *Emporium of Arts and Sciences* (founded 1812) or *Mechanics' Magazine* (founded 1825) increased the accessibility of information on mechanical design and the availability of graphic models for imitation.[2] These developments facilitated the process of industrialization and accelerated the pace of mechanization, fundamentally transforming the nature of American manufacture from an economy driven by manual labor to one principally powered by machines. My dissertation examines the role of drawing in the production and circulation of knowledge within this industrializing society. It looks at the ways in which drawing came to replace the forms of embodied knowledge that had long governed practices of construction and manufacture, and it examines the ways in which both artistic creativity and agency were reinvented through their interaction with the processes of both mechanization and industrialization.

By way of introduction to the complex relationship between body and machine engineered through graphic practice, I want to begin by looking at one very particular sort of

---

[1] For the important relationship between imagery and technological development, see also Eugene S. Ferguson, "The Mind's Eye: Nonverbal Thought in Technology," *Science* 197 (1977): 42–46; and in the context of the early Republic in particular, Brooke Hindle, *Emulation and Invention* (New York: New York University Press, 1981), 127–42.

[2] Edward W. Stevens, "Technology, Literacy, and Early Industrial Expansion in the United States," *History of Education Quarterly* 30, no. 4 (Winter 1990): 524–26; Ken Alder, "Making Things the Same: Representation, Tolerance and the End of the Ancien Régime in France," *Social Studies of Science* 28, no. 4 (August 1998): 518.

mechanical drawing. [Figure 1] At first glance, the drawing looks much like any other page torn from a mid-nineteenth century sketchbook—its subject matter sentimental and vaguely neoclassical, its composition ordered but uninventive. The occasionally unsteady hand and variations in line weight seem to suggest an amateur experimenting with technique, while the lines' fuzzy edges, particularly apparent in the tree foliage at left, indicate an artist unskilled in the mending of his or her pen. Upon closer inspection of the drawing, however, numerous oddities begin to appear. Cupid, reaching out to grasp his bow, clasps only air—the draftsman unwilling or unable to connect the bow's shaft through the archer's hand. Moments like this occur throughout; lines that should intersect rarely meet, instead stopping just short or well overshooting their mark. The jitter that seemed to indicate an unsure hand now appears a bit too regular and strangely pervasive. A single line wraps up and through the tree's bark and into its branches—the draftsman seemingly overtaken by a compulsion to never lift the pen. One might wonder over these peculiarities—what manner of instruction the drawing reveals, what assistive devices the draftsman might have employed—were it not for the drawing's caption, rendered in a second hand and different ink. "Drawn by Mealzels automiton [*sic*], April the 29th, 1835."[3]

Obviously, this mechanical drawing is not an image of a machine, but rather an image produced by a machine itself. It is one of seven pictures and poems programmed into a device known to Americans in the 1830s as "Maelzel's Juvenile Artist," its idiosyncrasies the result of the draughtsman's mechanical ligaments. [Figure 2] Designed by Swiss clockmaker Henri Maillardet circa 1805, the device was likely purchased in Europe in the 1830s by traveling showman Johann Nepomunk Maelzel. Maelzel toured the United States in the mid-1820s and

[3] My thanks to Jessica Linker for directing me toward this drawing in the Minot family papers at the Massachusetts Historical Society. Her account of the automaton may be found here: Jessica Linker, "Souvenir of a 'Splendid Exhibition': Cupid as Drawn by Maelzel's Automaton, the Juvenile Artist," *Massachusetts Historical Society: Online Collections*, accessed May 2, 2017, http://www.masshist.org/objects/2012january.php.

again in the mid-1830s exhibiting a variety of mechanical devices.[4] His 1835 exhibition in Boston incorporated the Juvenile Artist into a show including a selection of automata—slack rope dancers, a trumpeter, various speaking figures—and something he called a "physioramic pyrotechnicon," an animated panorama similarly mobilized by mechanical action.[5] Now on view at the Franklin Institute in Philadelphia, the Juvenile Artist testifies to the remarkable complexity of these devices. The machine's sixty rotating cams use a polar coordinate system to encode seven unique designs, requiring a total storage capacity equivalent to 37.4 kilobytes in a modern computer. This is by far the largest memory of any such automaton produced in the eighteenth or nineteenth century.[6] These cams are connected to the automaton's jointed metal arm via a set of levers that precisely calibrate the artist's movements. [Figure 3] To watch the device in action is to marvel at the surprising subtlety of motion and life-like effects that can be achieved through the machinist's manipulation of cold, hard brass.

Although exhibited in 1835, Maelzel's mechanical draftsman played upon philosophical and physiological analogies dating back to the seventeenth century at least. Drawing on both ancient traditions and empirical science, René Descartes had, in his 1662 *Traité de l'homme*,

---

[4] Maelzel's exhibition of a purported mechanical chess-player was debunked by Edgar Allan Poe in his 1836 essay, "Maelzel's Chess-Player." Unlike the chess-player, however, the Juvenile Artist was fully automated, requiring no human input other than an initial cranking of its spring-loaded mechanism. Edgar Allan Poe, "Maelzel's Chess-Player," *Southern Literary Messenger* 2 (April 1836): 318–26.

[5] "Maelzel's Exhibition," *Boston Traveler*, August 5, 1835. Maelzel's biography and an extensive account of his various entertainments may be found in Joseph Arrington, "John Maelzel, Master Showman of Automata and Panoramas," *The Pennsylvania Magazine of History and Biography* 84, no. 1 (1960): 56–92.

[6] To produce the cams, Maillardet likely graphed each design onto a grid and then converted those Cartesian coordinates into points on a polar coordinate system, thereby translating the rectilinear space of the page into a circular form compatible with the cam's rotational logic. Attempting to specify the storage capacity of those cams in contemporary digital terms, one analyst has noted that, if each point on the artist's page was 1mm apart, a page 120mm wide by 89mm high would require storage capacity of 10,680 points. A margin of error of .5mm would increase that to 42,720 points. Seven designs in all would require a capacity of 299,040 points. Each of these points may be analogized to one digital bit (or an eighth of a byte). Thus 299,040 points is the equivalent to 37.4 kilobytes in a modern computer. James M. Williams, "Antique Mechanical Computers, Part 2: 18th and 19th Century Mechanical Marvels," *Byte* 3, no. 8 (August 1978): 106.

proposed the idea of the "*bête-machine*."[7] This model of the physical body as a mechanical system of moving parts found parallels in the anatomical science of physician William Harvey, the philosophical treatises of John Locke, the political theory of Thomas Hobbes, and the aesthetics of Joseph Addison.[8] It was a premise that went on to underwrite the principles of much of eighteenth-century Continental philosophy—from the radical mechanism of Julien Offray de La Mettrie's *L'homme machine* (1747) to the more restrained materialism of Etienne Bonnot de Condillac and Denis Diderot.[9] At mid-century, skilled craftsmen like Jacques Vaucanson and the family Jaquet-Droz produced complex clockwork devices that seemed to recreate, not just the appearance, but the very operations of biological life—from flautists with mobile embouchures to the rather grotesque movements of a defecating duck. Occupying a blurry boundary between

---

[7] As Jessica Riskin has noted in her work on the body/machine dialectic, Descartes's writings are filled with analogies between the operations of the body and those of the machine. In the *Traité de l'homme*, written between 1630 and 1632 (published 1662), Descartes proposes the idea of the body as "a statue, or a machine made from earth." In the "Discourse on Method," (1637) he offers a description of the operations of the heart in comparison to the movements of a clock, and in the "Méditation sixième" (1641), he argues for "the body of man as being a machine constructed in a certain way and composed of bones, nerves, muscles, veins, blood and flesh." For a fuller discussion of Descartes's mechanistic philosophy, see Jessica Riskin, *The Restless Clock: A History of the Centuries-Long Argument over What Makes Living Things Tick* (Chicago: University of Chicago Press, 2016). For more on mechanism and seventeenth-century philosophy, see Peter Dear, "A Mechanical Microcosm: Bodily Passions, Good Manners, and Cartesian Mechanism," in *Science Incarnate: Historical Embodiments of Natural Knowledge*, ed. Christopher Lawrence and Steven Shapin (Chicago: University of Chicago Press, 1998), 51–82; Otto Mayr, *Authority, Liberty, & Automatic Machinery in Early Modern Europe* (Baltimore: Johns Hopkins University Press, 1986).

[8] Again, see Riskin, *The Restless Clock*, 57–89; but also Thomas Fuchs, *The Mechanization of the Heart: Harvey and Descartes*, Rochester Studies in Medical History (Rochester, NY: University of Rochester Press, 2001); Steven Shapin, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton: Princeton University Press, 2011).

[9] In *La Logique*, for example, Condillac suggests an affinity between rational thought and the organization of the machine, suggesting, "If I wanted to know a machine, I would decompose it in order to examine each element separately. When I got idea about each of them, and I was able to put them in the same order as they had been put before, I would know the machine because I decomposed and recomposed it," quoted in George Gusdorf, *Les Sciences Humaines et La Pensée Occidentale* (Paris: Payot, 1973), 303. See also, Etienne Bonnot de Condillac, *Traité Des Sensations* (Paris: Bure l'Aîné, Quay des Augustins, 1754). In the *Traité des sensations* (1754), the literary device of a gradually animated sculpture, by which Condillac attempts to explain the operation of the senses, may also be understood as a version of the automaton. On Diderot's relationship to mechanism, see Marx W. Wartofsky, "Diderot and the Development of Materialist Monism," in *Models: Representation and the Scientific Understanding*, Boston Studies in the Philosophy of Science; v. 48 (Dordrecht; Boston: D. Reidel Publishing Company, 1979), 297–337.

science and public entertainment, these automata were astonishing materializations of Descartes's theoretical abstractions—objects that appeared to confirm the soundness of the philosopher's mechanistic principles.

Yet even as these marvelous objects offered to entertain and educate audiences throughout Europe and the American colonies, ideas about the relationship between body and machine were in the process of transformation. Metaphysical concerns about the nature of the human soul and scientific inquiries into the dynamics of human action and reaction prompted the rise of an alternate philosophy, known as "vitalism"—a model of human physiology premised on the existence of "a non-mechanical animating force" intrinsic to matter and essential to biological life.[10] By the second half of the eighteenth century, the principles of mechanical physiology had been largely subsumed within this new school of vitalism, and although the idea of the man-machine conjured by Cartesian philosophy did not wholly disappear, its implications did begin to change.[11] With the concurrent rise of sentimentalism, especially in Anglo-American culture, one finds the idea of the automaton increasingly deployed, not as a physiological analogy, but as a form of character analysis—often with negative connotations. Rather than referencing the body as an exquisite example of divine craftsmanship, comparisons with the machine conveyed the image of an individual incapable of independent thought or action.[12]

Both these versions of the automaton coexisted in the early American Republic.

---

[10] Minsoo Kang, "From the Man-Machine to the Automaton-Man: The Enlightenment Origins of the Mechanistic Imagery of Humanity," in *Vital Matters: Eighteenth-Century Views of Conception, Life, and Death*, ed. Mary Terrall and Helen Deutsch (Toronto: University of Toronto Press, 2012), 156.

[11] See Kang, "Man-Machine to Automaton-Man"; Robert E. Schofield, *Mechanism and Materialism; British Natural Philosophy in an Age of Reason* (Princeton: Princeton University Press, 1970); Theodore Brown, "From Mechanism to Vitalism in Eighteenth-Century English Physiology," *Journal of the History of Biology* 7, no. 2 (1974): 179–216.

[12] Kang, "Man-Machine to Automaton-Man," 148.

Throughout the 1780s and -90s, one finds myriad instances in which the new nation—an institution expressly understood as individuals organized into a collective body—is likened to a machine or understood to operate upon the principles of Newtonian mechanics.[13] Among the most famous of these instances is, perhaps, Benjamin Rush's argument that "I consider it 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 government of the state."[14] Here, Rush describes a republic populated by individuals so carefully attuned to each other and to the public good that the nation could function with the extraordinary precision of a clockwork device. This idealistic vision, however, coexisted alongside other, darker depictions of the human-machine. They appear in newspaper articles referring to individuals—be they foreign kings or local party hacks—as no more than automata, unthinking and unfeeling, merely controlled by hidden interests. Such figures also arise in the work of noted American authors like Henry Brackenridge and Charles Brockden Brown, who opposed the vibrant sentimentality of their heroes to the calculated machinations of their antagonists.[15]

By the early nineteenth century, this darker vision was being fed by changes in the very nature of mechanical technology itself. In the century's first decades, mechanization of American manufacturing was on the rise. Pre-industrial machines had greatly amplified the effects of

---

[13] "Organic and Mechanical Metaphors in Late Eighteenth-Century American Political Thought," *Harvard Law Review* 110, no. 8 (1997): 1832–1849. One may also find a comprehensive overview of the historiography relating American constitutionalism and Newtonian mechanics in Michael Foley, *Laws, Men and Machines: Modern American Government and the Appeal of Newtonian Mechanics* (London; New York: Routledge, 1990).

[14] Benjamin Rush, *A Plan for the Establishment of Public Schools and the Diffusion of Knowledge in Pennsylvania: To Which Are Added Thoughts upon the Mode of Education, Proper in a Republic: Addressed to the Legislature and Citizens of the State.* (Philadelphia: Printed for Thomas Dobson, in Second-Street, two doors above Chesnut-Street, 1786), 27.

[15] A compelling account of the republican machine as a negative literary trope may be found in William Huntting Howell, *Against Self-Reliance: The Arts of Dependence in the Early United States* (Philadelphia: University of Pennsylvania Press, 2015), 151–91.

bodily exertion, but the steam engines, spinning frames and cotton gins of the nascent Industrial Revolution introduced fundamentally different sources of power and principles of motion. From a technological standpoint, the machine was increasingly understood, not as an analog or extension of the body, but as its antithesis. In 1823, U.S. politician Thomas Cooper used a tract on tariffs to assail this process of mechanization, arguing that it produced laborers who "work not for themselves, but for the capitalist who employs them…they are machines, as much so as the spindles they superintend."[16] Widely read on both sides of the Atlantic, Thomas Carlyle's 1830 essay "Signs of the Times" similarly characterized the consequences of industrialization, suggesting,

> Men are grown mechanical in head and in heart, as well as in hand…Not for internal perfection, but for external combinations and arrangements, for institutions, constitutions—for Mechanism of one sort of other, do they hope and struggle. Their whole efforts, attachments, opinions, turn on mechanism, and are of a mechanical character.[17]

Both Cooper and Carlyle's texts rework long-standing analogies between body and machine to suggest that such an alliance is somehow unnatural. The machines they invoke are unthinking and unfeeling. They lack individual agency and serve no purpose but to labor. In this context, the automaton's uncanny verisimilitude takes on a more ominous mien, representing a harsh economic reality for a growing class of American workers and a new understanding of human subjectivity under the influence of industrialization.

Given this context, I want to focus on the significance of Maelzel's choice to exhibit the possibilities of automation via the figure of a draftsman—a choice that was neither isolated nor, I

[16] Thomas Cooper, "The Disadvantage of Machinery (1823)," in *The Philosophy of Manufactures: Early Debates over Industrialization in the United States*, vol. 1, Documents in American Industrial History (Cambridge, MA; London: MIT Press, 1982), 257.

[17] Thomas Carlyle, "Signs of the Times (1829)," in *The Philosophy of Manufactures: Early Debates over Industrialization in the United States*, vol. 1, Documents in American Industrial History (Cambridge, MA; London: MIT Press, 1982), 265.

believe, incidental. In the 1770s, Swiss watchmakers Pierre and Henri-Louis Jaquet-Droz had produced two automata on which the Juvenile Artist was likely based—one a Draughtsman who drew pictures in charcoal and the other a Writer capable of inscribing any message the operator chose.[18] The father and son are also known to have produced a pair of prosthetic hands, designed for the son of a French nobleman and dexterous enough to permit the young man to both write and draw.[19] A decade later, a figure similar to the Jaquet-Droz Writer toured Britain, this one built by English tinkerer Thomas Denton.[20] After Denton's death, the figure found its way to Philadelphia in 1795, actually predating the American debut of Maelzel's Juvenile Artist by forty years.[21] As Jessica Riskin has argued, these eighteenth-century automata "seemed active, self-moving…imbued with inner agency."[22] Like the clockwork dancers and mechanical musicians they appeared alongside, these artists performed tasks that demanded responsiveness to their environment and suggested, by extension, the appearance of life. However, amongst the physical feats of these other automata, the figure of the draughtsman assumed particular significance. Producing pictures and writing words, its activities suggested more than liveliness. They suggested the possibility of cognition.

As a part of this lineage, Maelzel's Juvenile Artist stages an important confrontation. Exhibited just a year after textile workers at the nearby Lowell Mills waged the nation's first factory strike, the replacement of manual labor with mechanical motion in the Juvenile Artist's

---

[18] D. Coleman and H. Fraser, *Minds, Bodies, Machines, 1770-1930* (New York: Palgrave Macmillan, 2011), 84–90. Henri Maillardet, the Juvenile Artist's designer, worked with the Jaquet-Droz family, and the automaton Maelzel eventually exhibited in the U.S. is likely based on their work.

[19] Riskin, *The Restless Clock*, 144–45.

[20] Richard Daniel Altick, *The Shows of London* (Cambridge, Mass.: Belknap Press, 1978), 68.

[21] "[No Title]," *The Philadelphia Gazette & Universal Daily Advertiser*, August 14, 1795.

[22] Riskin, *The Restless Clock*, 114–15.

display gestured toward a set of technological, social, and economic changes already at work in the industrializing present. But in contrast to the laborers described by Cooper and Carlyle—those who had "grown mechanical in head and in heart, as well as in hand"—this mechanical draftsman appears to maintain some sense of agency, some self-awareness. Its poems are coy reflections on the fascination it must provide to viewers and its own intense desire to please. [Figure 4] As it draws, its head tilts and its eyes move to follow the pen, as though to signal the coordination of mind and hand. The automaton is thus simultaneously a sign or symptom of mechanization's encroachments on the domain of the body and a challenge to conceptions of the mechanized body that would strip it of the powers of cognition.

Numerous counterparts to the Juvenile Artist exist amongst the draftsmen of early America's industrializing society—young hands trained to write with mechanical precision, engineers who learned to draw machines by studying the lineaments of the human form, whole bodies enmeshed in the apparatus of new-fangled drawing instruments. Through a series of confrontations between the practice of drawing and the process of industrialization, this dissertation considers the mechanical drawing as a distinctive form of artistic practice in early America and the draftsman's body as an equally unique site of knowledge. It looks at the ways in which the forms of knowledge possessed by the body were both challenged and remade through its encounter with an evolving technological context. Placing explicitly technical drawings—geometric proofs, construction drawings, patent specifications—in conversation with work in landscape, portraiture, even penmanship, this project explores the interdependence of representation and industrialization as a broad cultural phenomenon, with repercussions well beyond the walls of the manufactory. The hope is to uncover a vibrant visual and material culture largely overlooked by the history of American art, but essential to understanding the origins of industrial capitalism and the subsequent estrangement of body and machine that has come to define the modern industrial paradigm.

The Mechanical Age

This distinction between body and machine is an essential characteristic of nineteenth-century industrialization and a fundamental component of modern culture. From Mary Shelley's *Frankenstein* in the early nineteenth century to Francis Picabia's mechanomorphs of the early twentieth, western culture has drawn significant creative and critical force from the seemingly unnatural integration of technology and the human body. Substituting inorganic circuitry for supple flesh, the cyborgs and androids of contemporary science fiction alternately fascinate and repulse as they disrupt a conventional understanding of the parameters that constitute human existence. Of course, as Donna Haraway argues in her seminal *Cyborg Manifesto*, "By the late twentieth century, our time, a mythic time, we are all chimeras, theorized and fabricated hybrids of machine and organism; in short we are cyborgs."[23] As an early foray into the field of posthumanism, Haraway's *Manifesto* refers to the many ways in which the human body has been remade through science and technology, from the consumption of pharmaceuticals to a reliance on automotive travel. With the cultural ascendancy of mobile technology increasingly governing the nature of social interactions, the availability of information, and the boundaries between public and private, such an argument is more poignant today than when first issued in 1991. However, the shock it produces and the force of the posthumanist theory Haraway's work has spawned emerges from the cultural persistence of a body/machine binary that first emerged in the early nineteenth-century.

Through the period of the Revolutionary War, technology in British North America was

[23] Donna Jeanne Haraway, "A Cyborg Manifesto: Science, Technology, and Socialist Feminism in the Late Twentieth Century," in *Manifestly Haraway* (Minneapolis: University of Minnesota Press, 2016), 7.

still largely medieval. The colonies' economy centered on agriculture and construction, relying principally upon wood-based, handcraft technologies and tools designed for one-off manufacture. With the exception of extractive industries like iron production, American manufacturers rarely produced in quantity, and colonial citizens largely turned to foreign imports when it came to goods like pins, nails, textiles, or porcelain—areas in which European manufacturers had already begun to experiment with mass production.[24] American mills—whether for the grinding of grain or fulling of cloth—were often water-powered, but the machines that otherwise populated the colonies' workshops and dotted their landscapes were by-and-large driven either by animal- or man-power. These machines were ox-driven plows and horse-pulled carts. They were hand-cranked drills and manually-turned presses. They demanded intimacy between body and machine, a certain conformation of one to the other. Discussing the depiction of such pre-industrial machines in the plates of the *Encyclopédie*, Roland Barthes has observed that "man, always present in some corner of the machine, does not accompany it in a simple relation of surveillance; turning a crank, pressing a pedal, spinning a thread, he participates in the machine in a manner that is both active and delicate." [Figure 5] This intimate acquaintance of body and machine means, "the energy here is essentially transmission, amplification of a simple human movement; the Encyclopedic machine is never anything but an

[24] Carroll W. Pursell, *The Machine in America: A Social History of Technology* (Baltimore: Johns Hopkins University Press, 1995), 5, 9–10; Darwin H. Stapleton, *The Transfer of Early Industrial Technologies to America*, Memoirs of the American Philosophical Society ; v. 177 (Philadelphia: American Philosophical Society, 1987), 4–7. There are a few notable, if abortive, exceptions to this. For example, colonists had attempted to establish silk enterprises in America beginning in the seventeenth century. Gousse Bonnin and George Anthony Morris established the first porcelain manufactory in North America in 1769 (although it lasted only until 1772). And the first glasshouse in North America was established at Jamestown in 1608. For more on these industries, see L. P. Brockett, *The Silk Industry in America: A History: Prepared for the Centennial Exposition* (New York: Silk Association of America, 1876); *Ceramics in America 2007* (Milwaukee, WI; Hanover, NH: Chipstone Foundation, Distributed by University Press of New England, 2007); Dwight P. Lanmon and Arlene M. Palmer, "The Background of Glass Production in America," *Journal of Glass Studies* 18 (1976): 14–19; Arlene Palmer, "Glass Production in Eighteenth-Century America: The Wistarburgh Enterprise," *Winterthur Portfolio* 11 (1976): 75–101.

enormous relay."[25]

In this context, it is easy to see how Descartes's notion of the *bête-machine* not only took hold amongst his contemporaries, but persisted well into the eighteenth century. Descartes had buttressed his arguments about bodily mechanism by turning to the real world, finding analogies for physiological systems in the clocks, fountains and mills that were an integral part of the early modern landscape. Well into the eighteenth century, there was little about this landscape—and the machines that populated it—that had really changed.[26] As Alan Morton has argued, "Up to the mid-century the perception was that in terms of power and uses, machines were equivalent, broadly speaking to horses and men."[27] When it came to the exercise of strength or the performance of labor, differences between the three were understood as a matter of degree rather than kind. In the words of eighteenth-century natural philosopher John Theophilus Desaguliers, "Mechanics teach us not to make, but to apply Powers, such as we find them in Nature."[28] Rooted in classical mechanics, this interpretation of power, and by extension agency, posited a necessary continuity between body and machine. One was the model for the other, and the action of the machine was no more than an extension or transferal of the action of the hand.

This relationship began to change toward the end of the eighteenth century, particularly in England, where steam technology was drastically reshaping the nature of manufacturing. Although Thomas Newcomen's atmospheric engine had been powering English mines and mills since 1712, the superior efficiencies of James Watt's innovations in the last quarter of the

[25] Roland Barthes, "The Plates of the Encyclopedia," in *New Critical Essays*, trans. Richard Howard (New York: Hill and Wang, 1980), 25.

[26] Riskin, *The Restless Clock*, 59.

[27] Alan Q. Morton, "Concepts of Power: Natural Philosophy and the Uses of Machines in Mid-Eighteenth-Century London," *The British Journal for the History of Science* 28, no. 1 (March 1995): 68–70.

[28] Ibid., 68.

eighteenth century transformed the steam engine from an unwieldy tool to the lynchpin of industrialization.[29] The situation was somewhat different in the United States, where an abundance of land encouraged the continued growth of the new nation's agricultural economy and an extensive system of waterways obviated the need for alternative sources of power. This does not mean, however, that the American landscape and American technology remained unchanged. The nation's first textile mill was constructed by Samuel Slater in 1791 in Pawtucket, Rhode Island, using the same model employed by English entrepreneur Richard Arkwright in his cotton mills in Derbyshire. By 1813, the Boston Manufacturing Company had established the first vertically-integrated factory in the United States. Located in Waltham, Massachusetts, the water-powered site brought carding, spinning and weaving all under one roof, providing the model for the highly successful textile mills constructed at Lowell just a decade later and by the same entrepreneurs.[30] Steam technology also found its way into the U.S. through the mechanisms used to supply water to two of its major cities—Philadelphia and New York—and in the innovations of engineer and entrepreneur Robert Fulton, whose 1807 launch of the *The North River* marks the origin of the first successful steamboat venture on either side of the Atlantic. We find a steam-powered rolling mil in operation in eastern New Jersey by 1802 and a steam-driven hammer at work in the Washington Navy Yard by 1813.

These developments fundamentally altered the relationship between body and machine in early America. Vertically integrated factories increasingly relied on semi-skilled labor, pushing the body to the periphery of productive action—swapping spindles, threading bobbins, resetting

[29] Watt improved upon Newcomen's engine by introducing a separate condenser (patented 1769) that permitted a more efficient use of heat in powering the engine, as well as a system of planetary motion (patented 1781) and a double-acting piston (patented 1782) to make the transfer of motion from engine to the machine it powered more efficient. See Ben Marsden, *Watt's Perfect Engine: Steam and the Age of Invention* (New York: Columbia University Press, 2002).

[30] Pursell, *The Machine in America*, 45.

stopped machines. With respect to the mechanical action at the center of productivity, neither the water-powered looms of the nation's first textile mills nor the steam-driven paddles of its steamboats bear any analogy to human movement. Unlike the fully articulated joints of the human hand and body, their mechanisms depend upon the restriction of motion to a limited and carefully calibrated range. Their extraordinary speed and efficiency derives from the consistent application of rotary motion along a single axis—a type of motion that, as Helmut Müller-Sievers has argued, has no counterpart in humans' experience of the natural world. In his words, such machines "are not sufficiently understood as tools, they are not monstrous 'projections' of human organs into the world. Rather, they disrupt the imaginary continuity of nature and human being and introduce with their motions a literally 'inhuman' element into the world."[31]

From this disruption followed a new understanding of the machine in the nineteenth century. As discussed above, although the machine continued to be understood as a closed and coherent system of parts that act one upon the other, the usefulness of this system as an analogy for human existence was on the wane. In contrast, interest in the science of physical mechanics was on the rise.[32] Where the machine of metaphysics had been resolutely material—for therein lay its usefulness as an analogy for the body—the machine of physical mechanics was a deracinated abstraction, stripped of all physical attributes other than the mathematical calculations of force and the direction along which such force might be applied. This evolution of the machine itself is paralleled by changes in the term "mechanical," the machine's adjectival counterpart. Early modern usage associated the mechanical with physical practice. Distinguished

[31] Helmut Müller-Sievers, *The Cylinder: Kinematics of the Nineteenth Century* (Berkeley: University of California Press, 2012), 4.

[32] See Morton, "Concepts of Power: Natural Philosophy and the Uses of Machines in Mid-Eighteenth-Century London"; Larry R. Stewart, *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660-1750* (Cambridge; New York: Cambridge University Press, 1992).

from the seven "liberal arts" inherited from antiquity and rooted in language and mathematics, the "mechanical arts" were activities requiring the exercise of physical strength or prowess. Thus we have Shakespeare's identification of the band of craftsmen in *A Midsummer Night's Dream* as "rude mechanicals" or French theorist André Felibien's characterization of the skills of delineation and coloring as the "mechanical" parts of painting.[33] The term's nearest synonym was "artificial," as in having to do with artifice or skillful assembly. Yet again, in the late eighteenth and early nineteenth centuries, the connotations of these words were subtly rearranged. Although the mechanical retained its association with the artificial, these terms were increasingly opposed to the authentic experiences of the body and inspiration of the mind.

By contrast, once liberated from mechanistic analogies, the human body grew newly incoherent. As Jonathan Crary has argued, inquiries into the physiology of vision in the early nineteenth century questioned the mechanical models of perception that had undergird earlier philosophical and scientific models. Vision became newly subjective—dependent, not only on individual physiology, but on individual psychology.[34] Within the sciences, a growing mistrust of the physical body and the reliability of its perceptual capacities arose over the first half of the nineteenth century, resulting in what Lorraine Daston and Peter Galison have referred to as "mechanical objectivity"—a form of empirical observation that "attempts to eliminate the mediating presence of the observer."[35] Privileging the information gathered by supposedly

---

[33] William Shakespeare, "A Midsummer Night's Dream," in *The Yale Shakespeare*, ed. Wilbur L. Cross and Tucker Brooke (New York: Barnes and Noble Books and Yale University Press, 1993), 3.2.9; André Félibien, *Conferences de l'Academie royale de peinture et de sculpture pendant l'année 1667.* (Paris: Chez Frederic Leonard, 1669), preface (n.p.).For an excellent analysis of the "mechanical" in an early modern context, see Patricia Parker, "Rude Mechanicals," in *Subject and Object in Renaissance Culture*, ed. Margreta de Grazia and Peter Stallybrass (Cambridge, UK: Cambridge University Press, 1996), 43–82.

[34] Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambridge, MA: MIT Press, 1992), 70–76.

[35] Lorraine Daston and Peter Galison, "The Image of Objectivity," *Representations* 40, no. 1 (1992): 81–128; see

unbiased machines over that collected by an obviously imperfect body, scientists of the latter nineteenth century reified distinctions between body and machine that had been building for a century and that would persist until the present day.

Drawing and Knowing

Other scholars have addressed the ways in which these changes altered the administration of labor and the production of goods in early industrial society, but the central question addressed in this dissertation revolves around what these changes meant for the production of knowledge. How were makers—individuals whose knowledge resided in the manipulation of matter and the physical exercise of skill—impacted by the process of industrialization? And how were such changes explored and/or resisted within the physical form and material practices of drawing?

Such questions center on yet another contentious relationship, that of the body's relationship to the mind. Tracing the evolution of the machine in eighteenth- and nineteenth-century France, Jessica Riskin has argued that the principal effect of industrialization was not actually the division of body from machine, but of mind from mechanism. She points to the proliferation of unskilled and semi-skilled labor within the nineteenth century's new factory systems to suggest that although the body remained an integral element of industrial production, its connection to the mind was severed. In her words, "The industrial reformers and inventors of automated machinery alike understood their task as the ingenious and lucrative division of intelligence from labor, design from execution, agency from mechanism."[36] This is to say, the process of industrialization stripped the machine of any claims to agency, intelligence or

also, Lorraine Daston and Peter Galison, *Objectivity* (New York: Zone Books, 2007).

[36] Riskin, *The Restless Clock*, 163.

cognition. Whether performed by unthinking hands or unthinking rotors, in industrial production all forms of labor were equal and all laboring bodies, whether composed of metal or flesh, were machines.

This argument finds fodder in the late eighteenth-century novels of Brackenridge and Brockden Brown discussed above, as well as in critical essays like those published in the 1820s and -30s by Cooper and Carlyle. However, it most clearly echoes the description of alienated labor found several decades later in Karl Marx's *Capital* (1867, trans. 1887). In the chapter on "Machinery and Modern Industry," Marx traces the passage from hand manufacture to the factory system and the simultaneous "separation of the intellectual powers of production from the manual labor," driven by the rise of industrial capitalism.[37]

> In handicrafts and manufacture, the workman makes use of a tool, in the factory, the machine makes use of him. There the movements of the instrument of labour proceed from him, here it is the movements of the machine that he must follow. In manufacture the workmen are parts of a living mechanism. In the factory we have a lifeless mechanism independent of the workman, who becomes its mere living appendage.[38]

This passage rather succinctly maps out the transformations in the body-machine relationship I have spent the last several pages attempting to describe. In pre-industrial manufacture, the machine—which Marx suggests might be more aptly referred to as a tool—is a device that must to some extent conform to the body.[39] It has been built with both the body's unique capacities

[37] Karl Marx, "*Capital*," in *The Craft Reader*, ed. Glenn Adamson (Oxford ; New York: Berg Publishers, 2010), 76.

[38] Ibid., 75.

[39] Marx develops an interesting and very useful taxonomy of the machine in this chapter, introducing the machine through the language of mathematicians and mechanics, who in his words, "call a tool a simple machine, and a machine a complex tool." Believing this explanation to be irrelevant to both the economist and the historian, Marx proceeds to divide the machine into three distinct parts—the motor mechanism, the transmitting mechanism, and the tool or working machine—each of which has a unique history of development. Ibid., 70–71.

and its many limitations in mind.[40] Referring to the combination of craftsman and tool as a "living mechanism," Marx draws upon an early modern understanding of the machine as vibrant and responsive, but suggests that the subsequent process of industrialization has rendered this composite machine lifeless, with the body attached only as a subsidiary component and not its principal engine. As the "life-long speciality of handling one and the same tool, now becomes the life-long speciality of serving one and the same machine," factory work "confiscates every atom of freedom, both in bodily and intellectual activity" [41] To speak of the alienation of labor in a Marxist sense, then, is not merely to discuss the laborer's loss of economic control in a capitalist system, but to indicate the fundamental dehumanization of labor once it has been split from the powers of cognition and robbed of the conditions for self-determination. Thus, the transformation of labor under industrialization may be understood as two-fold. It involves not only the reorganization of the hierarchical relationship between body and machine, but also, and as a consequence, the estrangement of body and mind.

There is no need to point out the significance of Marx's *Capital* as a turning point in the history of Western thought. However, I do want to draw attention to the fact that Marx's assertion of labor as both a physical and intellectual act restructured existing cultural conventions regarding the nature of knowledge production. Western culture has long possessed a tradition opposing mental and manual labors, going back to Aristotle's notion that manual labor deforms the body and degrades the mind, thus making it an unfit occupation for the free ("liberal") citizen.[42] As the Marxist philosopher Alfred Sohn-Rethel has argued, this division between

[40] Ibid., 74.

[41] Ibid., 75–76.

[42] Aristotle disparages "the vulgar arts" that "deform the body and degrade the mind," arguing that "in the state which is best governed…the citizens must not lead the life of mechanics or tradesmen, for such a life is ignoble, and inimical to virtue." Aristotle, *Politics*, VII, 9 1328 b33-a2

mental and manual labor is a consistent feature of classed societies, used to produce and perpetuate class distinctions, such that physical labor has been consistently ranked as subservient to liberal (i.e. written) knowledge.[43] The mind/body divide that Marx identified as a product of industrialization was an opposition promulgated in Greek philosophy, reiterated in medieval theology, and reinvented in the humanistic studies of Renaissance Europe.[44] Penned at a moment of both economic and existential crisis for the laborer, however, Marx's suggestion that industrialization divorced mind from body actually reversed this course, offering up the radical proposition that intellectual and manual labor can and should be linked.[45]

Capital is now one hundred fifty years old, having spawned since its initial publication innumerable histories and critiques of industrialized labor. However, it is only in the last quarter of the twentieth century that historians have really attended to the subtleties of Marx's arguments regarding the complex relationship between tools, machinery, and traditional craftsmen in the evolution of industrial capitalism, and it is only in the last twenty years that we have started to examine the specific forms of knowledge embodied in craftsmen's labors.[46] Prompted by the

---

[43] Alfred Sohn-Rethel, *Intellectual and Manual Labour: A Critique of Epistemology*, Critical Social Studies (London: Macmillan, 1978), 4.

[44] Pamela H. Smith, *The Body of the Artisan : Art and Experience in the Scientific Revolution* (Chicago: University of Chicago Press, 2004), 6–8.

[45] Pamela O. Long has offered an alternative history of manual labor in Western culture, identifying a parallel tradition (dating back to antiquity) in which the mechanical arts have been valued as integral to the progress of society. Without disputing this history, I would argue, as Peter Caws does, that the two traditions exist in a dialectical relationship, and that it is, at least in part, Marx's observations on the transformation of labor under industrial capitalism that have allowed modern historians to identify and trace this dialectic. See Pamela O. Long, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore: Johns Hopkins University Press, 2003); Peter Caws, George Bugliarello, and Dean B. Doner, "Praxis and Techne," in *The History and Philosophy of Technology* (Urbana: University of Illinois Press, 1979), 227–38.

[46] E.P. Thompson sets the stage for this scholarship in using a Marxist framework to identify the emergence of a working-class consciousness from traditions of artisanal associations and workshops, but it is really from the work of Maxine Berg that a clear picture arises of industrialization as a multivalent process, formed by the uneven implementation of both mechanical and artisanal forms of knowledge across various industries. E.P. Thompson, *The Making of the English Working Class* (New York: Vintage Books, 1963); Maxine Berg, *The Age of*

material turn in cultural history more generally, historians of both art and science have been at the forefront of this work, locating the material and textual evidence for what Pamela Smith has called an "artisanal epistemology" in early modern practice.[47] Such histories look to the material forms of crafted objects for insight into the methods of their production. They offer descriptions of the kinds of physical skills and practical know-how that constituted the artisan's body of knowledge, but they also examine the ways in which craftsmen used their output to articulate a theory of knowledge as inextricably linked to material practice, to suggest that making is a form of knowing.

My own work engages the idea of an artisanal epistemology just at the point where its constitutive elements have begun to break down. Amidst the uneven progress of industrialization in early America, some areas of production (like textile manufacture) were readily mechanized, while others (like agriculture) adopted machinery more slowly, and many industries (from hat-making to gun-making) employed a hybrid model of production, incorporating both machines and handcraft into fully industrialized (if not fully mechanized) systems of divided labor.[48] In this context, "the intimate link of contemplative and manipulative knowledge" characteristic of

---

Manufactures, 1700-1820 : Industry, Innovation, and Work in Britain, 2nd ed. (London; New York: Routledge, 1994). See also Liliane Hilaire-Perez, "Technology as Public Culture in the Eighteenth Century: The Artisan's Legacy," *History of Science* 45, no. 2 (2007): 135–53. In the American context, see Herbert Gutman, "Work, Culture and Society in Industrializing America, 1815-1919," in *Work, Culture and Society in Industrializing America: Essays in American Working Class History* (New York: Vintage Books, 1976); Ronald Schultz, *The Republic of Labor: Philadelphia Artisans and the Politics of Class, 1720-1830* (New York: Oxford University Press, 1993); and, more recently, David Jaffee, *A New Nation of Goods: The Material Culture of Early America* (Philadelphia: University of Pennsylvania Press, 2010).

[47] Smith, *The Body of the Artisan*, 8.For a chronological overview of these developments and a brief historiography of the field, see Pamela H. Smith, Amy R.W. Meyers, and Harold J. Cook, eds., "Introduction: Making and Knowing," in *Ways of Making and Knowing: The Material Culture of Empirical Knowledge*, The Bard Graduate Center Cultural Histories of the Material World (Ann Arbor: University of Michigan Press, 2014), 1–16. See also, Lissa Roberts, Simon Schaffer, and Peter Dear, eds., *The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation* (Amsterdam: Koninkliijke Nederlandse Akademie van Wetenschappen, 2007).

[48] Laura Rigal, *The American Manufactory: Art, Labor, and the World of Things in the Early Republic* (Princeton: Princeton University Press, 1998), 14.

the early modern artisan was frequently exercised alongside forms of mechanized production that demanded alternative forms of attention and physical engagement.[49] Thus, in the first decades of American industrialization, the relationship between making and knowing grew ever more fraught, as multiple regimes of knowledge—from the artisanal to the administrative—increasingly overlapped, interacted, and sometimes clashed.

The practice of drawing occupies an essential place within this contested arena. As a critical means of communication in industrialized systems of divided labor, drawing is often characterized as an instrument of administrative control, used to direct and discipline labor across great distance.[50] In the words of Henry Braverman,

> The concept of control adopted by modern management requires that every activity in production have its several parallel activities in the management center… The result is that the process of production is replicated in paper form before, as, and after it takes place in physical form. Just as labor in human beings requires that the labor process take place in the brain of the worker as well as in the worker's physical activity, so now the image of the process, removed from production to a separate location and a separate group, controls the process itself.[51]

Written to describe conditions in the twentieth century, but largely applicable to the nineteenth, Braverman's critique of the industrial workplace incorporates design drawing into a larger administrative regime conducted on and through the exchange of paper, wherein the physical

---

[49] This phrase appears in Lissa Roberts and Simon Schaffer, "Preface," in *The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation*, ed. Lissa Roberts, Simon Schaffer, and Peter Dear (Amsterdam: Koninklijke Nederlandse Akademie van Wetenschappen, 2007), xxvi.

[50] Some of the most insightful work on this subject comes from Ken Alder, who examines drawings for artillery manufacture in France and their role in the production of revolutionary social dynamics at the end of the *ancien regime*. See Ken Alder, "Innovation and Amnesia: Engineering Rationality and the Fate of Interchangeable Parts Manufacturing in France," *Technology and Culture* 38, no. 2 (1997): 273–311; Alder, "Making Things the Same." See also, Glenn Adamson, *The Invention of Craft* (London: Bloomsbury, 2013), 15–22; Steven Lubar, "Representation and Power," *Technology and Culture* 36, no. 2 (1995): S54–82; Anne Puetz, "Design Instruction for Artisans in Eighteenth-Century Britain," *Journal of Design History* 12, no. 3 (1999): 232–35.

[51] Harry Braverman, "'The Primary Effects of Scientific Management,' from *Labor and Monopoly Capitalism*," in *The Craft Reader*, ed. Glenn Adamson, English ed. (Oxford ; New York: Berg Publishers, 2010), 79.

actions involved in the production of goods are abstracted into lines, letters, and numbers, so they might be analyzed and indexed in pursuit of an ever more streamlined process. Calling on Marx's notion of alienated labor, Braverman argues that this system tends to separate out the physical and intellectual aspects of labor into explicitly classed divisions of worker and supervisor, the former associated with the body and the latter with the brain.[52] However, this interpretation (and it is a common one) suggests that drawings are somehow immaterial abstractions that manifest without the exercise of physical labor or skill. In contrast, this project takes as its premise the notion that drawings are both material objects and records of physical practice. They are what remain of the draftsman's unique store of embodied knowledge.

As a parallel to Pamela Smith's "artisanal epistemology," this project seeks to assert the emergence of a distinct "graphic epistemology," apparent in the work of artists, architects, and engineers in the early national period. As Celina Fox has argued, drawing (alongside modeling) was the form of representation "closest to the innate skills of artisans in terms of spatial cognition and representation," however it was also irreducibly different—neither fully abstract, nor entirely material, the artisan's robust world of three and four dimensions compressed into two.[53] Drawing thus engendered and conveyed a very particular mode of cognition, one essential to the transformation of the United States into a powerful industrial economy, but one rooted in the assumptions and practices of its pre-industrial past.

Outline of the Dissertation

In an attempt to bring this graphic epistemology to life, this project has involved a significant act of recovery, delving into libraries and archives to unearth the largely overlooked

---

[52] Ibid.

[53] Celina Fox, *The Arts of Industry in the Age of Enlightenment* (New Haven; London: Yale University Press for The Paul Mellon Centre for Studies in British Art, 2009), 8.

practice of mechanical drawing in early America. To do justice to this rich archive, I have tried to select case studies that demonstrate the wide range of practices present in the early nineteenth century as well as the extent to which the effects of industrialization were felt well beyond the walls of the manufactory. Each case study thus addresses a different form of graphic practice, looking at penmanship, projective geometry, patent drawing, and portraiture in turn. In tandem with this study of genre, each chapter undertakes the analysis of a different aspect of artisanal practice and the ways in which drawing reinvented that practice for a new industrial era.

The first chapter considers the question of skill—how did drawing reinvent manual skill for an industrial age? Looking at late eighteenth- and early nineteenth-century writing and drawing manuals, the chapter focuses on the extended mechanical metaphor that structures the first of these texts to be published in the United States—John Jenkins's *The Art of Writing* (1791 & 1813). For Jenkins, the penman was an "ingenious mechanic," assembling a set of interchangeable strokes into the syntactical machine of written language; yet this mechanic was also himself a well-tooled machine, reliably reproducing a steady stream of uniform pen strokes. Focusing on the movements required to produce the written word rather than an image of the word itself, Jenkins and his successors developed a rich diagrammatic lexicon through which manual skill could be systematically dissected, documented, and reproduced. [Figure 6] Their work uses the logic of modern mechanics to valorize an older form of mechanical knowledge, recuperating manual skill for an industrial age and laying out the argument for graphic practice as essential to technological progress

Building on this discussion of drawing and skill, the second chapter examines the reinvention of expertise. Its focus is the drawing curriculum of the nation's first engineering school, established at the United States Military Academy at West Point in 1802. Tasked with producing the nation's first generation of professionally trained engineers, West Point approached education as the systematic rationalization of practical knowledge. Inherent to the institution's rationalizing project (and integral to the progress of industrialization more generally) was the notion that the possession of technical expertise might be separated from the manual skills required to manifest it. Hailed as a sort of universal language, drawing proved effective in this process, providing a repository for technical knowledge that might be accessed and shared without recourse to the artisan's body. But what becomes clear in a careful examination of West Point's curriculum is that drawing also provided cadets with an important conduit for tactile experience. Their drawing boards were sites of experimentation, requiring a variety of manual skills and reenacting various forms of physical construction. [Figure 7] In this manner, technical expertise was still made dependent on the exercise of skill, but that skill was of a fundamentally different (read, graphic) kind.

Drawing's capacity to virtualize tactile experience is again the subject of the third chapter, which considers both the act of invention and its monetization as intellectual property. With the Industrial Revolution's shift from the artisan's workshop to the manufactory's systems of divided labor, the relationship between an idea and its material embodiment became an issue of both philosophical and economic significance. Focusing on the work of artist and engineer Robert Fulton, the chapter looks at the ways in which both the mechanical and the fine arts used images to link "inventions"—that is to say the new devices that constituted turn-of-the-century technology—with a more capacious understanding of the combined physical and intellectual activities that constitute the process of "invention." Considering invention as both a process and a product, the chapter examines the various representational strategies used to resist industrialization's attempts to divide the inventive idea from its material embodiment. [Figure 8]

The fourth and final chapter considers the questions of agency raised by the turn-of-the-century craze for mechanically assisted portraiture. Focusing on the so-called "physionotrace" portraits produced by French émigré Charles B.J.F de Saint-Mémin, this chapter examines the bodily transformation of both artist and sitter in the course of their involvement with this drawing machine and the extent to which these transformations remade notions of artistic agency and creativity in the early nineteenth century. [Figure 9] The chapter considers Saint-Mémin's resistance to the hybrid form of artistic agency imposed by the use of the physiognotrace device and the ways in which his drawings reveal an attempt to carve out a space for the body amongst the machine's encroachments.

The Machine in Art History

Written in bold red letters, the term "MACHINE ESTHETIC" sits near the geometric center of Alfred Barr's well-known 1936 chart outlining the genealogy of modern art. [Figure 10] The red lines that radiate out from its neatly defined box touch nearly all of the schools and styles that later emerge in Barr's chronology—an apt representation of the significant role the machine has played in the history of art. Whether deployed as a proxy for discussions of both monetary and aesthetic value as Jennifer Marshall has found in her analysis of MoMA's 1934 *Machine Art* show or, as in Caroline A. Jones's *Machine in the Studio*, used to describe the unique forms of artistic practice that emerged under late industrial capitalism, the machine has been as valuable a conceit for practicing artists as it has been for those who write those artists' histories.[54] A full accounting of the machine in art history is far too vast a topic to be tackled here, but some sense of the machine's multiple valencies in this history seems necessary to

[54] Jennifer Jane Marshall, "In Form We Trust: Neoplatonism, the Gold Standard, and the Machine Art Show, 1934," *The Art Bulletin* 90, no. 4 (2008): 597–615; Jennifer Jane Marshall, *Machine Art, 1934* (Chicago ; London: The University of Chicago Press, 2012); Caroline A. Jones, *Machine in the Studio: Constructing the Postwar American Artist* (Chicago: University of Chicago Press, 1996).

communicate how the concerns of this dissertation fit into those of the broader field.

Although it was in the nineteenth century that the machine came of age, it is in the twentieth century, as Barr's chart suggests, that the machine has staked its boldest claim, both as a vehicle for artistic expression and an explanatory device for historians. It is thus the twentieth-century machine and its various interpretations that have dominated the historiography, with several notable exceptions. Among these are F.D. Klingender's classic *Art and the Industrial Revolution*, as well as a large body of excellent work on nineteenth century photography, to include Jonathan Crary's essential studies of visual technology, connoisseurial and curatorial treatments of the decorative and graphic arts, which have by necessity had to address changing modes of production, and newer analytical work by interdisciplinary scholars like Glenn Adamson, Celina Fox and John Tresch, who have attempted to take a rigorous and historically specific view of the interactions between industrialization and nineteenth century visual and material culture.[55] Still, trips through the pages of survey texts and gate-keeping publications like the *Art Bulletin, Art Journal*, or *American Art* reveal that it is largely in treatments of the twentieth-century that the machine has received the lion's share of attention.

For both artists and historians of the twentieth century, the machine has proved a productive instrument for many reasons, but perhaps most saliently because of its ability to simultaneously signal a sense of both progress and loss. For many artists and architects of the early twentieth century, the machine (be it airplane, grain elevator, or assembly line) spoke of futurity. In the words of architect Le Corbusier,

[55] F. D. Klingender, *Art and the Industrial Revolution,* ed. Arthur Elton (London: Evelyn, Adams & Mackay, 1968); Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century*; Jonathan Crary, *Suspensions of Perception: Attention, Spectacle, and Modern Culture* (Cambridge, MA: MIT Press, 1999); Fox, *The Arts of Industry in the Age of Enlightenment*; Adamson, *The Invention of Craft*; John Tresch, *The Romantic Machine: Utopian Science and Technology after Napoleon* (Chicago; London: University of Chicago Press, 2012).

> A great epoch has begun.
> There exists a new spirit.
> Industry, overwhelming us like a flood which rolls on towards its destined ends, has furnished us with new tools adapted to this new epoch, animated by the new spirit.[56]

This Machine Age was a new Renaissance, a paradigm shift, but as Le Corbusier suggests, a shift of overwhelming proportions in which old orders and old comforts were swept away. From the montage practices of Dada to the hard-edged forms of Precisionist painters, the incorporation of functional objects and reproductive techniques into artistic expression suggested a certain inclusive populism. However, the more "democratic" the art form—be it Duchampian readymade or the display of ball bearings in MoMA's *Machine Art* show—the more problematic did the category of artistic value become. Evidence of skill and the appearance of singularity, former guarantors of value, were lost in the machine's populist pitch.

In the history of art, the practice of photography has largely functioned as the *ur*-example of this process and Walter Benjamin's "The Work of Art in the Age of its Technological Reproducibility" as the *ur*-critique. As John Roberts has argued, "Benjamin's writing presaged a vast transformation in the content of artistic and social *technic* in the second half of the twentieth century. Since the 1930s, the realities of image reproduction and artistic surrogacy or authorship-at-a-distance have represented the high ground upon which debates on value in art have been fought out."[57] Benjamin viewed technological reproduction as a means to dissociate the work of art from an outdated model of value premised on authorial originality, authenticity and singularity. Technological reproduction could remove the work of art from the realm of ritual

---

[56] Le Corbusier, *Towards a New Architecture*, trans. Frederick Etchells (New York: Dover Publications, 1986), 6.

[57] John Roberts, *The Intangibilities of Form: Skill and Deskilling in Art After the Readymade* (New York: Verso, 2007), 17.

and resite it as an instrument of politics.[58] The potency of Benjamin's analysis (and the Marxist critique of capitalism on which it was based) has, to a large extent, focused the broader discussion of modern art on the closely intertwined issues of manual deskilling, authorship, authenticity and value, making of mechanization the essential condition under which modern art has been produced.

This project does not escape the discussion of skill, labor and value that the machine seems naturally to attract, but it does attempt to understand the ways in which skill and manual technique were not simply sidelined in the course of industrialization, but rather repurposed and reassigned. Focused on a period prior to the birth of photography, it examines a relationship between mechanization and picture-making in which the image is not "automatic" in any conventional sense. The drawings I study are intensely labored and exquisitely crafted. However, by offering this alternative origin point for a discussion of art in a mechanical age, "Drawing Machines" asks its readers to rethink categories like the automatic, the mechanical, the authentic, and the skilled. If, as Michael Polanyi has argued, the "aim of a skillful performance is achieved by the observance of a set of rules which are not known as such to the person following them," then an essential aspect of skill is that the maker is so adept that action happens without thought.[59] Making becomes automatic. With this notion of skill in mind, the dissertation's title of "Drawing Machines" refers not only to the mechanical subjects pictured in nineteenth-century technical drawings, nor just to the proliferation of drawing instruments that assisted in the production of such studies, but also to the draftsmen themselves. The project considers the ways

[58] Walter Benjamin, "The Work of Art in the Age of Its Technological Reproducibility: Second Version," in *The Work of Art in the Age of Its Technological Reproducibility and Other Writings on Media*, ed. Michael W. Jennings, Brigid Doherty, and Thomas Y. Levin, trans. Edmund Jephcott (Cambridge: Belknap Press of Harvard University Press, 2008), 21–25.

[59] Michael Polanyi, "Skills," in *Personal Knowledge: Towards a Post-Critical Philosophy* (Chicago: University of Chicago Press, 1958), 49.

in which the body of the draftsman was turned into a drawing machine and the implications that might have for our understanding of manual skill and practical craft.

The Machine in American History

From Leo Marx's seminal *Machine in the Garden* (1964) to Laura Rigal's more recent *American Manufactory* (1998), the chronological coincidence of industrial and political revolutions in the United States has given the machine a central role in the narration of American history. My dissertation necessarily builds on this substantial body of scholarship, acknowledging the closely intertwined ideologies of industrial capitalism and republicanism that this earlier work has sought to elucidate. However, "Drawing Machines" also departs from prior scholarship in significant ways, turning to the study of material form and physical practice to offer an interpretation of the machine in American life inaccessible through existing studies of labor history, political economy, or even literary production.

The conventional point of origin for this historiography is Leo Marx's *The Machine in the Garden*.[60] Marx's literary and intellectual history concerns the evolution of an ideology of industrialization in the eighteenth and nineteenth centuries, focusing on the emergence of a distinctly American form of industrialization coincident with notions of the "middle landscape" found in the pastoral literary tradition. According to Marx, the now familiar "American fable" of the New World as pastoral reverie was complicated in the late eighteenth and early nineteenth centuries by the emergent forces of industrialization. However, advocates for industrialization found creative ways to manipulate the pastoral motif so as to justify industrialization. Writers like Tench Coxe (Andrew Hamilton's co-author on the influential *Report on Manufactures*) deployed a range of metaphors to align the mechanisms of industry with the mechanisms of the

---

[60] Leo Marx, *The Machine in the Garden: Technology and the Pastoral Ideal in America* (New York: Oxford University Press, 2000).

natural world while also emphasizing the labor-saving capacity of mechanical devices, which would enable a greater portion of the population to participate in the morally and culturally improving work of agricultural cultivation.[61]

Published a decade later, amidst the nation's bicentennial fervor, John Kasson's *Civilizing the Machine* (1976) updates Marx's thesis with a shift from the literary concerns of pastoralism to a focus on the ideological origins of republicanism inherited from Gordon S. Wood.[62] Like Marx, Kasson believes the success of an industrial ideology was dependent on its proponents' ability to naturalize the machine's activities and effects, incorporating industrial manufacturing into the agrarian logic by which the American experiment in republicanism had heretofore defined itself. Identifying this sleight of hand, Kasson argues that the potentially disruptive forces of industrialization were actually put in service of a profoundly conservative (read elitist or Federalist) movement in early America, which sought to maintain social stability and control through an emphasis on republican virtue.

Through the late 1990s, much of the literature on American industrialization continued to rely on the tropes established by Marx and Kasson, but more recently an alternate narrative has begun to emerge.[63] This newer strain of scholarship is similarly concerned with the relationship

---

[61] Ibid., 150–69; Alexander Hamilton, "*Report on the Subject of Manufactures (1791)*," in *The Philosophy of Manufactures: Early Debates over Industrialization in the United States*, ed. Michael Folsom and Steven D. Lubar (Cambridge, MA; London: MIT Press, 1982), 81–94.

[62] John F. Kasson, *Civilizing the Machine : Technology and Republican Values in America, 1776-1900* (New York: Hill and Wang, 1999). For the historical apparatus with which Kasson was working, see especially Gordon S. Wood, *The Creation of the American Republic, 1776-1787* (Chapel Hill: Published for the Institute of Early American History and Culture by the University of North Carolina Press, 1969); but also Bernard Bailyn, *The Ideological Origins of the American Revolution* (Cambridge, MA: The Belknap Press of Harvard University Press, 2017); and Robert E. Shalhope, "Toward a Republican Synthesis: The Emergence of an Understanding of Republicanism in American Historiography," *The William and Mary Quarterly* 29, no. 1 (1972): 49–80.

[63] See, for example, Pursell, *The Machine in America*; Hindle, *Emulation and Invention*; Brooke Hindle, *Engines of Change: The American Industrial Revolution, 1790-1860* (Washington, D.C.: Smithsonian Institution Press, 1986); and David E. Nye, *American Technological Sublime* (Cambridge, MA: MIT Press, 1994).

between industry and national identity but has developed a more expansive approach to the relationship between industrial and cultural production in early America. Laura Rigal's *American Manufactory* builds upon Marx's work, examining the ways in which cultural producers engaged with the rhetoric of manufacturing as a means of literally and figuratively "constructing" national identity.[64] However, Rigal brings a new dimension to this story by examining the ways in which literary and visual representations of labor and class identity were instrumental in the construction of a national character. In like manner, David Jaffee's *A New Nation of Goods* looks beyond the urban centers and burgeoning factory towns that occupy the center of Kasson's intellectual and social history to investigate the dynamics of proto-industrial production amongst the new nation's rural and village populations.[65] This new approach engages a wider range of objects, individuals and productive practices than the work of previous scholars and reveals the relationship between industrialization and national identity to be the product of multiple, overlapping forms industrial development rather than a monolithic contest between the ideals of an agrarian nation and those of an industrial state.

All these works are significant milestones in the larger project identifying the importance of the "republican machine" as a rhetorical device in the early national period and the role of industrialization in shaping both political and cultural institutions in early America. However, they are all marked by the underlying premise that there is something unique about the process of American industrialization, whether due to the nature of the American landscape (Marx), the ideological origins of the American political system (Kasson), or the unique class structure of American society (Rigal and Jaffee). This approach is perhaps best summarized by the words of

[64] Rigal, *The American Manufactory*.

[65] Jaffee, *A New Nation of Goods*. See especially the chapters on "Itinerants and Inventors," "A Tale of Two Chairmaking Towns," and "Daguerreotypes: The Industrial Image."

historian of technology Carroll Pursell, "The most important fact about the history of early American technology—and perhaps about our entire early history—is that the American Revolution and the Industrial Revolution happened at the same time."[66] As evidenced by Pursell's sweeping generalization, this is an approach that can easily give way to mythology, treating the coincidence of the nation's political and industrial revolutions as natural and an American exceptionalism founded on technological achievement as somehow inevitable.

Without ignoring the obvious entanglement of industrialization and nation-building identified by these authors, this project seeks to engage the history of the machine on both a broader and a more intimate scale. Built upon a selection of case studies that highlight lines of exchange between North America and Europe, this project works to locate the United States within the expansive and dynamic knowledge economy of the "Industrial Enlightenment"—a term coined by Joel Mokyr to describe the process of rationalizing and cataloguing practical knowledge that drove the development, expansion, and refinement of industrial technology in the late eighteenth and early nineteenth centuries.[67] As discussed above, the project also seeks to engage the broader study of craft practice as knowledge production and to tie the work of American artists and engineers into what Glenn Adamson has described as the broader transition from an "undifferentiated world of making" in the early modern period to a system of production defined by "a set of linked binaries: craft/industry, freedom/alienation, tacit/explicit, hand/machine, traditional/progressive."[68] Looking at the ways in which the graphic practices of American artists and engineers both produced and complicated these binaries, this project turns

[66] Pursell, *The Machine in America*, 35.

[67] Joel Mokyr, *The Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton: Princeton University Press, 2002). See also the special issue of *History of Science* dedicated to a discussion of Mokyr's work and its implications for future study, Maxine Berg, ed., "Reflections on Joel Mokyr's *Gifts of Athena*," Special Issue, *History of Science* 45, no. 2 (June 2007).

[68] Adamson, *The Invention of Craft*, xii.

toward individual histories, examining industrialization and mechanization as forces that reshaped individual identities as well as national discourse.

This attention to individual histories has allowed me to engage the relationship between body and machine on an intimate level, to really probe the ways in which industrialization altered the acquisition and implementation of technical knowledge on a granular scale. That said, I believe this approach has implications beyond the micro-history. Attention to this level of physical practice has allowed me to nuance some of the conventional interpretations of the history of industrialization. Throughout the dissertation, the reader will find an attempt to put pressure on Adornian and Foucauldian interpretations of modern society that treat industrialization's rationalization of the body and mechanization of production as instruments of administrative control and intellectual impoverishment. My intent is not necessarily to deny such assertions but to draw attention to the myriad ways in which industrialization's relationship to the body was perhaps more pliable than it looks on a grand scale. Likewise, I look to suggest that the oppositions between body and machine that such interpretations stage are a retrospective view imposed on the past by a present duly concerned by a super-abundance of technology in our daily lives.

With that said, I also feel compelled to draw attention to a particular blind spot in this project—one that became apparent in the work's final stages and one that will have to be addressed as the dissertation transitions into book form. As much as this project has been about complicating conventional understandings of the relationship between body and machine and about demonstrating the various ways in which this relationship was described and/or represented at the turn of the nineteenth century, there is still more work to be done in understanding this relationship as one constructed by and through many different *bodies*, rather than a singular, generic *body*. The principal actors in my current case studies are largely white, male, and affluent, and it is that white, male body that is presumed to be universal in both their writings and their drawings. Yet industrialization impacted the body differentially depending on its physical and social circumstances—white, black, male, female, genteel or common. As Sarah Lewis has noted, the emergent opposition of body and machine that I trace in the course of this dissertation was really only applicable to the privileged position of the white and well-educated.[69] The bodies of others (and of the enslaved, in particular) were more easily elided with the machine and incorporated into the stream of resources that underwrote the rise of industrial capitalism.[70] Building on the groundwork laid here, the next incarnation of this project will more explicitly examine the ways in which drawing engaged with the body as a marker of race, gender, and class, enriching our understanding of the body-machine dialectic explored here by engaging forms of productive and reproductive labor that lie outside conventional histories of engineering.

A Note on Method

This new work will draw upon the same methods developed in this phase of the project—an approach to objects and images that grants them a certain measure of agency in the construction of social relationships and physical circumstances. It is an approach that I (along with many others) first encountered in the work of American art and material culture scholar Jules Prown, but it is an attitude (or perhaps more properly an ethos) that reaches its apotheosis in the project of posthumanism.[71] Mentioned earlier in relation to the work of Donna Haraway on

[69] Professor Sarah Lewis, in conversation with author, April 27, 2017.

[70] For a recent take on this argument as it pertains to slavery, see Edward E. Baptist, *The Half Has Never Been Told: Slavery and the Making of American Capitalism* (New York: Basic Books, 2014).

[71] See, for example, Jules David Prown, "Mind in Matter: An Introduction to Material Culture Theory and Method,"

the cyborg, posthumanism rejects the anthropocentric world-view that has largely structured Western industrial society in favor of a social order that incorporates the human into a non-hierarchical association with other entities both biological and technological.[72] My principal touchstone within this literature is Bruno Latour's understanding of the material world as a "collective of humans and non-humans," proposed in his essay collection *Pandora's Hope*.[73] Latour posits agency as the collective action of multiple entities (both human and non-). In combination, each individual entity mediates the capacities and intentions of the other to produce a unique, but aggregate "actant."[74] My affinity for this methodology is not arbitrary, but rather embedded in the historical moment under study. Grappling with precisely these issues, artists, architects, and engineers of the late eighteenth and early nineteenth centuries sought to understand what it was to be human when confronted with the extraordinary capacities of the machine. With automatons that sprang to life and laborers characterized as machines, where was one to draw the line between human and non-? Enmeshed in communities distributed across great geographic distance and enrolled as participants in industry's emergent systems of divided labor, these individuals could not help but discover agency in objects and to see objects as proxies for human agency within an increasingly diverse, diffuse and chaotic society.

That said, the Latourian focus on incorporating objects into a discussion of agency has tended to direct attention to the period after the object has been created. One can see this

---

Winterthur Portfolio 17, no. 1 (1982): 1–19.

[72] See Haraway, "Cyborg Manifesto"; N. Katherine Hayles, *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics* (Chicago: University of Chicago Press, 1999).

[73] Bruno Latour, "A Collection of Humans and Nonhumans: Following Daedalus's Labyrinth," in *Pandora's Hope: Essays on the Reality of Science Studies* (Cambridge, MA: Harvard University Press, 1999), 174–215. See also, Bruno Latour, *Reassembling the Social : An Introduction to Actor-Network-Theory*, Clarendon Lectures in Management Studies (Oxford ; New York: Oxford University Press, 2005).

[74] Latour, "Humans and Nonhumans," 176–93.

particularly in Latour's essay "Visualisation and Cognition," in which the drawing manifests as something to be looked at, circulated, or interpreted, but never as something that itself is involved in a process of coming into being.[75] In an attempt to discover the forms of collaborative agency that emerge once we enter into the drawing's process of production, I have sought to incorporate into this study the rich phenomenological tradition in the interpretation of drawing more generally. As David Rosand has argued, "Drawing something is a complex action; it involves subject and object, perception and representation, eye and mind, and, most obviously—yet too often the neglected components in critical discussion—hand and body."[76] The manner in which one holds a pen, whether the hand's motion originates in the wrist, elbow or the shoulder, the size of the page in relation to the draftsman's body, the way in which certain movements are or are not constrained by the tools at the draftsman's disposal—all these factors are just as much at play in mechanical drawing as they are in the Old Master drawings of which Rosand speaks. The ability of the graphic trace to index these activities is accompanied by its ability to invite tactile sensation in the drawing's reception. Lines on the page are both a record of the draftsman's bodily movements in space and a means of suggesting depth, texture, substance and stability.[77] Long after the drawing is complete, the interplay of hand, paper, and tool can still be read, making the drawing the perfect instrument with which to investigate the nuances of collective agency and an essential component in understanding the dynamics of the body-machine collective in early America's industrializing society.

---

[75] Bruno Latour, "Visualisation and Cognition: Drawing Things Together," in *Knowledge and Society Studies in the Sociology of Culture Past and Present*, ed. H. Kulick, vol. 6 (Greenwich, CT: JAI Press, 1986), 1–40.

[76] David Rosand, *Drawing Acts: Studies in Graphic Expression and Representation* (Cambridge: Cambridge University Press, 2002), 113.

[77] Deanna Petherbridge, *The Primacy of Drawing: Histories and Theories of Practice* (New Haven: Yale University Press, 2010), 116.

CHAPTER 1

THE HAND OF A MACHINE

The human hand whether we consider its structure, its movements, or its uses, is, in itself, a little world of wonders; and it would probably strike us as such, were it not so common that no one thinks to observe it. Consider, first, its structure, or mechanism. Take it as a whole—as a piece of mere machinery—and look at it with reference to the objects it is designed to accomplish…

Is there, in the wide world a factory containing a tenth part as much curious and complicated machinery as the hand?[78]

William Andrus Alcott, *The Structure, Uses and Abuses of the Human Hand*, 1856

By the time William Andrus Alcott wrote his paean to the human hand in 1856, the United States had established itself as a modern industrial nation. In 1850, the U.S. Census had recorded the existence of some 121,855 establishments "producing any kind of manufactured article." The same assessment noted that although only 4% of the nation's 23.2 million inhabitants were employed in "the product of manufactures, mining, and the mechanical arts," the value of its industrial output had drawn nearly parallel with that of its agricultural production.[79] On the international stage, the London *Observer* reflected on America's

---

[78] William A Alcott, *The Structure, Uses and Abuses of the Human Hand.* (Boston: Massachusetts Sabbath School Society, 1856), 13 & 116.

[79] U.S. Census Bureau, *Statistical View of the United States...Being a Compendium of the Seventh Census* (Washington, D.C.: Beverley Tucker, Senate Printer, 1854), 169–79.

participation in the Crystal Palace exhibition of 1851 with the suggestion that "Great Britain has received more useful ideas, and more ingenious inventions, from the United States, through the exhibition, than from all other sources."[80]

It is from this point of view of industrial maturity that Alcott—noted physician, educator, and educational reformer—chose to reflect upon what he called the hand's "little world of wonders." Marveling over the many uses to which the hand could be put—"smoothing pin heads, setting card teeth, making needles, polishing penknives, catching the ends of the silk…and so on"—Alcott emphasized the continued importance of manual labor within the nation's burgeoning factory system. However, his text also stresses the superiority of bodily mechanics to any industrial system yet devised.[81] It bemoans the hand's neglect and mis-education in the modern era, imploring readers to attend to the hand's wondrous sensitivity, its dexterity, and its diverse capacities. Although in 1856 the machine had yet to fully replace the body in the realm of manufacturing, there is clearly a sense in Alcott's text of the hand's impending obsolescence, and the approach he uses—valorizing the hand's mechanisms by analogy with industrial machinery—serves largely to remind the reader of the many ways in which the hand's sphere of influence had been impoverished by the on-going process of industrialization. Acknowledging this himself and ultimately in search of some saving grace, Alcott asks, "But what if machinery has been substituted, very largely, for the human hand,—has the hand nothing to do, in devising,

---

[80] Merle Curti, "America at the World Fairs, 1851-1893," *The American Historical Review* 55, no. 4 (1950): 840.

[81] Alcott, *Human Hand*, 37.A year before issuing this pamphlet, geared primarily toward schoolchildren, Alcott had published a series of more formal medical lectures in which he made similar claims about the body and its various organs more generally. For example, comparing the vessels, glands and nerves of the skin with the workings of a gingham factory at Clinton, MA, he asks "Is it too much to say that in this little spot—this square inch of human skin—there appears to be vastly more of living machinery than there is of dead machinery in a whole acre of spinning jennies and power looms?" He goes on to discuss the "hundreds of operatives" required to operate the factory of the body and compares the body's various organs and parts to the factory's vast population of "working men." William A. Alcott, *Lectures on Life and Health; Or, the Laws and Means of Physical Culture.* (Boston: Phillips, Sampson, and Company, 1853), 208 & 307.

or at least in executing the very machinery which has become its substitute?"[82]

Here Alcott references the need for the hand's dexterity and sensitivity in the designing, drafting, and production of industrial machinery. Framed as a rhetorical question, Alcott's observation on the intimate relationship between hand and machine points, in fact, to the underlying premise of this dissertation—namely the essential role played by drawing in bridging the gap between bodily and industrial mechanics. Posed from a retrospective point of view, once the hand had been well and truly supplanted by the machine, Alcott's analogies between manual labor and mechanical production provide a provocative counterpoint to similar analogies made in the first decades of the nation's industrialization.

This chapter examines the formulation of the draftsman's hand as an instrument of industrial manufacture in the first decades of the nineteenth century. Its focus is the work of itinerant writing instructor John Jenkins, whose *Art of Writing* (1791 & 1813) was the first penmanship manual to be both authored and published in the United States. Like Alcott's *Uses and Abuses*, Jenkins's manual establishes a clear analogy between hand and machine, likening the written alphabet to a system of interchangeable parts and the draftsman himself to an "ingenious mechanic" who labors to construct the machine of language from its constituent components. The industrial analogies made in *The Art of Writing* are prospective, conceived just as industrialization had begun to gain traction in the U.S., but in them one can trace the antecedents of Alcott's rhetoric. For Jenkins, the hand is, in and of itself, a wondrous mechanism, but it can also be adapted, refined and reshaped according to industrial principles.

In the course of this chapter, I look at the structure of Jenkins's method, situating its process in relation to both the emulative system of instruction it sought to replace and the emergent industrial context it sought to engage. The underlying subject of investigation is the

[82] Alcott, *Human Hand*, 75.

question of skill: how did graphic practices reinvent manual skill for the industrial age? I thus begin by looking at the history of penmanship as a so-called “mechanical art”—that is to say a form of artifice requiring a certain degree of manual skill—and the way in which instruction in this “mechanical art” was corrupted by newer forms of mechanical reproduction. I then consider the ways in which Jenkins’s method sought to bring the two together, using the logic of modern mechanics to valorize an older form of mechanical knowledge and to recuperate manual skill for an industrial age. Jenkins does this by subjecting the body’s movements to intensive study and rationalization, thus I conclude with a consideration of what I will call his “mechanization” of the body and the radicality of this approach in the context of the early Republic. This mechanization of the body is significant both because it imagines an industrial future intimately connected to the body and because it posits graphic representation as a means to channel and control the body’s exercise of physical skill.

Writing and Drawing

At first glance, this study of Jenkins may appear peripheral to the history of drawing my dissertation intends to engage, let alone the history of art in which I hope to stake my broader claims. Outside of scholarship on twentieth century “language art,” the literature on writing has consistently treated it as a practice fundamentally divorced from drawing by its association with the word.[83] Much attention has been devoted to the fundamental differences between oral and written speech (Ong and Goody) and between written and typographic text (McLuhan, Thornton and Warner), but too little attention has been paid to the essential similarities between the writer’s and the artist’s modes of graphic inscription, particularly within the context of the early

[83] Martine Reid and Nigel Turner, “Editor’s Preface: Legible/Visible,” *Yale French Studies* 84 (1994): 1–12.

modern period.[84] As revealed in the course of my research, this is in spite of their intentional intertwining in the work of educators and theorists from the fifteenth through the nineteenth centuries. Leon Battista Alberti's *Treatise on Painting* implores his readers to model their learning on the methods employed by handwriting instructors.[85] In *Some Thoughts Concerning Education*, John Locke suggests pupils should be instructed in drawing only after they have successfully mastered the art of penmanship. Diderot and D'Alembert's *Encyclopédie* refers to "The Writer" as "a type of painter," while Bentham's *Chrestomathia* argues that "*writing* is itself but a mode of *drawing*," and Rembrandt Peale suggests, "Writing is nothing else than drawing the forms of letters. Drawing is little more than writing the forms of objects."[86]

Notable exceptions to the lack of scholarly interest in this subject include Jonathan Goldberg's work on the practices of English Renaissance writing masters, an issue of *Yale French Studies* devoted to "Boundaries: Writing & Drawing," and a fascinating edited volume by Jeffrey Masten, Peter Stallybrass, and Nancy Vickers entitled *Language Machines*.[87] Following in the footsteps of these authors, I hope to draw the study of writing out of the fields

---

[84] Walter Ong, "Writing Is a Technology That Restructures Thought," in *The Written Word: Literacy in Transition*, ed. Gerd Baumann (Oxford: Clarendon, 1986); Jack Goody, *Literacy in Traditional Societies* (Cambridge: Cambridge University Press, 1975); Tamara Plakins Thornton, *Handwriting in America: A Cultural History* (New Haven: Yale University Press, 1996); Marshall McLuhan, *Understanding Media: The Extensions of Man* (New York: McGraw-Hill, 1964); Michael Warner, *The Letters of the Republic: Publication and the Public Sphere in Eighteenth-Century America* (Cambridge, MA: Harvard University Press, 1990).

[85] Leon Battista Alberti, *On Painting* (New Haven: Yale University Press, 1966), 92.

[86] John Locke, "Some Thoughts Concerning Education," in Some Thoughts Concerning Education *and* Of the Conduct of the Understanding, ed. Ruth W. Grant and Nathan Tarcov (Indianapolis: Hackett Publishing Company, Inc., 1996), 119–20; Jaucourt, "Ecrivain," in *Encyclopédie, Ou Dictionnaire Raisonné Des Sciences, Des Arts et Des Métiers, Etc.*, ed. Denis Diderot and Jean le Rond d'Alembert, vol. 5 (Paris: Briasson, David, Le Breton & Durand, 1755), 372; Jeremy Bentham, *Chrestomathia*, ed. W.H. Burston and M.J. Smith (Oxford; New York: Clarendon Press; Oxford University Press, 1983), 63; Rembrandt Peale, *Graphics: A Manual of Drawing and Writing, for the Use of Schools and Families* (New York: J. P. Peaslee, 1835), 6.

[87] Jonathan Goldberg, *Writing Matter: From the Hands of the English Renaissance* (Stanford: Stanford University Press, 1990); Jeffrey Masten, Peter Stallybrass, and Nancy Vickers, eds., *Language Machines: Technologies of Literacy and Cultural Production* (New York: Routledge, 1997); Martine Reid and Nigel Turner, eds., "Boundaries: Writing/Drawing," *Yale French Studies* 84 (1994).

of book history and literacy studies in which it has so long resided. By bringing penmanship into conversation with other forms of graphic production, I intend to focus on the material aspects of writing as these other authors have done, but from a position that may more easily relate such materialism to the wealth of scholarship on visual technologies that already exists within the disciplinary bounds of art history. In return, the issues of originality and imitation that so naturally find a home in the world of the copybook can help expand art history's understanding of the graphic arts in this period and open our eyes to new sites of intersection between artistic practice and mechanical reproduction.

For example, in her account of the influence of the curriculum at Philadelphia's Central High School on the work of painter Thomas Eakins, Elizabeth Johns has argued that, "industrialization and commercialization between 1820 and 1860 made it desirable that citizens in the working classes be competent in writing and in drawing and interpreting plans."[88] She draws attention to the work of educational reformers like Horace Mann, Henry Barnard, Calvin Stowe and Alexander Dallas Bache, whose detailed reports on the common practices of European schools profoundly influenced the course of progressive education in the U.S., and to the explosion of printed methods and materials during this period that answered these educators' calls for expansive and accessible instruction in drawing and writing.[89] A key component of these methods was the application of a systematic and progressive model of instruction to the practice of drawing, intended to encourage a universal graphic literacy. Rejecting the idea of genius in favor of the power of human industry, drawing book authors insisted that the

[88] Elizabeth Johns, "Drawing Instruction at Central High School and Its Impact on Thomas Eakins," *Winterthur Portfolio* 15, no. 2 (1980): 141.

[89] In this article, Johns has drawn heavily on the work of Peter Marzio, whose account of the mid-nineteenth century's "art crusade" provides much of the background for her interpretation. Peter C. Marzio, *The Art Crusade: An Analysis of American Drawing Manuals, 1820-1860* (Washington, D.C.: Smithsonian Institution Press, 1976). See also, Elliot Bostwick Davis, "Training the Eye and the Hand: Drawing Books in Nineteenth-Century America" (Dissertation, Columbia University, 1992).

acquisition and repetition of a few key principles would provide the building blocks with which anyone could learn to draw. In Johns's words, this "new pedagogy repudiated the imitative method by which students had previously been taught to write and draw. Educators now insisted that only with the comprehension of the basic principles of writing and of drawing could students thoroughly control these skills."[90]

Thus we have a text like John Rubens Smith's *Juvenile Drawing Book* (1822), which proceeds from exercises in drafting straight and curved lines to their combination into both basic geometric shapes and types of hatching or shading.[91] [Figure 1.1] Later plates in Smith's book grow more complicated, incorporating these basic principles into lessons on architecture, perspective and landscape drawing, [Figure 1.2] while his later texts turn this logic toward the construction of the human figure.[92] [Figure 1.3] Similarly, Rembrandt Peale's *Graphics* has been designed around a progressive set of lessons built upon the foundational lessons of straight, diagonal and curved lines. [Figure 1.4] Peale's method is closely tied to those developed by the late eighteenth-century Swiss pedagogue Johann Heinrich Pestalozzi, whose system of object lessons and material experiments sought to gradually lead the student to the recognition and comprehension of form and information by guiding him or her through steps that grew insensibly more complex.[93] Clearly evident in Peale's method, but also present in Smith's, is Pestalozzi's privileging of a few, inviolate geometric principles that are supposedly grasped intuitively by the

[90] Johns, "Drawing Instruction," 141.

[91] John Rubens Smith, *The Juvenile Drawing Book* (New York: The Author, 1822).

[92] John Rubens Smith, *Key to the Art of Drawing the Human Figure* (Philadelphia: S.M. Stewart, 1831).

[93] Clive Ashwin, "Pestalozzi and the Origins of Pedagogical Drawing," *British Journal of Educational Studies* 29, no. 2 (June 1981): 138–51.

student and only subsequently located in empirical observation of his or her surrounding world.[94] Peale goes farther than Smith in this process, interrupting his drawing manual halfway through to insert a section on writing based upon the same principles, intimately linking a graphic and verbal literacy together through a set of shared fundamental geometries.

The lessons of authors like Smith and Peale were not simply restricted to books. Both operated as drawing instructors, teaching students first hand, presumably with recourse to the methods they expounded in their texts. Smith, a sometime porter at the National Academy of Fine Arts, was permitted to offer drawing lessons within the Academy's rooms, while Peale (in company with Alexander Dallas Bache) formulated the curriculum for Philadelphia's Central High School—Pennsylvania's first public high school and a progressive institution designed to draw and educate students from all classes of Philadelphia society.[95] These lessons thus reached a broad swathe of society, to include artists like Emmanuel Leutze, instructed by Smith, as well as the children of carpenters, cordwainers, printers and physicians that passed through Central High School's halls. Thomas Eakins and John Sloan, both giants of early American modernism were educated at Central High, although decades apart, and you can see, in Eakins's work, in particular, the legacy of Peale's systematic drawing curriculum. Certainly, the precision with which Eakins would later construct a work like *The Pair-Oared Shell* can be traced to the crisp linearity and careful measurements found in his 1860 *Drawing of Gears*, part of his early training in mechanical drawing. (Figures 1.5 & 1.6) However, the importance of this training is as much about method as it is about style. It is about seeing the world as founded on a set of fundamental geometrical principles and about approaching the work of art as an object to be constructed,

---

[94] Ibid., 142.

[95] Johns, "Drawing Instruction," 143. See also, John Trevor Custis, *The Public Schools of Philadelphia: Historical, Biographical, Statistical* (Philadelphia: Burk & McFetridge Co, 1897); Franklin Spencer Edmonds, *History of the Central High School of Philadelphia* (Philadelphia: J.B. Lippincott Co., 1902).

piece by piece, from a set of pre-determined parts.[96]

As Elizabeth Johns, Peter Marzio and Eliot Bostwick Davis have all argued, these methods exercised a profound effect on the course of public education in the United States well into the twentieth-century. Offering a counterpart to the work Molly Nesbit has done in tracing the pedagogical origins of a graphic (and specifically technical) language shared by French modernists and deliberately deployed by Marcel Duchamp in his early readymade experiments, these authors (and Johns in particular) can help us see the extent to which modernity's visual lexicon has been built upon a graphic language deeply embedded in the material and administrative practices of nineteenth century industrialization.[97]

In the course of this chapter, I would like to open up the prehistory of this graphic language to better explore the social and political context of its earliest formulations. Johns and Nesbit both start their accounts *in media res*, with industrialization already proceeding apace. But by turning back the clock to look at one of the earliest formulations of this method in the work of Jenkins, I illustrate how this graphic language was not just responsive to, but constitutive of a new industrial ethos.

A Plan Entirely New: The Art of Writing *in the Early Republic*

The first edition of Jenkins's *The Art of Writing* was published in 1791. Although Benjamin Franklin's earlier *American Instructor* had appropriated and republished a set of English copybook designs, Jenkins's manual was the first to offer a new and substantive method for teaching students *how* as well as *what* to write.[98] With *The Art of Writing Reduced to a Plain*

[96] Johns, "Drawing Instruction," 142–47.

[97] Molly Nesbit, "Ready-Made Originals: The Duchamp Model," *October* 37 (1986): 53.

[98] George Fisher accomptant, *The American Instructor Or, Young Man's Best Companion* (Philadelphia: Printed by B. Franklin and D. Hall, at the New-Printing-Office, in Market Street, 1748). There is some suggestion that,

and Easy System on a Plan Entirely New, Jenkins proposed a method based in "certain first and fixed principles," namely the dissection of the alphabet into a few fundamental and interchangeable components.[99] According to Jenkins, the entire lower-case alphabet and most of the upper-case letters could be formed by some combination of six essential strokes: the Direct l, Inverted l, Curved i, Ja, o, and Stem. [Figure 1.7] He promised the acquisition of these few basic pen movements would substantially simplify and accelerate the learning process, and his method quickly became the standard for handwriting instruction in America, adapted and reproduced by many of his competitors.[100]

Twenty-two years after its first publication, Jenkins reissued *The Art of Writing* with a much-expanded introduction, designed to defend his work against the many instances of imitation and even outright plagiarism that had overtaken it in the intervening decades. At turns biographical, at others simply plaintive, the introduction takes every opportunity to establish its author's credibility and the singularity of his methods. In his most inventive moment, Jenkins turns to an extended mechanical metaphor to justify his methodology. He writes,

> An ingenious mechanic will ever obtain, as far as possible, a clear and distinct idea of all the component parts of the machine which he is about to form, otherwise he might labor for months to no purpose. It is also allowed by all, that for a youth to obtain the knowledge of any mechanical art, he must be taught the nature and use of tools, before he can make proficiency. Therefore, as writing

---

although the model Franklin used in *The American Instructor* was English, the handwriting that appears in the text is Franklin's own. Robert Williams, "Without a Borrowed Hand: The Beginnings of American Penmanship," *Society of Scribes Journal*, Fall 2000, 5.

99 John Jenkins, *The Art of Writing, Reduced to a Plain and Easy System: On a Plan Entirely New: In Seven Books* (Printed in Boston: by Isaiah Thomas and Ebenezer T. Andrews, 1791), 9.

100 For example: Anson Wrifford, *A New Plan of Writing Copies: With Accompanying Explanations and Remarks* (Boston: Printed by W. Hooker, 1810); Eleazer Huntington, *The American Penman: Comprising the Art of Writing, Plain and Ornamental: Designed as a Standard Work, for the Use of Schools* (Hartford: Published by Eleazer Huntington, 1824); Henry Dean, *Dean's Recently Improved Analytical Guide, to the Art of Penmanship* (New-York: Published for the author, 1808).

> is in some measure a mechanical art, it should be mechanically taught."[101]

Likening his dissection of the alphabet to the component parts of a machine and potential pupils to the nation's growing class of "ingenious mechanics," Jenkins uses this passage to claim contemporary relevance for his methods and to stage a remarkable alliance between the art of penmanship and the pressing concerns of a nascent Industrial Revolution.

His logic is built on a fascinating sleight of hand, enacted by a doubling of the term "mechanical" in the passage's final phrase. In the first instance, where Jenkins refers to writing as a "mechanical art," he draws on his era's conventional terminology for artisanal labor, used in a society in which the hand-craftsman possessed mechanical skill and painters devoted to the perfection of technique were no more than "mechanics of the art."[102] But Jenkins was also witness to a dawning "Mechanical Age" in which machine production had already started to replace hand manufacture. His notion that writing should be a skill "mechanically taught" certainly plays on older notions of penmanship as a rote and mimetic exercise accomplished by hand, but it also highlights his innovative system of instruction, which unlinked the practice of penmanship from traditional forms of scribal imitation and connected it to modern industry's iterative recombination of interchangeable parts. This subtle, but significant, semantic shift resonates throughout the expanded text of Jenkins's second edition. Through both word and diagram, *The Art of Writing* guides pupils through a retooling of hand and body so as to approximate the regularity, reliability and precision of the machine.

Although his manual advertises "The Art of Writing Reduced to a Plain and Easy System

---

[101] John Jenkins, *The Art of Writing, Reduced to a Plain and Easy System : On a Plan Entirely New, in Seven Books* (Cambridge, MA: Printed for the author, 1813).

[102] Roland Fréart de Chambray, quoted in Donald Posner, "Concerning the 'Mechanical' Parts of Painting and the Artistic Culture of Seventeenth-Century France," *Art Bulletin* 75, no. 4 (1993): 583.

on a Plan Entirely New," John Jenkins was by no means the first author to propose the grouping of letters into subsets based on their formal similarities. The very first printed writing manual, published by Ludovico degli Arrighi between 1522 and 1524, opens with a set of instructions that divides the alphabet into two principle groups based on overall shape and then further subdivides these groups based on stroke length.[103] Closer to Jenkins's day, the *Encyclopédie* entry on "Écritures" insists that "the art of writing possesses primitive elements, indispensable to producing the constructions that constitute its whole."[104] [Figure 1.8] But if Jenkins was not the first to identify such formal similarities, his manual broke new ground by incorporating these elements into a systematic and comprehensive method of penmanship instruction that reimagined the emulative traditions of the seventeenth and eighteenth centuries in new industrial form.

Prior to Jenkins, handwriting instruction in America was based on professional copies or exempla, either executed by the pupil's own instructor or distributed in printed copybooks. At its most basic, the copybook was a simple set of model alphabets and aphorisms, as we find in Franklin's *American Instructor*, mentioned above. But in its more spectacular iterations, the genre offered exhibitions of numerous and varied scripts in florid advertisement of a master penman's own unique and virtuosic skills. Widely used in the American colonies and early United States, a work like George Bickham's *Universal Penman* (1734-41) consists of two hundred fifty-one luxuriously engraved plates, illustrating work by twenty-six of England's most

103 Ludovico degli Arrighi, *La Operina Di Ludouico Vicentino: Da Imparare Di Scriuere Litettera Cancellarescha* (Roma: Per inuentione di Ludouico Vicention, scrittore, 1524).

104 "[L]'art d'écrire a des élémens primitifs, dont la pratique est indispensable pour acquerir la construction de ceux qui composes tout son ensemble," accompanied by a plate that illustrates the reduction of all writing's elements to two basic strokes—"la droite" and "la courbe." [Unknown], "Ecritures, Planche VI," in *Encylopédie, Ou Dictionnaire Raisonné Des Sciences, Des Arts et Des Métiers, Etc.*, ed. Denis Diderot and Jean le Rond d'Alembert, vol. 19 (Paris: Briasson, David, Le Breton & Durand, 1763), 21:4.

renowned penmen.[105] The significant differences between the penned and the engraved hand will be addressed later in the chapter, but for now note the way in which each virtuosic display was prominently signed by both the original penman and its engraver. In turning the book's pages, the reader thus witnesses a form of calligraphic competition, each penman jockeying for position in relation to the other and each engraver for a superlative mimeticism—one that might disguise the design's translation from the penman's medium into his own. [Figure 1.9]

For demonstration pieces signaling significant accomplishment, a student might reproduce an entire alphabet outright, ornamenting it with flourishes and penstrokes in the manner of the most ornate professional copies. But for more mundane instruction, students progressed letter by letter, moving from A to B through Z, copying out first single letters and then words and phrases until their letterforms matched either a handwritten or printed original. A separate genre of writing manuals existed to instruct students in correct posture, paper choice, the means of mixing ink and making pens, but they offered little in the way of explaining proper formation of the letters themselves. In 1790, a student in Salem, Massachusetts copied out an aphorism in his notebook that perfectly describes this method's underlying pedagogical principle, "Observe the copy and write better if you can."[106]

This act of copying facilitated a two-fold notion of what one might call "character formation." Throughout the early modern period, copybooks fit into what Tamara Plakins Thornton has called a "more generalized habit of copying by hand," in which the act of copying from authoritative texts—sermons, lectures, essays, etc.—was understood as a way of recording

[105] George Bickham, *The Universal Penman, Engrav'd by George Bickham* (London: Printed for the author, 1733).

[106] Samuel Salisbury, "Copybook" 1790, Penmanship Collection, vol. 5, American Antiquarian Society.

their lessons on the transcriber's soul and mind.[107] This idea of the written character's relationship to moral character was joined by a separate, but affiliated, relationship to social status. Since the Middle Ages, scripts had been identified by the particular functions they were meant to serve—the pipe-roll hand for transactions of the English Exchequer, variants on the Gothic script for ecclesiastical and administrative purposes, Italian hands for testimonies of humanist learning. Conformation to these models was so strong that in 1516, Erasmus wrote to friend and fellow scholar Guillaume Budé, complaining of having to recopy Budé's last letter into his own hand due to its illegibility. As Erasmus explained to Budé, his letter was illegible "not so much because it was so carelessly written as that you write like no one else." [108] In other words, handwriting in the early modern period was not a signifier of individuality, as it is in contemporary society, but rather a signifier of belonging. Budé's letter was illegible because it failed to conform to a set of visual conventions around which a specific social group cohered.

By the eighteenth century, the range of available typologies had considerably narrowed so that roundhand scripts based on the Italian *basterde* prevailed, but minute variations on this hand rapidly multiplied to distinguish their authors' social station through signifiers of economic status and gender. In the relatively flat social structure of eighteenth-century America, these distinctions were divided into what Thornton classes as "overlapping pairs of opposites: mercantile versus epistolary, practical versus ornamental, male versus female."[109] Thus we might expect the accounts kept by a secretary to differ in appearance from the letters written by his gentleman employer, and those again from the script used by the same gentleman's wife or daughter.

---

[107] Thornton, *Handwriting in America*, 18.

[108] Quoted in Goldberg, *Writing Matter*, 114.

[109] Thornton, *Handwriting in America*, 22.

The notion that one's manner of forming written characters might testify to the formation of one's own moral or social character is strongly embedded in practices of early Republican penmanship instruction. On page after page of student notebooks, alphabetically organized aphorisms are lined up top to bottom, and phrases like "Art is gained by great labour and industry" and "By a commendable deportment we gain repute," explicitly link the possession of a well-formed hand with that of a well-formed mind and moral code.[110] Such copies partake in the early Republic's pervasive "spirit of emulation," or what William Huntting Howell has called the desire "to become oneself by becoming more like a commonly held model…to construct a psychological interior by persistent identification with exterior examples."[111]

But a closer investigation of some of these penmanship exercises reveals the extent to which this spirit of emulation was also profoundly complicated by the basic structures of reproduction through which penmanship copies were made and circulated. Take, for example, a writing sample from the Boston South Writing School, executed by William Molineux under the instruction of Abiah Holbrook in 1763. [Figure 1.10] The content of the poem copied into the frame's interior underscores the exercise's emulative purpose:

> From School to School, while You, our Patrons move,
> And see the Polish of the PEN improve,
> With all our Powers in Rivalship we cope,
> And look with ardent Emulation up.

The page in which this short verse appears is a composite object, part engraving and part the work of quill and ink. A subtle fading of Molineux's black penwork alerts the modern viewer to the distinctions between the student's work and the elaborate frame designed and engraved by George Bickham in 1753; yet, in certain situations, it can still be difficult to tell where the

---

[110] Salisbury, "Copybook."

[111] William Huntting-Howell, "Spirits of Emulation: Readers, Samplers, and the Republican Girl, 1787-1810," *American Literature* 81, no. 3 (2009): 499. See also, Howell, *Against Self-Reliance*.

engraved line ends and the hand-worked one begins. In the emulative tradition, imitation of another's written work was thought to facilitate identification and sympathy, fostering a desire to reproduce, in both word and deed, the thoughts and feelings of that individual. However, this image's near-seamless integration of engraved and hand-drawn lines shows a young student seeking, somewhat perversely, to imitate the hand of a man located ten years in the past and thousands of miles away. Moreover, the hand he imitates is not really that of the master penman at all, but that of the master engraver who has, in order to reach the student, laboriously translated his own pen strokes in intaglio.

This distinction between penmanship and engraving was more than just semantic. It would have involved a fundamental reorganization of the physical act of mark-making. It begins with the basic orientation of the body to the mark-making surface. Compare the images of writing and intaglio engraving provided in the *Encyclopédie*. [Figures 1.11 & 1.12]. For one, there are simply *more* bodies involved in the engraving process than in the work of penmanship, but the delicate pose of the penman (to some extent a stylization, of course) contrasts with engraver's hunched embrace of the plate, using both hands to apply countervailing forces to the surface. Compared to the engraver's slow channeling of burin in copper, the fluidity of pen and freely-flowing ink makes even the most elaborate work of penmanship a relatively speedy process. Given the nature of the printing process, which involves the reversal of the image as print is pulled from plate, the engraver is forced to work the penned letters backwards, such that the words he engraves become effectively dissociated from linguistic sense.

Bickham himself seems to have been aware of these strange slippages between the printed and written work. His engraving offers both a coy reflection on the tools and material underpinnings of the practice of penmanship and a frame into which Holbrook's student could insert his own exercises in this medium. Depicting a variety of birds enmeshed in ornamental scrollwork, the image slyly nods toward the calligraphic practice it imitates. The intricate volutes and flourishes that entrap the birds proceed from their own beaks, almost certainly a playful punning on the term "bec," the French term for the pen's nib. Their feathered bodies then become proxies for the quill pen, and the varied attitudes of each species potential allegories for different manners of speech or calligraphic hands. Although the term "chicken scratch" does not appear as such in reference to poor handwriting in this period, the two chickens who face off at the bottom of the frame do seem to complete the circle, so to speak, of Bickham's pictorial analogy. Their sharp nails scratching grooves into the ground seem to make oblique reference to the engraver's art, and their lowly positioning appears alternately a comment on the incommensurability of pen and burin or the novice status of the student penman who would eventually complete the work. [112]

The extended chain of production and reproduction involved in this method is made particularly clear in George Shelley's *Penman's Magazine* (1705). [Figure 1.13] The full title of the *Magazine* is instructive, as it advertises,

> English, French and Italian hands, After the Best MODE; Adorn'd with about an Hundred New and Open Figures & Fancies never before Published. After the Originals of ye Late Incomparable Mr. Seddon. Perform'd By George Shelley Writing-Master at the Hand and Pen in Warwick-Lane London. Engrav'd by Joseph Cutting in Carter Lane near St. Paul's.[113]

---

[112] I have yet to pin down the etymology of this phrase, so this connection is speculative, at best. However, the two chickens facing each other beak to beak at the base of the frame seem impossible to ignore. There is a reference in antiquity, found in Plautus' comedy *Pseudolus*: "*An opsecro hercle, habent quas gallinae manus? / nam has quiem gallina scripsit*," which translates as "Hey, do chickens have hands? / It looks to me like a hen wrote this letter," so it is possible that Bickham has made a classical allusion here. For a discussion of Pseudolus' text, see John R. Clark, "Early Latin Handwriting and Plautus' 'Pseudolus,'" *The Classical Journal* 97, no. 2 (December 2001): 183–89.

[113] George Shelley, *The Penman's Magazine, or a New Copy Book of the English, French, and Italian Hands* (London: Sold by R. Parker, under the Piazza Royal-Exchange; J. Holland; B. Lintott; J. Dewell, 1705).

No fewer than three individuals are implicated in the production of this work—the "incomparable" John Seddon, writing-master George Shelley, and engraver Joseph Cutting. George Shelley's "performance" of Mr. Seddon's originals attempts to endow the copybook with vivacity and immediacy, connecting the first two links of an emulative chain intended to terminate in the student's own re-enactment. However, as with Bickham's engraving of the birds, *The Penman's Magazine* traveled through both extended time and space to reside in a Boston writing-master's library, setting the original penman (and all his supposed attendant virtues) at some great physical and even greater emotional distance from the pupil.

Whether through engravings like Bickham's or more comprehensive works like Shelley's, the circulation of printed penmanship opened up a gap in the emulative system of education due to the fact that the printed copy could never provide direct access to the hand of the copy's author. The physical acts of penmanship and engraving were too fundamentally different and the chain of authorship too geographically and temporally attenuated. By the turn of the nineteenth century, as handwriting instruction increasingly shifted from a model based on private tutorship and toward inclusion in broader school curricula and even self-instruction, the mediation of handwriting by its mechanical reproduction became inescapable and the models students were expected to emulate both physically perverse and increasingly remote.[114] During this period, the practice of penmanship was also beset by certain suspicions, traceable to an Aristotelian tradition that viewed the "mechanical arts," i.e. the work of artisans or tradesmen, as unsuitable to the status of a virtuous citizen. Propagating this distinction into the Middle Ages, we find scribes of the monastic *scriptoria* undertaking the manual labor of writing as a form of physical penitence, and among some authorities, the material of graphic inscription understood

---

[114] Meredith L. McGill, "The Duplicity of the Pen," in *Language Machines: Technologies of Literary and Cultural Production*, ed. Jeffrey Masten, Peter Stallybrass, and Nancy Vickers (New York: Routledge, 1997), 42.

as no more than a corrupted, even adulterated, version of the original Word.[115] By the late eighteenth century, this notion of carnal corruption had dimmed somewhat, but the practice of handwriting remained tainted, so much so that Thomas De Quincey discusses French aristocrats of the 1790s cultivating poor penmanship "as if in open proclamation of scorn for the arts by which humbler people oftentimes got their bread."[116] Likewise, Erasmus Darwin argued in his 1797 *A Plan for the Conduct of Female Education* that an activity like writing "should not be too long applied to at a time; since the body, and even the countenance, may thus get a certain tendency to one attitude; as is seen in children, who are brought up to some mechanic art, as in polishing buttons or precious stones on a lathe."[117]

By the turn of the nineteenth century, these complications had situated penmanship instruction in America in a strange, liminal zone. As an instrument of moral instruction, penmanship was fundamentally compromised by its association with the mechanical arts. The social stability secured by associations between particular scripts and particular social classes had been undermined by the circulation of printed copybooks that made any script available to anyone capable of paying the book's purchase price. And in like manner, the strength of the copybook as an emulative model was weakened, as the copy's own mechanical reproduction interrupted any affective relationship its imitation was expected to promote.

Trained in the eighteenth century's emulative tradition, John Jenkins strongly believed in its association between proper penmanship and a proper frame of mind. His *Art of Writing* actively promotes the importance of a common standard for students to imitate as well as the

---

[115] Elizabeth Pittenger, "Explicit Ink," in *Premodern Sexualities*, ed. Louise Fradenburg and Carla Freccero (New York: Routledge, 2013), 290.

[116] Thornton, *Handwriting in America*, 13.

[117] Erasmus Darwin, *A Plan for the Conduct of Female Education* (Derby: J. Drewry for J. Johnson, London, 1797), 17.

social and moral improvements that instruction based on such a standard might effect.[118] But as indicated by his invocation of the "ingenious mechanic," Jenkins refused to shy away from penmanship's status as a mechanical art, and instead enthusiastically embraced and extended such comparisons. His manual is a unique and important resolution of the copybook tradition's complexities, reflecting fundamental changes in the structure of emulation in Republican society.

Jenkins prided himself on *The Art of Writing*'s natural and self-evident principles, and the account he provides of the system's genesis signals a reluctance to join the imitative sequence of the copybook tradition. In the manual's 1813 preface, he writes,

> From his early youth he had been highly gratified by examining beautiful specimens of penmanship, and felt a strong desire to imitate them; but had, after frequent attempts, for years despaired of ever obtaining a handsome hand…
>
> At first he procured well written copies for the use of his pupils; but he soon felt the truth of an observation made by some of his employers, that a teacher ought to be capable of instructing his pupils without a borrowed hand. This intimation at once inspired him with a renewed desire, not only of his own improvement, but that of his pupils also, in the art in which he felt himself so very deficient.
>
> In his course of instruction, the author was led to a careful and frequent inspection of the performances of his pupils, and to criticize every letter, and parts of letters; thus, when he observed a defect in the part of an *n*, *m*, *h*, *p*, &c. he required his pupils to draw several of these distinct parts, and labored to correct the errors and defects of their pen.[119]

Unlike the insistent display of virtuosity in the *Universal Penman*, Jenkins's preface self-consciously constructs its author as the possessor of a naturally impoverished hand, who has necessarily had to construct the system that follows from his own empirical experience. There is emulation here, certainly—the observation and appreciation of another's work led Jenkins to recognize his own deficiencies and strive to alleviate them. However, the path to achievement

[118] Jenkins, *The Art of Writing* 1791, 10.

[119] Jenkins, *The Art of Writing* 1813, viii.

was not through rote imitation—indeed he "despaired of ever obtaining a handsome hand" by this method. Instead, Jenkins's success was achieved through scientific analysis in the observation of his pupils and not, it should be noted, in imitation of his supposed superiors. The work he describes seems to foreshadow the motion studies of Frank and Lilian Gilbreth, undertaken in the early twentieth century, at the dawn of modern management science.[120] [Figure 1.14] Fitting workers' hands with an electric light to record their movements, the Gilbreths sought to rationalize and streamline the repetitive processes that constituted industrialized labor. Working a century earlier, Jenkins used nothing but his own eyes to study the motions of his pupils, but his method is, like the Gilbreths' photographs, an attempt to scientifically understand and refine manual action so as to achieve a reliable and consistent product.

Earlier studies of Jenkins's work have focused on his method as a democratization of the copybook's emulative system, highlighting Jenkins's pursuit of what Richard Bushman has called a "modest, vernacular gentility."[121] Where a work like Bickham's *Universal Penman* features two hundred fifty-one plates, showing dozens of different styles and manners of ornamentation in an attempt to highlight the penman's virtuosic performance, *The Art of Writing* offers instructions for the formation of only a single, straightforward roundhand, suitable for men and women of the middling sort—a term used by contemporaries "to refer to shopkeepers, manufacturers, better-off independent artisans, civil servants, professionals, lesser merchants, and the like."[122] Similarly, scholars have highlighted Jenkins's embrace of the printed

---

[120] Frank Gilbreth, *Motion Study* (New York: D. Van Nostrand Co., 1911); Reginald Townsend, "The Magic of Motion Study," *The World's Work*, July 1916, 321–36; Anson Rabinbach, *The Human Motor: Energy, Fatigue, and the Origins of Modernity* (Berkeley: University of California Press, 1992).

[121] Quoted in Richard S. Christen, "John Jenkins and The Art of Writing: Handwriting and Identity in the Early American Republic," *The New England Quarterly* 85, no. 3 (September 2012): 516. See also McGill, "The Duplicity of the Pen"; Thornton, *Handwriting in America*; Williams, "Without a Borrowed Hand."

[122] Margaret R. Hunt, *The Middling Sort: Commerce, Gender, and the Family in England, 1680-1780* (Berkeley:

copybook's more distributed audience, emphasizing his advertisement of the system's particular utility in rural locations, where the distance from established schools and the expense of private tutoring pushed formal instruction out of reach.[123] But the changes wrought by Jenkins's manual go beyond attempts to access an expanded audience newly responsive to the social advantages of writing a fair hand. Certainly *The Art of Writing* extended the copybook's emulative model to a wider constituency, but it also reimagined that model using mechanical production as more than just a means of distribution. Mechanical reproduction became *The Art of Writing's* organizing principle.

Ingenious Mechanics

The idea that Jenkins's method employs the logic of mechanical reproduction has already been touched upon in the work of Meredith McGill. Her comparison between Jenkins's incremental method of handwriting instruction and the principles of moveable type has highlighted *The Art of Writing*'s clear dependence on the language and operations of print production.[124] Jenkins's text speaks of how correct forms must be "impressed" on the student's mind, and his notion of characters that are "instantly ready to drop from the pen when called for" shares many of the same principles of uniformity and automation that characterized Gutenberg's revolutionary invention. McGill's printerly analogy is highly useful, drawing our attention to Jenkins's own self-consciously constructed affinities between manual and mechanical reproduction. However, it also masks a much more essential relationship between *The Art of Writing*'s methods and mechanical principles.

The manual begins with simple accounting of the six principal strokes identified as

---

University of California Press, 1996), 15.

[123] McGill, "The Duplicity of the Pen," 43–44; Christen, "John Jenkins and *The Art of Writing*."

[124] McGill, "The Duplicity of the Pen," 45.

fundamental to the art of writing and explicit instructions on their formation and recombination.[125] [Figure 1.15] These pages describe the construction of each letter in some detail, with Jenkins giving instructions as to appropriate thickness and length of each basic stroke, followed by an illustration of how this stroke might combine with another to form a more complex letter. [Figure 1.16] Following this introduction, we find a series of summary charts, in which the construction of each character is drawn out, stroke by stroke. [Figure 1.17] These charts are interleaved with dialogues that ask the student to recite from memory the characteristics of the principle strokes and the various letters that might be formed from each. Copious directions for proper posture and a proper grip are then followed by "exercises of the pen"—a series of postures and movements to be executed with a dry quill in hand, so as to accommodate the student's body to a proper form before ink is ever put to paper.

Dissecting the alphabet into what can only be called a set of interchangeable parts, Jenkins's method engaged with a new logic of assembly then emerging among the manufactories of Europe and the United States. A hallmark of modern industrial production, the principle of interchangeable parts was first introduced in 1760s France by Jean-Baptiste Gribeauval, as a means to streamline the production of cannon carriages. In the late 1790s, Eli Whitney began a series of experiments with interchangeable musket locks, which culminated in a public demonstration for the president and several members of Congress, fitting ten different lock mechanisms to the same musket using only a single screwdriver. This ideal of standardization and replicability was to have far-reaching effects on U.S. industry, giving rise to what has come to be known as the "American System of Manufacturing."[126]

---

[125] Unless otherwise indicated, references to *The Art of Writing* from this point on will indicate the 1813 edition, which offers a more robust and detailed account of Jenkins's mechanical system of instruction.

[126] See Merritt Roe Smith, "Eli Whitney and the American System of Manufacturing," in *Technology in America: A*

The success of a system based on interchangeable parts relies on the exercise of control in two separate, but interrelated, categories: precision and uniformity. With respect to artillery manufacture, "precision, as measured against a background uniformity, ensured that a single weapon behaved the same over time. And uniformity, as measured with precision, ensured that numerous weapons behaved similarly to one another."[127] With respect to handwriting, this system returns us to a notion of likeness valorized by the copybook's emulative tradition, but in such a way that no single model is privileged as a masterful point of origin. Instead the system promotes the possibility of multiple originals, each identical to each other, but originating independently at the stroke of the student's own pen.

It is worth drawing attention to the strangeness of this idea at the turn of the nineteenth century. The possibility of "multiple originals" suggested by Jenkins's model strongly correlates to what Mimi Hellman has identified as the eighteenth century's fascination with serial design or "The Joy of Sets." Arguing that the tendency among historians and curators to privilege originality has distorted our view of the period's material culture, Hellmann turns her focus to the preponderance of matched sets in French decorative arts of the eighteenth century, asking "what it meant to make objects that look alike in a culture in which alikeness was not a given." What did it mean "to reproduce before the age of mechanical reproduction?"[128] With these questions, Hellman tries to de-familiarize the fact of self-similarity so prevalent in modern culture, drawing

History of Individuals and Ideas, ed. Carroll W. Pursell (Cambridge, MA: The MIT Press, 1981); Robert Woodbury, "The Legend of Eli Whitney and Interchangeable Parts," *Technology and Culture* 1 (Summer 1960): 235–53. It should be noted that Whitney's demonstration was largely a sham. The demonstration offered evidence of the *principle* of interchangeable parts, but Whitney's actual method of fabrication never actually approached this level of industrialization. The set of bores and locks that Whitney used in his demonstration were carefully and individually crafted so as to be variously reassembled, but the same standard did not hold true within his manufactory more generally.

[127] Alder, "Making Things the Same," 509.

[128] Mimi Hellman, "The Joy of Sets: The Uses of Seriality in the French Interior," in *Furnishing the Eighteenth Century: What Furniture Can Tell Us about the European and American Past*, ed. Dena Goodman and Kathryn Norberg (New York: Routledge, 2007), 131.

our attention to the really extraordinary phenomenon of alikeness in a culture where everything was made by hand. She argues that the homogeneity of matched sets in the Rococo interior offered the opportunity to display virtuosity in artisanal manufacture. The production of self-similarity was a way of asserting individual dominance over manual accident. Relying on Alfred Gell's notion of the "technology of enchantment," Hellmann writes, "The object attracts through a kind of opacity; it is compelling precisely because its manifest madeness is at odds with the natural behavior of intractable physical materials and awkward human hands."[129]

The desire to control this intractability of matter and human fallibility is, in large part, what brought about many of the innovations of the early industrial era, including the principle of interchangeable parts. It was not the pursuit of mechanical intelligence *per se*, but rather the incremental adaptation of traditional methods of manual precision to techniques of mass production that resulted in modern systems of automated assembly. Although Eli Whitney claimed that, “[one] of my primary objects is to form the tools so the tools themselves shall fashion the work and give to every part its just proportion,” analysis of his workshop system has revealed his innovations lay, not in the automation of production as he himself advertised, but in the system of divided labor he devised, controlled by gauges, guides and rulers, which could regulate similarity across multiple objects produced by multiple sets of human hands.[130]

It is in this refinement of physical operations and the elimination of material accident that we find an underlying definition of the mechanical, one that bridges between an earlier notion of the mechanical as fundamentally linked to the body and a more modern understanding of its connection to the machine. The field of mechanics, whether in relation to bodily movement or

---

[129] Ibid., 141. See also, Alfred Gell, “The Enchantment of Technology and the Technology of Enchantment,” in *Anthropology, Art and Aesthetics*, ed. Jeremy Coote and Anthony Shelton (New York: Oxford University Press, 1992).

[130] Quoted in Smith, “Eli Whitney and the American System of Manufacturing,” 47.

the operation of an automated device, necessarily concerns the unavoidable tension between concrete materiality and abstract ideals of precision. In one of the essential texts on mechanics used in eighteenth and early nineteenth century America, William Emerson describes the underlying set of assumptions that define the field's study,

> We are to suppose all planes perfectly even and regular, all bodies perfectly smooth and homogenous; and moving without friction or resistance, lines perfectly straight, and inflexible, without weight or thickness; cords extremely pliable; &c. For tho bodies are defective in all these; and the parts of matter whereof engines are made, subject to many imperfections; yet we must set aside all these irregularities, till the theory is established; and afterwards make such allowance as is proper.[131]

Although mechanics is fundamentally concerned with the action of one form of matter on another, its principles are taught in an essentially dematerialized world.[132] The language of Emerson's text is exceptionally evocative—"tho bodies are defective," they are assumed to be "perfectly smooth and homogenous;" although "subject to many imperfections," lines are "perfectly straight and inflexible, without weight or thickness." The plates that accompany Emerson's text offer a wonderful illustration of the field's essential tension. [Figure 1.19] Held together by a sturdy integument of white space, these graphics combine diagrammatic traces of the flow of forces (numbers 28, 29, 31, 33, 34 and 34 on the accompanying plate) alongside more illusionistic renderings of these principles' practical applications (numbers 32, 36, 37, 38, 39 and 42). Line in these images slips between a state of geometric abstraction and signifying substance, its common appearance in both instances confusing what is real and what is ideal. Material reality is invoked, as with the tree and rope in an illustration of pulley design, only to be overset by an absurdity of scale that renders the whole exercise diagrammatic.

---

[131] William Emerson, *The Principles of Mechanics* (London: Printed for G.G. and J. Robinson, in Pater Noster-Row, 1794), 2.

[132] Ibid.

We find a similar set of concerns enacted in *The Art of Writing*. Jenkins's instructions on proper posture and exercises of the dry pen are attempts to train the body in a precise choreography so as to limit its unruly interruptions and minimize its capacity for error. Likewise, Jenkins's discourse on the "Movement of the Pen" connects a letter's elegant proportions to the "proper, natural, and easy motion of the fingers" and seeks to engender such movement by guiding readers through a series of what he calls "skeletons" for each of the principal strokes. Given Jenkins's desire to reform or reframe the actions of the body via these diagrams, his choice of an anatomical metaphor here is rather apt. These frames would form the physical structure around which the penman's movements would be built. [Figure 1.20] In the "j stroke" skeleton, a pair of converging lines guides the downstroke's taper, signaling to the writer a gradual release of pen pressure. A carefully placed circle secures the radius of the lower swell, while the elongated em-dash acts as a spacer to measure out the upstroke's dotted line track. Using handwriting's conventional elements of lines, circles, and dashes in a manner foreign to their typical use, these skeletons bear a strong resemblance to the wireframe diagrams of Emerson's text on mechanics, while they function in principle like the metal rules, gauges, and jigs that would have populated a machine shop like Whitney's. They would have enforced what David Pye has called "the workmanship of certainty," a means of production in which the outcome of each operation has been predetermined. Contrasted with the "workmanship of risk," which privileges judgment, dexterity and care, the workmanship of certainty is, in Pye's words, "always to be found in quantity production, and found in its pure state in full automation."[133]

The extraordinary character of these skeletons becomes particularly pronounced when compared with the lush and luxurious engravings of the copybook tradition. Such works were

---

[133] David Pye, "From *The Nature and Art of Workmanship*," in *The Craft Reader*, ed. Glenn Adamson (New York: Berg, 2010), 341–42. Notably, Pye chooses penmanship as his prime example of "the workmanship of risk," contrasted with modern printing as "the workmanship of certainty."

driven by a desire to transcend their own printedness, to convince viewers that what they saw was in fact the authorial inscription of the master penman's own hand. As discussed above, there are numerous distinctions to be made between the penman's practice and that of the engraver, such that this translation of the written line into the engraved one is not so much an act of transcription as it is one of transformation. The penman's scroll is produced by rotating hand and pen around on paper, such that the line's thickness changes in accordance with the pen nib's orientation to the page. The engraver's curve is, in contrast, created by rotating the plate beneath his hand.[134] In engraving, the thickness of a line is determined not so much by its width on the printing matrix, but by its depth, as a deeper well holds more ink.[135] Thus the engraver must translate the subtle variations in shade and thickness that come with the penman's lightest change in pressure into the copperplate's shallow landscape of varying relief. In spite of these, and many other challenges, engravings in a work like *The Universal Penman* appear effortless, spinning off into hypertrophic displays of ornamental flourish that belie the two mediums' material distinctions. [Figure 1.9] In contrast, the engravings and woodcuts used in *The Art of Writing* sit awkwardly on the page, neither part of the printed text, nor a convincing replica of the pen-marks they direct the reader to produce. Where the *Universal Penman* offers images, *The Art of Writing* offers diagrams, showing movements to be enacted rather than images to be reproduced.

This categorical difference between image and diagram is the substance of Jenkins's innovation in handwriting instruction and the key to understanding the significance of his method to both a history of the mechanical arts and a history of mechanical drawing in the early Republic. John Bender and Michael Marrinan have defined diagrams as "visual forms of

---

[134] On the curve in engraving practice, see Richard Benson, *The Printed Picture* (New York: The Museum of Modern Art, 2008), 28; Michael Gaudio, *Engraving the Savage: The New World and Techniques of Civilization* (Minneapolis: University of Minnesota Press, 2008), 48–54.

[135] Benson, *The Printed Picture*, 30.

description that make few concessions to imitation, meaning by 'imitation' a staging of content as if belonging to a world both contiguous and similar to our own," comparing them to other so-called "working objects" that occupy a space between raw nature and concept, between materiality and idealization.[136] This diagrammatic operation is where the essence of mechanical reproduction in Jenkins's work lies. In its use of graphic means to bridge the gap between a material world rife with idiosyncrasy and an idealized one in which parts and processes are perfectly smooth and seamless, the diagram offers a space in which the mechanical's older associations with the manual, the tactile, and the technical are conjoined with its newer implications of precision and automation. In diagrammatic space, both are subject to the same rules, the same controls, the same assumptions. The organization of Jenkins's manual on the principles of mechanical reproduction is achieved, not through any analogy with a particular machine like the printing press, nor even by analogy with more contemporary models of industrial production, but by its institution of a system and set of graphic standards that reconfigure the body as though it were itself a machine.

The rather draconian potential of this method is teased out in the manual of Jenkins's most influential successor, Benjamin Franklin Foster. In Foster's "Carstairian system," the penman's novice hand may be carefully bound in order to limit its range of motion to only those mechanical operations necessary to successfully execute a proper letterform. [Figure 1.21] Such limitations are akin to the engineer's attempts to limit a given mechanism's "degrees of freedom," as various forms of material constraint are implemented to increase the mechanism's

[136] John B. Bender and Michael Marrinan, *The Culture of Diagram* (Stanford: Stanford University Press, 2010), 33. The term "working objects" is borrowed from the work of Lorraine Daston and Peter Gallison, and refers to late eighteenth-century scientific atlases that may "be seen as a hybrid of the idealizing and naturalizing modes." Bender and Marrinan highlight the correspondence between this hybrid mode and "the productive discontinuity established by the use of visual catalogues and tableaux in the diagrams of the *Encyclopedia*."

efficiency in movement along a prescribed path.[137] Although Jenkins's model stops short of direct physical intervention, his instructions and diagrams certainly posit the body as an instrument or machine whose parts must be coordinated and synchronized in order to harmoniously execute its proper function. Such associations are confirmed by the text of one of Jenkins's imitators who, having not so much adapted as plagiarized *The Art of Writing's* illustrative plates, refers in his text to the bodily positions necessary "to keep our wonderful piece of machinery in order."[138]

Republican Machines

Jenkins's mechanical model of instruction places his work at the intersection of a set of practical and philosophical concerns particular to the early Republic's nascent Industrial Revolution. Debates over political economy in the early national period sought to defend the country's adherence to one of two seemingly antithetical constructions, either the genteel pastoralism undergirding Jeffersonian democracy or a self-sufficient proto-industrialism advocated by a Federalist like Alexander Hamilton. The former position relied on a classical tradition in which the mechanical arts, and all their associations with carnal corruption, were opposed to the morally improving activities of agriculture and husbandry, as Jefferson himself articulated in his 1787 *Notes on the State of Virginia*: "While we have land to labour then, let us never wish to see our citizens occupied at a workbench, or twirling a distaff. Carpenters, masons, smiths, are wanting in husbandry: but, for the general operations of manufacture, let our workshops remain in Europe."[139] But Hamilton's industrializing ideology eventually won the

---

[137] Müller-Sievers, *The Cylinder*, 34–98, 139–42.

[138] James Carver, *A New and Easy Introduction to the Art of Analytical Penmanship* (Philadelphia: Hall and Pierie, 1809), 37.

[139] Thomas Jefferson, *Notes on the State of Virginia* (Richmond, VA: J.W. Randolph, 1853), 176.

upper hand, its success due to its proponents' ability to naturalize the machine's activities and effects, incorporating industrial manufacturing into the agrarian logic by which the American experiment in republicanism had heretofore defined itself. This naturalization was effected by emphasizing the labor-saving capacity of mechanical devices—first spinning wheels, then water-powered spinning frames, then automated looms, and so on. Such devices would occupy the unskilled, but idle, hands of women and children (i.e. those already supposed unfit for republican citizenship), while the nation's male population would be left free to participate in what both the agriculturalists and the industrialists referred to as the morally and culturally improving work of husbandry and cultivation.[140]

Jenkins's *Art of Writing* was closely aligned with this ideology. Among the principal benefits that Jenkins believed would accrue to society through an adherence to his methods were: 1. An economy of time and money—his method promised the acquisition of the art of writing "in half the time consumed in the common way," and 2. A significant improvement in the soundness of mind and body among America's youth.[141] Although as noted elsewhere, *The Art of Writing* openly embraced association with the mechanical arts, and its careful attention to the positioning and maneuvering of the penman's body reminds the reader of connections to an older notion of the mechanical arts as manual labor, Jenkins's promotion of the method's time and labor-saving attributes connects it to an ideology that viewed the machine as an asset to, rather than a detraction from, the maintenance of a free and virtuous society. Far from a corrupting influence, *The Art of Writing* was marketed as a healthful and productive exercise of the human mind and body. In addition to the encomia from noted men of letters and practical school instructors that typically decorated the front leaves of any new educational text of the period, Jenkins included

[140] See Kasson, *Civilizing the Machine*, 3–36.

[141] Jenkins, *The Art of Writing* 1813, 9.

recommendations from noted physicians like Benjamin Rush, who believed the system to be "easy and natural; and that the action of the muscles, and the circulation of blood, are less interrupted by it, than by any of the usual positions in writing." Likewise, Doctors Danforth, Warren and Spring were "fully of opinion, that by giving less interruption to respiration, and to the circulation of the blood, and admitting of a free and easy action of the muscles, it is preferable to any other in common use."[142] With these statements, Jenkins's graphic system was declared harmonious, not only with those systems necessary to sustaining biological life, but also those social systems necessary to sustaining republican virtue.

This coordination between internal and external systems relates directly to a mechanistic understanding of human physiology developed throughout the Enlightenment and employed in the United States' early national period to link the individual citizen's soundness of mind and body with the political health of the Republic.[143] In attempting to understand the formation and operations of human thought, sensationist philosophers of the eighteenth-century asserted an inviolable chain of cause and effect that explicitly linked external sensation to human action and cognition.[144] This theory found its most aggressive and controversial proponent in Julien Offray de La Mettrie, whose treatise *L'homme machine* rejected the notion of an immaterial soul altogether, concluding instead "that man is a machine, and that in the whole universe there is but

---

[142] Ibid., 8.

[143] Colleen E. Terrell, "'Republican Machines': Franklin, Rush, and the Manufacture of Civic Virtue in the Early Republic," *Early American Studies* 1, no. 2 (Fall 2003): 102. See also, Paul Gilmore, "Republican Machines and Brackenridge's Caves: Aesthetics and Models of Machinery in the Early Republic," *Early American Literature* 39, no. 2 (2004): 299–322.

[144] For a discussion of sensationism in its broader historical context, see Jessica Riskin, *Science in the Age of Sensibility: The Sentimental Empiricists of the French Enlightenment* (Chicago: University of Chicago Press, 2002); John C. O'Neal, *The Authority of Experience: Sensationist Theory in the French Enlightenment* (University Park, PA: The Pennsylvania State University Press, 1996).

a single substance differently modified."[145] Mechanical explanations also found their way into the less polemical, but far more influential, works that exercised a profound effect on Jenkins and his generation. John Locke's notion of the mind as a *tabula rasa*, receptive to the direct impression of the body's sensory input, undergirds Jenkins's insistence that "as the pen must follow the mind of a writer, a just idea of the best formed characters ought to be well impressed on the mind, that they may be instantly ready to drop from the pen when called for."[146] Likewise Jenkins's analogy of the ingenious mechanic, who "will ever obtain, as far as possible, a clear and distinct idea of all the component parts of the machine which he is about to form," finds its origins in mechanistic models of human cognition, such as Étienne Bonnot de Condillac's *La Logique*, translated into English in 1809 by Joseph Neef. Condillac's work compares the structure of human thought to the structure of a machine, arguing that as one must decompose and recompose a machine in order to understand its power or structure, so must one deconstruct and reassemble one's own thoughts.[147]

And so we find that *The Art of Writing* is built upon a single fundamental premise: that both the human body and the written form are like machines. Both are composed of a set of independent but interrelated parts, and by setting those parts in proper relationship to each other, "we shall soon perceive the agreeable effect of that harmony and similarity which will be the natural consequence."[148] Following in the footsteps of Noah Webster, whose *American Spelling*

---

[145] Julien Offray de La Mettrie, *Man a Machine*, ed. Gertrude Carman Bussey (Chicago: The Open Court Publishing Co., 1912), 148.

[146] Jenkins, *The Art of Writing* 1813, 2.

[147] Etienne Bonnot de Condillac, *The Logic of Condillac, Translated by Joseph Neef, as an Illustration of the Plan of Education Established at His School near Philadelphia* (Philadelphia: [unknown], 1809), 19. Perhaps not coincidentally, Josef Neef was also the first translator of Pestalozzi's work in the United States and an early proponent of the Swiss educator's methods.

[148] Jenkins, *The Art of Writing* 1813, 10.

Book of 1789 sought to promote political harmony through uniformity of language, Jenkins believed the systematic repetition of a single graphic standard would produce a unity of feeling beneficial to the political health of the young republic.[149] Richard Christen has argued that Jenkins sought to offer his readers an explicitly Republican penmanship that signaled an alignment with artisanal and mercantile politics against a perceived Federalist aristocracy. But I would argue that Jenkins's work was, to an even greater extent, a Federalist penmanship, concurrent with other forms of graphic standardization that sought to harmonize and unify the country's diverse citizenry behind an identifiable set of national symbols. Jill Lepore has traced numerous such attempts in the fields of grammar and literacy, from the work of Noah Webster to Samuel Morse. More recently Martin Brückner has identified a similar trend in the field of cartography, going so far as to call the development of peculiarly American form of geographic description and representation in the eighteenth and early nineteenth centuries a "geographic revolution."[150]

This impetus toward standardization in the early Republic finds its strongest statement in the work of Dr. Benjamin Rush, the same doctor who testified to the salubrity of Jenkins's instructional model in 1791. Rush's influential, Federalist politics promoted a republic built upon the conjoined labor of both the "mechanical and learned professions," and envisioned a society in which the practitioners of these various professions were brought into political consensus through the process of education.[151] In 1787, Rush had authored a treatise on *The Mode of Education, Proper in a Republic*, in which he argued,

---

[149] Noah Webster, *Dissertations on the English Language* (Boston: Isaiah Thomas and Company, 1789), 19–20.

[150] Jill Lepore, *A Is for American : Letters and Other Characters in the Newly United States*, 1st ed. (New York: Alfred A. Knopf, 2002); Martin Brückner, *The Geographic Revolution in Early America : Maps, Literacy, and National Identity* (Chapel Hill: Published for the Omohundro Institute of Early American History and Culture by University of North Carolina Press, 2006).

[151] Rigal, *The American Manufactory*, 36–41.

> I consider it as 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 government of the state. That republic is sophisticated with monarchy or 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.[152]

Many of Rush's interpreters have attempted to soften the startling character of this text, which can appear to a modern audience familiar with the twentieth century's history of totalitarianism and labor exploitation as extraordinarily dehumanizing. Such scholars have linked Rush's argument with precisely those forms of eighteenth century mechanical philosophy already discussed. In the words of Douglas Sloan, Rush's sentiments have far more to do with Newtonian mechanics than "Orwellian apocalyptics," and as Colleen Terrell has argued, "Contextualizing Rush's vocabulary within the mechanical philosophy that was a hallmark of seventeenth- and eighteenth-century science reveals the ways in which the line between mechanism and *human* nature remained every bit as indistinct as that between the proverbial machine and garden."[153] Rush believed all internal impressions to be the product of external stimuli, and that a moral sense was as environmentally determined as the senses of smell, touch or taste. For Rush, the success of the Republican experiment was ultimately dependent on the internal motivations of the nation's citizens, and those motivations were in turn the result of a system of environmental cause and mechanically produced effect. To produce the unity of will and feeling necessary for a democratically governed people, the various environmental and social stimuli that generated such feeling needed to be standardized and harmonized, largely through the process of education.

Rush's metaphorics and Jenkins's instructional methods are clearly linked by a shared

---

[152] Rush, *A Plan for the Establishment of Public Schools*, 27.

[153] Douglas Sloan, *The Scottish Enlightenment and the American College Ideal* (New York: Teachers College Press, 1971), 201; Terrell, "Republican Machines," 101.

heritage of eighteenth century materialist philosophy and a responsiveness to the particular political climate of the early Republic. Jenkins's manual is thus a useful heuristic in the attempt to understand Rush's commentary, and by extension both the symbolic and functional registers in which "the machine" was understood to operate in this period.

A side by side reading of Rush and Jenkins encourages us to walk back some of the metaphorical softening that historians have applied to Rush's work and to remember the basic strangeness of self-similarity that his call for a nation of "republican machines" would seek to enact. The language and methods of Jenkins's text make clear that to understand the body as a machine in late eighteenth- and early nineteenth-century America is not just to believe it subject to the impressions of external stimuli, but to believe that through the exertions of those external stimuli the actions of both body and mind may be simultaneously disciplined and refined such that the outcomes of these actions might be routinely predictable and uniform. In order to "perform their parts properly, in the great machine of the government of the state," the bodies and minds of Rush's republican machines required disciplining and alignment through precisely the sort of mechanical exercises that Jenkins's manual constructs. The principles of Newtonian mechanics that underlie his system may not be Orwellian apocalyptics, but they do seek to mitigate the effects of idiosyncrasy, irrationality and accident inherent in bodily practice and a resolutely material world.

The effects of this standardization become particularly acute when one considers the basic demographic facts of the early Republic. In a nation of nearly 3.9 million inhabitants—among them individuals of English, African, Irish, German, Dutch and French descent (to say nothing of the Native American nations over which the U.S. had unilaterally imposed its sovereignty)—alikeness was by no means a given in the early Republic. And in a country in which nearly a sixth of the population was enslaved, the conviction that an individual might be turned into some sort of productive (and reproductive) device was by no means innocent.[154] In this context, Jenkins's simplification of the eighteenth-century's manifold alphabets into a single, universal roundhand cannot be identified solely as a democratization of penmanship. It should also be interpreted as an erasure of difference. As discussed above, the eighteenth century's proliferation of hands functioned as signs of gender, class, and profession. Their erasure, in favor of a model suitable to a "modest, vernacular gentility," does not necessarily indicate equality, but rather the assertion of one particular identity as standard. And as with the standards of American citizenship in this period, both Rush's "republican machines" and Jenkins's "ingenious mechanics" have to be understood as fundamentally coded in terms of race (white), gender (male), and class (genteel).

Read in this way, Rush's vision of the "republican machine" is both remarkably radical and deeply problematic—far closer to the dehumanizing implications of advanced industrial capitalism than many of his interpreters have cared to admit. Indeed, his statement appears eerily similar to Andy Warhol's 1963 suggestion that,

> I want everybody to think alike….
> Everybody looks alike and acts alike, and we're getting more and more that way.
> I think everybody should be a machine.
> I think everybody should like everybody.[155]

As Jonathan Flatley has explained, although the precise mechanism by which Warhol links the status of "being-like" and the process of liking remains unclear, he "implies that the appreciation of likeness, of people thinking, acting, and looking alike, sets the stage for liking. Warhol

[154] U.S. Department of State, *Return of the Whole Number of Persons within the Several Districts of the United States, According to "An Act Providing for the Enumeration of the Inhabitants of the United States," Passed March the First, One Thousand Seven Hundred and Ninety-One.* (Philadelphia; London: J. Phillips, George-Yard, Lombard-Street, 1793).

[155] Quoted in Jonathan Flatley, "Like: Collecting and Collectivity," *October*, no. 132 (Spring 2010): 73.

appears to be suggesting that the apprehension of similarity—the work of what Walter Benjamin called the mimetic faculty—is the condition for affective affiliation."[156] To like someone, we must be like that someone; we must reproduce that other as ourselves. To do this is to make ourselves into machines. No one doubts that when voicing his desire to be like a machine Warhol was referring to the large-scale automated instruments of the modern industrial economy. Warhol's entire career depended upon a willful engagement with and perversion of the processes of mass production. But when we turn to Rush and the early Republic in general, we are suddenly cast into doubt, even though Warhol's logic is remarkably similar to the emulative tradition that Jenkins's method sought to reinvent and upon which Rush's understanding of the "republican machine" was based.

Do we hear Rush with the same ears as his audience? Do we interpret his references in the same way? The answer is of course not. But by attending to the work of Jenkins and the other material practices by which Rush's "republican machines" were to be effected, one can begin to understand the varied registers in which his speech operated and to recover perhaps the truly startling character of "the machine" at the dawn of the industrial revolution. In particular, Jenkins's manual is an important reminder that this process of becoming a machine is inseparable from the body. Jenkins's ingenious mechanic and Rush's republican machines are embodied performers—flesh and blood alternatives to Maelzel's "Juvenile Artist," discussed in the dissertation's introduction. And in this way, although our contemporary understanding of the machine may be similar to his, it is and always will be somehow separate.

Following contemporary critiques of the Enlightenment, we are accustomed now to understanding the machine as an instrument of techno-scientific rationalism—part of an ideological structure that subjugates and standardizes the idiosyncrasies of pre-industrial culture

[156] Ibid.

and belief.[157] Certainly Jenkins's strategies for disciplining the body through the precise cataloguing and choreographing of its movements conforms to existing narratives of the Enlightenment, extending from Adorno to Foucault and beyond. But by way of conclusion, I want to suggest that, although the enfolding of manual and mechanical processes into a single stream of production can *and has* effected the subjugation of the hand to mechanical control, their collapse into a hybrid epistemology can also be seen to exercise a destabilizing effect on the structures of Enlightenment rationalization.

Among the structures most fundamental to Enlightenment ordering and control is the alphabet. For thinkers of the seventeenth century, the alphabet surpassed even the printing press as an invention of scientific rationality and epistemological transparency. Organizing the immensity of western language's diverse phonic character into a relatively straightforward system of twenty-six elements, the alphabet represented an extraordinarily elegant and simple solution for the reduction of vast complexity to a small number of basic and interchangeable components. For thinkers like Bacon and Boyle "the 'alphabetum naturae' became one of the standard images of the new science," and "the same image was extended by Leibniz, Locke, Berkeley and Hartley to describe human thought, which, they argued, consisted similarly of basic units or 'simple ideas.' A great aim of philosophy, proclaimed the young Leibniz, was to determine the 'alphabetum cogitationum humanarum'—the alphabet of human thought."[158] In

---

[157] Here, I am thinking in particular of the work of Max Horkheimer and Theodor Adorno in *Dialectic of Enlightenment* and their assertion that "Bourgeois society is ruled by equivalence. It makes dissimilar things comparable by reducing them to abstract quantities." Quantifying and cataloging were for them a process by which human intellect was standardized and made uniform. This process of abstraction made "everything in nature repeatable," preparing the way for industrialization, and industrialization in turn transformed the Enlightenment's supposedly liberated subject into just a member of the herd, capable of only the most impoverished thought. Max Horkheimer and Theodor W. Adorno, *Dialectic of Enlightenment: Philosophical Fragments*, ed. Gunzelin Schmid Noerr, trans. Edmund Jephcott (Stanford: Stanford University Press, 2002), 5 & 28.

[158] Nicholas Hudson, *Writing and European Thought 1600-1830* (Cambridge: Cambridge University Press, 1994),

early America, children's texts like the nearly ubiquitous *New England Primer* synthesized the acquisition of descriptive language with the acquisition of the alphabet to such an extent that the alphabet developed as an active cultural agent, "seemingly able to organize the world around itself."[159] In its attempt to reduce the varied characters that translate verbal language into a restricted set of graphic forms, Jenkins's system, in many ways, reproduces this fascination with the alphabet's systematic character. But by prioritizing the acquisition of the system's six fundamental strokes, Jenkins's system also challenges basic alphabetical order and its intimate connections to contemporary systems of knowledge acquisition. Nowhere, in the entirety of *The Art of Writing*, does the alphabet from A to Z appear. Grouping characters by formal similarity, Jenkins produces, as we have seen, an order based on material structure and bodily movement, not on alphabetic logic.

This challenge to Enlightenment logocentrism is brought up again and again in the work of Jenkins's successors, among them Henry Dean, a prolific engraver and writing instructor who operated schools in both Massachusetts and New York. Over the course of his career, Dean published at least four titles built upon the analytical foundations of Jenkins's model, but his 1806 publication *The Printers Academical Companion* is perhaps the most intriguing.[160] The manual intermingles a history of typesetting with instructions on the proper proportions of both roman capitals and the roundhand alphabet, as well as a series of alphabetically organized penmanship examples, as in a traditional copybook. In an extraordinary plate entitled "A

38.

[159] Patricia Crain, *The Story of A: The Alphabetization of America from The New England Primer to The Scarlet Letter* (Stanford: Stanford University Press, 2000), 100–101. See also Johanna Drucker, *The Alphabetic Labyrinth: The Letters in History and Imagination* (London: Thames and Hudson, 1995).

[160] Henry Dean, *The Printer's Academical Companion: Containing an Account of the Origin and Progress of Printing, the True Method of Forming Letters by Scale, to Any Dimensions: With Geometrical Problems, Illustrated by Examples Beautifully Ornamented for Penmanship ... Collected from the Best Authorities* (Salem, MA: Printed for the author, by Haven Pool, 1806).

Mathematical Projection of the Whole Round Text Alphabet," Dean sought to bridge the gap between printing and penmanship with an analytical diagram illustrating the proportions and proper design of a roundhand script. [Figure 1.22] The plate offers, with great spatial economy, a visual synthesis of Jenkins's analytical model, depicting the various elemental strokes laid atop each other such that the entire alphabet can be contained within an area no larger than three inches square. Such a diagram subjects the alphabet to a morphological study of similarity and variance in the gestures necessary to its construction, but in the process it obliterates any sense of the alphabet as a linguistic code capable of forming words, phrases and eventually intelligible syntax. Apparently "Intended for the Use of Schools and as an Aid to Engravers, Painters, Masons, Etc.," the project conflates the lessons appropriate to a schoolhouse and those necessary for a workshop, suggesting a method of instruction that posits both the gestural and its diagrammatic translation as a universal language essential to the processes of both analysis and construction.

Like Jenkins and Dean before him, Benjamin Franklin Foster's "Carstairian method"—explained and demonstrated in his *Practical Penmanship* (1830) and *System of Penmanship or the Art of Rapid Writing* (1835)—offers a method of instruction based on the deconstruction of the alphabet into its interchangeable component parts.[161] But as indicated by the earlier discussion of Foster's image depicting a pupil's ligature-bound hand, the manual focuses even greater attention on the choreography and control of bodily movement. In *Practical Penmanship*, Foster developed an extensive repertoire of practical exercises to perfect these movements. [Figure 1.23] Using the repetition of a single letter in long unbroken lines to train the free and

[161] Benjamin Franklin Foster, *Practical Penmanship, Being a Development of the Carstairian System* (Albany: B.D. Packard and Co., Printers, 1830); Benjamin Franklin Foster, *Foster's System of Penmanship; Or, The Art of Rapid Writing Illustrated and Explained. To Which Is Added the Angular and Anti-Angular Systems. Exemplified with Plates.* (Philadelphia; Boston: H. Perkins; Perkins, Marvin, & Co., 1855).

fluid motion of the hand, this method transforms these linguistic signs into graphic nonsense. No longer recognizable as distinct letters, these diagrams present us, not with Ms and Ns, but with the "mmms" and "nnns" of pre-linguistic communication. *The Art of Rapid Writing* goes even farther, dedicating an entire chapter to discussing "The Movement of the Arm, Hand and Fingers." Exercises in this section begin by dispensing with the letterform altogether, replacing it with scribbled patches of varying length and density. [Figure 1.24A] Over and again, the accompanying instructions insist that the hand should never lift from the paper, but persist in a continuous and uninflected motion from top to bottom of the page. Subsequent assignments introduce lines and ellipses into these applications of continuous motion, but these are treated as graphic patterns to be repeated, not letters to be read. [Figure 1.24B]

Confronted with these images, what is one to make of their significance within an Enlightenment episteme in which the word is synonymous with knowledge? What kind of subjectivity is produced through their mechanization of the body—a mechanization that actively resists the act of writing's communicative potential? On one hand, their attempts to automate bodily movement readily invite charges of inauthenticity. As William Huntting-Howell has recently argued, the automaton was as much a subject of skepticism as a figure for inspiration in the early Republic's attempts to imagine the ideal republican citizen. Following the same chain of associations between "mechanical" methods of instruction and republican politics, he has focused on the dark side of automation and sympathetic attraction exposed in the eponymous character of Charles Brockden Brown's *Ormond* (1799). A conman and murderer, but also a confirmed materialist, Ormond's uncanny ability to manipulate those around him by inspiring envy and imitation suggests, in Huntting-Howell's words, that the result of a "repetitive and systematized moral perfection is vicious automata" and "the bureaucracy and mechanicity of the self encoded by Rush's emulatory regime is a recipe for disaster—producing technically correct but ruthless or inhuman individuals."[162] Venturing beyond the novel to the public forum of the newspaper, one finds a similar level of skepticism and even vitriol registered *vis à vis* the machine. Alongside advertisements extolling the extraordinary liveliness of automata when displayed as entertainments, the term is used almost as frequently as a term of opprobrium, predictably signifying a lack of independent will and most often directed at political actors who—as puppets of their party, advisors, or financial interests—have failed to act of their own accord. For example, a column in Boston's *Independent Chronicle* from 1799 asked, in establishing the qualities necessary to a member of the electoral college, "Should I not feel mortified in becoming an automaton, and though I might move my *hand*, yet feel unable to move my *tongue*?"[163] In like fashion, although far more problematically, we find an 1803 subscriber to the *Boston Gazette* who, in applauding attempts to educate "the Deaf and Dumb," asks "who can doubt the obligation incumbent on *humanity,* to effect the conversion *(so practicable)* of all those *automatons*, into *real* (and respectable) *men* and *women*?"[164] Capable of action, but not authentic speech, the machine is presented in these excerpts as an entity fundamentally different from their human counterparts, something other, something lesser.

The images and lessons presented in the text of Jenkins and his successors push back against this reading. In contrast, their texts seem to suggest the possibility of an alternate, nonverbal form of intelligence. They use a new, and growing excitement about the machine to engender the valorization of an older mechanical epistemology, one rooted in the body and

---

[162] Howell, *Against Self-Reliance*, 160.

[163] "To the Electors," *The Independent Chronicle and the Univeral Advertiser*, May 9, 1790.

[164] "[Mr Sheriff; Language; Gentleman; Mess. Braidwood; London; Deaf; Dumb]," *Boston Gazette*, August 15, 1803.

displayed through manual skill. The difference between these methods and the emulative tradition upon which earlier forms of instruction were based (both in penmanship and in other arenas of artisanal production) is the conviction that the body's movements can be not only rationalized and systematized, but also visually coded and reproduced. This coding is necessarily a process of abstraction. It requires stripping away the nuances of physical experience. Nothing in Jenkins's diagrams explains how the pen feels in the hand, how its nib slips when the well is overfull of ink, or how it stutters when the well has run dry. Instead, these codes set up a reliable system for enactment. They establish a set of parameters within which the proper turn of the pen or twist of the wrist is not only natural, but inevitable. These kinds of physical phenomena defy verbal description. They are only available via the process of enactment. The work of Jenkins and his successors' gives credence to the idea that this kind of tacit knowledge can and should be systematically taught, and it seeks to produce a set of non-linguistic codes by which this form of intelligence can be communicated.

More than a reaction to the forces of industrialization, these methods are part of the visual language through which an ideology of industrialization was initially formulated. It is useful, then, to compare Jenkins's analogies between hand and machine, formed at the outset of American industrialization, to those proclaimed by Alcott upon the nation's assumption of industrial maturity. There is no nostalgia in Jenkins's assertions, no sense of impoverishment in aligning the arts of the hand with the operations of the machine. Clearly, conditions would change by mid-century, but the work of Jenkins and his successors is instructive as it demonstrates how the seeds of such change were sown through the body itself.

CHAPTER 2

THE LANGUAGE OF DRAWING

Man, in his primitive state, surrounded by innumerable and dissimilar forms, and possessing only a limited language, soon found that he was unable fully to pourtray [sic] the vivid impressions made on his faculties; but by availing himself of the straight and curve line, he was able to represent every thing, living or material. Thus, man, as by a new creation, multiplies resemblances of all he sees or admires on the globe, and joyfully discovers that with two lines he can give apparent life and animation.[165]

Thomas Gimbrede, "Lecture," January 1832

In 1832, Thomas Gimbrede—drawing instructor at the United States Military Academy at West Point—published an extract from one of his lectures at the Academy in the *American Journal of Science and Arts*. Discovered amidst pages of dense description on topics as varied as acoustic rainbows and the habits of cleanliness in birds, Gimbrede's text offers a full-throated endorsement of drawing as a skill indispensable, even intrinsic, to scientific study. With a world so large and varied, and a vocabulary so small and circumscribed, Gimbrede's primitive man struggles to account for his experience of the world until the moment he discovers drawing. In a journal in which scientific inquiry is asserted as humanity's highest calling, the drawing instructor's essay presents his craft as the first, and most essential, tool of scientific investigation. It is a notion of drawing as God-given, elemental and proto-linguistic that pervades early modern

[165] Thomas Gimbrede, "Lecture," *Journal of American Arts and Sciences* 21, no. 2 (January 1832): 364.

culture.[166] From the image-based instruction in Johann Amos Comenius's *Orbis Sensualium Pictus* (1658), praised for showing that a "*picture* is a kind of *Universal Language*" to John Locke's likening of the human mind to "a white paper, void of all characters" on which "the busy and boundless fancy of man" paints "its vast store," graphic inscription was repeatedly invoked as the mechanism by which sensory impressions were communicated to the brain, positing drawing as both the model for and agent of the understanding.[167] Gimbrede's account of primitive man's first encounter with images builds on this legacy, ascribing to drawing a certain Promethean capacity for world-building.

Gimbrede's world is one constructed of resemblances—imitations of a material world observed—and it is this capacity for imitation that has preoccupied scholars interested in the role representation has had to play in the production of scientific knowledge. As Ann Bermingham has argued, for empiricists like Comenius and Locke, scientific illustrations—as iconic representations of the natural world—seemed to neatly side-step the troubling arbitrariness of conventional language, denying any "gap between seeing and knowing and between optical truth and pictorial formula."[168] In his work *On the Rationalization of Sight*, William Ivins insists that perspectival representation initiated a revolution, not only in image making but in spatial thinking, because it promised "optical consistency." A more perfect, because monocular, model of human vision, rational perspective "made it possible to establish logical relations not only

---

[166] Ann Bermingham, *Learning to Draw: Studies in the Cultural History of a Polite and Useful Art* (New Haven: Published for the Paul Mellon Centre for Studies in British Art by Yale University Press, 2000), 42, 71–73. Although the Renaissance revived an Aristotelian tradition that connected writing and drawing under the shared rubric of *graphice*, as Bermingham has argued, it was really the ambitions of the seventeenth century's new science that connected drawing, not just with the physical mechanics of writing, but with the communicative function of language.

[167] John Evelyn, *Sculptura*, quoted in Svetlana Alpers, *The Art of Describing: Dutch Art in the Seventeenth Century* (Chicago: University of Chicago Press, 1983), 96; John Locke, *An Essay Concerning Human Understanding*, ed. Kenneth P. Winkler (Indianapolis: Hackett Publishing Company, Inc., 1996), 33.

[168] Bermingham, *Learning to Draw*, 73.

within the system of symbols but between that system and the forms and locations of the objects that it symbolizes."[169] In other words, the systematic rules of perspective permitted a consistent relationship of resemblance between what one saw on the page and what one witnessed in real space. Building upon Ivins's work (and that of Svetlana Alpers, Chandra Mukerji and Elizabeth Eisenstein, among others), Bruno Latour has argued that graphic inscription offers scientific argument an "immutable mobility"—a portable and permanent means of making the world visible. For Latour, the great innovation of the West's so-called scientific revolution lies not in any fundamental difference in the western mind, economy or politics, but in this more "parsimonious" explanation of a series of incremental changes in graphic technology that inextricably linked scientific authority and visible proof.[170]

Noticeably absent in, although certainly not precluded by, these arguments is any sense of the drawing as a physically constructed object. Latour gets closest, reminding us that picturing is a process of "*making* visible" [emphasis my own] and acknowledging with Heidegger that, "Thinking is hand-work."[171] But even in Latour's analysis, the emphasis remains on what graphic inscription has been able to show rather than what it enacts. Given the privileging of vision within an early modern hierarchy of the senses, a certain "blindness" (if you'll excuse the

---

169 William Mills Ivins, *On the Rationalization of Sight, with an Examination of Three Renaissance Texts on Perspective* (New York: Da Capo Press, 1973), 12.

170 Latour, "Visualisation and Cognition: Drawing Things Together." Other scholars have taken a similar tack. See, for example, Martin Jay's assertion that, "Broadly speaking, the innovations of the early modern era took two forms; the extension of the range and power of our ocular apparatus and the improvement of our ability to disseminate the results in visually accessible ways." Martin Jay, *Downcast Eyes: The Denigration of Vision in Modern Thought* (Berkeley: University of California Press, 1993), 65. More recently, the essays in Horst Bredekamp, Vera Dünkel, and Birgit Schneider's *The Technical Image* have collectively emphasized the importance of style in the construction of scientific and technical knowledge. Although these essays all acknowledge the role of images as active agents in knowledge production, this emphasis on style reinforces the importance of appearance, and thus vision, in the interpretation of scientific imagery. See Horst Bredekamp, Vera Dünkel, and Birgit Schneider, eds., *The Technical Image: A History of Styles in Scientific Imagery* (Chicago: The University of Chicago Press, 2015).

171 Latour, "Visualisation and Cognition: Drawing Things Together," 20.

expression) to the work of the hand is to be expected. Comenius's own explication of the "five outward senses" in the *Orbus Pictus*—a synecdoche of his larger epistemological framework—clearly favors the eye, "which seeth Colours," over the ear, which "heareth *Sounds*, both natural, Voices and Words, and artificial," and both these over the hand, which "by touching discerneth the quantity and quality of things."[172] [Figure 2.1] From Locke's metaphor of the mind as a camera-obscura to Thomas Reid's assertion in *An Inquiry into the Human Mind* that "of all the faculties called the five senses, sight is without doubt the noblest," the power of the eye is inescapable within the Enlightenment's sensationist epistemology.[173]

The hegemony of sight has been in the history and theorization of industrialization as well. As Glenn Adamson has argued, the growing importance of drawings within the design process increasingly placed artisans within a "reactive mode," in which they continued to exercise manual skill and inventive agency, but only in response to designs already worked out on paper. Artisanal expertise became largely a stop-gap solution in the process of moving between sketch and product, and the drawing emerged as a means of administrative control.[174] Along the same lines, Ken Alder has suggested that "by enabling engineers to translate objects into geometric figures, which they could then manipulate and break down analytically, projective drawing enabled engineers to discipline artifacts—and hence to discipline artisans who failed to follow instructions."[175] Recognizing the corrective utility of mechanical drawing, these authors have invoked a Foucauldian account of the period's persistent disciplining of the body through observation and highlighted a parallel narrative concerning the elevation of the eye over the hand

[172] Johann Amos Comenius, *The Orbis Pictus of John Amos Comenius*, ed. C. W. Bardeen (Syracuse, NY: C.W. Bardeen, 1887), 52–53.

[173] Quoted in Jay, *Downcast Eyes*, 85.

[174] Adamson, *The Invention of Craft*, 7 & 18.

[175] Alder, "Making Things the Same," 518.

as the nineteenth century's principal agent of perception.

But is this hierarchy of the senses, in fact, borne out by the objects of scientific and technical inquiry themselves? Consider this pair of images, produced by a cadet at West Point in 1816. [Figures 2.2 & 2.3] The first offers a rigorous and scientific shadow study of a compound form displaying multiple instances of complex curvature. Its network of coded lines, dashes and dots links it to the world of mathematical exercise. Marks that record the object's geometrical construction, lines that delineate its final contour, arrows that indicate the direction of a distant light source—all are similarly precise and equally weighted. The second drawing displays a sensitively shaded rendering, tentatively hinting at tactile sensation. The soft gradient of ink wash that sweeps across the urn's surface gives the object depth, heft, and a mild sheen that suggests an ambiguous materiality. Unlike the hard-edged and carefully drawn shadows of the other drawing, these indicate the subtle interplay between ambient light and physical substance. The light in this image is not a matter of mathematical projection, but a material reality. In isolation, each image seems to fit neatly into predetermined categories. One is a mathematical exercise, wonderfully precise but remarkably abstract. The other a delicate and lyrical rendering of a neoclassical urn, an object made almost tangible by the draughtsman's nuanced brushstroke. Each image seems to encode a different kind of knowledge—the former relying on the observational stance of the scientist, the latter on the embodied understanding of the artist—but within the space of the cadet's drawing book, these two images exist in conversation with each other. They are dependent on each other for explication and justification.

These images illustrate the remarkable fluency of graphic representation—the many and diverse uses to which the draftsman's mark may be put. They certainly suggest the possibility of drawing as a universal language, capable of representing knowledge forms both tangible and abstract, but they also prompt the question: if drawing is, in fact, a universal language, then of what does that language consist? In the previous chapter, I argued that the systematization of graphic instruction we saw in Jenkins's *Art of Writing* had a two-fold effect. On one hand, it rationalized the draftsman's body, transforming his actions into a series of infinitely repeatable movements that could be executed with mechanical precision. On the other, it valorized the exercise of embodied knowledge and the process of graphic inscription as critical forms of nonverbal intelligence. Again, looking to process rather than product, this chapter examines the role that such nonverbal intelligence had to play within the new nation's emergent forms of techno-scientific instruction. Building on the previous chapter's discussion of skill, it examines the reinvention of technical expertise through the practice of drawing. Within a culture of Enlightenment science that focused on "making things visible" and as part of industrialization's division of production into unskilled labor and administrative oversight, the concept of technical expertise had gradually diverged from the manual skills required to manifest it. Drawing proved effective in this process, providing, as has already been suggested, "a universal language" through which technical knowledge might be accessed and shared without recourse to physical experience. However, if we momentarily suspend our understanding of drawing as an image and instead consider it in terms of process, then we come to understand drawing practice as an important conduit for tactile experience and a crucial link between the practices of artisanship and industrialization.

In this chapter, drawing is posited as both a site of action *and* a site of observation, and its utility as an instrument of scientific inquiry and communication is based as much on the knowledge gleaned through the physical act of drawing as it is on the image's mimetic capacity. The chapter's focus is the drawing curriculum at the United States Military Academy at West

Point, the nation's first (and, for over two decades, its only) school of engineering. West Point was, at its inception, more than just a military training-ground. An oft-overlooked site of exchange between art and science in early America, its curriculum privileged courses in natural philosophy, mathematics and drawing over those in the military arts, and its graduates were as much civil engineers as officers, integral to the development of the new nation's physical infrastructure. Self-consciously modeled on the Parisian *Ecole polytechnique* and its predecessors under the *ancien régime*, the Academy participated in the Enlightenment's systematic rationalization of practical knowledge, approaching the theoretical sciences and their material applications as inseparable lines of inquiry. This synthetic curriculum relied upon drawing as a *lingua franca*, again, capable of representing knowledge forms both tangible and abstract. At West Point, cadets applied skills learned from a trained painter and engraver to assignments designed by a French mathematician. In the cache of cadet drawing books stored in the institution's archives, exercises in projective geometry share space with experiments in ink wash, while a thorough knowledge of hydrodynamics, masonry systems and watercolor technique combine in their designs for canal locks and hydraulic foundations. These books illustrate the act of drawing understood as both a form of looking and a form of making. They reveal early America's emergent technical culture as deeply dependent upon a graphic language that engaged both the eye and the hand as instruments of knowledge production.

This chapter engages with a history of sensory epistemology that goes beyond knowledge acquired by the eye to consider, in particular, the sense of touch. It draws on the methods of Pamela Smith and her attempts to recover the tacit skills involved in the production of early modern scientific knowledge and of David Rosand, who has eloquently described the sort of haptic experience embedded in the lines of Old Master drawings.[176] It also engages the scholarship of Jacqueline Lichtenstein, which mines the extraordinary relationship between drawing and touch uncovered in the writings of the French seventeenth century critic Roger de Piles, and it builds upon the research of Wendy Bellion, whose work in *Citizen Spectator* has demonstrated the extent to which the senses were actively politicized in the early Republic.[177] Highlighting the exhibition of trompe-l'oeil painting and pseudo-scientific spectacle as "thresholds for the practice and performance of discernment" Bellion has identified these sites of looking as significant "spaces of citizen formation. [178] Examining West Point as yet another significant site of citizen formation, this chapter suggests that vision was not the only sense being tested in the early Republic and looks at the ways in which the drawing curriculum mandated the integration of sensory experience. The work that follows thus engages with drawing as a form of representation trapped between two modes of knowing—the observational and the performative. It asks that we consider drawing as both a site of resemblance and a site of action, prompting changes in the way we think about the kinds of knowledge early modern technical illustration might encode and the way we understand the role of the body—as a multi-sensory device—in the production of such knowledge.

West Point's Origins

West Point's inception was the result of a number of different, competing needs and ideologies in the early Republic—the recognition that American military success during the

---

[176] Rosand, *Drawing Acts: Studies in Graphic Expression and Representation*, 13–19.

[177] See Smith, *The Body of the Artisan*; Smith, Meyers, and Cook, "Introduction: Making and Knowing"; Jacqueline Lichtenstein, *The Eloquence of Color: Rhetoric and Painting in the French Classical Age* (Berkeley: University of California Press, 1993); Wendy Bellion, *Citizen Spectator: Art, Illusion, and Visual Perception in Early National America* (Chapel Hill: Published for the Omohundro Institute of Early American History and Culture by the University of North Carolina Press, 2011).

[178] Bellion, *Citizen Spectator*, 5.

Revolution had been largely dependent on the participation of foreign military expertise, the woefully inadequate state of national infrastructure, and the insistence that the success of the nation's republican experiment depended on the existence of an educated and technically literate electorate.[179] Months before the first meeting of the Constitutional Convention in 1787, Benjamin Rush published his "Address to the People of the United States" in *The American Museum*, arguing that "To conform the principles, morals, and manners of our citizens to our republican forms of government, it is absolutely necessary that knowledge of every kind, should be disseminated through every part of the united states." To accomplish this, Rush believed the Congress should, in lieu of appropriating funds for the establishment of a new national capital, direct a smaller amount toward the founding of a federal university that might teach subjects uniquely associated with government, commerce, agriculture, manufactures, military defense and fortification.[180] West Point was the eventual outgrowth of Rush's argument, buttressed by similar pleas from George Washington, Pierre Samuel du Pont de Nemours, and Revolutionary War veteran General Friedrich Wilhelm von Steuben, among others.[181]

The continued existence of a small officer's school at a garrison located on "the west point of the Hudson River" provided proponents of this national institution with a foothold

---

[179] See the arguments put forth in Stephen E. Ambrose, *Duty, Honor, Country: A History of West Point* (Baltimore: Johns Hopkins University Press, 1966), 3–23; Todd A. Shallat, *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers* (University of Texas Press, 1994), 79–116; Jennings L. Wagoner, Jr. and Christine Coalwell McDonald, "An Educational Interpretation," in *Thomas Jefferson's Military Academy: Founding West Point*, ed. Robert M.S. McDonald (Charlottesville: University of Virginia Press, 2004), 118–53.

[180] Benjamin Rush and Carey, "Address to the People of the United States," *The American Museum: Or Repository of Ancient and Modern Fugitive Pieces* 1, no. 1 (1787): 8.

[181] On the broader project of a national university and its various proponents, see George Thomas, *The Founders and the Idea of a National University* (New York: Cambridge University Press, 2015). For specific proposals, see George Washington and Jared Sparks, "Speech to Both Houses of Congress, December 7th, 1796," in *The Writings of George Washington*, vol. XII (Boston: American Stationers' Company, 1837), 65–74; Pierre Samuel Du Pont de Nemours and B.G. Du Pont, *National Education in the United States*, Translated from the Second French Edition of 1812 (Newark, DE: University of Delaware Press, 1923); Baron Friedrich von Steuben, "Memoir on Military Academies and Manufactories" n.d., no. 38, Library of Congress, Papers of the Continental Congress, MS Division.

within the Army's Corps of Engineers. The U.S. Military Academy grew out of this garrison, established at West Point in 1778, and there is some evidence that technical instruction was administered to officers stationed there between 1778 and 1782, under engineers from the French legation to the Continental army.[182] A map of the garrison in 1780, published in 1830 by the former secretary to this legation, indicates the presence of not only a library within its borders, but also locations for an engineering school and a laboratory. [Figure 2.4] After a series of abortive attempts, the Academy was officially established by act of Congress in 1802.[183] At its founding, the school's purview was narrow; only twenty engineers and cadets together were to be stationed at West Point, and the academy itself was to be little more than a temporary mathematical school that might shrink or expand as the nation needed to draw on the engineers stationed there.

In 1803, the inadequacies of the original program were recognized, and as indicated in a letter from Corps of Engineers Colonel and West Point Superintendent Jonathan Williams to Congress, "It was soon discovered that mere mathematics would not make either an artillerist or an engineer and a power was given, by law, to appoint a teacher of drawing and of the French language."[184] Between 1803 and 1810, courses in civil engineering, French, and drawing were all taught by the same individual, Francis Desiré Masson, a French engineer and émigré from Saint-Domingue who had graduated from Paris's Ecole royale militaire.[185] Masson was joined by Superintendent Williams himself, who taught mathematics and surveying, as well as a constantly

---

[182] Peter Michael Molloy, "Technical Education and the Young Republic: West Point as America's École Polytechnique, 1802-1833" (Dissertation, Brown University, 1975), 176.

[183] "An Act Fixing the Military Peace Establishment of the United States," Statute I § 27 (1802).

[184] United States Congress, *American State Papers, Class V, Military Affairs*, vol. II (Washington: Gales and Seaton, 1834), 229.

[185] Molloy, "Technical Education and the Young Republic," 249.

shifting cast of characters—among them, English émigré George Barron, who had taught at the Royal Military Academy at Woolwich; Ferdinand Rudolf Hassler, a Swiss émigré educated at the *Ecole polytechnique* and the *Ecole des mines*; as well as several homegrown scholars, to include William Amherst Barron, Alden Partridge and Sylvanus Thayer.[186]

This profoundly volatile institution underwent a significant restructuring and subsequent stabilization in 1817, with the appointment of Thayer as Superintendent. In 1815, Thayer had been dispatched to Europe to survey the continent's institutions of technical instruction and to collect books and materials for the academy's use. Of principal interest was the curriculum of the French *Ecole polytechnique*, the revolutionary inheritor of the *ancien régime*'s multi-tiered system of civil and military engineering. Established in 1794 as the *Ecole central des travaux publics*, the *Ecole polytechnique* sought to centralize and streamline technical instruction, combining the extensive practical training of engineering schools under the *ancien régime* with the pedagogical goals of the Enlightenment.[187] Due to political instability following Napoleon's defeat at Waterloo, the *Ecole* was closed during much of Thayer's time abroad, but he conversed at length with many of the school's professors and returned to the United States with a collection of its annals, textbooks, and notes from the course on descriptive geometry—then unavailable anywhere outside France.[188] Upon his return, Thayer was billeted to West Point to assume

---

[186] Ibid., 242–54.

[187] A comprehensive history of this institution may be found in Bruno Belhoste, *La formation d'une technocratie: l'École polytechnique et ses élèves de la Révolution au Second Empire* (Paris: Belin, 2003).

[188] Evidence of these interactions may be found in Thayer's correspondence: "We have made a contract with one of the Professors of the Polytechnic School for the execution of the models of (Charpente), -de pierres, etc but have found some difficult to procure a set of the tables of Gribeauval—It will probably be necessary that Mr. Gallatin should procure these tables by an application to the Minister of War or at least to borrow them for the purpose of having them copied….We have applied to the French Gov'tment for permission to examine the Mil'y School of Metz & the fortifications of Metz, Lille, Cherbourg & Brest. A very polite answer was yesterday received offering every facility to examine the Mil't'y School but refusing our further request as being contrary to the standing regulations." Sylvanus Thayer to Jonathan Swift, February 12, 1815, quoted in *The West Point Thayer Papers*, Cindy Adams and J. Thomas Russell, eds., (West Point, NY: Association of Graduates, 1965).

superintendency.

Although drawing was taught at West Point from the institution's inception, the subject assumed far greater importance under the revamped course of study undertaken by Superintendent Thayer. A chart provided alongside an 1824 report to Congress by West Point's Board of Visitors provides an overview of Thayer's curriculum and a clear picture of the important role played by drawing within the Academy's instructional program. [Figure 2.5] In the first year (also called the fourth class), the curriculum was entirely composed of basic mathematics and French, to account for the uneven qualifications of students from a variety of backgrounds entering the Academy. But for the third class, two hours of drawing instruction, three days a week, were added to these basic skills. Second class cadets were taught topographic and landscape drawing for two hours, six days a week. And in the final, first class year, drawing was incorporated into the three-hour recitations on the main body of their studies in "engineering and the military arts." Reading through student records, it becomes clear that students who performed well in drawing assessments were frequently ranked at the top of their class generally. The scale on which cadets were graded shifted constantly during these years, but in 1818, drawing itself was assigned a grading factor of 1 and descriptive geometry, a factor of .5; combined they gave to graphic expertise the same weight assigned to drills and military conduct.

Why this emphasis on drawing? To what social, cultural, or even political purpose does it speak? Regarding the similar curriculum at the Ecole Polytechnique, Theresa Levitt has argued for the emphasis on graphic instruction as a pedagogical workaround, permitting the school to recruit and train the large quantity of engineers needed by the Revolutionary government from a population mostly uneducated in higher mathematics. In her words, "the democratization of technical education would be achieved…through a new science of representation."[189] Certainly the same might be said of West Point, where, under Thayer, the cadets' ranks were increasingly open to students from a variety of economic stations.[190] But this graphic emphasis was also more than just a pragmatic solution to a demographic issue; it represented a clear statement regarding the terms in which scientific inquiry was to be understood and the means by which knowledge, of all kinds, was to be acquired. For West Point (like the Ecole) was more than a simple technical school; it was a revolutionary project—an attempt to establish a national system of education and to define the ideal condition of the new Republic's knowledgeable electorate.

Historians of techno-scientific education in America, and of the U.S. Military Academy in particular, have eagerly drawn comparisons between the French system and that installed in the United States under West Point's influence. Peter Molloy's unpublished dissertation "Technical Education and the Young Republic" (1975), has carefully traced the parallels between the French and American institutions, while Todd Shallat's more recent *Structures in the Stream* (1995) has illustrated the cultural controversies engendered in antebellum America by the Academy's wholesale adoption of French military tactics, science and aesthetics.[191] These works join the institutional histories of West Point, and those of American education more broadly, that have principally focused on the formal structures that influenced early technical instruction in this country.[192] However, the changes that West Point wrought were also built on

[189] Theresa Levitt, *The Shadow of Enlightenment: Optical and Political Transparency in France, 1789-1848* (Oxford: Oxford University Press, 2009), 23.

[190] Theodore J. Crackel, "Jefferson, Politics, and the Army: An Examination of the Military Peace Establishment Act of 1802," *Journal of the Early Republic* 2, no. 1 (1982): 35–37.

[191] Molloy, "Technical Education and the Young Republic"; Shallat, *Structures in the Stream*.

[192] The most current of these is Ian C. Hope, *A Scientific Way of War: Antebellum Military Science, West Point, and the Origins of American Military Thought*, Studies in War, Society, and the Military (Lincoln, NB: University of Nebraska Press, 2015, 2015). See also, Marvin J. Anderson, "The Architectural Education of Nineteenth-Century

the foundations of an *ad hoc* system of native educational ventures built up over the course of the eighteenth century. Terry Reynolds has noted the dualistic origins of American engineering practice, tracing its nineteenth-century formation on one hand to French institutional structures and on the other to English empirical science.[193] However, there is still significant work left to do in understanding the content and scope of these less formal, more empirical avenues for pursuing technical knowledge in early America. Traceable largely through newspaper advertisements, student notebooks, and the odd pedagogical treatise, these more informal structures of instruction are important for understanding the growth of technical literacy over the course of the eighteenth century, as well as the political, economic and cultural significance such literacy held within early national society.

Practical Pedagogy and a Universal Language

In eighteenth-century America, vocational training remained largely the purview of traditional apprenticeships while higher education focused on literary and historical subjects taught through the study of Latin, Greek and Hebrew. However, as early as 1709, a third educational path opened up in the guise of private instruction in subjects such as geometry, trigonometry, astronomy, surveying, navigation, and eventually even architecture. [194] These

---

American Engineers: Dennis Hart Mahan at West Point," *Journal of the Society of Architectural Historians* 67, no. 2 (2008): 222–47; Wagoner, Jr. and McDonald, "An Educational Interpretation"; Institute of Western American Art and Denver Art Museum, *West Point, Points West* (Denver: Institute of Western American Art, Denver Art Museum, 2002); United States Military Academy, Edward S Holden, and W. L Ostrander, *The Centennial of the United States Military Academy at West Point, New York. 1802-1902.* (Washington, D.C.: Government Printing Office, 1904).

[193] Terry S. Reynolds, "The Engineer in 19th-Century America," in *The Engineer in America: A Historical Anthology from Technology and Culture* (Chicago: University of Chicago Press, 1991).

[194] Robert Francis Seybolt, *The Evening School in Colonial America.* (New York: Arno Press, 1971). These courses were built upon an existing tradition of evening schools that first appeared in New Amsterdam in the 1660s and offered instruction in reading, writing and cyphering (basic arithmetic). The earliest reference to such an institution with a more expansive, technical curriculum can be found in a 1709 advertisement in Boston. Similar announcements for private instruction followed in Philadelphia in 1723, as well as Boston, New York and

classes were marketed to both the informed artisan and the classical scholar as supplementary instruction. They were envisioned, on the one hand, as a means of disciplining and refining the artisan's exercise of manual skill, and on the other, as a purposeful and practical outlet for gentlemanly study. In the latter part of the century, these topics found their way into designs for more formal academies geared toward the progeny of a growing middle class. They also found expression in a proliferation of technical texts—imported at first, but later published by American authors. *The Country Builder's Assistant* (1797), by Asher Benjamin, is perhaps the best known of these early American publications—combining basic rules of thumb for design and proportion with line-work illustrations in the manner of a pattern book. [Figure 2.6] After 1800, an ever-increasing number of advertisements for "Mathematical Schools" exhibited the American population's desire for a pragmatic, scientifically-based curriculum, with institutions spreading outside the early Republic's major cities to places like Albany, Richmond, Portland, Columbia, and Savannah. Aimed largely at craftsmen, these private classes persisted well into the nineteenth century—antecedents to the American Lyceum movement and the explosion of Mechanics' Institutes in the 1820s and -30s.[195]

Benjamin Franklin's 1749 *Proposals Relating to the Education of Youth in Pensilvania* offers one of the earliest formal statements respecting this "English education" in America—so-called because it privileged pragmatic subjects like English grammar over instruction grounded in the classical languages. Within the context of this study, Franklin's text is remarkable for the pride of place it assigns to drawing within the structure of this more modern education. Desiring that students be taught "those Things that are likely to be *most useful* and *most ornamental*,"

Charleston in the 1730s.

[195] For the history of the Academy movement, see Theodore R. Sizer, "The Academies: An Interpretation," in *The Age of Academies*, ed. Theodore R. Sizer, Classics in Education (New York: Bureau of Publications, Teachers College, Columbia University, 1964).

Franklin highlights the twin arts of penmanship and drawing as the necessary preliminaries to a curriculum otherwise encompassing English grammar, history, and geography, as well as natural history (including gardening, planting, grafting, & inoculating), the history of commerce, and principles of mechanics. He argues, "All should be taught to write a *fair Hand* and swift, as that is useful to All. And with it may be learnt something of *Drawing*, by Imitation of Prints, and some of the first Principles of Perspective." In an extended note, Franklin goes on to explain that,

> *Drawing* is a kind of Universal Language, understood by all Nations. A Man may often express his Ideas, even to his own Countrymen, more clearly with a Lead Pencil, or Bit of Chalk, than with his Tongue. And many can understand a Figure, that do not comprehend a Description in Words, tho ever so properly chosen.[196]

He then further enumerates the many trades in which a knowledge of the practice would be useful—carpentry, ship-building, engraving, painting, and cabinet-making, to name just a few—while later on in the text he specifically highlights the importance of drawing for the nation's technical advancement, noting that instruction in draftsmanship not only prepares a traveler abroad with the tools to document the various labor-saving devices he encounters there, but also trains his powers of observation, the better to translate what he has seen in foreign manufactories to his compatriots at home.[197]

As with the *Proposal* as a whole, Franklin's brief discourse on drawing relies heavily on the educational theories of John Locke, and the language he uses appears nearly identical to that employed by Locke in *Some Thoughts Concerning Education*.[198] Locke similarly places

---

[196] Benjamin Franklin, *Proposals Relating to the Education of Youth in Pensilvania* (Philadelphia: [Benjamin Franklin], 1749), 11–12.

[197] Ibid., 29.

[198] The section on drawing from which Franklin so heavily borrows reads, "When he can write well, and quick, I think it may be convenient, not only to continue the exercise of his and in writing, but also to improve the use of it farther in drawing, a thing very useful to a Gentleman in several occasions, but especially if he travel, as that

instruction in handwriting and drawing at the forefront of his educational program, albeit after an extended section on various means of teaching children to read. But while Franklin's ideas themselves may not be original, their context and implementation are of his own devising. Writing in 1750 to Samuel Johnson, whom he hoped to attract as the director of an academy modeled on the *Proposal*'s framework, Franklin indicated that the balance of students in the school would be boys destined for "merchandizing, Husbandry, or any other Profession (that does not need the learned Languages.)"[199] Presenting his program for the academy to Johnson for critique, he excused its deficiencies with the explanation that its composition was a task "for which I am indeed very unfit, having neither been educated myself (except as a Tradesman) nor ever concern'd in educating others."[200] Franklin's (likely false) modesty aside, it is clear that the *Proposal* was deliberately conceived as an educational model for America's "middling sort" and not the young gentleman of Locke's *Thoughts.*

Parroting Locke, Franklin uses the mouthpiece of a scholar to describe the education of a merchant or tradesman. His *Proposal* thus speaks directly to complex counter-currents at work in the education of America's emergent middle class and the ambivalent status of technical knowledge inside that social sphere. Within the eighteenth century British model of civic virtue, artisanal labor was believed "to deform the body…and degrade the mind," and those who practiced it were, as a class, deemed unsuitable for the mental rigors and civic duties demanded

which helps a Man often to express, in a few Lines well put together, what a whole Sheet of Paper in Writing, would not be able to represent, and make intelligible. How many buildings may a man see, how many machines and habits meet with, the ideas whereof would be easily retained and communicated by a little skill in drawing; which being committed to words, are in danger to be lost, or at best but ill retained in the most exact descriptions?" Locke, "Some Thoughts Concerning Education," 119–20.

[199] Benjamin Franklin to Samuel Johnson*,* October 25, 1750, The Packard Humanities Institute, "The Papers of Benjamin Franklin," accessed May 10, 2017, http://franklinpapers.org/franklin//.

[200] Ibid.

of the virtuous citizen.[201] Within the arts, it was the mental labor of Alberti's *istoria* that gained Royal Academician Sir Joshua Reynolds's celebrated approbation, and not the "mechanical" parts of painting—the handling of line and color, painterly craftsmanship—that so fascinated eighteenth-century connoisseurs. On the other hand, the advances of seventeenth-century science were by-and-large built on the embodied knowledge of Europe's artisan class, and the pragmatism of the seventeenth century's New Science drew attention to this intimate relationship between manual labor and mental exercise.[202]

Thus we find, in educational treatises affiliated with the New Science's empiricism, a coy curiosity about certain manual pursuits that might be suitable to a gentleman. Locke recommended carpentry and turning as acceptable trades. Building on Locke's theories, sensationist philosophers of the eighteenth-century emphasized the importance of manual labor as a means to engage the senses and physically train the body.[203] In *Emile*'s radically empiricist program for the education of a young republican citizen, Jean-Jacques Rousseau argues his student "will learn more by one hour of manual work than he will retain from a whole day's verbal instructions."[204] Rousseau's Emile "is ready for anything. He can handle the spade and hoe, he can use the lathe, hammer, plane or file; he is already familiar with these tools which are common to many trades. He needs only to acquire sufficient skill in the use of any one of them to rival the speed, the familiarity, and the diligence of good work-men."[205] Published over a decade before Rousseau's *Emile*, Franklin's *Proposal* similarly engages with the educational advantages

---

201 Aristotle, *Politics*, vol. VII, 9.1238.b33-a2.

202 This is the central argument of Smith, *The Body of the Artisan*. See also, Long, *Openness, Secrecy, Authorship*.

203 Frederick Binkerd Artz, *The Development of Technical Education in France, 1500-1850* (Cleveland: Society for the History of Technology, 1966), 65.

204 Jean-Jacques Rousseau, *Emile, or On Education*, trans. Allan Bloom (New York: Basic Books, 1979), 199.

205 Artz, *Technical Education in France*, 65.

of manual labor, suggesting, "It would be a Pleasure and Diversion to Boys to be led now and then to the Shops of Artificers, and suffer'd to spend some Time there in observing their Manner of working."[206]

Franklin's gloss on drawing and the preeminent place he assigns to it in his program of study similarly highlight the several ways in which drawing critically negotiated the period's divide between technical and liberal education. His loosely sketched program for drawing instruction, based first on the imitation of prints and second on a familiarity with the principles of perspective, relies on an academic tradition formulated in the artists' academies of Renaissance Italy, in which mimesis and geometry were identified as the two essential components of an artist's training, with geometry (and mathematical perspective in particular) serving to elevate the mechanical skill of mimesis to a science, making it worthy of liberal study.[207] However, in calling out these different modes of instruction, Franklin's text also intertwines a pragmatic approach to early American society—in which genteel accomplishments like drawing were viewed as important to social advancement—with a utilitarian pedagogical tradition that dates back to Bacon's *Novum Organum*. On one hand, drawing was part of a courtly tradition that appended drawing to the accomplishments of a well-educated gentleman; on the other, graphic skills were acquired as the inevitable by-product of advanced mathematical instruction in subjects like geography, geometry, surveying, and perspective.[208]

Franklin's discussion of drawing incorporates these academic, amateur and technical

---

[206] Franklin, *Proposals*, 28.

[207] K.-E. Barzman, "The Florentine Accademia Del Disegno: Liberal Education and the Renaissance Artist," in *Academies of Art between Renaissance and Romanticism*, ed. Anton W.A. Boschloo et al. ('s-Gravenhage: SDU Uitgeverij, 1989), 14–32; Carl Goldstein, *Teaching Art: Academies and Schools from Vasari to Albers* (Cambridge; New York: Cambridge University Press, 1996).

[208] Bermingham, *Learning to Draw*, 34–91. For the Americanist, a brief but useful partner to Bermingham's account of British amateur drawing practices be found in Diana Strazdes, "The Amateur Aesthetic and the Draughtsman in Early America," *Archives of American Art Journal* 19, no. 1 (January 1): 15–23.

traditions into a single, ecumenical definition of drawing—in his own words, a "Universal Language" that is "no less useful to a *Mechanic* than to a Gentleman."[209] This definition of drawing—one that does not seek to distinguish between its useful and its ornamental aspects—is essential to understanding the increasing importance of drawing to both technical and general education in the late eighteenth and early nineteenth centuries. It describes a growing acceptance of drawing as a universally intelligible language that exceeds the possibilities of verbal communication, and as a corollary to this, the central role assigned to drawing as a point of mediation between direct sensory experience and analytical thought.

Evidence of Franklin's pedagogical principles in action may be found in the 1760 notebook of Jasper Yeates, a student at the College of Philadelphia (founded by Franklin in 1751).[210] Concerned with "Trigonometry, Plain Sailing, Surveying with Heights and Distances," the book's pages of text and calculations are liberally interspersed with a variety of diagrams—some offering visual explanations of the text, others clearly graphical solutions to propositions or problems put to Yeates by his instructors or copied from authoritative texts. [Figure 2.7] Yeates's notebook suggests that, in eighteenth-century America, skill in technical drawing was acquired in the course of instruction in surveying, navigation, and other forms of applied geometry, rather than as a subject of study in and of itself.

A similar body of work in the archives of Harvard University illustrates how thoroughly Franklin's utilitarian principles came to permeate American higher education. Long a bastion of the classical curriculum Franklin sought to supplant, Harvard College had, by the 1780s, begun

---

[209] Franklin, *Proposals*, 12.

[210] Jasper Yeates, "Trigonometry, Plain Sailing, Surveying, with Heights and Distances. Collected from the Most Approved Writers on Each Subject" (Philadelphia, PA, May 1, 1760), UPA 3.1660, College of Philadelphia, Archives General Collection of the University of Pennsylvania, 1740-1820.,University Archives, University of Pennsylvania.

to require its students to submit a mathematical thesis at the completion of their third academic year.[211] In the 1790s and early 1800s, perspective renderings of buildings in and around Cambridge became an increasingly popular subject for these theses, finding their place alongside graphic descriptions of various astronomical phenomena, stereographic projections of the globe, precise surveys of local plots of land and exclusively numerical solutions of algebraic problems. Jonathan Fisher's thesis, submitted in 1791, is typical of these submissions and indicative of the many graphic strategies called upon in the service of technical illustration in this period. [Figure 2.8]

Four distinct graphic languages have been incorporated into a single representational space: the spare uniform weight of the perspective exercise, the lushly rendered watercolor wash of Hollis Hall *in situ*, the decorative spray of stylized carnations and strawberries that surround the inscription, and finally the ornamental lettering used to label the various projections and the sheet as a whole. When one considers that, in the 1790s, unique and dedicated manuals existed for landscape painting as distinct from flower painting, and both of these differ again from the graphic conventions illustrated in technical texts, the concentration of all three within a single frame becomes increasingly strange. Consider also that had such a sheet been transferred to a printer for reproduction, the plate that eventually found its way to press would have almost certainly passed through at least three different sets of hands during the process of production—one to engrave the line work, another to execute the shading of both architecture and floral decoration in mezzo- or aquatint, and yet another to undertake the plate's ornamental lettering.

[211] Although the laws of Harvard College had since 1655 decreed that "What Bachelours soever shall present unto the President a written synopsis or compendium of Logick, Naturall Philosophy, moral philosophy AFF (sic) Arithmeticke, Geometry or Astronomy within a week of the Summer Solstice in his third year after his degree," there is little evidence to suggest that a sustained study of geometry, let alone its practical applications, was undertaken at the college until the last quarter of the eighteenth century. Lao G. Simons, "Short Stories in Colonial Geometry," *Osiris* 1 (January 1936): 585 and *passim*.

(This is to say nothing of the distinct process of coloring that would have taken place after the impression had been pulled.) Fisher's thesis thus offers a remarkable catalogue of the multiple manual skills involved in the production of such a drawing and a window onto a world in which the display of analytical thought is intimately tied to the exercise of physical skill.

The French Connection

It was into this practically prepared ground that the pedagogical innovations of the French polytechnic system were transplanted. Franklin's notion of drawing as a universal language has its counterpart in the graphic underpinnings of the *Ecole polytechnique's* founding curriculum, but the preeminent place of drawing within the French system goes back even farther—to the mid-seventeenth century and the artillery schools established at various French garrison towns, where both civilians and military personnel instructed cadets in mathematics, fortifications, artillery tactics, history, and drawing. In 1748, the first modern school of engineering was established at Mézières to provide instruction to the military's apprentice engineers or *ingénieurs volontaires*.[212] It was at the *École royale du génie de Mézières* that the modern idea of the engineer as both scientist and practitioner developed, reflected in a curriculum equally divided between theoretical and practical instruction.

Drawing emerged as a hinge between these two halves of the curriculum, particularly through the study of stereotomy or "*coupes des pierres*"—an arcane progenitor of modern projective geometry that systematized the cutting of solids into discrete shapes.[213] The drawings or "*traits*" of stereotomy are a graphic formalization of a tacit knowledge possessed by stonemasons for centuries, residing at the hazy border between craft and science. Now known to

---

[212] Molloy, "Technical Education and the Young Republic," 2–8.

[213] Bruno Belhoste, Antoine Picon, and Joêl Sakarovitch, "Les exercices dans les écoles d'ingénieurs sous l'ancien régime et la révolution," *Histoire de l'education* 46 (May 1990): 62–65.

history only through reproductions in printed treatises, these drawings traced out the complex intersections of two or more (often curved or inclined) surfaces so as to precisely define the shapes into which stone blocks would have been cut in order to produce such geometries. The example provided here depicts Philibert de l'Orme's famous *trompe d'Anet*, produced by the intersection of a small lobed tower and the conical undercroft on which it rests. [Figure 2.9] The *trait* records this intersection in the course of fifteen separate, but overlayed drawings—each one either a vertical or horizontal slice through the complex construction. Independently, the tower's plan and undercroft possess relatively straightforward geometries. However, their intersection produces wildly idiosyncratic curves that could not have been fully understood prior to their description in the *trait*. As Robin Evans has argued, "The shape of the *trompe* was not merely facilitated by projective drawing, but generated by it."[214]

This projective capacity of stereometry was seized upon at the *Ecole du génie* as a means for the engineer to simultaneously invent and communicate. Refined and systematized first by *Ecole* director Nicolas Chastillon and later by instructor Gaspard Monge, the artisanal techniques of stereometry were gradually transformed into the science of descriptive geometry.[215] In Monge's work, the practical problems of the stonemason were progressively generalized and abstracted to produce a system of graphic notation that allowed the draftsman to 1. rigorously define on the two-dimensional page the full extents of any three-dimensional body and 2. to be able to deduce from this precise representation all dimensions and spatial relationships required

---

[214] Robin Evans, *The Projective Cast: Architecture and Its Three Dimensions* (Cambridge, MA: MIT Press, 1995), 189. A comprehensive description of the construction of the *trait* and the means of its translation into the constructed *trompe* may be found in Evans's chapter on "Drawn Stone."

[215] The history of stereometry and its negotiation of the relationship between craft and science is most comprehensively treated in the work of Joël Sakarovtich. See Joël Sakarovitch, "The Teaching of Stereotomy in Engineering Schools in France in the XIIth and XIXth Centuries: An Application of Geometry, an 'Applied Geometory,' or a Construction Technique?" in *Entre Mécanique et Architecture/Between Mechanics and Architecture* (Basel: Birkhäuser Basel, 1995), 205–20; Jöel Sakarovitch, *Epures d'architecture: de la coupe des pierres à la géométrie descriptive XVIe-XIXe siècles* (Basel; Boston: Birkhäuser, 1998).

to then reconstitute that object in three dimensions.

When the French Revolution dismantled the existing royal institutions for military and engineering instruction, Monge, like many of the instructors from the *Ecole royale du génie*, found his way into the new revolutionary power structure. In 1794, he submitted to the Committee of Public Safety a brief entitled "*Développement sur l'enseignement adopté pour l'École central des travaux publics*," which outlined the program for a new polytechnical institution that would streamline and regularize the many different strands of engineering education that had persisted under the *ancien régime*. The *Ecole central* combined an education in abstract mathematics and theoretical science with practical applications in architectural design, civil engineering, ballistics, hydraulics, mechanics and industrial chemistry, all underwritten by Monge's own course on descriptive geometry. At the *Ecole central*, students were given instruction in the graphic methods of descriptive geometry one hour a day, eight days out of the revolutionary calendar's ten-day week. One day a week they also received a one-hour lecture on figure drawing, and in addition a three-hour drawing practicum every evening of the week.[216] Although the *Ecole central* quickly splintered into the more complex system of *Grands Ecoles*, and its successor the *Ecole polytechnique* became largely a preparatory school focused exclusively on theoretical mathematics, Monge's revolutionary, synthetic and graphically-driven project would be continued at the U.S. Military Academy.

World-making

Unfortunately, no student work survives from the first decade of West Point's existence, thus we have no material record of the drawing curriculum under its first drawing instructor, the

[216] Belhoste, *La formation d'une technocratie*, 201.To supply this practice, a wide array of materials were retrieved from the dismantled libraries of the *ancien régime*, among them innumerable prints and drawings from the *École royale du génie des Mézières*. A large workshop of draftsmen—36 strong in the spring of 1795—was also assembled to produce even more images specifically geared toward the school's curriculum.

French engineer Masson. Given the extraordinary credentials ascribed to him—he was, in Superintendent Williams's words "perfect master of the French and English languages, fully acquainted with all that has been written on the art of fortification, and eminently distinguished in science and general erudition"—we might suspect that graphic instruction was provided in topography and fortification, and possibly more specific courses of architecture and civil engineering, but it is, in the end, impossible to know.[217] What we do know is that the earliest surviving student work from West Point are exercises in topographic depiction—delicately drawn aerial views of imagined landscapes that offered the cadets the opportunity to practice the graphic vocabulary of military plan drawing. The earliest of these is a plan by Cadet A. Brockenborough, dated to 1816 and executed under the tutelage of Christian Zoeller, a Swiss graduate of the University of Karlsruhe and a surveyor by trade, who was brought to West Point by professor of engineering Ferdinand Hassler, alongside 3000 volumes for the institution's library and a substantial collection of surveying instruments.[218] [Figure 2.10]

Brockenborough's fictive landscape fits a conventional type, found scattered throughout the work of his fellow cadets' and canonized in the key instructional text on cartography used at West Point, Charles Stanislas Malortie de Martemont's *Instructions for Officers on Military Plan-Drawing*.[219] [2.11] Like Brockenborough's image, fellow cadets' renderings universally include a winding river, fed by several tributaries and crossed by at least one bridge; forested stands; fields cultivated and open; some evidence of topographic variation, whether hillock or valley; and always at least one gridded municipality of indeterminate size. Such depictions drew,

---

[217] United States Congress, *American State Papers, Class V, Military Affairs*, II: 229.

[218] Molloy, "Technical Education and the Young Republic," 244–52.

[219] C. Malortie de Martemont, *Instructions for Officers on Military Plan-Drawing* (London: Printed by J. Barfield, 1805), i.

in turn, from the cadets' catalogs of topographic conventions, contained in a series of grids that distilled the infinite variety of the Euro-American landscape into a finite set of neatly drawn swatches.[220] [Figure 2.12] The diagrammatic simplicity of the students' "swatch books" positions the draftsman of both maps and views as a landscape taxonomist, responsible for visually assessing the characteristics of various topographic formations and assigning them to a predetermined category. Both the fully-rendered plans and the taxonomic swatchbooks were, like Brockenborough's landscape, occasionally tinted in watercolor, but they also frequently appear only in pen, with densely packed line-work supplying the material specificity otherwise evoked by colored pigment.

As Malortie argues in the introduction to his *Instructions*, "All well-informed military men are convinced, that success in war depends, in a great measure, on the knowledge of the ground where operations are carried on," and so it is that an officer should "know how to survey, and to represent it on paper; or at least, to be acquainted with the topographical signs…so that by inspecting a plan, he may be able to form an accurate judgment of the ground which it represents.[221] The defense of or attack on a military position necessitates a firm grasp of the landscape features—both natural and man-made—that might help or hinder such an action. Topographic drawing was a skill essential to the design of fortifications—the central fixture of military science throughout the sixteenth, seventeenth and eighteenth centuries. The military officer must be able to foresee how fortification and terrain will interact to produce the optimal defensive position while also maximizing the visibility of any approaching enemy. For West

[220] This practice appears in some form in both the course records of the *Ecole polytechnique* and in Malortie de Martemont's text. Its specific use at West Point was later codified in Seth Eastman, *Treatise on Topographical Drawing* (New York: Wiley and Putnam, 1837). Eastman was a member of the USMA class of 1824. His text was used as a textbook at the Academy until at least the Civil War.

[221] Malortie de Martemont, *Military Plan-Drawing*, i.

Point cadets, many of whom never actually entered professional military service, this method of instruction had still additional pragmatic ends—namely the surveying and representation of the American landscape essential to the nation's own self-knowledge and internal improvement.

This line of reasoning closely intertwines the practice of drawing and the exercise of sight, what Michel de Certeau has called the "scopic and gnostic" drive of the aerial view—the desire to see and to possess by seeing.[222] But the observational justification of this exercise is simultaneously undermined by the images' status as pure fancy, objects that strangely unite the utilitarian and the fictional. These topographic studies are, quite literally, "fabrications"—landscapes that have been made physically through the process of drawing. Taking part in what Dennis Wood has referred to as the "naturalization" of geographic knowledge, these images piece together fictional landscapes from culturally determined forms of cartographic convention, repeating and reifying these descriptions to the point that they appear more natural than nature itself.[223]

Take, for example, the matrices of landscape features from which these landscapes were concocted. It is clear these swatches were as much recipes as they were diagnostic tools. In Cadet Richard Delafield's matrix, each landscape formation possesses a specific material equivalent, spelled out in mixtures of pigment. "Vines in cultivated country" are "1 Part Gamboge 1 Lake and ¼ Ink," while "Barren Ground" is a mixture of "Olive Green and aurore" in the same mixture as "Sand." [Figure 2.13] These pages transubstantiate the natural world into unique chemical formulas, pigments that might as easily be deployed to recreate flesh, fur, silk or ceramic as marsh, heath, forest or field. Such formulas foreground the constructed-ness of these

[222] Michel de Certeau, "Walking in the City," in *The Practice of Everyday Life* (Berkeley: University of California Press, 1984), 92.

[223] Denis Wood, *The Power of Maps* (New York: The Guilford Press, 1992), 76–78.

images—objects far removed from the process of empirical observation.

Similarly, we might look at a pen-and-ink study by Cadet Edward Deering Mansfield in which line—the drawing's most basic unit of construction—takes on its own logic with surprising topographic effects. [Figure 2.14] Mansfield's page pulses with linear energy, every square inch of the pictorial field filled. The alternating patches of pattern that spread across the draftsman's fields push and pull the surface of the page, creating a register of spatial depth wholly separate from the topographer's conventions. The river's in-fill—the result of concentric lines propagating out from the contours of the banks themselves—produces spectacular eddies and currents, an appearance of motion and vivacity that stems, not from observed phenomena, but from the practice of drawing itself. [Figures 2.14 - detail] In a Morellian bout of connoisseurship, we can trace the unique quirk of Mansfield's hand in the banks of his river, the ridgeline of his mountains and the perimeter of his marshes—all linked by the same over-articulated curvature, all independent of any real physical referent.

These drawings express an ethos pervasive in the graphic culture of West Point. They exhibit an understanding of the space as a unique and active site of experimentation. It is a pictorial world, yes, but one physically constructed of marks on a page—lines, shapes and shades that are at least as "real" as the objects they purport to represent. Although these drawings predate the tenure of Gimbrede as drawing instructor at West Point, they clearly illustrate the Promethean character he would later ascribe to "the straight and curve line" and the extraordinary capacity for world-building granted to drawing within the Academy's curriculum.

This capacity for world building grows more expansive when we examine the complete contents of a cadet's drawing book. The earliest of these to survive in the West Point archive belonged to Cadet Richard Delafield. Delafield finished at the top of his class in 1818, commissioned as a topographic engineer by the Army's Corps of Engineers upon graduation, and eventually returned to the Academy, serving as its superintendent from 1838 to 1845 and 1856 to 1861. Progressing from exercises in descriptive geometry through the traditional *traits* of stereotomy, shadow studies or "sciagraphy" to topographical sample studies, the layout of fortifications and the design of bastion foundations, the book takes the viewer through an incremental transformation in both the drawings' subject matter and their material specificity. [Figures 2.15-2.16] The latter drawings engage with tactility through illusionism, fooling the eye into seeing what the hand cannot touch. In contrast, the earlier drawings, although they appear materially destitute, offer traces of real time operations in real space. In between, we are presented with objects that play on both the sense of touch and the sense of sight, connected by a common graphic language and controlled by the same manual techniques.

Delafield was a product of Superintendent Thayer's complete overhaul of the West Point curriculum, and in particular, one of the first students to undertake the Academy's new course of descriptive geometry, as taught by Professor of Engineering Claudius Crozet, recruited by Thayer in 1816.[224] Crozet was a student of Gaspard Monge at the *Ecole Polytechnique*, and it is clear from a comparison of the exercises in Delafield's drawing book with notes and examples from the *Ecole*'s archive, that Crozet's course was nearly identical to that taught by Monge and that the fluidity we witness in Delafield's various representational experiments is an integral aspect of polytechnic pedagogy.

As discussed above, Monge's system of descriptive geometry grew out of the courses in stereotomy or "*coupe des pierres*" taught to the French military's *ingénieurs volontaires* at the

[224] Molloy, "Technical Education and the Young Republic," 444. See also, Robert F. Hunter, *Claudius Crozet, French Engineer in America, 1790-1864* (Charlottesville: University Press of Virginia, 1989).

Ecole royal du génie de Mézières.[225] In the exercises Monge devised, students were presented with a set of givens—for example horizontal and vertical projections of two cylinders—and then asked to find and describe within these projections the line of their intersection. [Figure 2.17] Rather than physically construct a model of the coordinate space, students used the alignment of the two projections in relationship to each other and to the line at which the horizontal and vertical planes of projection cross to painstakingly plot out, point by point, the site of intersection. Construction lines traced back and forth across the planes' line of intersection permitted students to coordinate points in the horizontal and vertical projections. The challenge (and extraordinary potential) of these exercises lay not in the description of the relatively simple geometries of points, planes, cylinders, and cones upon which they were based; the tools for coordinating plan and elevation in this manner had existed since the Renaissance. Rather, the promise of descriptive geometry lay in its capacity to precisely describe, through means that could be tested out in the physical space of the page, the complex geometries that resulted from the intersections of these geometrically regular shapes. Descriptive geometry provided a rigorously defined set of spatial parameters into which different formal problems could be inserted, thereby offering a powerful tool for formal and spatial analysis. But it was also a way of simultaneously inventing and communicating an infinite variety of new and mathematically predictable forms—forms that could be tested out within a virtualized coordinate space. As a descriptive, analytical, and projective tool, descriptive geometry provided, in Monge's opinion at least, a universal graphic language through which artists, engineers, and scientists might seamlessly communicate.[226]

---

[225] Belhoste, Picon, and Sakarovitch, "Les exercices dans les écoles d'Ingénieurs," 78–79.

[226] Belhoste, *La formation d'une technocratie*, 196.

Implicit in Monge's understanding of descriptive geometry as this sort of universal language was an appreciation of its method as a physical form of construction. Lorraine Daston has charted the emergence of what she calls a "physicalist" tradition in the early nineteenth century French mathematics upon which much of the instruction at both the Ecole and West Point was based. Citing their "Lockean psychology," she argues that mathematicians of this tradition—among them Monge, Carnot, Poncelet, Chasles and Dupin—preferred the practice of synthetic geometry (with its proofs built upon geometric constructions physically laid out on paper) to analytic geometry (whose proofs existed solely in the realm of numeric abstraction). They did so because both the means and concerns of synthetic geometry lay so much closer to the realm of direct experience and sensation.[227] The movement of lines, magnitudes and angles on the page were not just *signs* of physical manipulation—they were that physical manipulation itself. By this way of thinking, there is an exact and direct correspondence between actions on the page and actions in real space, and to reproduce one of the cadets' geometrical proofs is to gain a very real sense of the physicality of the practice of mechanical drawing and the extent to which the drawing is itself a tangible construction—an object of touch as much as one of sight.

I would like to walk through one of these exercises in order to convey a sense of the material conditions of construction enacted through the drawing process. In 1832, West Point instructor of mathematics Charles Davies published *A Treatise on Shades and Shadows, and Linear Perspective*, which formalized in written method the Academy's course on shadow projection (sciagraphy) and perspective as it had been taught for at least the previous decade.[228] One of the exercises contained in this text appears in Cadet Hannibal Day's 1826 drawing

[227] Lorraine Daston, "The Physicalist Tradition in Early Nineteenth Century French Geometry," *History and Philosophy of Science Part A* 17, no. 3 (1986): 272.

[228] Charles Davies, *A Treatise on Shades and Shadow, and Linear Perspective* (New York: J. & J. Harper, 1832), 58.

book—a figure of an oversized screw shown in raking light. [Figure 2.18] Sciagraphic projections like this one are essentially more advanced versions of the descriptive geometry exercises designed by Monge. They exist within the same coordinate space—the intersection of the two perpendicular reference planes again marked by a line that horizontally bisects the page. However, instead of finding the relatively simple intersection of two geometrically regular cones, Day was tasked here with a far more challenging assignment. This drawing seeks the myriad intersections between a screw's helicoid form and the infinite rays of light projected from a distant source. It describes the shade cast on the unlit side of the screw as well as the shadow cast by the screw on the horizontal plane.

The screw itself is a complex geometric construction—a spiral surface produced by simultaneously rotating and elevating an inclined line (called the "generator") around and along a vertical axis. Before a draftsman can even begin to determine the shape and location of shade and shadow, he has to carefully lay out this helical geometry. The entire procedure begins with just a circle in the horizontal projection, centered on a vertical line that defines the screw's central axis. A diagonal line extending from this vertical axis to the line of intersection between the horizontal and vertical reference planes represents the helicoid's generator. The process of defining the vertical projection of the screw's spiral requires registering, on the page, successive points of stasis in the generator's movement up and around the vertical axis. The solid radial lines that divide up the circle's right hemisphere describe the generator's location in equal increments of rotation. Each dashed line in the dense band at the screw's base indicates how far the generator has moved vertically in the space of one of these radial increments. Dashed vertical lines crossing the reference planes' line of intersection coordinate points of stasis in the generator's horizontal and vertical motion. Plotting these intersections in the vertical projection reveals the circuitous line traced by the screw's upper helix.

This line is the backbone of all of the drawing's subsequent graphic calculations. An isosceles triangle, its apex centered on the path and swept along the rising spiral, defines the upper and lower surfaces of the screw's threads. The arcs fanning out from the plan of the screw connect segments that record the intersection of a ray of light and a tangent plane, revolved around the screw's central axis such that it remains tangent to this spiral. From these segments, the line of shade across the screw's lower surface may be deduced by finding their intersections with the inner and outer perimeters of the screw's threads and tracing these intersections from the plan below into the vertical projection above.

Although a full reconstruction of the drawing process would occupy more space than I have at my disposal—Davies's instructions in *Shades and Shadows* run a full twenty pages of dense mathematical jargon—what becomes clear in even just the small selection I have summarized is the extent to which each line drawn lays the groundwork for the next. As it evolves, the drawing serves as a scaffold for its own production. Following Davies's instructions, one discovers that the drawing is itself as much agent in its own production as the draftsman. The dense network of construction lines and fletched light rays covering the page testify to the importance of this drawing as a working document. Throughout its production, the drawing is itself a machine in action, with the draftsman's hand guided along its path by the guides and gauges of his square and straightedge. These tools slide smoothly against each other, perpetually in motion, defining and redefining the parameters within which the force applied by the draftsman's hand may operate. The lines left on the page are traces of this force, sediments sifted out in the interaction of hand and tool. As lines accumulate on the page, those used to construct the object assume as much significance and substance as those used to delineate its profile. This strange hardening of the ineffable becomes particularly apparent in the description of the shadow cast on and by the screw. Rendered with the same ink and in the same weight as the lines in which the screw itself has been described, the sciagraphic projections make it seem as though light (or rather its absence) has calcified on the paper's surface. Its substance is so demonstrative that, in the plan view of the screw occupying the drawing's lower half, the presence of the screw itself has been obscured by the figure of its shadow.

The physicality of both the drawing process and its product is not incidental. It is deeply embedded in the philosophy that undergirded the polytechnic model. Placing these drawings within the context of the early nineteenth century, we have to understand them as part of a system of education designed to meet the needs of early industrial society and the growing recognition that machinists and mechanics "thought within a different paradigm, not easily expressed in written language, guided by experience and visual representation, and inseparable from the production process itself."[229] During this period, mechanical drawing became an invaluable tool of communication, facilitating the exchange of ideas between designer, client and mechanic without resorting to the use of a verbal vocabulary often inadequate to machines' increasing complexity. However, as discussed at the chapter's outset, drawing has been understood conventionally as a vehicle for administrative control. Identifying the first steps toward modern industrialization as based, not on the division of labor, but on "the labor of division," Glenn Adamson has argued that industrialization is effectively a process that "'enables greater control over the social and material world through enhanced clarity, transparency, and visual certainty *at a distance.*' Only when a task is seen clearly can it be controlled from afar. So

[229] Stevens, "Technology, Literacy, and Early Industrial Expansion," 535–36. See also Edward Stevens, *The Grammar of the Machine: Technical Literacy and Early Industrial Expansion in the United States* (New Haven: Yale University Press, 1995). A similar argument appears in David Brett, "Drawing and the Ideology of Industrialization," *Design Issues* 3, no. 2 (Autumn 1986): 59–72.

techniques of visual representation, like drawing, were necessary for the development of systems of distributed agency."[230] However, an understanding of the engineer's grounding within a "physicalist tradition" brings an entirely other interpretation to bear on the practice of mechanical drawing. An awareness of these drawings as sites of action and physical experimentation allows us to see them as part of a revolutionary, if ultimately failed, project to integrate the experiences of artisan, engineer and scientist. There thus is a subtle, yet important, distinction to be made in recognizing that the world of nineteenth-century engineering is not one in which tacit knowledge has been entirely displaced, but one in which it has been virtualized. A continuity between touch and vision—their necessary coordination—is implicit in these works.

Drawing and Self Knowledge

It is a commonplace of drawing books and pedagogical treatises in the late eighteenth and early nineteenth centuries that the practice of drawing fosters the discernment of the eye and the dexterity of the hand.[231] But behind this commonplace lurks a broader epistemological concern regarding the means by which the human mind collects and coordinates sensory data culled from its environment. Drawing manuals and texts of this period implicitly assert their craft as an essential tool in facilitating such coordination, and what we see in the polytechnic model adopted at West Point is this coordination in action.

Introduced to the West Point curriculum in 1822 by Thomas Gimbrede, figure drawing has a fascinating role to play within this pedagogical model. Gimbrede was a French miniaturist and engraver, appointed by Thayer in 1819 as a replacement for Christian Zoeller. His tenure as drawing instructor was an important turning point in the conceptualization of drawing at the

---

[230] Adamson, *The Invention of Craft*, 17.

[231] See, for example, the work of Charles Antoine Jombert in France or John Rubens Smith in the United States. Charles Antoine Jombert, *Nouvelle methode pour apprendre à dessiner sans maître* (À Paris: Chez Charles Antoine Jombert, 1740); Smith, *Key to the Art of Drawing the Human Figure*.

Academy. He oversaw the development of a clearer structure and progression in West Point's drawing courses and the integration of the technical forms of drawing—geometry, topography, fortifications—already taught at the Academy with a more artistic tradition of instruction based on the French academic model. The few scholars who have even briefly addressed the early drawing curriculum at West Point have largely dismissed Gimbrede's qualifications as a teacher, relying on the opinions of his contemporary and critic William Dunlap.[232] Dunlap's *History of the Rise and Progress of the Arts of Design in the United States* (1834) refers to Gimbrede as one whose prints "show his utter want of skill or knowledge in the art" and who "must have required uncommon talents, or what is called cleverness, to teach that which he did not know."[233] But rather than marvel, as Dunlap did, that Gimbrede's appointment as drawing instructor was "one of the mysteries never to be explained," it seems both probable and more productive to assume that Gimbrede's utility for the Academy was twofold: 1. as an engraver, who might help supply the dearth of printed pedagogical models necessary for instruction across the institution and 2. as a conduit for the technical and artistic renown of his country of origin—in particular the practice of figure drawing.[234]

France was early to recognize the importance of formal technical education for the progress of manufactures and economic success, and in turn, the importance of drawing

[232] The most reliable histories of West Point's early drawing curriculum may be found in David M. Reel, "The Drawing Curriculum at the U.S. Military Academy in the Nineteenth Century," in *West Point, Points West*, ed. David M. Reel (Denver: Denver Art Museum, 2002); Anderson, "Education of Nineteenth-Century American Engineers." Most scholarship on drawing at West Point may be found in accounts of the career of Robert Weir, but these tend to gloss over the particulars of the drawing curriculum prior to Weir's appointment in 1833. See, for example, Michael E. Moss, ed., *Robert W. Weir of West Point : Illustrator, Teacher and Poet*, USMA Library, Occasional Papers 4 (West Point, NY: United States Military Academy, 1976); Betsy Fahlman, *John Ferguson Weir, the Labor of Art*, The American Arts Series (Newark, DE: University of Delaware Press, 1997).

[233] William Dunlap, *History of the Rise and Progress of the Arts of Design in the United States* (New York: G.P. Scott, printers, 1834), 255.

[234] No such objects survive, but the West Point Museum possesses several examples of the institution's first diploma engraved by Gimbrede, so it may be possible the instructor was engaged for this purpose.

instruction to this program of technical education. At the Ecole polytechnique, students were taught to draw from drafts and prints produced by the institution's *bureau des dessinateurs*, staffed by artists educated in the ateliers of Jacques-Louis David, François-André Vincent and Jean-Baptiste Regnault, among others.[235] These models consisted of drawings in red chalk and graphite and depicted figures arranged in conventional academic poses, occasionally accompanied by inked diagrams of the figures' underlying geometries and proportions. [Figure 2.19]

Whether Gimbrede knew of this kind of training first-hand is unclear—perhaps he had been educated in one of the similarly structured *écoles gratuites du dessin*, designed to instruct French youth in principles of design and taste and to better prepare them for entry into various French industries.[236] We do know he introduced a similar course of figure drawing in the cadets' second year of coursework, deeming it "essential to just delineation."[237] The course functioned as the foundation of their graphic instruction, as three days a week they drew from prints (and a few paintings) culled largely from Gimbrede's own collection.[238] The few surviving examples of student work from this period indicate the subjects were predictably classical in tone—from Jefferson Davis's rendering of a helmeted warrior [Figure 2.20] to the sculpted torso of James Duncan's marble fragment. [Figure 2.21]

One of the most interesting aspects of this part of the curriculum is the extent to which it

---

[235] François-Marie Neveu, "Dessin," in *Journal polytechnique ou Bulletin du travail fair à l'École central des travaux public publié par le consel d'isntruction et administration de cette École*, vol. 1 (Paris: L'Imprimerie de la république, 1794), 79.

[236] The history of these institutions is treated in Ulrich Leben, *Object Design in the Age of Enlightenment: The History of the Royal Free Drawing School in Paris* (Los Angeles: The J. Paul Getty Museum, 2004).

[237] Alexander Macomb to Sylvanus Thayer, August, 22, 1822, in Adams and Russell, *The West Point Thayer Papers*.

[238] Thomas Gimbrede to John Quincy Adams, 12 February 1827, quoted in Andrew Oliver, *Portraits of John Quincy Adams and His Wife* (Cambridge, MA: The Belknap Press of Harvard University Press, 1970), 76–77.

had to be justified as essential to the engineer's education. Its introduction at West Point in 1822 was initially on a trial basis, and even instructors at the Ecole polytechnique appeared to exhibit a certain self-consciousness about the incorporation of figure drawing into the school's program of study. The records of the École repeatedly address the incorporation of figure drawing as though to justify the presence of an artistic practice within the otherwise explicitly scientific institution. For example, in his introduction to the school's drawing curriculum, lead drawing instructor François-Marie Neveu argues,

> Figure drawing is an indispensable study; of all possible forms, that of man is the most precise, it is by his form that the perfection of all others is judged. It would thus be appropriate to introduce figure drawing into the education of engineers, not to make them painters *per se*, but to render their instruction in all manner of necessary sciences complete, to link drawing and the other work with which they are concerned.[239]

Similarly, Gimbrede asks,

> What models shall we select, to improve our graphic faculties, and to form our taste?...Among the many regular forms, the figure of *man* stands the most conspicuous, for beauty and symmetry and for intellectual expression. In the attempt to delineate such a difficult subject, correct principles and well selected rules will enable the pupil to establish a perfect harmony betwixt the eye and hand, *the faithful messengers of the mind*…Then it may be said that we are best prepared to apply our graphic knowledge to many of the pursuits and occupations of life.[240]

As we see here, one of the recurrent claims regarding the importance of figure drawing to all manner of technicians was that in mastering the supreme complexity of the body—its convoluted geometries, the motion and relation of its varied parts, one to another—the design of all other

[239] "Le dessin de la figure est d'une étude indispensable; de toutes les formes, celle de l'homme étant la plus precise, c'est par elle que toutes les autres sont appréciées dans leur perfection. Il était donc convenable que le dessin de la figure entrât dans l'éducation des ingénieurs, non pour en faire des peintres proprement dits, mais pour que cette etude en facilitate d'autres, pour completer l'enseignement de diverses sciences qui leur sont nécessaires, pour associer le dessin aux autres travaux don't ils s'occupent." Neveu, "Dessin," 83.

[240] Gimbrede, "Lecture," 364.

objects becomes an issue of relative simplicity. The body thus evolves as an analogue for all sorts of artificial form—be it architectural ornament, military fortification, or mechanical mechanism.

But "*le dessin de l'imitation*," as it was called, also served an alternate purpose. Engineers rely on the communicative capacity of their drawings. In the absence of text, or even an adequate vocabulary to account for all the elements and actions required to construct the objects depicted therein, the drawings' material contents themselves are laden with meaning. Lines acquire semantic significance through the process of their precise combination, and imitative drawing—the actual process of reproducing another's prints and drawings—supplied an effective means to train students in the nuances of graphic semantics.[241] Thus Jefferson Davis's helmeted figure convincingly replicates the manner and style of contemporary neoclassical prints. Likewise, James Duncan's rear view of a classical sculpture recreates the crisp lines and interlaced hatch-work of an engraved model. With these exercises, cadets were instructed in not only the fashionable language of neoclassicism, but also how to imitate the scale, spacing, and texture of the engraver's line and the peculiar linear effects used to distinguish the sheen of metal from the matte surface of cloth.

Figure drawing thus sets up a fascinating recursivity at the foundation of the cadets' graphic knowledge, by which the functioning of the artist's body is trained through the study of the human body more generally. Students learned how to manipulate their hands and direct their fingers, how in effect to control their own bodies by studying the bodies of others. Figure study thus situates the body as both the object and agent of perception. This recursivity suggests the possibility of drawing as a model of self-knowledge, acquired through the simultaneous practices

[241] Carl Goldstein has emphasized that the practice of copying from prints, a staple of French Academic training, in fact grew out of a workshop practice and can thus be associated as much with the practices of artisanal training as with Academic professionalism. Goldstein, *Teaching Art*, 118–21.

of looking and making.

Although historians have been more concerned with the ways in which sight and touch (and the forms of knowledge they represent) diverged in this early industrial moment, the possibility of their convergence was a phenomenon that clearly preoccupied its inhabitants. Writing of the "Utility of Visible Illustrations," nineteenth century educator Walter Johnson makes plain the complex relationship between sight and touch that pervaded the period. He argues that through the eye,

> "we are enabled to reach every intellect. It is the medium which conveys delight to the soul, while it fixes the conviction of truth on the understanding. It is the instrument with which the mind not only grasps and takes up, but also holds fast, while she rivets together into a consistent whole, the separate links in her longest chains of reasoning."[242]

Johnson's language is exceptionally telling. Although he goes on to deride the reliance on touch as a "*childish* propensity," secondary to sight's "mature faculties," he cannot explain the power of vision without resorting to the actions of the hand.[243] Sight "grasps," "takes up," and "holds fast." It is an agent of manufacture, which "rivets together" reasoning's "separate links." Although America's industrializing society may have elevated the visual and applauded its ability to communicate across time and distance, it did not do so without ambivalence. If visual illustration appealed to an early nineteenth century audience, it did so through tactile means.

This argument helps incorporate mechanical drawing into a broader discourse around drawing more generally—one that has long acknowledged the practice's relationship to touch. In the seventeenth century's battle between line and color, the colorists (most notably Roger de Piles) cast drawing as ultimately a material concern, distinct from the transcendental potential of

---

[242] Walter R. Johnson, "On the Utility of Visible Instruction," *American Annals of Education and Instruction* 3, no. 3 (1833): 97.

[243] Ibid., 101.

color. Jacqueline Lichtenstein has argued that for de Piles, drawing “addresses itself not to the eye but to the hand and requires not distance but contact. Since an individual need not see something in order to trace its contour, a blind man could draw very well. How could he paint, being incapable of placing the light and shadow and deprived of the intelligence of *coloris*? But he could sculpt, sculpture being essentially an art of contour and of touch, that is, of drawing.”[244] Throughout the seventeenth and eighteenth centuries, this question of blindness became a central conceit in philosophical debates over the nature of human cognition. Known as the Molyneux Problem, the question of whether a whether a blind man made to see might distinguish by sight shapes he had previously only known by touch obsessed medical professionals and philosophers alike.[245] Fundamentally, Molyneux's Problem asks whether it is possible to translate information from one sense to another. Are visual and tactile concepts essentially the same, or is the information recorded by each sense fundamentally different from the others? How is sense information coordinated to produce complex thought?

The philosophical controversy surrounding the Molyneux problem led to attempts at empirical investigation like the Cheselden experiment, in which Dr. William Cheselden removed the cataracts of young boy blind from birth, subsequently publishing his findings on how the boy seemed to coordinate the new information fed to his eyes with that long ago learned by his hands. It also lead to philosophical treatises like Etienne Bonnot de Condillac’s *Traité des Sensations*, who built his model of sensory perception on the model of Pygmalion’s Galatea, a

---

[244] Jacqueline Lichtenstein, “The Clash between Color and Drawing,” in *The Eloquence of Color: Rhetoric and Painting in the French Classical Age* (Berkeley: University of California Press, 1993), 158.

[245] Molyneux's Problem was brought to the attention of the wider European audience by its publication in the second edition of John Locke's *An Essay Concerning Human Understanding*. Molyneux submitted the query to Locke in a letter sent in 1688, but the problem was not addressed by Locke until the 1694 publication. For a discussion of the problem and its historical context, see Marjolein Degenaar, *Molyneux’s Problem: Three Centuries of Discussion on the Perception of Forms*, trans. Michael J. Collins (Dordrecht: Kluwer Academic Publishers, 1996), 22.

stone sculpture gradually awakened by the animation of her senses, one by one.[246] In the *Traité*, Condillac notably refuses to acknowledge the possibility of full cognition without the sense of touch, believing that in the absence of touch individuals would be unable to distinguish knowledge of self from knowledge of the surrounding world.

As I have sought to demonstrate, drawing at West Point constituted the production of knowledge in just such tactile terms. Cadets' drawing boards were sites of action as much as sites of observation, opportunities for invention and experimentation, places where knowledge about the world and of the self were produced through the simultaneous actions of looking and making. To rely on graphic description as the *lingua franca* of an institution like West Point was to highlight drawing's unique capacity to unite and variously coordinate the experience of the senses as instruments of inquiry and agents of knowledge. Through drawing, technical expertise was again made reliant on the exercise of manual skill, albeit skills of a novel kind. Like the artisan, the technical draftsman was intimately concerned with questions of material manipulation, but those materials were watercolor pigments and india ink. His tools were both the solid implements of rule, straight edge, and compass, but also the graphic traces left by his own hands. Drawing became a mechanism for reconnecting the tangible with the abstract and for relocating the body within the space of scientific inquiry and technological production.

[246] The sensationists' philosophical debates over the relationship between sight and touch are eloquently analyzed in the first chapter of Jessica Riskin, *Science in the Age of Sensibility*, 19–67. See also, O'Neal, *The Authority of Experience*.

CHAPTER 3

THE IMAGE OF INVENTION

That ideas should freely spread from one to another over the globe, for the moral and mutual instruction of man, and improvement of his condition, seems to have been peculiarly and benevolently designed by nature, when she made them, like fire, expansible over all space, without lessening their density in any point, and like the air in which we breathe, move, and have our physical being, incapable of confinement or exclusive appropriation. Inventions then cannot, in nature, be a subject of property.[247]

Thomas Jefferson to Isaac McPherson, 13 August 1813

In the late 1790s, the American artist and engineer Robert Fulton began designing and testing a system of submarine and torpedo warfare along the coast of France. At first, he attempted to market the project to the Napoleonic Navy, but when the imperial government refused to fund his venture, he found himself lured to England with the promise of massive financial reward.[248] The engineer arrived in London in 1803, in the apparent belief that the government would pay out somewhere between £40,000 and £100,000 for his system of warfare—presumably to keep it out of the hands of the French. Over the next three years,

---

[247] Thomas Jefferson to Isaac McPherson, 13 August 1813 in Thomas Jefferson, *The Papers of Thomas Jefferson*, ed. J. Jefferson Looney, vol. 6, Founders Online, National Archives (Princeton: Princeton University Press, 2009), 379–86, http://founders.archives.gov/documents/Jefferson/03-06-02-0322.

[248] Evan Nepean to Admirals Lord Keith Sheerness, Admiral Montagu, Rear Admiral Montagu, Honorable Admiral Cornwallis and Admiral Sir Jonathan Colpoys, June 19, 1803 in The William Barclay Parsons Robert Fulton Collection," MS18137, New York Public Library.

however, Fulton engaged in endless quarrels with the administration of Prime Minister William Pitt.[249] Pitt's government had failed to follow through on the remuneration Fulton believed he had been promised, and his correspondence is filled with complaints to the prime minister and his advisors, as well as preparations for the eventual arbitration that would decide whether, in fact, his designs merited a government payout.

Benjamin West's 1806 portrait of Fulton was painted amidst this arbitration over intellectual property, and its contents offer a unique sort of testimony as to the power and peril of ownership. [Figure 3.1] The painting juxtaposes the figure of the gentleman-inventor—neatly attired and minimally adorned—with a background scene illuminated by the destructive energy of his new invention. The relaxation of his pose—legs crossed, an arm swung easily over the back of his chair—operates counter to the intensity of his gaze and the coiled clasp of his hands. Viewed against the backdrop of Fulton's conflicts with the British government, the portrait's somewhat menacing portrayal of creativity seems no accident. One cannot help but read into its content a somewhat aggressive defense of an invention so dangerous that, according to fellow inventor Edmund Cartwright, it merited "total Annihilation," and "cou'd scarcely be purchased at too great a price."[250]

This association between invention and conflagration is not unique within Fulton's biography. Just a year after the completion of West's portrait, Fulton launched his newly designed steamboat *The North River* on a 160-mile trip up-river from Manhattan to Albany, New York—the first voyage of the first commercially successful steamboat venture to operate anywhere in the world. In 1809, the engineer applied for and received a patent on the

[249] Details of Fulton's correspondence with the Pitt administration may be found in the William Barclay Parsons Robert Fulton Collection, MS18137, New York Public Library.

[250] Edmund Cartwright to Lord Grenville, Woburn, October 6, 1806 in Robert Fulton, Edmund Cartwright, and W. Powell Jones, "New Light on Fulton's Submarine," *Huntington Library Quarterly* 4, no. 4 (July 1941): 495.

steamboat's design, using a portfolio of writing and drawings likely executed in his own hand.[251] Almost thirty years later, these materials were destroyed—alongside an additional two hundred sixty-eight volumes of case records, seven thousand patent models, and at least nine thousand specification drawings—all consumed in an 1836 fire that burned the United States Patent Office to the ground. In the wake of the fire, patents without corroborating records were vacated, and only by reapplication could they be reinstated. Of the approximately ten thousand patents issued since the passage of the first Patent Act in 1790, only 2,845 were ever restored.[252] As one newspaper reported in the fire's aftermath, "The Patent Office is *extinct!* All its books, papers, drawings, and models, are utterly stricken out of existence; not a scrap, save a few cinders, remains."[253]

Sharing more than an incidental relationship to flammability, these two instances in Fulton's career prompt a pair of important questions. First, how was invention defined in the early nineteenth century? And second, how was it connected to notions of property? A matter of considerable debate among artists in the late eighteenth and early nineteenth centuries, invention was also a newly problematic category in the field of technology. Was invention a fundamentally cognitive function or was it inextricably linked to the material realm of "inventions"—that is to say the new-fangled devices that constituted turn-of-the century technology. Closely connected

---

[251] Preliminary drawings by Fulton's machinist Charles Stoudinger in the collections of the New Jersey Historical Society suggest that Stoudinger may have had a hand in the preparation of Fulton's original specification. However, an examination of the facsimile in the collection of the Archives of Soho (discussed below) suggests stylistic similarities with drawings we know were produced by Fulton himself, thus it seems safe to argue that the original steamboat patent was, at least in part, executed by Fulton's own hand. See Fulton Steamboats, Stoudinger-Alofsen-Fulton Drawings, MS1508, New Jersey Historical Society; Robert Fulton, "Description of Discoveries, Patent Drawings. Jan. 1809, Oct. 1810, 1811," Archives of Soho, MS3147, Library of Birmingham.

[252] A comprehensive account of the fire and its aftermath can be found in Kenneth W. Dobyns, *A History of the Early Patent Offices: The Patent Office Pony* (Fredericksburg, VA: Sergeant Kirkland's Museum and Historical Society, 1997).

[253] "Destruction of the General Post-Office, City Post-Office, and Patent-Office," *Columbian Register*, December 24, 1836.

to this discussion was one that concerned how an inventor might profit off of his invention. This issue of intellectual property was a relatively untested legal concept in the early nineteenth century, but one increasingly put under pressure by the growth of industrialized systems of labor, administration and capitalization. Together, West's depiction of Fulton's intellectual property as an act of destruction and the physical destruction of Fulton's intellectual property in the Patent Office fire highlight the fundamental instability of invention as a concept, a material practice, and a source of profit in the early nineteenth century.

As discussed in the previous chapter, the process of industrialization spawned something of an epistemological crisis in early America concerning the kinds of experience that might constitute knowledge and what forms such knowledge might take. At West Point, drawing was posited as a means to access the kinds of tactile knowledge that had long-defined artisanal production, even as it served to abstract that knowledge into forms that could be more easily read and reproduced within industrialized systems of labor and administration. In this chapter, I again consider the ways in which representational practices were used to knit back together the realms of abstraction and materiality, but in this case I consider drawing's role in complicating an emergent distinction between idea and material embodiment in the category of invention.

This distinction manifests most clearly in the context of intellectual property. In an 1813 letter that has become a rallying cry for critics of intellectual property in our own digital age, Thomas Jefferson compared invention to "fire, expansible over all space" as well as the air in which we breathe…incapable of confinement or exclusive appropriation."[254] In this text,

[254] Thomas Jefferson to Isaac McPherson, 13 August 1813. For the relationship between Jefferson and contemporary discussions of intellectual property, see Jeffrey H. Matsuura, *Jefferson vs. the Patent Trolls: A Populist Vision of Intellectual Property Rights* (Charlottesville: University of Virginia Press, 2008); Adam Mossoff, "Who Cares What Thomas Jefferson Thought about Patents? Reevaluating the Patent 'Privilege' in Historical Context," *Cornell Law Review* 92, no. 5 (2007): 953–1012; David Post, "The Continuing Saga of Thomas Jefferson and the Internet" (Lecture, "Unfinished Constitution" series, The David Library of the American Revolution, Washington Crossing, PA, October 13, 2011).

Jefferson summons associations with both the breath of life and the fire of genius to proclaim invention's resistance to conditions of ownership and to reject popular notions of intellectual property as a natural right. His interpretation of intellectual property reflects the social and economic position of America's agrarian elite, steeped in an Enlightenment logocentrism that failed to comprehend physical skill as a form of knowledge and accustomed to thinking of property only in terms of arable land, moveable goods or human chattel. However, Jefferson's position runs counter to a philosophy then current among the early Republic's growing class of craftsmen, mechanics, and other small producers. Seeking to assert their franchise within a political system that conferred rights only upon those who possessed property, mechanics like Philadelphia's William Brewster asserted that their skills were a form of property acquired through the expenditure of years of hard labor. These skills were not, as Jefferson would describe them, a natural occurrence, but rather "the purchase of industry in the strictest sense."[255]

Brewster's line of reasoning was relatively unproblematic for preindustrial systems of production, where distinctions between a craftsman's ability and its material embodiment were largely theoretical. The tacit knowledge and carefully honed skills of the workman were his intellectual property, but those skills were also obviously invested in the product of his own hands. Material and idea were effectively one. However, as production shifted from the artisan's workshop to the manufactory's systems of divided labor, the ostensibly intellectual work of design was increasingly separated from the physical labor of construction, and the relationship between an idea and its material embodiment became an issue of both philosophical and

---

[255] Walter Brewster, "The Mechanic on Taxation," *Norwich Packet*, April 4, 1792. Brewster is an active figure in Ronald Schultz's account of the emergence of a laboring-class consciousness in early Republican Philadelphia, a consciousness in large part built around this idea of the "property of skill." Schultz, *The Republic of Labor*. See also, John Rule, "The Property of Skill in the Period of Manufacture," in *The Historical Meanings of Work* (Cambridge: Cambridge University Press, 1987), 99–118.

economic significance.[256]

In the course of this chapter I will look at the ways in which representational practices were used to reconstruct this relationship between idea and embodiment, paying particular attention to the ways in which the body itself was invoked as a reference point in order to tether the immaterial idea to the tangible realm. The first part of the chapter uses Fulton's transatlantic career to examine the material and social instabilities of technological development in the early nineteenth century, emphasizing the extent to which the drawing functioned as a proxy for the inventor's body in the transatlantic's multi-directional flow of information. I then venture into a discussion of the specific representational techniques that inventors used to secure control over their inventions within this dynamic economy. Again, this analysis reveals the extent to which proprietary control was dependent upon both the inventor's ability to somehow render the idea material and the dependency of this materialization, in turn, on the draftsman's capacity to evoke an embodied experience of the device depicted. The final section examines the ways in which this intimate connection between idea and embodiment came to impinge upon nineteenth-century ideas about creativity—that is to say, invention as neither an idea nor an object, but as a process.

The Knowledge Economy

To set the stage for this discussion, we will go back in time—back before the Patent Office fire, before Jefferson's inflammatory analogy, before Fulton even filed his steamboat specification with the U.S. Department of State, to the origins of *The North River* itself. Writing from Paris in August of 1803, Fulton sent the firm of Boulton and Watt the following request:

> Gentlemen, If there is not a law which prohibits the exportation of Steam engines, to the United States of America, or if you can Get a

---

[256] Mario Biagioli, "Patent Specification and Political Representation: How Patents Became Rights," in *Making and Unmaking Intellectual Property: Creative Production in Legal and Cultural Perspective*, ed. Mario Biagioli, Peter Jaszi, and Martha Woodmansee (Chicago: University of Chicago Press, 2011), 30.

> permit to export parts of an engine, Will you be so good as to make me a Cylinder of a 24 horse power double effect the piston making a 4 foot Stroke;
> Also, the piston and piston rod
> The Valves and movements for opening and shutting them
> The Air pump piston and rod
> The condenser with its communications to the cylinder and air pump
> The bottom of the cylinder cast in form as in the drawing, and the dispositions of the parts as near as possible as they stand in the drawing. The other parts can be made at New York.[257]

As his message indicates, Fulton included with the missive an annotated drawing, depicting the design, dimensions and arrangement of his desired engine. [Figure 3.2] Carefully drawn and delicately tinted, the drawing occupies the center of a separate page, folded several times over to fit within the outer sleeve of Fulton's written request. Relying on composition to shore up the unruly arrangement of his design, Fulton has pinned the engine's piston rod to the top of the page and anchored the air pump and condenser to its base. A large block of text offsets the bulk of the engine cylinder, bestowing stability on a system that, in real life, would collapse under its own weight. As with the language of his request, which asked that the parts be disposed "as near as possible as they stand in the drawing," the drawing itself reveals the numerous gaps between ideation and materialization that arise in any creative process, but which are particularly exacerbated here, in the context of international exchange.

Between August 1803 and February 1805, Fulton sent thirteen letters (that we know of) to Boulton and Watt, first from France and later from London. These letters—and the drawings that accompany them—trace the origins of *The North River*, and the expansive network of technological exchange that fostered the development of technology in the early nineteenth-century more broadly. The engineer had first applied to Boulton and Watt in writing in 1794, but

[257] Robert Fulton to Matthew Boulton and James Watt, August 6, 1803, Archives of Soho, MS3147, Library of Birmingham.

with no success.[258] Ostensibly an order for a four-horse-power engine, this early letter was, in truth, a rather uninformed (and un-illustrated) inquiry as to the firm's own experiments in steam navigation—an inquiry Messrs. Boulton and Watt declined to answer. A decade later, Fulton's second query (quoted above) was far more educated. As we have seen, he included a draft of his own design, perhaps to guarantee the sincerity of his application. From its careful shading, to the appropriate use of orthographic conventions and an orderly disposition on the page, the drawing was more than just an assemblage of lines on paper. Its material sensibility encoded a degree of graphic skill and technical knowledge that must have attracted notice, for it was to this letter that Boulton and Watt finally responded. An 1804 visit to their state-of-the art manufactory in Birmingham allowed Fulton to finally lay eyes (and almost certainly hands) on James Watt's miraculous machines. Witnessing the design and production process at Soho Works, Fulton felt compelled to revise his initial and now seemingly ill-informed scheme. His letter of July 13, 1804, referring to this recent visit, requests a set of alterations to his original plans and was accompanied by a drawing to clarify his meaning.[259] [Figure 3.3] In this drawing, the engine has started to take its final form. The delicately balanced composition of the earlier drawing has been replaced by a firmer grasp of the system's true arrangement in space. The coloring has grown less materially specific, in inverse proportion to the mechanism's level of specificity, and the quantity of text has been substantially reduced. In a further revision, sent ten days later, the text appears appended as almost an afterthought, a continuation of ideas already begun in graphic form.[260] [Figure 3.4]

[258] Fulton to Boulton and Watt, November 4, 1794, Archives of Soho, MS3147, Library of Birmingham.

[259] Fulton to Boulton and Watt, July 13, 1804, Archives of Soho, MS3147, Library of Birmingham.

[260] Fulton to Boulton and Watt, July 23, 1804, Archives of Soho, MS3147, Library of Birmingham.

As an American, writing from France to a British engineering firm, Fulton epitomizes the mobility of both people and technical knowledge that characterized the nineteenth-century Atlantic. Apprenticed at age fifteen to a silversmith in Philadelphia, Pennsylvania, a twenty-one-year-old Fulton travelled to London in 1786 to study painting, and in 1797 to Paris to hawk his plans for a new system of canal navigation and the designs for a panorama, modeled on those of English painter Robert Barker.[261] Returning to London in 1803 to sell his new scheme for submarine and torpedo warfare to the British government, he sailed for New York in 1806, finally bringing his plans for inland steam navigation to fruition on the Hudson in 1807.

Although Fulton's biography suggests a remarkable freedom of movement, his letters to Boulton and Watt also testify to the numerous obstacles posed to such a peripatetic career. First and foremost, there is the British government's embargo, alluded to in the letter quoted above, on the movement of technical drawings, tools, machines, and craftsmen beyond the borders of the British Isles.[262] Then, following a year-long gap in the engineers' correspondence, we find a clear indication of the impact of open hostilities between Britain and France in Fulton's repeated requests for information via "the circuitous but certain rout [*sic*] by which the Post office in

---

[261] Biographical information on Fulton comes from Cadwallader D. Colden, *The Life of Robert Fulton* (New York: Kirk & Mercein New York, 1817); Alice Crary Sutcliffe, *Robert Fulton and the "Clermont": The Authoritative Story of Robert Fulton's Early Experiments, Persistent Efforts, and Historic Achievements. Containing Many of Fulton's Hitherto Unpublished Letters, Drawings, and Pictures* (New York: The Century Co., 1909); Cynthia Owen Philip, *Robert Fulton, a Biography* (New York: F. Watts, 1985); Kirkpatrick Sale, *The Fire of His Genius: Robert Fulton and the American Dream* (New York: Free Press, 2001).

[262] Prohibitions on the export of materials and the emigration of craftsman associated with various industrializing trades were exercised through various pieces of legislation built up over the course of the eighteenth-century: in 1750 a law forbidding the exportation of machinery and the expatriation of workers associated with silk and wool manufacturing, in 1774 a similar law related to cotton and linen-cotton textiles, and in 1781 a law to close the loopholes in previous laws to cover sketches, plans, and models. See Witt Bowden, *Industrial Society in England towards the End of the Eighteenth Century* (New York: The Macmillan Company, 1925), 129–31; Carroll W. Pursell, "Thomas Digges and William Pearce: An Example of the Transit of Technology," *The William and Mary Quarterly* 21, no. 4 (1964): 552.

London has adopted for passing letters on to the continent."[263] Even within national borders, communication could be constricted, as indicated by Fulton's somewhat cloak-and-dagger assumption of the alias Robert Francis upon returning to London in 1804.[264] With England leading the charge towards industrialized capitalism and the Napoleonic Wars well underway, the Atlantic was a space roiled by both economic competition and armed conflict. Manifold uncertainties attended both the transfer of knowledge and the movement of people through its waters, and Fulton's correspondence is riddled throughout with anxieties provoked by this uncertain climate. Have his letters been received? If received, have they been properly understood? Drawing became one of the principal tools upon which Fulton relied to ensure the sound delivery of his messages. It allowed him to broker the difficulties associated with distance and the deficiencies of language, to bridge the gap between immaterial idea and physical object, to point toward his intentions when his hand was too far away to reach.

Fulton's story is not an isolated one. Following the declaration of war with Britain in June of 1812, the U.S. State Department required the registration of nearly 10,000 foreign-born, non-naturalized, male residents. Of the 7,500 whose occupations are known, approximately 3,000 were registered as industrial laborers, some 1,000 of them in textile manufacture or machining alone.[265] This transit of technology ran east as well as west. Of the nearly 5,000 applications for letters patent recorded in the close rolls of English Chancery Court between 1775 and 1830, approximately two percent were filed by or on behalf of non-citizens.[266] Some

---

[263] Fulton to Boulton and Watt, September 1, 1803, Archives of Soho, MS3147, Library of Birmingham.

[264] Fulton to Boulton and Watt, July 13, 1804, Archives of Soho, MS3147, Library of Birmingham.

[265] Herbert Heaton, "The Industrial Immigrant in the United States, 1783-1812," *Proceedings of the American Philosophical Society* 95, no. 5 (10): 519–21.

[266] This statistic comes from my own survey of Bennett Woodcroft, *Patents of Invention: From March 2, 1617 (14 James I) to October 1, 1852 (16 Victoriae)* (London: Queen's Printing Office, 1854).

applicants were, like the American steam-engineer James Rumsey, individuals who had traveled to London specifically to file patents when legal protections or commercial markets at home had failed them.[267] Others, like civil engineer Marc Isambard Brunel, sought work at home (France) and abroad (the U.S.) before permanently settling in England.[268] In France, the system of thorough examination to which patent applications were subject made the country a less hospitable place for the kind of speculation that drew inventors to London, but there too, the archive of *brevets d'invention* and *brevets d'importation* granted by both the revolutionary and imperial governments reveal an infusion of foreign-born talent into the country's technical knowledge base.[269]

Since at least the 1960s, studies of the diffusion of technical knowledge in the eighteenth- and early nineteenth centuries have rightfully emphasized the important role played by these international migrations and, in particular, the significance of the movement of actual bodies in real space—the transit of technology in and through the embodied experience of immigrant artisans.[270] This is, perhaps, one of the few areas of historiography where formalized systems of knowledge transmission—in the shape of textbooks or treatises—has long taken a backseat to the

---

[267] James Rumsey to Charles Morrow, 14 May 1788, quoted in full in Ella May Turner, *James Rumsey: Pioneer in Steam Navigation* (Scottdale, PA: Mennonite Publishing House, 1930), 121–22.

[268] See Richard Beamish, *Memoir of the Life of Sir Marc Isambard Brunel* (London: Longman, Green, Longman, and Roberts, 1862).

[269] To date, I have been unable to locate comprehensive lists of the French *brevets* in the way I have the British patent rolls. Using the database provided by the *Institut National de la Propriété Industrielle*, I have been able to search for the names of specific inventors or technologies and can thus offer an anecdotal account of the role of foreigners with the French knowledge economy, but nothing quantitatively definitive. See Institut National de la Propriétée Industrielle. *Brevets français 19e siècle*, http://bases-brevets19e.inpi.fr. For a comparative account of British and French patent systems, see H. I. Dutton, *The Patent System and Inventive Activity during the Industrial Revolution, 1750-1852* (Dover, NH: Manchester University Press, 1984).

[270] Pursell, "Thomas Digges and William Pearce"; Hindle, *Emulation and Invention*, 46–48; David J. Jeremy, *Transatlantic Industrial Revolution: The Diffusion of Textile Technologies between Britain and America, 1790-1830s* (Cambridge, MA: MIT Press, 1981); Stapleton, *The Transfer of Early Industrial Technologies to America*.

more informal models understood to be at work in the artisan's tacit forms of knowledge production and acquisition. More recently, however, scholars of the eighteenth- and early nineteenth-century "knowledge economy" have tried to shift focus toward the role of theoretical knowledge in the ultimate success of industrialization, asserting that it was technologists' growing familiarity with the principles of Newtonian science that provided the necessary knowledge base for individual innovations to take root and evolve across multiple applications.[271]

However, if we actually trace the vectors along which information travelled—if we examine both the interpersonal and the material networks that grew up around sectors of technological innovation—we find (unsurprisingly) that the story is far more complex and that the paths travelled by skilled bodies were paralleled by flows of information at various degrees of abstraction.

Fulton's own story illustrates this as well as any. When Fulton contacted Boulton and Watt with his request for a steam engine in 1803, he kicked off a flow of both objects and individuals that would traverse the Atlantic Ocean multiple times. Following these flows offers a unique opportunity to examine the ways in which ideas and information circulated through the transatlantic knowledge economy and, in particular, at the various representational strategies that collected, collated, and ultimately re-dispersed knowledge in a variety of contexts. One node in this network of exchange was Fulton, who we might describe as something of a moving target—settling first in France, then in London, and finally in New York. The other prominent node was Boulton and Watt's Soho Manufactory, which functioned in many ways as its own small network of technological exchange.

---

[271] Mokyr, *The Gifts of Athena*; Margaret C. Jacob, *The First Knowledge Economy: Human Capital and the European Economy, 1750-1850* (Cambridge: Cambridge University Press, 2014).

Powered by Watt's own engines, the Soho Manufactory incorporated a rolling mill, forge furnace and casting shop, engine yard, offices, and dwelling space for the operation's workmen within an imposing, if spare, neoclassical façade. Inside the bustling hive of the manufactory, the flow of information was carefully regulated through drawing and written correspondence. With Watt at the helm, the Drawing Office oversaw the production of all design and construction documents—an average of twenty pages per month in the year of Fulton's commission—and recorded the daily progress in the pages of the Drawings Day Book.[272] Each drawing was assigned a three-letter code, written in red ink in the upper left corner and cross-referenced with its entry into the Day Book, allowing the Drawing Office to track its movements through the space of the manufactory and beyond. The Day Book's entries inform us that just three days after receipt of Fulton's letter of July 13th, guaranteeing payment for the engine, the Drawing Office produced a sketch of the engine housing. Two days after that, the drawing was sent by post to "Robert Francis" in London. The drawing retained in the Soho Archives is a copy, produced via Watt's patented copying press.[273] [Figure 3.5] More than a month later, a second, more detailed drawing of the piston cylinder and air pump in both plan and section was produced and transferred to William Brunton, superintendent of the Soho Works engine yard—the first step toward production. [Figure 3.6] A month after that, the Office completed the design of the engine's working and injection gear—the mechanical apparatus used to open and close the valves that were to control the flow of steam within the engine cylinder—the final drawing in the Fulton set. [Figure 3.7] Heavily annotated with comments, calculations, and quick sketches executed by multiple hands, these pages were active sites of invention and communication—

[272] Drawings Day Book, Archives of Soho, MS3147, Birmingham Library.

[273] James Watt and Company, *Directions for Using the Machine for Copying Letters and Other Writings.: Invented and Made by James Watt and Company, of Birmingham.* (Birmingham, 1780).

mobile workshops that collected and organized the knowledge stored throughout the institutional hierarchy of the manufactory. If Soho was the terminus of a communication vector originating with Fulton, it was also an informational ecology all its own.

Such a vibrant ecology was nearly impossible to contain. Fed as much by the craft knowledge of their metal workers and engine erectors as Watt's own experimental research or the scientific findings of their colleagues—Boulton and Watt's manufactory produced workmen who were highly skilled, technologically astute, graphically literate, and thus highly sought after. Machinists from Soho found employment in Holland, Germany, Russia, and the United States (among other locations)—at times with the authorization of the firm, at others in direct contravention of the British government's prohibitions on the export of mechanical knowledge in all its forms.[274] These men brought with them what historian of technology Brooke Hindle has called "fingertip knowledge"—the cerebellar training and spatial thinking native to the craftsman—but they also imported a healthy store of graphic instruments and printed models, funneling technical knowledge out of England through a range of parallel channels.[275]

In one salient example, former Boulton and Watt employees John Hewitt and James Smallman were hired by American entrepreneur Nicholas Roosevelt in 1796 to construct and oversee a facility closely modeled on the Soho Manufactory.[276] Located on the banks of a Passaic River tributary in what is now Belleville, New Jersey, Roosevelt's own Soho Works were ideally placed to take advantage of the growing momentum of industrial manufacturing in

[274] Eric H. Robinson, "The Early Diffusion of Steam Power," *The Journal of Economic History* 34, no. 1 (1974): 99–100.

[275] Hindle, *Emulation and Invention*, *passim*.

[276] Carroll W. Pursell, *Early Stationary Steam Engines in America; a Study in the Migration of a Technology* (Washington: Smithsonian Institution Press, 1969), 29–30; 29; Darwin H. Stapleton, "The Engineering Practice of Benjamin Henry Latrobe," in *The Engineering Drawings of Benjamin Henry Latrobe*, ed. Darwin H. Stapleton (New Haven: Published for the Maryland Historical Society by Yale University Press, 1980), 29, 34–35.

both Pennsylvania and New York.[277] Alongside German engineer Charles Stoudinger, Hewitt and Smallman oversaw a mixed crew of American and European miners, smelters and craftsmen and the production some of the earliest steam engines built in the United States.[278] Among the archives of Roosevelt's Soho Works, we find drawings marked with the telltale lettering system of the Boulton and Watt Drawing Office, drawings then re-created in Smallman and Stoudinger's own hands.[279] In Smallman's later drawings for the low-pressure steam engine installed at the Washington Navy Yard in 1811, similar tonalities and shared symbolic conventions link the engineer's American work to the graphical training he received in Birmingham. [Figures 3.8 & 3.9] As in the drafts produced by Watt's Drawing Office, Smallman tended to limit himself to a singular view per page—a methodology we might contrast with Benjamin Henry Latrobe's drawing for the same project, which collapses multiple scales and section cuts into a single composition. [Figure 3.10] Unlike Latrobe's synoptic approach, Smallman's drawings march systematically from plan to elevation to section to detail, in the same ordered progression we saw recorded in the Drawings Day Book. However, they also detail parts of the machine routinely left out of the drawing sets produced in Watt's Birmingham office at the time, allowing graphic simulations to fund potential deficits in local technical knowledge.

This outpost of Boulton & Watt's carefully cultivated brain trust reconnected with Fulton

[277] A full description of the New Jersey Works may be found in the diary of Thomas P. Cope, quoted in Robert Briggs, "History of the Steam Engine in America," *Journal of the Franklin Institute* 72, no. 1 (July 1876): 259–60.

[278] In the 1780s, John Fitch and James Rumsey had experimented (unsuccessfully) with the construction of engines for steam-driven boats and Irish engineer Christopher Colles built the engine that powered the waterworks for New York City, but contemporary accounts appear to confirm Soho Works as the first commercial producer. See Benjamin Henry Latrobe, "First Report of Benjamin Henry Latrobe, to the American Philosophical Society, Held at Philadelphia: In Answer to the Enquiry of the Society of Rotterdam, 'Whether Any, and What Improvements Ahve Been Made in the Construction of Steam-Engines in America?" *Transactions of the American Philosophical Society* 6 (1809): 92; Frederick Graff, "Notice of the Earliest Steam Engines Used in the United States," *Journal of the Franklin Institute* 55, no. 4 (1853): 270. See also, Pursell, *Stationary Steam Engines*, 29–30; Stapleton, "The Engineering Practice of Benjamin Henry Latrobe," 34–35.

[279] These drawings are in the collection of the New Jersey Historical Society, which prohibits researchers own photographs and has not shared reproductions of these images.

in 1808 when the American engineer hired Smallman's colleague Charles Stoudinger to oversee operations of his steamboat construction and charter company. Stoudinger brought the knowledge he had acquired at the New Jersey Soho Works to Fulton's aid, assisting him in the design and production of both the steamboats and the engines that powered them.[280] Preliminary drawings in Stoudinger's hand suggest that Fulton's 1809 application for a patent on the steamboat was at least partially authored by the German engineer.[281] When Fulton died in 1815, these drawings were circulated by Fulton's patent agent Joseph Dyer amongst his friends and acquaintances in London, Manchester in Birmingham. Boulton and Watt were among this circle, and given the destruction wrought by the 1836 fire at the U.S. patent office, the only instance of Fulton's steamboat specifications still extant is the copy produced by the Boulton and Watt Drawing Office. Thirty pages of written specification and twenty fully colored, illustrated plates, this facsimile is an odd sort of ghost—its words and images conceived by Fulton, but executed in a different hand. [Figures 3.11-3.14] Knowledge that had originally departed Boulton and Watt's Birmingham manufactory in both bodily and graphic form was thus returned to them in new guise.

This tour of the various overlapping and intersection trajectories that circulated between the Soho Manufactory and Fulton's own workshop illustrates an expansive and uncertain space of social and technological exchange. But, as I have tried to emphasize, drawings were routinely used to ground and guide the flow of information within the community, and I want to look now at the ways in which these images routinely indexed the uncertain conditions of their own production. As these images traveled paths parallel to the bodies that produced them, they encoded the tensions inherent in the dispersed communities of the Atlantic World and the

[280] Philip, *Robert Fulton, a Biography*, 215.

[281] Fulton Steamboats, Stoudinger-Alofsen-Fulton Drawings, MS1508, New Jersey Historical Society.

anxieties engendered by industrialization's divisions of labor. In particular, they encoded anxieties about ownership and proprietary control, for drawings even as the graphic instrument facilitated the transmission of proprietary information it also permitted knowledge to escape beyond its author's direct physical control.

The drawings that accompanied Fulton's 1809 steamboat specification bear out these tensions perhaps better than most. Opening with a picturesque sketch of *The North River* churning through the waters of the Hudson River headlands, the plates move quickly into the realm of diagram to illustrate a series of Fulton's experiments in hydraulics. [Figures 3.11 & 3.12] The contrast is stark, pitting an illusionistic depiction of the vessel's transit through real space against the mathematical abstractions upon which that movement is based. Several plates later, we find a longitudinal section through the boat that reveals the engine works, as though cut and pasted from Boulton and Watt's own construction drawings. In its graphic form, this engine had traveled hundreds of miles, folded up into Fulton's correspondence with the engineering firm. Once fully realized as a three-dimensional machine, it then traveled thousands more between the Birmingham manufactory and Fulton's own workshop in New York. Yet in this drawing, its mobility has been restrained, locked into place by its connection to a brick-sided furnace on one side and a system of planetary gearing on the other. [Figure 3.13] A subsequent "Perspective View of the Machinery" again combines the conventions of pictorialism and diagram to present an uncanny experience of the boat's complex propulsive mechanism, bizarrely rendered in absence of the boat itself. [Figure 3.14] This perspectival treatment permits the viewer to simultaneously access far more of the machine's many interconnected parts than a conventional plan or section, but its recessional logic also draws the viewer across an impossibly narrow strip of solid ground and into the eerie void beyond. On one hand, these drawings serve to document the conditions of the *The North River's* voyage "as it really happened," seeking to guarantee the invention's viability with proof that this event, which many had long believed impossible, did in fact take place.[282]

The material specificity of the drawings, their attempts to physically draw the viewer into an immersive experience of the machine, the attempt to contextualize the entire project with that first, introductory sketch on the Hudson—all these have been summoned to convey the sense of eyewitness testimony. At the same time, the drawings use precise measurements and orthographic projections—what Thomas Nagel has called "views from nowhere"—to lay claim to a universal intelligibility, without which their utility as instruments of scientific inquiry would be moot.[283]

Juxtaposing these "views from nowhere" with a range of scenographic techniques, these drawings intermingle abstraction and a subjective viewpoint in a manner unique to an emergent discourse of scientific objectivity. As defined by Lorraine Daston and Peter Galison, objectivity aspires to "knowledge that bears no trace of the knower—knowledge unmarked by prejudice or skill, fantasy or judgment, wishing or striving. Objectivity is blind sight, seeing without inference, interpretation, or intelligence."[284] Daston and Galison have identified objectivity as an historically specific epistemological model, with its apotheosis in the latter nineteenth-century's automated systems of data acquisition—Etienne-Jules Marey's portable polygraph or Eadweard

---

[282] As late as 1803, America's pre-eminent architect and engineer (and Fulton's soon-to-be colleague) Benjamin Henry Latrobe believed steam navigation to be impracticable, saying of the experiments that had so far come to pass, "Nothing in the successes of any of these experiments appeared to be a sufficient compensation for the expense, and the extreme inconvenience of the steam-engine in the vessel." Latrobe, "First Report," 90.

[283] Thomas Nagel, *The View from Nowhere* (Oxford: Oxford University Press, 1986); cited in Lorraine Daston, "Objectivity and the Escape from Perspective," *Social Studies of Science* 22, no. 4 (1992): 599.

[284] Daston and Galison, *Objectivity*, 17.

Muybridge's chronophotographic apparatus, for example.[285] Yet the antecedents of this mechanical objectivity lie here, in images like those accompanying Fulton's specification, which exhibit the early nineteenth-century's struggles with the role of subjective experience in the communication of empirical data.

Daston and Galison's work has focused on the emergence (and subsequent divergence) of objectivity from an early modern episteme that deliberately invited subjectivity into the realm of scientific description. Looking at illustrated botanicals and anatomies of the seventeenth- and eighteenth-centuries, they describe the importance of the faculty of judgment to the practice of early modern science. Shying away from direct imitations of nature in its raw and unadulterated state, the authors and illustrators of these scientific atlases accessed a more idealized vision of the world through composite studies and invented prototypes—what Daston and Galison have called "truth to nature." As they argue, this "synthetic image" was the ideal of eighteenth-century art and science, with both the painter and the naturalist seeking, in the words of Sir Joshua Reynolds, the outlines of "invariable general form."[286]

Yet, an analysis of the Fulton specification brings a new dimension to the subsequent divergence of subjectivity and science in the late eighteenth- and early nineteenth-centuries. Unlike the scientific atlases of Daston and Galison's study, the category of patent drawing to which Fulton's images belong combined the problems of technical explication with those of both personal and economic investment. They are transitional objects in the shift from a knowledge economy rooted in the tacit knowledge of the craftsman to one premised on divisions of labor and industrial capital. In this context, the drawing's capacity to obviate the knower—to render its views "objective"—is to challenge the deep traditions of craft knowledge that had long

[285] See especially, Daston and Galison, "The Image of Objectivity."

[286] Sir Joshua Reynolds, quoted in Daston and Galison, *Objectivity*, 81.

underwritten technological innovation, the transmission of technical skill, and personal investment in the products of one's own hands. The qualities that serve to make a drawing useful as an instrument of informational exchange—the dispassionate point of view of orthographic projection, the suppression of individual style in favor of shared conventions—serve to dispossess its author of a stake in his own creative output. Thus we see in these drawings, sent out into the world to secure an author's investment in his invention, indications of subjectivity introduced, not in the service of some moral imperative to render "truth to nature," but instead in the service of an economic imperative to protect personal property.[287]

The Material Properties of Intellectual Property

Having now suggested not only the importance of drawing within the context of technological exchange but also the economic significance of a subjective viewpoint with said drawings, I now want to look more intently at the range of representational techniques that developed to secure that subjectivity and its attendant proprietary interests. These techniques were developed in conjunction with an emergent and constantly shifting body of patent law in both the U.S. and Europe. Both this body of law and the drawings that served it were preoccupied with the problematic relationship between idea and its material embodiment.

The patent systems of both Europe and the United States developed out of the economic policies of medieval governments interested in the protection of local craft knowledge, with the first limited monopolies on specific craft practices granted in Venice in the thirteenth-century, and the first general patent law passed by the Venetian Senate in 1474.[288] The practice of granting such monopolies was premised on the notion that society might benefit from the

[287] See chapter on "Truth to Nature" in Daston and Galison, *Objectivity*, 55-114.

[288] Pamela O. Long, "Invention, Authorship, 'Intellectual Property,' and the Origin of Patents: Notes toward a Conceptual History," *Technology and Culture* 32, no. 4 (1991): 875.

protection of technical knowledge and skill as forms of property with commercial value, with the assumption that to protect that knowledge as property is to encourage individuals to use it, thereby enlarging the polity's economic base through more efficient or more desirable forms of production.[289] By the mid-eighteenth-century, however, the justification for these limited monopolies had evolved to encompass more than the economic benefit imparted by increased productivity. More and more, the patent grant was viewed as a means to facilitate the demystification of technical knowledge through informational exchange.[290]

The patent specification is an artifact of this era, joining the Enlightenment's profusion of encyclopedias and scientific atlases in their attempts to publicize and institutionalize technical knowledge through representation. We see specifications growing more frequent in English patent applications in the second half of the eighteenth-century and finally codified in the patent laws of the new American and French republics after 1790.[291] When the American patent system was conceived by act of Congress in 1790, it required the submission of a written specification "so particular" and drawings or model, "so exact … as to enable a workman or other person skilled in the art … to make, construct, or use the same, to the end that the public may have the full benefit thereof, after the expiration of the patent term."[292] The law promised to "promote the progress of the useful arts," not only or even primarily through the financial inducements a patent provided, but by creating a repository of technical knowledge that would, in time, become the property of the public.[293] In so doing, the law guaranteed that an idea could hold no value

---

[289] Ibid., 846.

[290] Biagioli, "How Patents Became Rights," 28.

[291] Ibid., 26.

[292] An Act to Promote the Progress of Useful Arts, 1 Stat. 109. United States Statues at Large 1 (1790).

[293] ibid

except as it was freely communicated, but it also mandated that such communication would have to take material form. This mandate was not an arbitrary legal requirement imposed upon those who would seek to claim protection for their intellectual property, but an acknowledgement of the material conditions necessary for technological exchange.

But how was this relationship between the material and immaterial established? How did representation work to make an inventor's idea manifest? What tools—both material and conceptual—were used? What challenges encountered? Although the American patent archive was destroyed in the 1836 fire, the movement of individuals, ideas, and images throughout the early industrial Atlantic has allowed a reconstruction of sorts, permitting a glimpse of the ways in which early American inventors (and their foreign representatives) negotiated the strange space between evanescent idea and material reality. Records in both the close rolls of English Chancery Court and the portfolios of *brevets* issued by the revolutionary and imperial governments in France reveal the period between 1775 and 1830 to have been one of extraordinary experimentation, with inventors themselves and the professional consultants they hired adopting a range of graphic techniques to bolster their claims to intellectual property.

At one end of the descriptive spectrum lies the specification filed in 1789 by Maryland native James Rumsey. [Figure 3.15] Frustrated by his lack of commercial success in the United States, Rumsey travelled to London in 1788 with funds assembled by Philadelphia's Rumseian Society and the express purpose of seeking British patents.[294] This is the second of four English patents for which he applied, and the last in which he used his own artwork to illustrate the specification. The document outlines a set of principles governing jet propulsion, which might be applied variously to milling, manufacturing and transportation. The drawings present these

[294] James Rumsey to Charles Morrow, May 14, 1788, quoted in full in Turner, *James Rumsey*, 121–22.

principles in a series of vignettes that take the viewer from basic principle through increasingly complex applications. Rumsey's visual vocabulary here is straightforward. [Figure 3.15 - detail] The constructions are built of elemental geometric forms—cylinders, cubes, prisms, and pyramids in shallow perspective; lines, circles and rectangles in section. Scale and material both appear irrelevant—one has no sense of these objects' true dimensions or relationship to real space. These are theoretical abstractions, drafted to explain principles and not to describe real form. And yet, the constructions themselves are solid, almost stodgy. Thickly built frames, obsessively shaded by a dense hatch-work, Rumsey's drawings perversely hide the operations they are meant to reveal. Although this is, in theory, a patent for principles of propulsion, there is little sense of the forces that act on and flow through the depicted constructions. It seems, instead, that the lure of the object has been too great. Compelled to render his ideas tangible, Rumsey has gone too far to the other side, obscuring the principles of his invention in a material morass.

Elisha Haydon Collier's 1819 specification approaches the problem of materiality from a very different tack. [Figure 3.16] Before emigrating to England in 1818, Collier worked with Artemus Wheeler and Cornelius Coolidge in Massachusetts to develop the design for this flintlock pistol with a revolving chamber.[295] The drawing that accompanies Collier's specification was produced by J. & W. Newton, a London firm of globe-makers-turned-patent-agents in the late eighteenth-century.[296] Among the largest of the drawings incorporated into the British patent rolls in these years, its vellum sheet measures approximately twenty-four by thirty-

[295] C.P. Bedford, "Collier and His Revolvers," *American Society of Arms Collectors Bulletin*, no. 24 (Fall 1971): 10–11.

[296] See John R. Millburn, "Patent Agents and the Newtons in 19th-Century London," *Bulletin of the Scientific Instrument Society*, no. 20 (1989): 3–6; Brian Gee, "The Newtons of Chancery Lane and Fleet Street Revisited, Part II: The Fleet Street Business and Other Geneaology," *Bulletin of the Scientific Instrument Society*, no. 36 (1993): 12–14.

six inches, illustrating Collier's revolver at full scale and in astonishing detail. Viewed in person, the Collier drawing seems to leap off the page, its hyper-realism tinged with a certain frisson as one finds oneself staring straight down the barrel of Collier's elegantly designed pistol. Yet, up close, this realism starts to slip away. The objects' solidity, so sure from a distance, gives way to a descriptive transparency designed to illuminate the relationships between external surfaces and internal couplings. Moving from the left to right across the image, the drawing's various projections become increasingly less substantial. Whereas the side elevation of the pistol shown at left is fully rendered with great material specificity, the cross-section that faces it combines moments of material illusionism (as seen in the head of the screw that alters the strike of the pistol's hammer) with large passages of fine-grained hatching—a professional draftsman's convention, used to indicate the plane along which a section has been cut. [Figure 3.16 - detail] The projection located all the way to the right surrenders even this degree of illusionism, offering what we would now call an x-ray view that collapses the pistol's entire depth into a single, infinitesimally thin plane. What was a complex arrangement of cold metal parts reveals itself to be a set of graphic conventions—lines dashed and solid, graduated layers of ink wash, varying densities of hatching—marks that reduce the threatening object to an assemblage of precisely defined lines and curves.

Separated by a space of thirty years, the differences between the Rumsey and Collier drawings are due, in part, to an evolving language of technical description. Rumsey's vignettes find their antecedents in the theoretical texts on mechanics that helped communicate British advancements in the applied sciences throughout the Atlantic world.[297] In particular, the stodgy

[297] See, for example, John Ferguson, *Lectures on Select Subjects in Mechanics, Hydrostatics, Pneumatics, and Optics* (London: Printed for A. Millar, in the Strand, 1764); John Ryland, *An Easy Introduction to Mechancis, Geometry, Plane Trigonometry, Measuring Heights and Distances, Optics, Astronomy* (London: Printed for Edward and Charles Dilly, in the Polutry, 1768).

frames and tortured perspectives of his patent drawings demand comparison with the illustrations accompanying James Ferguson's *Lectures on Select Subjects in Mechanics, Hydrostatics, Pneumatics, and Optics* (first edition 1760). [Figures 3.17 & 3.18] In contrast, the Collier drawing is the product of a newly professionalized class of patent draftsmen whose references included not only texts on mechanics, but also the practice of mechanical drawing itself. In his *Essay on Mechanical Drawing* (1811)—the first publication to use the term "mechanical drawing" *per se*—author Charles Blunt's illustrations manage the same tenuous hold on illusionism that characterizes the drawings of Collier's revolver and so many of the professionally executed patent drawings of this period.[298] [Figures 3.19 & 3.20]

Each of these texts offers a set of representational conventions particular to its context, and the relatively rapid transition from one to the other reveals a culture continuously working to understand and articulate the elusive connection between an object and the act of invention that spawned it. Ferguson's *Lectures* must be understood within the context of eighteenth-century public science, as a transatlantic proxy for its author's own itinerant practice as a scientific lecturer. With illustrations that resemble the wooden toys used to demonstrate mechanical principles in these public exhibitions, the *Lectures* would have provided Rumsey with a model in which the explication of a physical principle was inseparable from its instantiation in physical form. By comparison, Blunt's *Essay* is the work of a professional draftsman, self-conscious of his craft. His illustrations also depict toys, (see the lower image in Figure 3.20), but they do so to suggest the artifice of draftsmanship rather than the essential physicality of the objects depicted. Blunt has expertly rendered his small spool of thread and wooden cart in single-point perspective, but by setting these objects within an expansive and indeterminate landscape, he

[298] Charles Blunt, *An Essay on Mechanical Drawing* (London: Printed by L. Harrison & J.C. Leigh, 1811).

demonstrates the ways in which representation can test the limits of credulity. With a wink and a nod, Blunt sets out to acknowledge the importance of material illusionism in the draftsman's craft while also reminding his viewer that these images are, in fact, illusions.

Positing the Rumsey and Collier specifications as discrete points along a trajectory of stylistic development, the latter drawing displays a greater visual sophistication and self-consciousness regarding the role of representation. However, both images were designed as answers to the same question—how material are the materials that make intellectual property? Balancing in different measures a description of the machine as a mechanical principle with a description of the machine as material fact, these drawings (and the sources they reference) describe the evolution of patent drawing's formal language as a conditioned response to the patent's proprietary imperative to materialize.

The Narrative Structure of Invention

The limits of this balancing act are revealed in one of several drawings that accompany an 1811 specification for a machine to produce textile-cards—the wire-spiked surfaces used to smooth and homogenize raw fibers before they are spun. [Figure 3.21] Fulton's patent agent, Joseph Dyer, also filed this specification, this time on behalf of American inventor Amos Whittemore. It is unclear in what state the invention came to Dyer's patent draftsman John Farey, but whether it was through textual description, one of Whittemore's own drawings, or even the machine itself, the image Farey eventually produced offers up the invention in rather dramatic fashion.[299] The drawing is, in fact, two-in-one—an image of the machine's exterior design that folds open to reveal its inner workings. Physically involving the viewer's body in this process of literal "dis-covery," the drawing reenacts the process of invention.

[299] For more on Farey, see A.P. Woolrich, "John Farey, Jr., Technical Author and Draughtsman: His Contribution to Rees's Cyclopedia," *Industrial Archaeology Review* 20 (1998): 49–67.

The most remarkable moment in the drawing occurs inside the uncovered image, where we find the act of discovery has actually broken the machine—note the severed uprights along the machine's perimeter. [Figure 3.22] It was and is a common enough convention to represent as cut or broken those objects that intersect the plane of a section or extend beyond the image's selected frame. However, the abstraction with which we are familiar from technical drawing today comes nowhere near the violence with which this machine's structural supports have been shattered. The image offers a poignant example of what Martin Heidegger has called the broken tool's *Vorhandenheit* or "present at handedness." Normally *zuhanden* or "ready to hand," most objects slip seamlessly into the course of daily life, hovering below the register of human attention. Utility is the object's natural state of being. But when broken—when removed from the realm of utility—the object presents itself *as such*. In the case of the Farey drawing, attempting to access full knowledge of the object *as an object* breaks it, but it is also in that breaking that we are given a sense of its materiality..

Farey's rendering of Whittemore's machine brings to the fore the role of narrative in the patent drawing's construction of a proprietary relationship between material and idea. Enacting a process of sequential unfolding, Farey's image literalizes a narrative structure present in all of the drawings so far discussed. In Fulton's steamboat patent, narrative first appears in the opening plate depicting *The North River* vessel headed up the Hudson. For Rumsey, it manifests in the conceit of theme and variation—a gradual unspooling of a single principle into multiple iterations so as to claim an infinitude of possible applications as his personal property. In the Collier drawing, narrative emerges through composition. Rigorously and hierarchically structured, such an image moves out from the integrated object at the drawing's center out to detailed studies of the revolver's isolated components at the periphery. As though manually deconstructing the machine, the drawing provides layer upon layer of further detail, encouraging the viewer to believe she could pick up each piece in turn, allowing for total visual possession.

This assertion of the patent drawing's narrative function runs counter to much recent scholarship on diagrammatic representation. As John Bender and Michael Marrinan have argued, the diagram is defined by flexibility and open-endedness, characteristics that allow it to function as an epistemological tool, facilitating the viewer's engagement with the depicted objects from multiple points of entry.[300] In the context of the *Encyclopédie* plates they analyze, they also suggest that this indeterminacy renders the diagrammatic image essentially anti-narrative, seeing instead an open-endedness that runs directly counter to narrative's tendency to foreclose the possibility of play in favor of a clear beginning, middle and end. Yet here, it appears the diagram does not so much forestall narrative as it does depend upon it. More specifically, in order to serve the patent's purpose of securing intellectual property, these drawings depend on narrative structures to reinforce the inventor's claim to original discovery. Certainly, as Bender and Marrinan suggest, the integument of white space that binds these images' disparate parts together is "an arena of potentiality that fosters connections without fixing them or foreclosing thought experiments," but such play occurs within a carefully crafted sequence of discovery and visualization.[301] Ultimately, the progressive unfolding of knowledge produced through narrative offers a comprehensive grasp of the imagined object, rendering the idea more like physical

[300] I discuss Bender and Marrinan's work here for its clarity and chronological relevance, but we might also look at David Joselit's discussion of Duchamp's experiments with diagram, in which "the mono-direction of narrative"—literally materialized in the form of the book—is undone by the diagram's "tactical dispersion." We might also look to Benjamin Buchloh's discussion of the diagram's rejection of hierarchical order and authorial control in Frank Stella's early work. Bender and Marrinan, *The Culture of Diagram*, 33–34; David Joselit, "Dada's Diagrams," in *The Dada Seminars, CASVA Seminar Papers I*, ed. Leah Dickerman and Matthew S. Witkovsky (Washington, D.C.: The National Gallery of Art for the Center for Advanced Study in the Visual Arts, 2005), 225–26; Benjamin H. D. Buchloh, "Painting as Diagram: Five Notes on Frank Stella's Early Paintings, 1958–1959," *October* 143 (2013): 126–144.

[301] Bender and Marrinan, *The Culture of Diagram*, 23.

matter and thus more easily subject to possession.

As we have already seen in the drawings that accompanied Fulton's steamboat specification, one of the consequences of this narrativization is the introduction of a subjective viewpoint into the space of technical description. The object produced through narrative requires a subject to perceive it, making an embodied experience of the machine an integral part of the patent drawing's proprietary claims. However, this embodied experience is really a catch twenty-two. In providing this sense of embodiment, the drawings might also be understood to hand the machine over to the viewer. The viewer is thus made the possessing subject and the inventor is, in effect, dispossessed. As if to combat this problem, Fulton produced a unique set of drawings documenting his experiments in submarine and torpedo warfare between 1804 and 1806. This series of illustrated plates describes the design of a manually powered submarine and the clockwork-triggered mines the vessel would deliver to enemy ships. [Figures 3.23-3.27] Fulton's apprenticeship as a miniaturist in America and later as an aspiring portraitist and history painter in London had prepared him well for these descriptive duties. His drawings are finely drafted and deftly colored, with the level of precision and sensitivity one finds in his portrait miniatures. [Figure 3.28] Their narrative character portrays Fulton as someone comfortable telling a story through images, hinting at the history painter within. Like his later steamboat drawings, these images gradually unfold the project in time and space, transitioning from section drawings of the vessel as a whole to detailed drawings of its internal machinery. [Figures 3.23 & 3.24] A subsequent image depicts the submarine at sail and another various instances of the torpedoes afloat. [Figures 3.25 & 3.26] One drawing, in particular, stands out amongst this set. It depicts the conical glass sections inserted into the submarine's conning tower to permit ambient light into the vessel's interior and to allow its captain to visually chart a course without emerging from the hatch. [Figure 3.27] Fulton's own face, rendered in profile, has been encased within the drawing's cross-section. The figure of the inventor, referenced by so many of the drawings in this chapter but never fully rendered, is here finally pictured, giving explicit visual expression to both the intangible property and the material properties that constituted his unique forms of technical knowledge. Although not patent drawings *per se*, these images were produced as part of Fulton's protracted negotiations with the British government over compensation for the project. The appearance of Fulton's face within a set of documents designed to secure this financial compensation emboldens and literally embodies the drawing's claims to eye-witness testimony, affirming its author's assertions of proprietary interest and counteracting the otherwise potentially dispossessive force of the drawing itself.

The Subject of Invention

This somewhat eccentric self-portrait offers clear evidence of the continued relevance and authority of embodied experience in the early industrial age. However, the drawing also calls into question the nature of the subjectivity it pictures—where does the man stop and the machine begin? As this chapter draws to a close, I want to consider the various ways in which the patent drawing's insistence on a material connection between the inventor and his invention came to influence the early nineteenth century's understanding of creativity—of invention, not as an idea or an object, but as a process.

Depicted in conjunction with a drawing of a barometric gauge that allowed the crew to determine the vessel's depth within the sensory-deprived space of its interior, Fulton's self-portrait *cum* submarine engages the machine's tendency to reorganize the capacities of human perception. A pair of dashed construction lines correlates the taper of the conical glass with the diameter of the engineer's pupil, a piece of biometry that simultaneously asserts Fulton's control over the machine's design while also placing him subject to its mediation. A nearly contemporaneous patent application, filed by Fulton in France in 1799 and again in 1801, uses the same graphic device to illustrate the mechanical mediation of sight in a different context—that of the panorama. [Figures 3.29 & 3.30] The figures in these drawings, like Fulton in his submarine, have been placed within a massive and fully immersive optical device, which (by design) delimits the possibilities for viewing and understanding their surroundings. As Jonathan Crary has argued, the panorama could only be consumed as fragments, ultimately resisting even cognitive assembly into an imagined whole.[302] The same could be said of Fulton's submarine as a viewing machine, with its conical glasses permitting only brief, vignetted portals onto the exterior world. Subjecting the inventor's body to the strictures of his own machine, the self-portrait questions the nature of the inventive process and the role of both perception and representation in defining that process. In so doing, it joins a larger conversation concerning the relationship between invention and subjectivity in the early nineteenth-century, one that moves beyond the realm of technology to encompass the practice of both art and science.

I want to compare this account of the inventor's capacities with those depicted by West in the portrait discussed at the outset of this chapter.[303] [Figure 3.1] Like Fulton's drawing, West's portrait takes as its subject Fulton's system of torpedo and submarine warfare, but his more romantic depiction clearly links the explosive activity of Fulton's torpedoes with "the fire of his own genius," presenting an image of the inventor—and, it seems, the process of invention—very

---

[302] Jonathan Crary, "Géricault, the Panorama, and Sites of Reality in the Early Nineteenth Century," *Grey Room*, no. 9 (2002): 21.

[303] West was, in fact, more than just Fulton's portraitist—he was the engineer's friend and occasional mentor. Although Fulton was never an official student of West's, he was part of the loose affiliation of American expatriates that gathered around the Royal Academy president, what portraitist Matthew Pratt had earlier described as the "American School." See Dorinda Evans, *Benjamin West and His American Students* (Washington, D.C.: Published for the National Portrait Gallery by the Smithsonian Institution Press, 1980).

different from the measured precision of the engineer's self-portrait, encased within a machine of his own devising.[304] As an image of invention, this portrait sits somewhere between Mason Chamberlin's 1762 portrayal of Benjamin Franklin [Figure 3.31] and West's own, highly allegorical depiction of *Franklin Drawing Electricity from the Sky*, painted circa 1816. [Figure 3.32] Chamberlin's portrait presents Franklin as a staid figure, his gaze turned away from the extraordinary events outside and instead focused on the brass instruments to his right—instruments that could distill nature's violent electrical outbursts into a set of visible and sonorous data points. It is an image of genius mediated by laboratory devices.[305] West's more dynamic portrayal depicts Franklin actively conducting an electric charge out of the sky and into his outstretched fist, as though the polymath's extraordinary genius could be fed directly by the storm's perilous lines of "electrical fluid."[306]

Produced a decade earlier than his painting of Franklin, West's portrait of Fulton is far more sober, relying on many of the same conventions we see in the Chamberlin depiction. Yet the intensity of Fulton's gaze and the luminescence of his face and hands suggest that the violent energy of West's later portrayal is not absent here, merely sublimated—restrained by gentlemanly trappings and redirected into the explosive effects of his subject's work. West's

---

[304] DeWitt Clinton, *A Discourse, Delivered before the American Academy of the Arts* (New-York: Printed and published by T. & W. Mercein, printers to the Academy, 1816), 30. The phrase "the fire of his own genius" appears in the final lines of Clinton's eulogy for Fulton, delivered in this address to the American Academy of the Arts shortly after the engineer's death in 1815.

[305] Michael Gaudio has eloquently analyzed the multi-sensory aspects of representation at work in Chamberlin's depiction of Franklin. See Michael Gaudio, "Magical Pictures; Or, *Observations on LIghting and Thunder, Occasion'd by a Portrait of Dr. Franklin*," in *Picturing*, ed. Rachael DeLue (Chicago; Paris: University of Chicago Press for Terra Foundation for American Art, 2016), 84–99.

[306] In his writings on electricity, Franklin argues that all matter contains some quantity of electrical "fluid" or "fire" which may be activated by exposure to an external source of electricity, such as lightning. As he writes, "common matter is a kind of sponge to the electrical fluid," drawing in charge until it can contain no more and is "said to be electrified." Benjamin Franklin, *The Works of Benjamin Franklin: Containing Several Political and Historical Tracts Not Included in Any Former Edition, and Many Letters, Official and Private, Not Hitherto Published; with Notes and a Life of the Author*, ed. Jared Sparks (Boston: Whittemore, Niles, and Hall, 1856), 227–28.

treatment of the face is particularly fascinating. [Figure 3.33] The devilish halo of hair that surrounds Fulton's head repeats at nearly a one-to-one scale in the plumes of smoke that emanate from the splintered ship. The glint of light off his nose and eyes and the brilliant glow of his forehead find their counterparts in the wreck's shooting flames, receding into the distance. Drawing a comparison between the inventor's brooding genius and the violent effects of his work, West's painting is a romantic depiction of innovation's explosive potential.

However, the portrait is as notable for what it obscures as for what it illuminates. In the years Fulton spent pursuing the project, he proposed several different plans for torpedo warfare, all more akin to submerged mines than the self-propelled models we think of today. One, seen in an 1804 drawing, packed 200 pounds of powder and 150 to 180 bombs—what Fulton called "engines" or "combustible balls"— into a seven-foot-long watertight case made of three-inch-thick oak.[307] [Figure 3.34] The torpedo was ignited by a clockwork trigger mounted to its upper surface. Delivery mechanisms for these torpedoes varied, but his most surreptitious—and most extravagant—method was via submarine. Capable of moving along the water's surface under sail, the submarine was driven by hand power when submerged. Carrying upwards of 200 torpedoes in its hull, the submarine permitted its crew to approach enemy vessels surreptitiously, and then, upon resurfacing, to discharge the torpedoes either in the flow of the current or via harpoon. Fulton produced two full sets of drawings depicting these plans, accompanied by copious written specifications containing exhaustive financial calculations, as well as high-flying speculations on political economy and the potential for his invention to finally and permanently end maritime warfare. Yet for all these expansive details and exhaustive speculations, Fulton's inventive process is entirely concealed in West's depiction. West has instead placed the

[307] This technical information has been gleaned from Fulton's drawings themselves. See the William Barclay Parsons Robert Fulton Collection, MS18137, New York Public Library.

proximate cause of the inflammation at a distance, mired in smoke and shadow. In doing so, he has appropriated the language of the nocturne, used repeatedly by his contemporaries to describe the sublime scenes and terrifying ravages that industrialization had begun to enact within the English landscape. [Figures 3.35 & 3.36] The effect is both awesome and mysterious, linking Fulton's project, and his unique inventive genius, to newfound sources of industrial power. But in the process, West has also dissociated the image of genius from the physical instruments of invention. His portrayal is all energy and no substance, capable of tearing through material constraints with terrifying force.

At first glance, the distinctions between Fulton and West's take on invention appear relatively easy to categorize. Fulton's self-portrait marshals a mechanistic understanding of perception and cognition characteristic of an Enlightenment philosophy in which the mind can contain nothing that the body has not already sensed. In contrast, West's portrait seems to align both inventor and the process of invention with the figure of the "artistic genius" more familiarly theorized in Romanticism—the lone wolf, propelled by an inner light, and responsible to nothing but his own creative urges.[308] However, I believe these two images share more of a discursive territory than it might at first appear.

Turning first to Fulton, we cannot ignore the extent to which his ideas about invention were shaped as much by his artistic as by his engineering career. Fulton had few great successes in his career as a portraitist and history painter, but in 1793, he exhibited three history paintings at the Royal Academy's annual exhibition, all of them linked by the rather gruesome subject matter of a monarch awaiting execution: *Louis the XVI in Prison Taking Leave of His Family, Lady Jane Grey the Night Before Her Execution*, and *Mary, Queen of Scots Under Confinement*. All three originals are unlocated, but the last two survive in the form of mezzotints produced the

[308] Hugh Honour, *Romanticism* (New York: Harper & Row, 1979), 16-20-254.

same year by engraver James Ward.[309] [Figures 3.37 & 3.38] With both Lady Jane and Queen Mary bathed in an otherworldly light, it seems Fulton's theme for the series was one of eleventh-hour redemption, and it is this, as much as the several striking formal similarities, that bears comparison with Fulton's later work on the submarine. To say that Fulton deliberately modeled his self-portrait on these earlier paintings is perhaps a step too far—although Jane Grey's expectant profile and the cone of light illuminating her darkened cell do seem to echo in the context of this later depiction—but the paintings certainly foreshadow Fulton's own thoughts on the subject of invention and inspiration, expressed in the epigraph to his first published treatise on canal navigation:

> Men of true genius glow with lib'ral spirit, and bind a garland round the bust of merit; While blockheads, void of wisdom's grateful light, Bury distinction in eternal night.[310]

If there is a connection between Fulton's earlier paintings and the later drawings, it is in the terms of risk and redemption, specifically the redemptive light of inspiration. Vision, light, and life are the common themes among these images, and they are themes deployed to wholly identify their author's life and livelihood with the success or failure of his powers of invention.

Reading through the correspondence of Fulton and his friends, it becomes clear that Fulton totally identified himself with his "infernal machine." As he was in the midst of live trials of the submarine vessel, Fulton's patron Joel Barlow implored him to consider, "that the machine of his body is better and more worthy his attention than any other machine he can make; that preservation is more useful than creation; and that unless he could create me one in the image of

[309] Carrie Rebora, "Robert Fulton's Art Collection," *American Art Journal* 22, no. 3 (1990): 41.

[310] Robert Fulton, *A Treatise on the Improvement of Canal Navigation; Exhibiting the Numerous Advantages to Be Derived from Small Canals.* (London: I. & J. Taylor, 1796), xi.

himself he had better preserve his own automaton."[311] Clearly, Fulton was not unfamiliar with the idea of himself as a biomechanical body, but in later correspondence with representatives of the British government, this self-identification with his inventions became imbued with the same level of passion, indeed "fire" that appears in West's portrait. In this correspondence he frequently employs a strange, and somewhat threatening, slippage, in which he suggests, "Much experience has made me conscious of the power of the engines I possess, I am also sensible of my own resources and means of Action…I look to your Lordship and Lord Herrick for prompt justice. I demand it as my right and I never will Submit to plead for it as a favour."[312] Eliding the difference between explosive power and political pressure, these comments return a sense of urgency, immediacy and dynamism to Fulton's biomechanical hybridity.

Conversely, if we turn to West's painting, we discover a more nuanced engagement with the workmanly aspects of technological invention. The portrait's pairing of combustion and creativity clearly engages a broader metaphorics of fire and genius that held special currency amongst West's contemporaries. In his sixth discourse to the Royal Academy of Arts, Academy president Joshua Reynolds compared the process of invention to the burning of Corinth and the painter's great store of images and ideas inherited from the classical tradition to base metals, fused by "the fire of the artist's own genius" into a new and more perfect amalgam, akin to Corinthian brass.[313] West himself would later pick up on this molten metaphor in his own address to the Royal Academy, in the process turning Reynolds's lesson on its head.

---

[311] Charles Burr Todd, *Life and Letters of Joel Barlow, LL.D., Poet, Statesman, Philosopher: With Extracts from His Works and Hitherto Unpublished Poems* (G.P. Putnam's Sons, 1886), 179.

[312] Robert Fulton to William Pitt, 6 June 1806, The William Barclay Parsons Robert Fulton Collection," MS18137, New York Public Library.

[313] Joshua Reynolds, *The Literary Works of Sir Joshua Reynolds: First President of the Royal Academy* (London; Edinborough: T. Cadell, 1835), 397.

Commenting on the stultifying effect exercised by an overreliance on inherited traditions, West suggests,

> More harm than good has therefore been done by the systems of those schools, which, having their own ideas of excellence, have brought every genius to assimilate with them. …. It is there thrown, in fact, into a mould; it becomes like metal in fusion, and must take the impression for which the mould is prepared.[314]

Such metallurgical analogies evoke the work of yet another contemporary, namely the fire-lit scenes of labor depicted in Joseph Wright of Derby's forge series. [Figure 3.39] The glowing bars at the center of these compositions are no more than daubs of paint, but Wright's skillful handling has effected an extraordinary transformation, transmuting the physical properties of oil and pigment into the evanescent characteristics of heat and light. Locating this painterly transformation at the site of proto-industrial production, Wright has analogized the painter and the craftsman, suggesting that both shape their work through a combination of mechanical skill and the transformative force of fire—be it the metaphysical fire of genius or the physical act of combustion. Although Wright's glowing bars occupy a different material state than the molten metal of Reynolds and West's metaphors, his emphasis on the relationship between fire and physical labor focuses our attention on the shared rhetoric of workmanship that threads throughout all three of these examples; even West, who uses the casting process to denigrate artistic conformity, posits genius as something that is explicitly fabricated—something made.

This rhetoric of workmanship places these artists in the midst of a debate over the relationship between art, science and the imagination in the late eighteenth- and early nineteenth-centuries. In relation to the larger project on objectivity mentioned above, Lorraine Daston has

[314] Benjamin West, *A Discourse, Delivered to the Students of the Royal Academy, on the Distribution of the Prizes, December 10, 1792, by the President. Humbly Inscribed by Permission to His Majesty.* (London: Printed by Thomas Cadell, printer to the Royal Academy, 1793), 12.

persuasively argued for a progressive polarization between art and science in this period and the simultaneous "migration of imagination to the artistic pole."[315] Part of this process involved a reconsideration of the category of facts. Although derived from the Latin verb *facere,* meaning to do or to make, the word "fact" evolved over the course of the eighteenth-century to mean something "given by nature, not made by human art." Divorced from the scientifically factual, terms with similar etymologies, like manufacture or fabricate, acquired, in Daston's words, "an evil odor of forgery and deception in addition to their root senses of construction."[316] This strict dichotomy of fact/science/objectivity and fabrication/art/subjectivity is, of course, a simplification, but it clearly reflects, in broad strokes, the transition from eighteenth-century Enlightenment thought to nineteenth-century Romanticism.

What is interesting about West's depiction is that it features the engineer—a new profession in the eighteenth-century and one that sits uneasily between these two poles of art and science. Technological invention was necessarily a process of scientific experimentation, and the engineer's livelihood depended on the reproducibility of his experimental results. This is, in part, the significance of the scene depicted in the background of West's portrait and even the justification for Fulton's appearance within the technical drawings for his own machine. Both images suggest the possibility of eye-witness accounts, testifying to the performance of an experimental trial and recording the observable, objective fact of its success. At the same time, the engineer's work was fundamentally (and quite literally) an act of fabrication—the manufacture of a new object or set of objects where none had been before. It was both innovation (the act of making something new) and invention (in its Latin root of *invenīre*: to come upon,

[315] Lorraine Daston, "Fear & Loathing of the Imagination in Science," *Daedalus* 134, no. 4 (2005): 17.

[316] Ibid., 18.

discover or find out).[317] Thus the figure of the engineer offered West a unique opportunity to interrogate this continuum from fact to fabrication and the relationship between science and art it implied. On one hand, the fire that illuminates the background of the portrait draws on the notion of invention as a process of scientific experimentation. Indeed, it references the visual language of Fulton's own technical drawings. The figure of the exploding boat appears nearly identical to one Fulton used to record the test of his technology on the Danish brig *Dorothea* at Brest, testifying to the performance of an experimental trial and recording the observable, objective fact of its success. At the same time, his portrayal sublimates all of the details of Fulton's creative process into a single explosive event—a metonymy that makes reference to ancient associations between the transformative force of fire and the baser mechanical arts while also effacing any evidence of labor with its bright, white heat.[318]

By seeking out the discourse of technics that underlies the emotive force of West's depiction and in unearthing the frisson of violence betraying the cool rationality of Fulton's mechanical drawing, we get closer to understanding the rapidly transforming world these men occupied. For both West and Fulton, the figure of the engineer supplied an opportunity to rehearse relationships between fact and fabrication, creativity and destruction, body and machine—relationships that were aggressively reorganized in the first decades of industrialization. Moreover, the two artists' varied treatments highlight the fundamental

[317] "Invent, v.". OED Online. September 2015. Oxford University Press. http://www.oed.com.ezp-prod1.hul.harvard.edu/view/Entry/98960 (accessed December 01, 2015).

[318] As mentioned in the dissertation's introduction, Aristotle argues in *Politics* that "in the state which is best governed…the citizens must not lead the life of mechanics or tradesmen, for such a life is ignoble, and inimical to virtue." Aristotle, *Politics*, VII, 9 1328 b33-a2. Aristotle's term βάναυσοι (*banausoi*), conventionally translated as "mechanics," derives from βαῦνος (*baunos*) for furnace or forge and αὔω (*auo*), meaning to light a fire or make blaze. "Properly the designation of 'those who work with the techniques of fire…essentially blacksmiths, metallurgists, and potters,'" the term had by Aristotle's time expanded to encompass the full range of manual or technical arts, without losing the taint of hard, physical labor embedded in its origins. Leslie Kurke, *Coins, Bodies, Games, and Gold: The Politics of Meaning in Archaic Greece* (Princeton: Princeton University Press, 1999), 4.

instability of the body as a site of signification at this moment. West's interpretation takes the alchemical route, transmuting the body's activities into the fires of inventive genius, while Fulton's self-portrait insists on the use of his own body as physical testimony—a tangible link between the product of invention and the inventive process that produced it. And yet, the entanglement of body and machine enacted in this self-portrait brings new significance to the strained exercise of self-possession at work in West's subject. If Fulton is his own machine, then West's depiction demonstrates the consequences of stoking its engine's fires. Conversely, the explosive force of West's portrayal realizes the destructive potential buried in Fulton's mechanized self-portrait. The body that emerges from this comparison is one part metal, one part flesh, and one part smoke. Both armored and vulnerable, it willfully engages in acts of creative destruction.

After Fulton's death in 1815, De Witt Clinton, mayor of New York City and president of the American Academy of Fine Arts, delivered an address to the Academy on the subject of art and invention. Its conclusion offered a eulogy on the engineer's behalf and its final lines are a melancholy reflection on the paradoxical intertwining of creativity and destruction his career so clearly invoked:

> Like the self-burning tree of Gambia, he was destroyed by the fire of his own genius and the never ceasing activity of a vigorous mind. And O! may we not humbly hope that his immortal spirit, disembodied from its material incumbrance, has taken its flight to the world of pure intellect, 'where the wicked cease from troubling, and where the weary are at rest.'[319]

The image is a tragic one—a man used up by the activity of his mind, his flesh merely fuel for the fire—but it is also instructive, directing our attention to a thread that has woven throughout this chapter. Whether materialized in body or on paper, there is a necessary fragility to which the

[319] Clinton, *Discourse*, 30.

idea's immanence subjects it. We have seen it again and again: in the decades of invention obliterated in the Patent Office fire, in Farey's drawing of the card-making machine, which had to break the device in order to fully depict it, and here in the barely contained combustion that animates West's portrait. Fulton himself, foreseeing the dangers inherent in committing ideas to paper, prepared two sets of the submarine drawings before he left England for America. One was consigned to an agent in London, the other to transatlantic transport. These latter were lost at sea.

These episodes all speak to persistent anxieties around the possibility of dispossession in the early industrial Atlantic, and as the portraits produced by Fulton and West make clear, these are anxieties rooted in the body, in the need to maintain a physical relationship between oneself and the products of one's own mind and hands. As the principal tool of technological representation, drawing holds the capacity to transport demonstrative testimony across space and time, to extend the reach of the inventor beyond his physical person, and it is this capacity that has allowed for the possibility of intellectual property at all. However, while drawing's portability made possible the pursuit of intellectual property across national borders, it also threatened to compromise the integrity of that property right. The British patent rolls are filled with inventions purportedly "communicated from a foreigner residing abroad," and agents like Joseph Dyer made good business of filing these patents under their own name. The extent to which the original author might benefit from such a patent relied exclusively on whatever private contract he or she had made with the agent, not on any sort of governmental protection. By materializing the idea, drawing makes of it a commodity that may be identified, valued, and exchanged. And yet, it is also this imperative to materialize that threatens to compromise the integrity of that property right. Once an instrument used to secure property, the drawing eventually comes to undermine it. Such mobility—like theft, fire, or even gradual decay—is a necessary condition of the idea's materialization. The drawing's very imperative to render the idea material positions the inventor always and already at the verge of being dispossessed.

CHAPTER 4

THE MECHANICS OF LIKENESS

Shortly after the death of George Washington in December 1799, itinerant portraitist Charles-Balthazar-Julien Févret de Saint-Mémin produced a profile portrait of the former president, presented in the guise of a classical bust. [Figure 4.1] The portrait clearly joins the proliferation of images that emerged in the wake of the president's death, many of which drew on similar classical allusions and allegory. Circulated just weeks after Washington's death, the memorial print produced by James Akin and William Harrison, Jr. incorporates Washington's likeness into a pastoral scene populated by urn-topped obelisks and attended by a delicately weeping maiden, identified as "America" and dressed in classical style. [Figure 4.2] Rendered in watercolor and/or sewn in silk, similar iconography appears in the popular mourning scenes worked by young American women as part of their education in the genteel arts of drawing and needlework. [Figure 4.3] We also find it on English transferware vessels as part of the paradoxical, but not uncommon, practice of importing objects of American patriotism from the nation's former colonial sovereign, and there is some suggestion that such imagery drew inspiration from the stage sets used in the delivery of funeral orations and public eulogies in the weeks and months following the president's death.[320] [Figure 4.4] John James Barralet's widely circulated print *The Apotheosis of Washington* takes an alternate tack, setting his mourning scene in an indefinite celestial sphere. [Figure 4.5] Using Gilbert Stuart's Athenaeum portrait as a model for Washington, Barralet's design depicts the former leader's ascension to Mount Olympus, lifted by the winged figures of Genius and Immortality.[321] A classically garbed America, arms draped around her liberty pole and cap, mourns at the base of Washington's tomb, accompanied by what the print's publisher Simon Chaudron described as "an Indian crouched in surly sorrow" and figures representing "the mental virtues, Faith, Hope, and Charity."[322] Although more celebratory than mournful, Barralet's allegorical depiction of the reanimated leader epitomizes the classicizing spirit that pervaded the presidential cult of mourning.

Amidst this context, Saint-Mémin's sculptural rendering of Washington *à l'antique* would merit little remark, were it not for the method of its production. This particular image was produced with the aid of the newly popularized "physiognotrace," a device that permitted the artist to trace his subject's profile in space as its mechanical arm simultaneously drew the same outline on paper. [Figure 4.6] Adopted by a number of itinerant artists throughout the United States, the physiognotrace was thought to limit the interference of artistic interpretation in picture-making, providing an immediate and unmediated representation of the portrait sitter.

---

[320] Davida Tennenbaum Deutsch, "Washington Memorial Prints," *Antiques* 111, no. 2 (1977): 324. Analysis of the mourning picture as a genre, more broadly, may be found in Anita Schorsch, "Mourning Art: A Neoclassical Reflection in America," *American Art Journal* 8, no. 1 (1976): 14–15.

[321] An extensive account of the allegorical references and visual sources on which Barralet drew in constructing this image may be found in Phoebe Lloyd Jacobs, "John James Barralet and the Apotheosis of George Washington," *Winterthur Portfolio* 12 (1977): 115–137.

[322] Quote comes from the initial advertisement for the print in the *Aurora*, December 19, 1800. Quoted in Wendy Wick Reaves, *George Washington, an American Icon: The Eighteenth-Century Graphic Portraits* (Washington, D.C.; Charlottesville: National Portrait Gallery, Smithsonian Institution, Distributed by the University Press of Virginia, 1982), 166. A full catalogue of the printed portraits of Washington produced before 1802 may be found in this text, to include the wide range of mourning materials printed after the president's death. It should also be noted that Barralet's was not the only apotheosis image to emerge in this period. Just six days after Washington's death, Samuel Kennedy announced the publication of an engraving based on Rembrandt Peale's (now lost) *Apotheosis of General Washington*. The print is less compositionally ambitious than Barralet's later work, but similarly replete with classical allusion. Ibid., 157.

This mechanical aspect of the image's production renders several characteristics of the Washington portrait paradoxical. For one, there is the overt confrontation the image stages between the arts of antiquity and the very latest techniques of image production. Numerous scholars have emphasized the importance of classical culture to America's process of nation building, and as is evident in the mourning images discussed above, classical allusion was not simply a set of arcane symbols traded in by an intellectual and political elite, but rather a language familiar to the wider populace.[323] As Caroline Winterer has argued, early American society sought more than an intellectual understanding of antiquity. Its members craved a sense of the classical world's "palpable physicality."[324] At the same time, it was the great temporal distance between the classical past and the present that rendered its symbolism so powerful. As one of the former president's eulogists proclaimed, "He [Washington] seems so little to belong to modern times that he imparts to us the same vivid impressions as the most august examples of antiquity."[325] In other words, it was Washington's anachronistic embodiment of the classical virtues that made him a figure for emulation. He served as a physical conduit to a remote and inaccessible past. In using the physiognotrace's reputation for immediacy and authenticity to portray Washington in the guise of a Roman hero, Saint-Mémin's image enacts this strangely split sense of temporality, collapsing the distance between past and present while also revealing the fundamental instability of such historical reconstructions.

---

[323] Jacobs, "John James Barralet and the Apotheosis of George Washington," 115. See also, Caroline Winterer, *The Culture of Classicism: Ancient Greece and Rome in American Intellectual Life, 1780-1910* (Baltimore: Johns Hopkins University Press, 2002); Gordon S. Wood, *The Radicalism of the American Revolution* (New York: A.A. Knopf, 1992).

[324] Caroline Winterer, "From Royal to Republican: The Classical Image in Early America," *The Journal of American History* 91, no. 4 (2005): 1264.

[325] From the "Eloge Funèbre de Washington; pronounce dans le Temple de Mars, par Louis Fontanes," delivered in Paris, February 18th, 1800. Quoted in William Spohn Baker, *Character Portraits of Washington as Delineated by Historians, Orators and Divines: Selected and Arranged in Chronological Order with Biographical Notes and References* (R.M. Lindsay, 1887), 96.

Given Washington's passing in late 1799, there is also some question of how Saint-Mémin even produced this rendering. Although Washington and Saint-Mémin were both in Philadelphia in November or December of 1798, there is no evidence to suggest that the president ever sat for the artist directly. Instead, it seems likely that the artist worked from representations produced by others.[326] Some have suggested that Saint-Mémin may have used the physiognotrace to draw directly from one of Jean-Antoine Houdon's life casts of Washington, but the drawing also bears a striking resemblance to a pair of bas-relief medallions (one in plaster, one in wax) produced by the sculptor Joseph Wright in the 1780s—renderings that may have been based themselves on Wright's own life cast of the president.[327] [Figure 4.7] Any of these scenarios suggest that the drawing is the result of a set of mediated encounters. Each attempts to connect the drawing with the physical body of the sitter, even as that body has become unavailable through death. The drawing itself registers the strange effects of this mediation. Certain passages, particularly in the rendering of the hair, seem to suggest the softness and movement of organic tissue, but the blank eyes, the suggestion of a subtle sheen across the president's countenance, the deliberate and rather gruesome cut just below his neck—these all point to the cold stone of a marble effigy, the reification of the body that comes from the

[326] This would not have been an uncommon practice. John James Barralet (like many others) relied on Gilbert Stuart's Athenaeum portrait to provide the basis for his memorial print. The rampant reproduction of Stuart's likeness of Washington is discussed in Adam Greenhalgh, "'Not a Man but a God.' The Apotheosis of Gilbert Stuart's Athenaeum Portrait of George Washington," *Winterthur Portfolio* 41, no. 4 (2007): 269–304. Stuart himself worked from the Houdon life mask to produce a profile of Washington, which he then altered to produce a more telling "likeness." Christopher J. Lukasik, *Discerning Characters: The Culture of Appearance in Early America* (Philadelphia: University of Pennsylvania Press, 2011), 135. Charles Willson Peale is also known to have used a physiognotrace to trace a portrait bust of Thomas Jefferson. The image was sent from Peale to Jefferson in 1803, but Peale also circulated copies of the image for public consumption. Wendy Bellion, "Heads of State: Profiles and Politics in Jeffersonian America," in *New Media, 1740-1915*, ed. Lisa Gitelman and Geoffrey B. Pingree, Media in Transition (Cambridge, Mass.: MIT Press, 2003), 32.

[327] Ellen G. Miles, *Saint-Mémin and the Neoclassical Profile Portrait in America* (Washington D.C.: National Portrait Gallery : Smithsonian Institution Press, 1994), 102–3. For a brief history and the provenance of these objects, see Fiske Kimball, "Joseph Wright and His Portraits of Washington: Sculpture," *Antiques* 17 (January 1930): 34–39.

process of representation.

So why? Why turn the physiognotrace to such uncanny effect? Why perpetrate this collapse of past and present? Why put the machine's capacity for representing the idiosyncrasies of living flesh in service of rendering lifeless, immovable stone? The unsettling relationships between present and past, action and stasis, life and death enacted in this portrait certainly speak to the elegiac function of the memorial image. As Gary Laderman has argued, many of the funeral ceremonies and public observances of Washington's death relied upon a logic of simulation in many ways similar to that which appears in Saint-Mémin's portrait. "In towns throughout the republic…these observances were carried out *as if* the real body were present. Philadelphia citizens not only saw a mock coffin but also a 'symbolic reproduction' of the Mount Vernon ceremony."[328] In his funeral oration at the Mount Vernon ceremony itself, eulogist Major General Henry Lee allowed Washington to speak from beyond the grave, apparently voicing the president's post-mortem exhortation that the public "Be American in thought and deed. Thus will you give immortality to that union, which was the constant object of my [Washington's] terrestrial labors."[329] Through such acts of simulation, the American public replaced the president's physical body with a body of collective memory, and again, in Laderman's words, "The corpse, though treated as present in many ceremonies, was secondary to Washington's apotheosis in the collective imagination."[330] In both these ceremonies and in the Saint-Mémin portrait, the body of the president is simultaneously present and absent. In the physiognotrace

[328] Gary Laderman, *The Sacred Remains: American Attitudes toward Death, 1799-1883* (New Haven: Yale University Press, 1996), 17.

[329] Quoted in Burstein, "Immortalizing the Founding Fathers: The Excesses of Public Eulogy," in *Mortal Remains: Death in Early America*, ed. Nancy Isenberg and Andrew Burstein (Philadelphia: University of Pennsylvania Press, 2003), 97–98.

[330] Gary Laderman, "Locating the Dead: A Cultural History of Death in the Antebellum, Anglo-Protestant Communities of the Northeast," *Journal of the American Academy of Religion* 63, no. 1 (1995): 27–28.

portrait, in particular, the use of the machine is used to (literally) draw the physical body closer, even as the manner of its rendering seems to push such physicality farther away. Thus, we might view the drawing's ambivalence toward both temporality and physicality as an aid in the construction of memory—facilitating a transposition of experience from the physical world to a remembered one. We might also understand it as contributing to the assertion of Washington's immortality—a state that is both lived and not, an existence that is both of time and beyond it.[331]

While these elegiac functions are clearly in play, there is another aspect to consider in Saint-Mémin's unique use of the physiognotrace in this image. I would like to suggest that the unsettling relationship between life and death enacted in Washington's portrait speaks to broader concerns in this period regarding the nature of life itself, and in particular, to concerns regarding the nature of life *vis à vis* the machine's existence. I began the dissertation with a discussion of the automaton—the fascination it held for eighteenth-century audiences as a physical manifestation of Cartesian theories of mind and body; its ambiguous status at the turn of the nineteenth century, accompanying a philosophical shift from mechanistic to vitalistic interpretations of human physiology and cognition; and the problematic performance of Maelzel's mechanical draftsman in the 1830s, which exhibited the impression of a knowing, responsive machine amidst the dehumanizing realities of industrialized production. Here, the physiognotrace presents a different sort of drawing machine, but one no less embroiled in industrialization's transition from living to lifeless mechanisms.[332] As a machine used by the body to represent the body, the physiognotrace offers a unique vantage point from which to

---

[331] Wendy Bellion has noted a similar ambition in Rembrandt Peale's portrait of Washington known as the *Patriae Pater:* "Rembrandt's painting goes beyond the basic expectations of portraiture—that a portrait should represent a sitter with the vitality of life, persuading us that the person does once did exist—to suggest a president reenlivened by the painter's brush, a body animated in a sunny realm just beyond the spectator's reach," Rembrandt uses the language of "resurrection" to describe the painting "Outlining a two fold strategy of cognitive remembrance and pictorial re-membering as the foundation of his working methods." Bellion, *Citizen Spectator*, 299.

[332] Marx, "*Capital*," 75.

gauge Americans' understanding of the relationship between body and machine in the early nineteenth century. The physiognotrace image, in general, suggests early American society's willingness to subject the body to objectification, mensuration, and quantification. These, as we saw in the first chapter, are the very conditions necessary to transforming the individual's autonomous body into an instrument of industrial manufacture. However, the provocative synthesis of life and death found in Saint-Mémin's sculptural rendering of Washington seems to suggest an ambivalence, if not outright critique, of this analytical mode of depiction and the imbrication of body and machine required to produce it.

This chapter will examine the ways in which the physiognotrace enacted industrialization's incremental transfer of creative agency from body to the machine, while also looking for challenges to that transfer from within. It begins with a brief overview of the device's history and then proceeds to a study of Saint-Mémin's work in particular. After examining the very physical reorganization of the relationship between body and machine required in his drawing process, I look at the various ways in which Saint-Mémin's portraits register and respond to this reorganization. Returning once more to the George Washington portrait and its connections between mortality and mechanical reproduction, I explore the physiognotrace portrait as a vehicle for the critique of mechanization. Then, building on this critique, I look at the ways in which Saint-Mémin sought to stake out a role for the body within the mechanical drawing process through his sitters' own performative constructions of identity. Given that physiognotrace portraiture is the one form of drawing examined in the dissertation that explicitly involves the machine in the actual process of drawing, one need not look far for the intermingling of bodily and industrial mechanics in this particular case. Rather, this final chapter examines anxieties inherent to this intermingling, suggesting that both the body/machine hybrid and the anxieties attached to it have been an intrinsic aspect of industrialization since its inception.

The Origins of the Physiognotrace

Physiognotrace portraiture originated in Paris in the early 1780s, with a drawing device designed by a cellist at Versailles named Gilles-Louis Chrétien.[333] Unfortunately all trace of the machine itself has been lost, leaving only a diagram drawn by Chrétien's first business partner Edmé Quenedey. [Figure 4.6] The drawing has proved remarkably resistant to interpretation, and every scholar who discusses it seems to come to a slightly different conclusion as to its manner of operation. In my own reading, Chrétien's device consists of a large frame (approximately five feet tall) within which an interlocking set of hinged parallelograms have been installed. Some have referred to this mechanism as a "pantograph," a device invented in the seventeenth century by the German Jesuit Christopher Scheiner, but though visually similar, the mechanisms of the pantograph and Chrétien's physiognotrace are, in fact, distinct. [Figure 4.8] The pantograph consists of two intersecting "Vs," hinged at each crossing. A tracing stylus is fixed at one end of the larger, outer "V" and a drawing stylus is located at some point along the leg of the inner, smaller "V." The flex of the two "Vs" in tandem transfers every movement made by the tracing stylus to the drawing stylus, and by altering the location of the drawing stylus along its leg, one can alter the size at which the original image is reproduced. In contrast, the mechanism of the physiognotrace is actually far simpler. The left end of the upper parallelogram is formed by a vertical support that connects a sighting device above to a stylus below. These two elements are permanently fixed in relationship to each other, and by virtue of this fixed connection, any

[333] Background on physiognotrace portraiture comes from Miles, *Profile Portrait in America*; Bellion, "Heads of State"; Peter Benes, "Machine-Assisted Portraiture and Profile Making in New England after 1803," *Annual Proceedings/Dublin Seminar for New England Folklife* 19 (1994): 138–50.

movement of the sighting device is automatically reproduced by the stylus. Within this system, there is a one-to-one correlation between the movements made by the operator's hand and those recorded by the stylus. The hinged parallelograms are not involved in the transfer of motion from sight to stylus and they do not contribute to a rescaling of the image. Instead, they function to keep both elements within the same vertical plane as they move in parallel. A system of wires and rollers installed along the frame is designed to keep the entirety of this hinged device in contact with the frame as it moves.

During a portrait session, operator and sitter would stand on opposite sides of the physiognotrace, with the sitter turned perpendicular to the machine so that his profile appears in the open window in the top third of the frame. Later versions of the physiognotrace, designed by other inventors, would incorporate a stylus that physically touched the sitter's face. By dragging this stylus along the sitter's profile, the operator could take a direct and physical registration of his subject's physiognomy. In Chrétien's design, however, the tracing process is done by sight. The mobile sighting device contains a set of crosshairs. Facing the frame and peering through its sight, the operator would line up the center of the crosshairs with the edge of the sitter's face, and then carefully move this point along the perceived profile line. Because the device's movements were not restricted by physical contact with the sitter's face, this method had the advantage of allowing the operator to document the sitter's profile as well as any salient features that lay within the profile line. And as the device has no mechanism for shifting scale, the scale at which the portrait would have been rendered was entirely dependent on the distance the sitter stood from the machine—immediately against the frame and the portrait was essentially life-size, at some distance from the frame and the sitter's face was miniaturized. The image itself was rendered by the stylus connected to the sighting device via the fixed bar at one end of the upper parallelogram, such that any motion of the sighting device would simultaneously register as marks made on a sheet of paper fixed within the frame below. Although Chrétien and Quenedey's work is best known through the detailed engravings they did based on these mechanical tracings, a surviving drawing by Chrétien does suggest that a significant amount of detail would have subsequently been supplied by the draftsman's hand *after* the drawing was removed from the device's frame. [Figure 4.9]

This form of mechanically-assisted portraiture gained immense popularity in the late eighteenth and early nineteenth centuries, heralded for its naturalism, authenticity, and essential truthfulness. It has thus figured frequently in the history of art as a proto-photographic technology, connected to photography's claims to mechanical objectivity and automation. This connection is what makes the practice such a fascinating subject for my study of the relationship between representation and industrialization in a pre-photographic era and an apt test case for critiquing the various assumptions that have been made about this relationship. However, in order to understand the ways in which the connection between the physiognotrace and photography has been made, it is essential to understand the myriad cultural references upon which the earlier technology drew in order to assert its unique status.

Engaging both an enthusiasm for the antique and a contemporaneous interest in the emergent pseudoscience of physiognomics, the physiognotrace portrait quickly found favor, both inside and outside of France, in the late eighteenth and early nineteenth centuries. On one hand, the portraits echoed one of art's most famous origin stories—that is the Corinthian maid Dibutades's attempt to capture the likeness of her lover by tracing the outline of his shadow on the wall as he slept. Recorded by Pliny the Elder in his *Natural History*, the tale lent the weight of classical precedent to the practice of portraiture, bolstering its status *vis à vis* the more elevated practice of history painting.[334] Within the hierarchy of genres, portraiture's problematic associations with physical likeness and its associated particularity had rendered it secondary to the history painter's portrayal of events from Roman, Greek or Biblical antiquity—scenes that required a degree of idealism, invention and genius that the mimetic practice of portraiture ostensibly could not. By locating the origins of painting in portraiture rather than narrative art, the traced profile of Dibutades's lover offered more than just a classical justification for the arts of portraiture. It threatened the very hierarchies on which the genre system was based.[335]

The profile was also the cornerstone of Swiss minister Johann Caspar Lavater's new theory of physiognomics. The study of the permanent characteristics of one's facial features, physiognomics found enormous popularity in both Europe and American in the late eighteenth and early nineteenth centuries. Over the course of the eighteenth century, traditional social structures and conventional signifiers of status had been increasingly challenged—both by a growing market economy and by the onset of industrial modes of production. These changes offered individuals greater access to disposable wealth and to a greater range of material goods, opportunities that in turn facilitated both geographic and social mobility.[336] In the midst of this unstable environment of shifting signs, Lavater promoted physiognomics as a way of finding fixity.[337]

---

[334] Pliny, *Natural History*, n.d., XXV.35.15-16 and 43.12; Miles, *Profile Portrait in America*, 35. This origin story is the result of blending of two passages from Pliny's *Natural History*, both concerning the tracing of a man's shadow on the wall. For more on the history of this myth and its place in eighteenth-century society, see Robert Rosenblum, "The Origin of Painting: A Problem in the Iconography of Romantic Classicism," *The Art Bulletin* 39, no. 4 (1957): 279–290.

[335] Marcia R. Pointon, *Hanging the Head: Portraiture and Social Formation in Eighteenth-Century England* (New Haven: Published for the Paul Mellon Centre for Studies in British Art by Yale University Press, 1993), 83.

[336] Richard L. Bushman, *The Refinement of America: Persons, Houses, Cities*, 1st ed. (New York: Knopf : Distributed by Random House, 1992); T. H. Breen, *The Marketplace of Revolution: How Consumer Politics Shaped American Independence* (Oxford; New York: Oxford University Press, 2004).

[337] Lukasik, *Discerning Characters*, 12 & 53.

As scholars like T.H.Breen and Paul Staiti have argued, the practice of portraiture was intimately bound up with this newfound materialism and the construction of identity through external signifiers. Breen, in particular, suggests that "eighteenth-century painters were not engaged in the production of what we might call an objective 'likeness,'" i.e. a convincing imitation of facial resemblance, and argues instead that likeness for the eighteenth-century viewer was constructed through the liveliness of the sitter's dress and accouterments, in particular through the verisimilitude of represented cloth.[338] Margaretta Lovell has advanced a related, but distinct, argument regarding the repeated appearance of certain garments across multiple portraits in the work of John Singleton Copley. In contrast to Breen and Staiti, whose theories of portraiture center on class rivalry and emulation, Lovell instead argues that the ostentatious display of rich fabrics and elegant surroundings was not so much a means of constructing personal identity through the assertion of individual difference, but should instead be viewed as well-considered, self-conscious decisions to unite and cement communal relations across space and time.[339]

The trouble was, such conventions were mutable. Dress, ornamentation, even proper comportment could be purchased for the right price. Challenging the symbolic basis upon which both individual and class identity had been based, Lavater's theory of physiognomics was thus grounded in a set of features that could not, ostensibly, be feigned. In his *Essays on*

---

[338] T. H. Breen, "The Meaning of 'Likeness': Portrait-Painting in an Eighteenth-Century Consumer Society," in *The Portrait in Eighteenth-Century America*, ed. Ellen G. Miles, The American Arts Series/University of Delaware Press Books (Newark, DE: University of Delaware Press, 1993), 49. See also, Wayne Craven, *Colonial American Portraiture: The Economic, Religious, Social, Cultural, Philosophical, Scientific, and Aesthetic Foundations* (Cambridge, UK; New York: Cambridge University Press, 1986); Paul Staiti, "Character and Class," in *John Singleton Copley in America*, ed. Carrie Rebora Barratt et al. (New York: Metropolitan Museum of Art, Distributed by H.N. Abrams, 1995), 53–78.

[339] Margaretta M. Lovell, *Art in a Season of Revolution: Painters, Artisans, and Patrons in Early America* (Philadelphia: University of Pennsylvania Press, 2005), 49–93 & 141–83.

Physiognomy, he argued that an individual's temperament and moral character could be perceived in the permanent physical structures of his face. Searching for a form of representation that might fix these features into an image suitable for scientific study, Lavater seized on the profile. His *Whole Works* incorporates an illustration of an optical device for capturing profiles. [Figure 4.10] In the text, he characterizes the image produced by the device as both the most feeble of likenesses—because devoid of movement, emotion, dimensionality—and "the truest representation that can be given of man…because it is the immediate expression of nature, such as not the ablest painter is capable of drawing, by hand, after nature."[340] Allowing no indication of "motion, nor light, nor color, nor volume, nor features," the physiognotrace promised to distill the sitter's physical countenance and moral fiber into the single, indexical trace of the profile line.[341]

These concurrent interests—neoclassicism and physiognomy—are connected through the figure of the line. It is not merely that the profile line referred to the classical past, but that this reference was loaded with associations of clarity, purity, and authenticity. Take, for example, artist George Romney's assessment of his colleague John Flaxman's outline illustrations for *The Odyssey*. [Figure 4.11] In Romney's words, these images "look as if they have been made in the age when Homer wrote." They "are outlines without shadow, but in the style of ancient art. They are simple, grand, and pure."[342] This aesthetic, in turn, bore its mark on Lavater's notions of both beauty and moral rectitude. His own neoclassical bias is evident in the myriad images accompanying his texts on physiognomy, from imagined portraits of Plato and Socrates to

[340] Miles, *Profile Portrait in America*, 37.

[341] Quoted in Barbara Maria Stafford, "'Peculiar Marks': Lavater and the Countenance of Blemished Thought," *Art Journal* 46, no. 3 (1987): 188.

[342] Quoted in Alexis Cohen, "Domestic Utility and Useful Lines: Jean-Charles Krafft's and Thomas Hope's Outlines," *Journal of Art Historiography*, no. 9 (2013): 2.

engravings that purport to display the full range of creation's cranial structures, beginning with the frog as a "swollen representative of disgusting bestiality" and culminating with the "far-striking, the penetrating divinity" of Apollo.[343] [Figure 4.12]

The profile portrait's particular combination of neoclassicism and pseudo-scientific rationalism held particular sway within the United States, where, as Wendy Bellion has argued, the physiognotrace claimed to provide a uniquely democratic form of portraiture. Beyond the democratization of both production and consumption—the mechanical device made it easier and cheaper to both execute and purchase a portrait—the "device and the images it yielded were praised in the descriptive terms of actual representation, a period rhetoric that optimistically imagined political representation to be direct, particular, and true."[344] That is to say, the physiognotrace seemed to promise an immediate and unmediated means of visual communication that exemplified the principles of representative government upon which the new nation was founded. As this nation grappled with its relationship to the various models of democratic governance mobilized in classical Greece and Rome, the fact that the physiognotrace portrait made visual reference to the arts of antiquity only increased its cultural resonance.[345]

This notion of direct representation found a particularly acute expression in the physiognotrace device installed in the Philadelphia museum of artist Charles Willson Peale. Designed by John Isaac Hawkins, this mechanism was of a design that ostensibly allowed visitors to manipulate the device themselves, obviating the need for a trained operator.[346] [Figure

---

[343] Johann Caspar Lavater, *Essays on Physiognomy*, trans. Thomas Holcroft, 8th ed. (London: Tegg, 1853), 496–697.

[344] Bellion, "Heads of State," 32.

[345] On the intellectual and political project of classicism in the early Republic, see especially Winterer, *The Culture of Classicism*, 10–43.

[346] Scholars have since questioned whether the machine could, in fact, be operated by the sitter him or herself.

4.13] Affirming the machine's independence of artistic intervention, advertisements for the device suggest the physiognotrace was of "so simple a construction, that any person without the aid of another, can in less than a minute take their own likeness in profile."[347] This rhetoric of automation and self-evidence is characteristic of period descriptions of the device—note Lavater's suggestion that the physiognotrace image is such as "only nature could make." It is also a rhetoric reiterated in many of the period's visual representations of the machine. [Figures 4.6, 4.10, & 4.14] Adopting the conventions of technical drawing, these images efface the body of the artist from the scene, leaving the machine alone, autonomous, unadulterated. Even in the scene from Lavater's *Whole Works*, where there is some suggestion of the artist's body, it is hidden behind the physiognotrace's screen. The emphasis is placed instead on the shadow cast by the candle—a natural and effortless guide for the artist's hand to follow. This version of the machine is ghostly, haunted by the hand of an operator who never materializes. It is a strange device that attempts to fix an image of the body while denying all evidence that a body lies behind its animation.

These verbal and visual descriptions foreshadow the rhetoric that would develop around the rise of the photographic apparatus some thirty years later. In 1839, the daguerreotype process was heralded as the act of drawing "carried to a degree of perfection which art can never attain" and the images the camera produced were described as "faultless facsimiles." The London *Spectator* referred to daguerreotyping as a "self-operating process of fine art"—a description that effaced the body from the process of production altogether. Just a few years later, William Henry

---

Physical tests done on a contemporary replica suggest, in fact, that the machine was far more difficult to maneuver than Peale advertised and that a trained operator was almost certainly necessary to obtain a reliable likeness. Anne However, I would argue the rhetorical construction of the device as semi-autonomous is an important aspect of understanding the cultural purchase of the physiognotrace, in particular, and the machine, in general, in early American society. Anne Verplanck, email message to author, February 24, 2017.

[347] "Friendship Esteems as Valuable Even the Most Distant Likeness of a Friend," *Philadelphia Repository*, January 1, 1803.

Fox Talbot's *Pencil of Nature* would promote the idea of the photographic image as the product of Nature itself. Given this shared rhetoric, it has become common to speak of the physiognotrace as a proto-photographic technology, and by linking these portraits to photographic history, historians have tended to place the physiognotrace portrait within a discursive context in which the relationship between artist and machine has been defined largely in terms of automation, disembodiment and deskilling.[348] This narrative is complicated, however, when one turns to the work of Saint-Mémin.

The Body in the Machine

Born in 1770 in Dijon, France, Saint-Mémin was the son of a mid-level functionary in the Burgundian government.[349] As a young man, he received a gentleman's education, to include instruction in drawing from François Devosge, the founder of Dijon's *Ecole de dessin* and the *Musée des Beaux Arts Dijon*.[350] The few remaining materials that survive from this very early stage of his career suggest he received a fairly typical course of instruction, copying from prints and devising "original" compositions based on classical subjects. [Figures 4.15 & 4.16] In 1784, he entered the *Ecole militaire* in Paris, where his early lessons from Devosge would have been supplemented by instruction in technical drawing, from exercises in stereotomy or stone-cutting

---

[348] See especially, George Eastman House, "Before Photography," February 10, 2017, https://www.youtube.com/watch?v=me5ke7agyOw&list=PL4F918844C147182A,; Gwendolyn Dubois Shaw, "'Moses Williams, Cutter of Profiles': Silhouettes and African American Identity in the Early Republic," *Proceedings of the American Philosophical Society* 149, no. 1 (2005): 22–39; Penley Knipe, "Paper Profiles: American Portrait Silhouettes," *Journal of the American Institute for Conservation* 41, no. 3 (2002): 203–223. For the emergence of handcraft as oppositional to industrialization, see Adamson, *The Invention of Craft*. For a discussion of deskilling as a critical model, see especially Roberts, *Intangibilities of Form*.

[349] Biographical information on Saint-Mémin comes from Miles, *Profile Portrait in America*; Philippe Guignard, *Notice historique sur la vie et les travaux de M. Fevret de Saint-Mémin* (Dijon: Imprimerie Loireau-Feuchot, 1853); Pierre Quarré, *Un Descendant d'une grande famille de parlementaires bourguignons, Charles-Balthazar-Julien Févret de Saint-Mémin* (Dijon: Le Musée (impr. Darantière), 1965).

[350] For more on Devosge and drawing instruction in eighteenth-century Dijon, see Marcelle Impériali, *François Devosge. Créateur de l'École de Dessin et du Musée de Dijon, 1732-1811* (Dijon: Rebourseau, 1927).

to fortification design and geographic surveys.[351] With the onset of the French Revolution, Saint-Mémin's family was stripped of its property in France and its various members forced to disperse. Arriving alone and impoverished in New York in late 1793, Saint-Mémin passed the earliest phase of his exile amongst Robert Livingston's family at their Clermont estate along the Hudson River. Here, he seems to have picked back up his earlier habits of drawing and educated himself in the rudiments of engraving and etching [Figure 4.17], but by 1796 he had partnered with fellow Frenchman Thomas Bluget de Valdenuit to bring the French craze for physiognotrace portraiture to an American audience.[352]

Like Saint-Mémin, Valdenuit was a French expatriate, born in the Champagne region. As a young adult, he resided principally in Paris, where in 1788 he is known to have sat for a physiognotrace portrait in the studio of Chrétien and Quenedey. He arrived in the United States in late 1793, the same year as Saint-Mémin, and appears to have settled in Baltimore. By 1796, however, he had relocated to New York where, amidst a circle of other expatriates, he met and partnered with Saint-Mémin.[353] It is unclear where the impetus to design and sell physiognotrace portraits came from, although it appears Valdenuit was in contact with several profile portraitists prior to his partnership with Saint-Mémin.[354] In the early years of their practice, there seems to have been a fairly clear division of labor, with Valdenuit undertaking the physiognotrace drawings and Saint-Mémin tasked with engraving these portraits in miniature. .

Given Valdenuit's early contact with Chrétien and Quenedey, it seems likely that it was

---

[351] Henry Guerlac, "Science and War in the Old Regime: The Development of Science in an Armed Society" (Dissertation, Harvard University, 1941), 273–75.

[352] Quarré, *Un Descendant d'une grande famille*, 10–11.

[353] Biographical information on Valdenuit comes from Miles, *Profile Portrait in America*, 61–76. See also René Hennequin, in *Un "photographe" de l'époque de la révolution et l'empire, Edme Quenedey des Riceys (Aube), portraitiste au physionotrace*, vol. 2 (Troyes: J.L. Paton, 1926), 77–86.

[354] Miles, *Profile Portrait in America*, 62–65.

there he saw the tools and learned the techniques of physiognotrace portraiture, and although the device he used does not survive, one can hazard a guess that it was based on the mechanism used in their Parisian studio. Using such a device, Valdenuit traced out his sitters' profiles and other salient features on prepared paper colored pink by a thick mixture of red pigment, white chalk and water. [Figure 4.18] Once these contours had been laid out, the page was removed from the device and the artist literally "fleshed out" the drawing using a mix of charcoal, graphite, conté crayon and white chalk. Saint-Mémin subsequently reduced and reproduced the drawings as mezzotints, and many of the portraits came as packages, combining full-scale drawing with miniaturized mezzotints and the plate from which the prints had been pulled. Although Valdenuit returned to France in 1797, Saint-Mémin continued the business on his own, traveling throughout the Mid-Atlantic and Southeast to provide portraits and engraved miniatures to upper and upper-middling class patrons of the early Republic.

In his solo practice, Saint-Mémin relied heavily on the drawing prototype established by Valdenuit, but he also came to develop a more gestural style than that of his earlier partner, playing off the precise linearity of the mechanically-produced profile line with looser hatching and broadly rendered patches of shade. A portrait of a Marine Corps officer, identified as Paul Wheelock and executed by Saint-Mémin between 1798 and 1803, offers a useful inventory of the myriad mark-making techniques to which the artist made recourse in the course of rendering his portraits. [Figure 4.19] The texture of Wheelock's hair is a combination of wet paintbrush applied to broad areas of dry chalk, passages of forceful stumping, and a delicate scrawl of charcoal. To suggest the smooth and supple skin of his sitter's face, Saint-Mémin has combined an extraordinarily delicate course of hatchwork with a more judicious use of stumping and the very faintest hint of white heightening—techniques that contrast sharply with the rough, but regular strokes used to indicate the stiff wool of Wheelock's military coat. Saint-Mémin's tendency to stretch out his mark-making into broad, expressive strokes is aptly represented by his portrait of John Adams, taken between 1800 and 1801. [Figure 4.20] The contrast between the rough shading used in Adams's jacket, the wispy lines that suggest the airiness of his linens, and the delicate hatching used to render the contours of fleshy jowls is characteristic of Saint-Mémin's work and a key aspect of their extraordinary vivacity.

However, what is perhaps most fascinating about the production of these images is the relationship between the looser gestures used to develop the bulk of the portraits' descriptive detail and the hard edge of the profile line. Compare the portrait of Wheelock with the work of Saint-Mémin's contemporary James Sharples. [Figure 4.21] Sharples also used the aid of a physiognotrace in the production of his profiles, but his process of gradually building up pastel pigment eventually smoothed away any sign of the machine's presence, in favor of a more atmospheric rendering.[355] In contrast, Saint Mémin's portraits proudly display this contour line, going so far as to draw back in the mechanically produced profile over the richly toned textures. Saint-Mémin not only emphasizes the machine's presence in the drawing process, but he does so by forcing his own hand to mimic, and even amplify, the trace of mechanical movement. Thus, even as there are two distinct visual languages at work in Saint-Mémin's drawings, the linear and the gestural, it is not clear that these uniformly map onto parallel categories of mechanical accuracy and virtuosic skill.

This confusion requires a closer inquiry into the nature of the physiognotrace as an

[355] Although Sharples was, like Charles Willson Peale, an avid inventor, a skilled portraitist, and the patriarch of a relatively large and artistically-inclined family, his work and that of his family has received far less attention than that of the Peales. The standard reference text is Katharine McCook Knox, *The Sharples, Their Portraits of George Washington and His Contemporaries: A Diary and an Account of the Life and Work of James Sharples and His Family in England and America* (New Haven; London: Yale University Press; Oxford University Press, 1930).

instrument of image production. It can be tempting to imagine the operations of the machine as akin to the point-and-click of a modern camera, but it is essential to consider both bodily *and* instrumental mechanics in understanding physiognotrace production. How did the machine expand, restrict, or reorganize the operations of the artist's body? How did embodied knowledge and mechanical intelligence interact in the production of the physiognotrace portrait?

To do this, one has to go back to an earlier, pre-industrial understanding of the relationship between hand and tool. Take, for example, the plates of Denis Diderot and Jean le Rond d'Alembert's *Encyclopedia*. As a means of scientifically explicating both the fine and mechanical arts, these plates routinely begin with a visual inventory of the tools required, alongside a keyed vignette, demonstrating how such tools are put into use. [Figure 4.22] As Roland Barthes has remarked of these images,

> Man, always present in some corner of the machine, does not accompany it in a simple relation of surveillance; turning a crank, pressing a pedal, spinning a thread, he participates in the machine in a manner that is both active and delicate…the energy here is essentially transmission, amplification of a simple human movement; the Encyclopedic machine is never anything but an enormous relay.[356]

Barthes's description suggests a certain intimacy between the artist or artisan's body and the machine, a certain conformation of one to the other. This interpretation is confirmed in the text of a prospectus authored by eighteenth-century drawing instructor Joseph Fenn. In his proposal for a drawing school to be established in Dublin, Ireland, Fenn argues that, "However vigorous, indefatigable, or supple, is the naked Hand of man, it is capable of producing but a small Number of Effects. He can perform great matters but by the help of Instruments and Rules, which are as Muscles superadded to his Arms."[357] Going beyond just an intimacy between hand and tool,

[356] Barthes, "The Plates of the Encyclopedia," 25.
[357] Joseph Fenn, *Proposals for Printing by Subscription, the Instructions Given in the Drawing Schools Established*

Fenn's suggestion here is that the artist's instrument is but a supernatural adaptation of his physical body—an extension of the self that extends and expands its vigor, stamina, and skill.

The potency of the artist's tools is again beautifully illustrated in an oil portrait of Maryland architect William Buckland, produced by Charles Willson Peale between 1774 and 1789. [Figure 4.23] Consider first Peale's use of visual rhymes—Buckland's pen raised at a thirty-degree angle in the architect's hand, the similar angle of the table against which he leans, and again the disposition of the pair of dividers that rest along the table's edge. Positioned parallel to each other, these objects lend the painting a sense of rhythm and order. However, their orientation also resists a more painterly perspectivalism, suggesting instead the orthogonal ordering of space echoed in the architectural drawings unfurled beneath Buckland's elbow. This orthogonal ordering of space is again echoed in the grid that appears in the painting's upper left corner. The grid appears initially like a window (perhaps a reference to the Albertian notion of the perspectival window?), but upon closer inspection it appears to be a system of scaffolding—yet another instrument of architectural construction. The world of the portrait is one composed both literally and figuratively by the draftsman's tools. In portraying an architect—an individual himself charged with the organization of space—Peale has here emphasized the extent to which this agency is shared with the architect's instruments themselves.

Returning again to the physiognotrace, the device clearly fits within this operational model. But it also exceeds this model by incorporating the body into an immersive mechanical experience. Assuming that Saint-Mémin was working with a device designed along the lines of that employed by Chrétien and Quenedey, the machine he used to capture the likeness of the body could also be described as itself somewhat body-like. It is certainly scaled to human proportions, sixty-four inches tall and approximately twenty-two inches wide. Imagine the artist

---

in England, Scotland, and Other Parts of Europe.... (Dublin: Printed by George Cecil, 1767), 60.

standing before the machine, approximately the height and width of the frame, his eye more-or-less aligned with the sighting device at its fullest extension. To produce a portrait of a sitter located just a few feet beyond the frame, he will grab hold of this sighting device, dragging its crosshairs along what he perceives to be the subject's profile, slightly shifting his body to accommodate the sight's changing location. As his hand moves, the pair of parallelograms that constitute the physiognotrace's principal mechanism will operate not unlike the structure of his own anatomy. Hinged in three locations, the physiognotrace's mechanical arm mimics the movements of the artist's own appendage, such that it is not just the sitter's profile traced by the machine, but the gesture of the artist's whole arm that is magnified and reproduced.

Even as the device operates according to the logic of the artist's body, however, it also confines that body's operations to a single plane of motion, restricting the artist's actions within what engineers call two "degrees of freedom."[358] Sliding along the frame's horizontal and vertical supports, the hinged parallelograms permit the hand to move in any direction within the plane described by the frame itself. But any attempt to push in or out of that plane is prevented by the system of slides and wires that maintain contact between the frame and the device's mobile mechanism. This restriction preserves a consistent relationship between the artist and his subject, allowing him to capture, without distortion, the sitter's profile view. Like the forms of orthographic projection that Saint-Mémin would have learned as a cadet at the *Ecole militaire*, the profile view is an artificial construction—nowhere is this line drawn on the subject's face. The moment the artist's perspective shifts or the sitter turns his head even a degree, the line

---

[358] Müller-Sievers, *The Cylinder*, 34–38. As Helmut Müller-Sievers has argued, the transformation from artisanal to mechanical production can be described in terms of these limitations in the freedom of motion. Pre-dating the upheavals caused by steam power and automated assembly, workshop systems of guides and gauges sought to streamline, simplify, and regularize production by limiting variability in the workman's manual operations. When it came to machine design, a similar logic governed mechanical action, with rails, tracks and sleeves designed to restrict movements to a pre-determined path. See also, Alder, "Making Things the Same," 522–25.

changes and the profile disappears. Preserving that relationship, maintaining this practically impossible vantage point, is the entire purpose of the physiognotrace machine.

Thus, in the first stage of portrait production—as the physiognotrace is used to delineate a sitter's profile, there is clearly a total entanglement of the artist's body with his tool. The design of the machine itself seems premised on the anatomy of the body. The physiognotrace regularizes and stabilizes the motion of the artist's hand. It pre-determines the positioning of his body. Every line drawn is the composite action of both hand and tool. But even after the drawing has been removed from the physiognotrace frame and transferred to the artist's drawing board, the influence of the machine still lingers. There is a way in which the use of this tool seems to have demanded a specific type of manual response from Saint-Mémin—its peculiar rigidity inviting a contrasting fluidity and freedom when his hand was asked to act alone. And as noted earlier, when the hand is used to reiterate and reinterpret the physiognotrace's line, it becomes difficult to determine where the machine stops and the body begins. The nature of the artistic agent constructed through the combination of body and machine here is peculiar. In using the physiognotrace, the artist acts, but is also acted upon. The machine is certainly enlivened, but at the same time, the body is, to some extent, mechanized.

Questions of Liveliness

Unfortunately, Saint-Mémin left a scant textual record reflecting on his career as a physiognotrace artist. We have little written evidence of how he understood the relationship between body and physiognotrace machine to function, of how he understood this tool to impact the practice of his art. However, late in his life, long after he had put away the practice of portraiture in favor of the duties of museum conservator in his native Dijon, Saint-Mémin did pen a letter that describes to some extent his thoughts upon the work and offers just the barest hint of his understanding of artistic identity and creativity. Writing in 1849 to a Monsieur Sauvageot, Saint Mémin suggests that,

> The creation of my little engravings is so much my own work that I was obliged to be at the same time draughtsman and engraver, builder of pantograph, physionotrace and small-sized press, manufacturer of roulettes and other instruments necessary to engraving, brayer of my ink, and, furthermore, my own printer.
>
> For my ability in the drawing phase of art I make no claims, since I made use of an instrument in order to obtain the most essential features, and since, if there is any merit in the delicacy and studied exactness of the likeness, the draughtsman owes his ability, so entirely independent of his efforts, to providence; the possessor enjoys this faculty without having any right to be vain about it.[359]

It is an interesting little passage, for in it Saint-Mémin simultaneously downplays his abilities as a draftsman, assigning agency either to the machine or to the hand of providence. However, he does claim ownership over the images themselves, to the extent that he alone fabricated all the many tools and undertook all of the different steps required in their production. His remarks take us back to the previous chapter, in which we saw claims to inventiveness or genius intimately tied to physical control over the object of invention, but his abdication of responsibility with respect to the drawing process begs the question: how did the artist grapple with the intermingling of his body with the machine? Where, on Marx's scale from living to lifeless mechanism, was this hybrid agent located? As it would happen, this question of liveliness is conveniently embedded in the images themselves, through the physiognotrace's own claims to providing a true and direct representation from life. In the course of this section, I will consider how the image's own pretensions to liveliness offered Saint-Mémin an opportunity to reflect upon the nature of creative agency when it came to his imbrication with the machine.

Between 1793 and 1814, Saint-Mémin executed hundreds of portraits, producing a

[359] Quoted in Miles, *Profile Portrait in America*, 197.

remarkable visual archive that cuts across multiple sectors of early American society. These portraits were vastly different in style from the work coming out of the studios of Saint-Mémin's competitors, yet they were still enormously popular. Writing of Saint-Mémin's work in 1804, Thomas Jefferson's daughter Maria Eppes praised "the certainty" with which Saint-Mémin made his portraits and exclaimed over the pleasure it would give her and her sister to possess "so excellent a likeness" of their father.[360] [Figure 4.24] Similarly, in 1806, an individual identifying only as "Zophyrus" published a series of essays "On Physiognomy" in Baltimore's *Companion and Weekly Miscellany.* In one installment, Zophyrus speaks of visiting Saint-Mémin's studio, praising the "precision of drawing" and "justness of similitude" with which the artist rendered his sitters. "Amongst a thousand profiles delineated by an ingenious artist, with sure mechanical aid," Zophyrus was "imperceptibly" drawn to three. Of the third, in particular, he writes,

> How smooth and easy is every line. What undulation, congeniality, and proportion!...The thoughtful brow, the penetrating eye, the spirit-breathing lips, the deep intelligence of the assembled features; how they all conspiring speak the picture of the fair immeasureable mind within.—Oh God! How I adore that face.[361]

Such a description wavers between analysis of an image and of the individual represented. It conflates the reproduction and the original, discussing both in terms of line and form. Emphasizing the vitality of Saint-Mémin's rendering, Zophyrus remarks upon the profile's "spirit-breathing" lips and the way in which the features conspire together to "speak the picture" of the sitter's well-formed mind.

Such commentary is remarkable for the implicit comparison it draws between Saint-Mémin's sumptuous renderings—which literally "flesh out" the scant details provided by the

---

[360] Mary (Maria) Jefferson Eppes to Thomas Jefferson, Edgehill, February 10, 1804, in Edwin M. Betts and James Bear, Jr., eds., *Family Letters of Thomas Jefferson*, Reprint (Charlottesville: Thomas Jefferson Memorial Foundation, 1986), 256–57.

[361] Zophyrus, "On Physiognomy. No. III," *The Companion and Weekly Miscellany* 2, no. 21 (March 22, 1806): 162.

mechanical aid of the physiognotrace—and the simpler tracings executed by many of his competitors. For instance, where the Peale Museum portraits were made by cutting along an incised line produced by the machine and thus resulted in a flat expanse of black paper bounded only by the profile's contour [Figure 4.25], Saint-Mémin's drawings are, as I have already noted, composites of multiple techniques. It is the combination of these contrasting techniques—the crisp, mechanically produced profile juxtaposed with the rich textures of supple shading—that produces the portraits' startling evocation of liveliness. And it is, it would seem, this evocation of liveliness that allowed Saint-Mémin's portraits to stand out amongst those produced by his contemporaries.

Amidst this context, the portrait of Washington with which I began emerges as all the more curious. Not only was the physiognotrace a technique intimately connected to drawing from life, but Saint-Mémin's portraits, in particular, are associated with both an exceptional degree of verisimilitude and a particular air of liveliness. To introduce a memorial effigy into this body of work would have been to destabilize the assumptions that governed the practice of physiognotrace portraiture and the conditions under which such portraiture was received. As I mentioned at the outset, I believe this rendering reveals a sense of insecurity or trepidation about the type of testimony the mechanical device was capable of providing and even a critique of mechanization itself.

We might begin to think about this critique by examining the myth with which the profile portrait is traditionally associated. As I noted above, the myth of the Corinthian maid was frequently treated as the origin of painting, but, in fact, Pliny begins one version of this story with the comment that more than enough had already been said on the topic of painting, but something more was due to the plastic arts. He then provides the following account,

> Butades, a potter of Sicyon, was the first who invented, at Corinth, the art of modelling portraits in the earth which he used in his trade. It was through his daughter that he made the discovery; who, being deeply in love with a young man about to depart on a long journey, traced the profile of his face, as thrown upon the wall by the light of the lamp. Upon seeing this, her father filled in the outline, by compressing clay upon the surface, and so made a face in relief, which he then hardened by fire along with other articles of pottery.[362]

Whatever interpretation may have been invoked in later centuries, drawing is, in this passage at least, linked to sculpture rather than to painting, and its line has been staged as a transitional instrument between the body, present in all its fullness, and its three-dimensional representation. As Jacqueline Lichtenstein has argued in her analysis of the seventeenth-century search for the essence of painting in either line or color, this association between drawing and sculpture was used by the colorists to assert that painting's specific difference arises from the transcendent properties of pigment rather than the descriptive qualities of line. Speaking specifically of the arguments advanced by Roger de Piles, she notes the author's attempt to associate drawing with the sense of touch, "the most directly tangible of all the senses and the one that exercises a decisive action in sculpture," and suggests that "drawing is no longer for [de Piles] the sign of an idea and is instead attached to matter. It addresses itself not to the eye but to the hand and requires not distance but contact."[363] I am not suggesting that Saint-Mémin was necessarily familiar with the work of de Piles (although I do not know that he was not), but there is a certain coincidence between his drawing and the associations made by the noted colorist that bears consideration.

The connection becomes even more pronounced when one considers a comment from one of the physiognotrace's original operators, Edmé Quenedey. Advertising the speed with

---

[362] Pliny, *Natural History*, XXV. 43.12.

[363] Lichtenstein, *The Eloquence of Color*, 158.

which the device facilitated the process of drawing, Quenedey suggests,

> The two minutes, at the most, that I employ for drawing the overall shape is not enough time for the model's physiognomy to change. From this comes the great truthfulness that one sees in all the portraits made with the Physionotrace and which astonishes the most skillful artists. They compare these portraits to those which have been cast from life.[364]

By connecting the physiognotrace drawing to the life mask, Quenedey sought not only to tout the veracity of the mechanical portrait, but to secure that veracity through association with a physical object, and in particular, a physical object that had come into direct contact with the subject. Saint-Mémin's sculptural rendering of Washington might thus be read as emphasizing its proximity to the original sitter, denying the illusionism of the two-dimensional portrait in favor of the physicality of the sculptural simulacrum. Although seemingly a secondary representation, this sculptural rendering might, in fact, suggest that the physiognotrace renders an image "more real" than other representational techniques. This interpretation seems to support claims for the physiognotrace's perspicacity, not so much critiquing as celebrating the machine's intervention into the process of representation.

However, this association between drawing, sculpture, and touch also brings with it an alternate reading, one more troubling for the mechanical enthusiast. As I discussed briefly in the second chapter, sculpture had, in the course of eighteenth-century aesthetic discourse, served as an analog for both the human sensorium and artistic inspiration.[365] The prototype for this analogy is the story of Pygmalion, the misogynist sculptor who falls in love with the idealized form of a woman that he himself has shaped. As the story is originally found in Ovid's *Metamorphoses*,

---

[364] Miles, *Profile Portrait in America*, 43.

[365] J. Carr, "Pygmalion and the 'Philosophes,'" *Journal of the Warburg and Courtauld Institutes* 23, no. 3 (1960): 239–55; Mary D. Sheriff, "Passionate Spectators: On Enthusiasm, Nymphomania, and the Imagined Tableau," *Huntington Library Quarterly* 60, no. 1/2 (1997): 51–83.

Pygmalion, despairing of all other women, prays to Venus that he might find a bride like his sculpture. Venus acknowledges his prayer, and upon Pygmalion's laying a kiss upon the sculpture, the inanimate figure comes to life.[366] Revisited repeatedly in eighteenth-century art and literature, the story evolved in each iteration as different writers and artists used its framework to probe a variety of aesthetic and existential questions.[367] Most notable among these are Etienne Bonnot de Condillac's *Traité des Sensations* (1754), which uses an animated sculpture to discuss the relationship between physical sensation and human cognition, and Jean-Jacques Rousseau's short play *Pygmalion* (1762), which addresses the relationship between creativity and the construction of selfhood through the activating medium of the artist's touch.[368]

.

In both Condillac and Rousseau, the sense of touch is deployed as a means of acquiring self-knowledge. It is the gateway to self-awareness. For Condillac's animated sculpture, touch is the only sense "that in itself can judge of exteriority."[369] No other sense—not sight, sound, smell, or taste—allows the subject to distinguish between herself and her surroundings. Only through touch is one made aware that the thing one touches is not the same as oneself. As Ewa Lajer-

[366] Ovid, *Metamorphoses* X: 243-297.

[367] Although not found in the original Ovid, eighteenth-century renditions of the story frequently identified the sculpture as "Galatea" and often differ on the source of her animation. Some retain the divine inspiration provided by Venus, others give the motive power entirely over to Pygmalion, her creator. See Carr, "Pygmalion and the 'Philosophes'" for an overview of the theme's development in the eighteenth century.

[368] Condillac, *Traité Des Sensations*; Jean-Jacques Rousseau, "Scène Lyrique," in *Œuvres complètes*, ed. Bernard Gagnebin and Marcel Raymond (Paris: Gallimard, 1959). My reading of both Condillac and Rousseau is deeply indebted to that provided by Sheriff, "Passionate Spectators"; Ewa Lajer-Burcharth, "Pompadour's Touch: Difference in Representation," *Representations* 73, no. 2 (2001): 54–88. Lajer-Burcharth's interpretation is, in turn drawn from Paul De Man, "Self (Pygmalion)," in *Allegories of Reading: Figural Language in Rousseau, Nietzsche, Rilke, and Proust* (New Haven: Yale University Press, 1979), 160–87. See also, Wendy C. Nielsen, "Rousseau's Pygmalion and Automata in the Romantic Period," in *Romanticism, Rousseau, Switzerland: New Prospects*, ed. Angela Esterhammer, Diane Piccitto, and Patrick H. Vincent, Palgrave Studies in the Enlightenment, Romanticism and Cultures of Print (New York: Palgrave Macmillan, 2015), 68–83..

[369] Quoted in and translated by Lajer-Burcharth, "Pompadour's Touch," 57.

Burcharth has observed, touch "always generates a *double experience*: every kind of tactile perception reminds us of the particular part of the body engaged in producing it."[370] Touch simultaneously generates awareness of the world and awareness of oneself, facilitating discernment between the two. However, this correspondence between awareness and touch is put to particular use in Rousseau's *Pygmalion*. Rousseau certainly uses touch to indicate the animated sculpture's discovery of self-awareness. The sculpture (here called Galatea) engages her surroundings through touch, using the sense to identify herself ("me"), a marble block, ("not me"), and Pygmalion, ("also me"). However, as indicated by Galatea's conflation of herself with her creator, Rousseau gives special status to the *artist's* touch as the animating force behind Galatea's vitality. Venus's supernatural intervention disappears in his version of the story. Instead, Galatea's insensate figure is given life and awareness by Pygmalion's attempt to perfect her sculptural form. Upon Galatea's animation, Pygmalion again reaches out to touch her, confirming his agency in her creation by echoing her own moment of self-identification and referring to *her* as "Me!"[371] As Lajer-Burcharth has argued, Rousseau's account emphasizes "the circulatory, bidirectional effect of touch" in order to provide an allegory of artistic creativity in which two selves (artist and subject) coincide "in one form of representation."[372]

I would like to suggest that Saint-Mémin's physiognotrace portrait of Washington participates in this line of aesthetic discourse. As a drawing instrument, the physiognotrace would have fundamentally altered both the artist's sense of touch and his *touche*—his manner of putting pencil to page. Indeed, while using the machine, the artist never would have made a mark directly. His hand would have grasped only the eyepiece as he passed it across the sitter's

[370] Ibid.

[371] Ibid., 54–55; Sheriff, "Passionate Spectators," 65–66.

[372] Lajer-Burcharth, "Pompadour's Touch," 55.

profile, while the actual contour line—that which materially connects the drawing to the rendered subject—would have been made by the machine's stylus, located nearly two feet from the artist's hand. The machine's prosthetic expansion of the artist's capacity for precision would have been matched by a diminished capacity for inflection and nuance. By reorganizing the mechanics of touch, this hybrid of body and machine fundamentally altered the conditions of authorship, and I would argue that Saint-Mémin's decision to render his subject in sculptural form calls attention to this new perceptual and creative reality.

The use of a machine to render this sculptural likeness effectively collapses multiple facets of the eighteenth century's preoccupation with the possibility of artificial life. As Joan Landes has argued, the animated statues of Condillac's *Traité* and Rousseau's *Pygmalion* are close intellectual cousins of the various automata that emerged from the workshops of artisans like Jacques Vaucanson or the family Jaquet-Droz. For both the automata maker and the philosopher, these artificial life forms were more than clever conceits. They were object lessons in an on-going discussion of how the mind knows what it knows—pointed provocations that probed the limits of human agency and cognition.[373]

In Saint-Mémin's hands, however, this intermingling of the mechanical and the sculptural takes on unique implications. As I have already noted, there is a perversity in Saint-Mémin's use of a drawing apparatus largely associated with drawing from life in order to portray a memorial

---

[373] This conflation of sculptural and the mechanical can be traced back to Descartes, at least, who suggests in his *Traité de l'homme*, "I suppose the body to be nothing but a statue or machine made of earth, which God forms with the explicit intention of making it as much as possible like us." A similar proximity between sculpture and machine can be found in the work of noted machinist Jacques Vaucanson, who coated his flute-playing faun in a special paint so as to render the automaton like a marble statue in texture and appearance. Likewise, the sculpture that forms the centerpiece of Condillac's traité was not simply a solid block of marble--contoured on the surface, but essentially homogenous within. It was, instead, imagined as a precise replica of the human body, endowed with all its various structures and systems—a sculpture far closer to the anatomical machinations of Vaucanson's famous defecating duck than to the pristine forms that populated Paris's annual salons. See Daniel Cottom, "The Work of Art in the Age of Mechanical Digestion," *Representations* 66, no. 1 (1999): 55; Joan Landes, "The Anatomy of Artificial Life: An Eighteenth-Century Perspective," in *Genesis Redux: Essays in the History and Philosophy of Artificial Life*, Jessica Riskin, ed., (Chicago: University of Chicago Press, 2007), 110–11.

sculpture. Not only does it introduce an element of artificiality into what was supposed to be a direct and unmediated portrayal, but in so doing, it renders the liveliness of the depiction lifeless. The invocation of death in this image implies a loss of awareness, of sensorial capacity, of cognitive function. It is a loss registered in the sculptural rendering's blank eyes—a convention, of course, that signals the image "as sculpture," but also a sign of lost perception, a sense that has not (or cannot) be animated. The significance of this loss becomes particularly acute when one considers the ways in which this image positions Saint-Mémin in the role of the sculptor Pygmalion. As a composite actor—a hybrid of body and machine—Saint-Mémin and his physiognotrace have not rendered the inanimate body full of life, but have accomplished rather the reverse. Saint-Mémin has thus turned the conceit of the animated sculpture on its head, and I believe we have to see in this reinterpretation a reflection on the conditions of the image's own mechanical production. It appears to question both the possibility of any sort of artificial form of sensory perception and to critique the creative capacity of the artist's hybrid drawing practice. If it is the artist's touch that brings the block of marble to life, then the mechanical mediation of touch appears to once again render that matter inert.

This critical position is, admittedly, a significant burden to lay upon just a single image, particularly one that is an outlier in terms of subject matter and style. However, that outlier status merely draws attention to a concern latent in Saint-Mémin's body of work more generally. The artist's struggle with mechanical perception and production can be read across his portraits, most notably in the contrast described above between the uniformly hard line of the portraits' profiles and Saint-Mémin's dexterous manipulation of surface texture. On one hand, by going back in and reiterating the profile line produced by the machine, Saint-Mémin seems to be amplifying the distinction between the work of his hand and that of the physiognotrace, calling attention to the deadening stillness of the device's documentary notation when compared with the enlivening capacities of artistic touch. However, by reiterating the machine's mark, Saint-Mémin also implicates himself in the mechanization of his own body, reminding the viewer of the imbrication of body and machine required by the mechanical drawing process. There is clearly no escaping this hybrid agency in the production of the physiognotrace image, but what one finds in Saint-Mémin's portraiture practice more broadly is an attempt to stake out a role for the body in the space of mechanical production. This role manifests through an exploration of his subjects' own performative forms of identity construction—the markers of identity that lay beyond the capacities of the physiognotrace machine to represent. It is through an engagement with these extra-mechanical markers that Saint-Mémin constructs his own unique artistic identity and a counterpoint to the bleak portrayal of artistic agency suggested by the Washington portrait.

The Body Before the Machine

In order to explore this dynamic, I want to examine a series of portraits in which the stakes of identity performance are particularly potent. Between 1804 and 1807, the artist produced eight portraits of Osage, Mandan and Lenape leaders who had travelled to the new U.S. capital in Washington, D.C. [Figure 4.26] In a series of visits spawned by the 1803 Louisiana Purchase, these diplomatic delegations were deployed to negotiate trade and territorial relationships. Their arrivals were received with a significant amount of fanfare in the capital, followed by similar receptions in Baltimore, Philadelphia and New York. Likely produced as the various entourages passed through either Washington or Philadelphia, these portraits depict Payouska, Great Chief of the Osage; a Chief of the Little Osage, occasionally identified as Le Soldat du Chêne; an Osage man identified by Saint-Mémin as Cachasunghia; two men identified only as Osage warriors; individuals now believed to be the Mandan chief Shahaka and his wife

Yellow Corn; and a man previously identified as Shahaka, but now believed to be a member of the Lenape, and tentatively identified as Montgomery Montour.[374]

This group of portraits is unusual among Saint-Mémin's body of work. For one, they were not produced on commission, nor were they ever sold. There are no records to suggest that either the U.S. government or the sitters themselves paid for these images, and there is scant indication of the use to which Saint-Mémin imagined such images might be put. By his own admission, portraiture was a practice Saint-Mémin took up out of economic necessity. Later in life, he would refer to the work he executed as a portraitist as his "gagne-pain"—a word that may be literally translated as "bread-winning," but which also carries with it the suggestion of drudgery.[375] Saint-Mémin did produce five watercolor reproductions and at least one exact copy these drawings, and there is some suggestion that Merriwether Lewis may have commissioned reproductions for an (unrealized) illustrated account of his expedition through the American interior. However, the originals remained in Saint-Mémin's personal collection until his death in Dijon in 1852. In this context, the images present themselves as private experiments, unique opportunities to test the relationship between body and machine.[376]

At the same time, these images suggest the presence of a third agent in their production, that is sitter him- or herself. These eight portraits are the only depictions Saint-Mémin ever produced of Native Americans, and the wide range of graphic techniques explored in these

---

[374] A comprehensive overview of these images and the historical circumstances of their production may be found in Ellen G. Miles, "Saint-Mémin's Portraits of American Indians, 1804-1807," *American Art Journal* 20, no. 4 (1988): 3–33.

[375] Quoted in Miles, *Profile Portrait in America*, 197.

[376] Miles, "Saint-Mémin's Portraits of American Indians, 1804-1807," 25. Miles similarly notes that these images were likely produced as a result of Saint-Mémin's private interest, and she has also raised this prospect of their reproduction as part of Merriwether Lewis's proposed publication. Due to Lewis's death, the account was not produced as he had intended, and Saint-Mémin's images were not included. However, I am currently at work on a parallel project that considers these images within the context of that projected publication and the nature of the ethnographic, historical and moral testimony the physiognotrace image would have been thought to provide within that context.

images appears to be a response elicited specifically by his Native sitters' choice of dress and bodily adornment. Saint-Mémin was always an attentive observer of surface and texture, but the level of detail and material curiosity is particularly heightened in these works. Although quickly sketched, note the surety with which the reflective surface of Payouska's silver armband has been rendered through the combination of dampened chalk and a few quick strokes of white highlight. [Figures 4.27 & 4.28] The portrait of an Osage warrior is a masterful study of textural contrasts, from the dampened chalk and quick strokes of charcoal used to articulate the brush-like character of his hairpiece (or roach) to the mixture of white and black chalk used to suggest the tuft of wool that hangs from his ear. [Figure 4.29] Yet, for all this attention, Saint-Mémin shows little interest in documenting the European-style military coats worn by Payouska and the Chief of the Little Osage, suggesting that this curiosity was driven by cultural difference and the perception of these individuals as exotic or somehow other. Problematic as this perception is and was, this dynamic also highlights the extent to which the portrait is more than the product of a bilateral relationship between artist and tool. The process of depiction necessarily engages the body of the sitter himself.

In the case of physiognotrace portraiture, this engagement with the process of depiction would have occurred even at the level of physical contact. Consider the setup of the physiognotrace device. The artist would have been positioned on one side of the frame, looking through the device's open window at the sitter, standing in profile. Because these portraits are rendered at approximately life-size, we can assume that the sitter would have been stationed quite close to the device (remember, the machine as devised by Chrétien has no mechanism for scaling). Moving the machine's sighting device along the sitter's perceived profile, the artist would have effectively caressed the contours of his subject's face (although never touching that face directly). With the mark-making stylus positioned almost two feet below the sighting device and the prepared paper positioned round about the artist's mid-section, the tracing would likely have been made without the artist ever making reference to his drawing. Instead, his eye would have been fixed on his subject the entire time. By the same token, the sitter would have been witness, either through peripheral vision or haptic sense, to the artist's own movements and their echoes in the anatomy of the device. The encounter between artist and sitter would thus have been a remarkably intimate one, interrupted only by the plane of the machine. This intimacy would have amplified the effects of the body's presence within the performative space of the portrait studio. As numerous scholars have acknowledged, portraiture is not simply the transcription of a sitter's self-evident likeness, but rather a fundamentally symbolic structure whose underlying codes are constantly redefined through the interaction of artist, sitter, and society. There is, as a result, an "inherent theatricality" to portraiture—an acknowledgement that the body of the sitter is presented to the public for the express purpose of being beheld.[377]

Notably, this inherent theatricality was actually one of the "problems" that the physiognotrace purported to solve. [378] One of the most common arguments advanced by proponents of the device was that the ease and speed with which the image could be made precluded any sort of subterfuge on the part of the sitter—recall Edmé Quenedey's assertion that, "The two minutes, at the most, that I employ for drawing the overall shape is not enough time for the model's physiognomy to change. From this comes the great truthfulness that one sees in all the portraits made with the Physionotrace."[379] The machine's direct translation of the profile

[377] See, for example, Pointon, *Hanging the Head*, 112; Michael Fried, *Absorption and Theatricality: Painting and Beholder in the Age of Diderot* (Chicago: University of Chicago Press, 1988), 109–15; Peggy Phelan, *Unmarked: The Politics of Performance* (London; New York: Routledge, 1993), 36.

[378] Lukasik, *Discerning Characters*, 12; Stafford, "Peculiar Marks," 176.

[379] Quoted in Miles, "Saint-Mémin's Portraits of American Indians, 1804-1807," 43.

from sitter to page ostensibly meant there was no self-presentation to witness, no performance to behold. This interpretation is similarly implicit in Peale's assertion that Hawkins's physiognotrace could be operated by the sitter alone, thus allowing for a direct and unmediated (and therefore precisely representative) image.[380]

However, Saint-Mémin's work obviously challenges this understanding. Self-presentation and public performance appear to be integral aspects of these images. This is a point made all the more forcefully by the Native American portraits, when one considers the massive pageant of diplomatic ceremony amidst which they were produced and in which the process of image-making actively took part. The interactions between artist, sitter and society manifested in these images certainly incorporate the physiognotrace's reputation for veracity into the picture's symbolic structure, but they also resulted in a set of pictorial operations fundamentally in excess of the machine's capacities.

These portraits join a category of images, dating back to the seventeenth century, that document diplomatic envoys and instances of encounter between Native American and European cultures.[381] In the first decades of the nineteenth century, this portraiture practice was regularized and bureaucratized in the United States. It has been argued that Saint-Mémin's portraits may have, in fact, established a precedent for future diplomatic missions, in which Native American envoys to the U.S. capital were first outfitted by Washington tailors and shoemakers and then shepherded through various social engagements, among them sittings at

---

[380] Bellion, "Heads of State," 45–47.

[381] For discussion of the representation of Native Americans within these diplomatic contexts, see Stephanie Pratt, "Warfare, Diplomacy, and Visual Representation, ca. 1700-1760," in *American Indians in British Art, 1700-1840* (Norman, OK: University of Oklahoma Press, 2005), 30–52; Beth Fowkes Tobin, "Cultural Cross-Dressing in British North America," in *Picturing Imperial Power: Colonial Subjects in Eighteenth-Century British Painting* (Durham, NC: Duke University Press, 1999), 81–109.

one or more local portrait studios.[382]

This protocol, eventually formalized under Superintendent of Indian Affairs Thomas L. McKenny, mirrored a centuries' old practice in Britain, and Saint-Mémin's portraits share with the images produced in this guise a number of normative qualities. Among the most famous of these images are, perhaps, Jan Verelst's portraits of the so-called *Four Indian Kings*—Etow Oh Koam, Sa Ga Yeath Qua Pieth Tow, Ho Nee Yeath Taw No Row and Tee Yee Ho Ga Row.[383] [Figure 4.30] Like Verelst's paintings, Saint-Mémin's drawings submit their subjects to an homogenizing gaze. In Verelst's work it is an effect accomplished by the faintly classical white tunics in which three of the four sitters are dressed, the red blankets in which each of them is draped, the darkly forested background in which Verelst has located each of his subjects, and even the uniformity of the japanned frames in which each portrait finds a home. In Saint-Mémin's work, however, the impression of homogeneity is achieved by the strictly limited palette and the rigid compositional structure enforced by the physiognotrace itself. Fixing its subjects in a single attitude, the mechanical tool delivered a sense of order and careful control, belying the complex politics of the diplomatic delegations amidst which these images were produced. Like the tunics and red blankets Verelst used to drape his subjects, the mechanical gaze trained on Saint-Mémin's sitters is both classicizing and classificatory—a means of locating these individuals in a specific time and assigning them to a specific social order.

One could argue that the physiognotrace imposes this same classicizing gaze on Saint-Mémin's white sitters—indeed we have seen that gaze made explicit in the laureated bust of

[382] William H. Truettner, *Painting Indians and Building Empires in North America, 1710-1840* (Berkeley: University of California Press, 2010), 72.

[383] A useful overview of the Verelst portraits and their historical context is provided in Kevin R. Muller, "From Palace to Longhouse. Portraits of the Four Indian Kings in a Transatlantic Context," *American Art* 22, no. 3 (2008): 26–49.

George Washington. However, this gaze takes on new significance within the political and social dynamics of the United States' relationship with Native American nations in the late eighteenth and early nineteenth centuries. The classicizing format of the profile portrait clearly links these individuals to some version of antiquity, albeit a hybridized and highly problematic one that conflates the histories of classical Greece and Rome with a poor understanding of both continental history and contemporary Native culture. Beginning in the seventeenth century, European colonists had attempted to link Native American customs to ancient civilizations of the Old World or, in the words of James Clifford, "to map descriptions of the other onto conceptions of the "*premier temps*," the better to conceptually displace such cultures into an earlier stage in the "assumed progress of Western history."[384] Renato Rosaldo has referred to this impulse as an "imperialist nostalgia," that seeks to use a "putatively static savage society" as "a stable reference point for defining (the felicitous progress of) civilized society."[385]

Such attempts were assisted by the emergent trope of the "vanishing Indian," traceable to the writings of seventeenth-century Anglo-American missionaries who connected the image of the dying Indian with the rhetoric of spiritual salvation and cultural progress.[386] By the late eighteenth century and early nineteenth centuries, this trope had evolved into a thriving genre of Indian death songs, found among the work of British and European poets, but it was also implicit in the scholarly efforts of individuals like William Bartram, Thomas Jefferson, or Benjamin

[384] Clifford, James, "On Ethnographic Allegory," in *Writing Culture: The Poetics and Politics of Ethnography: A School of American Research Advanced Seminar*, ed. James Clifford and George E. Marcus (Berkeley: University of California Press, 1986), 101–2.

[385] Renato Rosaldo, *Culture & Truth: The Remaking of Social Analysis* (Boston: Beacon Press, 1989), 70.

[386] See, for example, John Eliot, *The Dying Speeches of Several Indians* (Cambridge, Mass.: Printed by Samuel Green?, 1685). This evolution of this literary form is discussed in Laura Stevens, "The Christian Origins of the Vanishing Indian," in *Mortal Remains: Death in Early America*, ed. Nancy Isenberg and Andrew Burstein (Philadelphia: University of Pennsylvania Press, 2003), 17–30. See also Laura M. Stevens, *The Poor Indians: British Missionaries, Native Americans, and Colonial Sensibility*, Early American Studies (Philadelphia: University of Pennsylvania Press, 2004).

Smith Barton, who sought to develop a more ethnographically specific and diverse understanding of Native American culture. Such efforts certainly pushed back against early Republican society's tendency to "flatten" the image of "the Indian" into a one-dimensional representation of either the "primitive" or the "savage", but they did so with an eye to collecting and preserving aspects of indigenous cultures that were either evolving or disappearing under the influence of Euro-American contact and territorial expansion.[387]

The physiognotrace portrait plays a paradoxical role within this context. On one hand, it is an extraordinarily apt instrument of "imperialist nostalgia." It provides an exceptionally detailed representation of the individual, bolstered by the machine's associations with precision and scientific accuracy, but it is an image that, when viewed amongst the aggregation of other similarly produced portraits, in fact conveys a remarkable sense of homogeneity, helping to create both a general class of individuals that might be identified as "Indian" and to integrate this class into a broader representational scheme and historical order managed by Euro-American society. On the other hand, the classicizing impulse in these images is forced to exist alongside a very real sense of contemporaneity also imparted by the machine. The whole point of the physiognotrace is its instantaneity—its capacity to draw directly from life. The portraits testify to a present-tense existence, documented by the very latest in image-making technology, even as they attempt to situate their subjects in a distant cultural past. Here again, one sees the same sort of temporal disjunction raised by the portrait of Washington *à l'antique*, but this time played out upon the bodies of individuals who are very much alive and very much participants in their own self-presentation.

[387] Eve Kornfeld, "Encountering 'the Other': American Intellectuals and Indians in the 1790s," *The William and Mary Quarterly* 52, no. 2 (1995): 290, 297–314. Kornfeld draws on earlier work by Roy Harvey Pearce, Richard Slotkin, Robert F. Berkhofer, Jr. and Bernard W. Sheehan to make this point, but goes on to offer direct evidence from early American authors like Susannah Rowson and Charles Brockden Brown.

I noted above the heightened level of detail and material curiosity that Saint-Mémin displays in his treatment of the dress and ornamentation of these various Native American sitters, but I want to draw attention to it again here for the way in which it emphasizes the sitters' active role in the construction of these portraits. In her analysis of eighteenth-century portraiture and stage performance, Marcia Pointon has emphasized that clothing should not be read "as naturalistic attributes…but understood as components in a language, in a vast repertoire of signifiers."[388] However, this refusal to recognize boundaries between "representation and actuality" takes on particular significance within the context of U.S.-Native relations at the turn of the nineteenth century. For individuals occupying the geographic and cultural border regions of indigenous and Euro-American societies, choices of dress were important signifiers of not just individual identity, but of political allegiances and cultural awareness. Perhaps the most famous and most widely represented of these figures is Joseph Brant, a Mohawk leader and British military officer active in diplomatic negotiations in the last quarter of the eighteenth century. [Figure 4.31] Brant sat for some thirty-nine portraits over the course of his life, appearing in each one wearing garments and objects of both European and Native origin—the so-called "Indian Dress." As Elizabeth Hutchinson has argued, his exclusive appearance in these garments suggests Brant's sophisticated management of his own public image and an acknowledgment of his role as an interlocutor between Native and European cultures.[389] Like Brant, both Payouska and the Chief of the Little Osage appear in some version of this hybridized dress, a choice that throws into relief several of the other sitters' more overt assertions of Native identity.[390]

[388] Pointon, *Hanging the Head*, 112.

[389] Elizabeth Hutchinson, "'The Dress of His Nation.' Romney's Portrait of Joseph Brant," *Winterthur Portfolio* 45, no. 2/3 (2011): 209–228.

[390] It should be noted that Hutchinson's reading of Brant's portraits as positive signs of his multicultural affinities and fluency sidesteps some of the more insidious aspects of the so-called "Indian Dress" in the British Atlantic

Given these conditions, Saint-Mémin's portraits have to be understood as complex constructions that combine, but do not resolve, a range of contradictions. They juxtapose Euro-American society's attempts at continental dominance with the vibrancy of indigenous self-determination. They pair the seeming self-evidence of physiognomic identity with the important markers of cultural identity signaled by dress. They bear witness to the present-tense enactment of both cultural and individual identities, albeit identities performed under the homogenizing and classicizing gaze of the physiognotrace machine. We see in these images a tension inherent to the nature of performance, one that contemporary art historian Carrie Lambert-Beatty has identified as the difference between "the body being, and being watched."[391] Put otherwise, it is the tension between the objective and the subjective representation, the difference between the person and the persona represented.

In this way, these Native American portraits offer important evidence of the way in which Native identity was constructed in and through the representational practices of Euro-American society, but they also point toward a unique construction of artistic identity vis à vis the machine. In their negotiation of line and surface, these portraits insist upon material distinctions between the fixity of physiognomy and the transience of public performance, while inextricably linking the two in a composite definition of likeness. This composite likeness, in turn, maps onto an interplay of manual and mechanical technologies that similarly joins the action of the body and the action of the machine into a composite performance of artistic identity. The artist's attempt to construct a vision of the self through confrontation with the Other

World. As Beth Fowkes Tobin has argued, this form of dress can also be seen as a form of cultural appropriation widely employed by white British officers. This appropriative strategy denies to the Native objects they wear "the power to speak of Indian culture and Indian political power." In this scenario, Brant's adoption of hybrid dress thus signals both a subjugation to the powers of British imperialism and a site of resistance within it. It is with this complexity in mind that we should view the range of sartorial choices adopted by the sitters in Saint-Mémin's portraits. Tobin, "Cultural Crossdressing," 101–102;108.

[391] Carrie Lambert-Beatty, *Being Watched: Yvonne Rainer and the 1960s* (Cambridge: MIT Press, 2008), 6.

is a common enough trope in the history of art, and certainly not one that was new in the work of Saint-Mémin.[392] What makes this case of particular interest, however, is the tripartite nature of this construction—the combination of artist's body, sitter's body, and machine into a singular artistic agent—and the emergence of this construction amidst the broader social, technological, and economic context of industrialization.

Earlier, I cited Barthes's description of an underlying sympathy between the body and the pre-industrial machine. But by the turn of the nineteenth-century, this assumption of sympathy had begun to give way to a new interpretation of the machine colored by the realities of industrialized production. As I discussed in the introduction to the dissertation, the steam engines and spinning frames of the nascent Industrial Revolution were fundamentally different entities from their pre-industrial counterparts—driven by different sources of power and organized by a different logic. As these innovations pushed the laboring body to the periphery of productive action, the machine was increasingly understood, not as an analog or extension of the body, but as its antithesis. As discussed above, there seems to have been an attempt to incorporate the operations of the physiognotrace into this dichotomy. Much of the period rhetoric around the device seems to point to the possibility of automation and certainly to the diminution of the role of artistic skill in image-making. Looking back on his earlier work, Saint-Mémin himself disclaimed all agency in the production of his images, committing their "delicacy and studied exactness" to the operations of the machine and the hand of providence.[393]

Yet, physical performance was clearly essential to the physiognomist's practice. The

[392] Here, I am clearly relying on Edwards Said's notion of identity construction as a "contrapuntal" process in which dominant social groups construct their own identity through the identification of other cultures as "opposites, negatives, oppositions." Edward W. Said, *Culture and Imperialism* (New York: Knopf, Distributed by Random House, 1994), 52.

[393] Miles, "Saint-Mémin's Portraits of American Indians, 1804-1807," 197.

body's relationship to the machine was not peripheral, but instrumental—their intermingling deliberately performed both in the space of the studio and in the image the artist ultimately produced. In its amalgam of physical performance and mechanical control, in the manifestation of subjects that are both depicted and participate in the act of depiction, in the very confusion of bodily and instrumental anatomy it enacts, physiognotrace portraiture presents us with a version of the machine that is both vital and dispassionate—one that is animated and expressive, yet emotionally detached.

This dual identity is what is so compelling in the physiognotrace's history. It is the source of the underlying frisson in Saint-Mémin's images. On one hand, there is a will to see the device as a participant in an on-going process of automation, to see mechanical production as an achieriopoietic practice, that is to say untouched by human hands. On the other, there is the machine's own resistance to such an interpretation. The physiognotrace, in fact, *demands* the incorporation of the body into its operations. Through this device and the images it produced, one sees early American society struggling with its relationship to mechanization—to both the physical and metaphysical implications of the industrial path upon which the nation had embarked.

* * *

Having begun the dissertation with the automaton, it seems only fitting to end here, with the physiognotrace. As I mentioned above, the physiognotrace is, like Maelzel's automaton, a very literal drawing machine. It is also, like the automaton, something of a technological dead-end—a means of representation quickly forgotten once the photographic apparatus appeared on the scene. In this failure of the physiognotrace and the ultimate ascendancy of the photographic apparatus, there is a particular history of art and industrialization to be told. It is one that witnesses the demise of Marx's "living machine" and the undoing of the early modern period's intimate relationship between hand and tool. Walter Benjamin, working from within this Marxist paradigm, posits the ascendancy of the camera as a transfer of artistic function from active hand to passive eye.[394] From this has proceeded a whole history of art premised on the notion that the relationship between body and machine is defined by the devaluation of manual skill and that to produce art in the industrial or post-industrial era is to be forced into a position of critique *vis à vis* the alienating effects of industrial production. Such critique takes one of two forms. One may defend the practice of art as the mastery of physical processes, as in the genealogy of craft from John Ruskin to the contemporary culture of "makers."[395] Alternately, one may fully surrender to the encroachments of the machine and invest art's essential character in the practices of "immaterial labor," be that the magic of photographer Henri Cartier-Bresson's "decisive moments," the readymade provocations of Marcel Duchamp, or the linguistic *Statements* of conceptual artist Lawrence Weiner.[396] This is, of course, an over-simplification, and there are certainly innumerable artists' practices that hover between these two poles, but my point is that these are the two poles around which history has organized its understanding of art and industry—with the hand at one end and the machine at the other.

As I conclude, I would like to suggest that the complexity of the body/machine relationship that I have explored with both the physiognotrace and the automaton has persisted

[394] Benjamin, "The Work of Art," 20–21, 37.

[395] As Glenn Adamson has argued, it is the process of mechanization and industrialization that has elicited the category of "craft" at all. Prior to industrialization, artisans existed within "an undifferentiated world of making." Post-industrialization, this world was bifurcated "into a set of linked binaries: craft/industry, freedom/alienation, tacit/explicit, hand/machine, traditional progressive." Adamson, *The Invention of Craft*, xiii.

[396] That said, John Roberts has (relatively) recently mounted a critique of this critique, noting that the valorization of immaterial labor in contemporary society overlooks the ways in which such labor is still trapped within capitalism's technical division of labor and its temporal regimes. In his view, this has been one of the driving forces of the recent craft revival, in so far as makers may be understood to possess control over their own time. John Roberts, "Labor, Emancipation, and the Critique of Craft-Skill," *The Journal of Modern Craft* 5, no. 2 (2012): 137–148.

well beyond the demise of these devices themselves. It is a relationship constructed in each of the case studies I have examined, wherein the interaction of body and machine has resulted not in the body being deskilled but in being *reskilled*. In each case, mechanization has demanded that the movements of the body be understood as phenomena that can be mapped, analyzed, and reproduced. In each situation, graphic representation has been treated as the visible trace of both physical movement and mechanical know-how. And last, but certainly not least, in each instance, the practice of art has been found to be inseparable from the application of technical knowledge.

This is the legacy of the automaton—a machine that reveals technical knowledge to be fundamentally hybrid, the combined output of body and machine. It is a legacy that should be familiar to the twenty-first century reader. Every day, more and more of our lives seem given over to automation, but we have never been more physically and emotionally entangled with our technology. Again, as I mentioned in the introduction, Donna Haraway's notion of contemporary society as an association of cyborgs is even more poignant today than it was when she first published her *Cyborg Manifesto*. Ruled by big data and bio-pharma, perpetually connected via a range of mobile device, western society is a collective of "chimeras, theorized and fabricated hybrids of machine and organism."[397] My ambition with this study has been to illuminate the extent to which this chimerical entity was there at the inception of industrial society. Although it has often been played out in flawed and frequently failed experiments, it has ultimately been constitutive of the way in which modernity's relationship to technology has evolved.

[397] Haraway, "Cyborg Manifesto," 7.

BIBLIOGRAPHY

This list incorporates those sources I have cited in the course of my dissertation, but does not encompass the full range of materials I have consulted in my research. I have broken it into several sections, in order to make the unusual archival and instructional sources included in my research more accessible.

Archival Sources

Archives Ecole Polytechnique. Bibliothèque Centrale Ecole Polytechnique.

Chancery Records. The National Archives, United Kingdom.

College of Philadelphia, Archives General Collection of the University of Pennsylvania, 1740-1820. University Archives. University of Pennsylvania.

Institut National de la Propriétée Industrielle. *Brevets français 19e siècle*. http://bases-brevets19e.inpi.fr.

Papers of the Continental Congress, Manuscript Division. Library of Congress.

Penmanship Collection, undated; 1762-1856, American Antiquarian Society.

Archives of Soho. Library of Birmingham.

Stoudinger-Alofsen-Fulton Drawings. New Jersey Historical Society.

William Barclay Parsons Collection of Robert Fulton manuscripts, 1796-1919. The New York Public Library.

Drawing and Writing Manuals

Alberti, Leon Battista. *On Painting*. New Haven: Yale University Press, 1966.

Arrighi, Ludovico degli. *La Operina Di Ludouico Vicentino: Da Imparare Di Scriuere Litettera Cancellarescha*. Roma: Per inuentione di Ludouico Vicention, scrittore, 1524.

Betts, Edwin M., and James Bear, Jr., eds. *Family Letters of Thomas Jefferson*. Reprint. Charlottesville: Thomas Jefferson Memorial Foundation, 1986.

Bickham, George. *The Universal Penman, Engrav'd by George Bickham*. London: Printed for the author, 1733.

Blunt, Charles. *An Essay on Mechanical Drawing*. London: Printed by L. Harrison & J.C. Leigh, 1811.

Carver, James. *A New and Easy Introduction to the Art of Analytical Penmanship*. Philadelphia: Hall and Pierie, 1809.

Davies, Charles. *A Treatise on Shades and Shadow, and Linear Perspective*. New York: J. & J. Harper, 1832.

Dean, Henry. *Dean's Recently Improved Analytical Guide, to the Art of Penmanship*. New-York: Published for the author, 1808.

———. *The Printer's Academical Companion: Containing an Account of the Origin and Progress of Printing, the True Method of Forming Letters by Scale, to Any Dimensions: With Geometrical Problems, Illustrated by Examples Beautifully Ornamented for Penmanship ... Collected from the Best Authorities*. Salem, MA: Printed for the author, by Haven Pool, 1806.

Eastman, Seth. *Treatise on Topographical Drawing*. New York: Wiley and Putnam, 1837.

Fenn, Joseph. *Proposals for Printing by Subscription, the Instructions Given in the Drawing Schools Established in England, Scotland, and Other Parts of Europe....* Dublin: Printed by George Cecil, 1767.

Fisher, George, accomptant. *The American Instructor Or, Young Man's Best Companion*. Philadelphia: Printed by B. Franklin and D. Hall, at the New-Printing-Office, in Market Street, 1748.

Foster, Benjamin Franklin. *Foster's System of Penmanship; Or, The Art of Rapid Writing Illustrated and Explained. To Which Is Added the Angular and Anti-Angular Systems. Exemplified with Plates.* Philadelphia; Boston: H. Perkins; Perkins, Marvin, & Co., 1855.

———. *Practical Penmanship, Being a Development of the Carstairian System*. Albany: B.D. Packard and Co., Printers, 1830.

Huntington, Eleazer. *The American Penman: Comprising the Art of Writing, Plain and Ornamental: Designed as a Standard Work, for the Use of Schools*. Hartford: Published by Eleazer Huntington, 1824.

Jenkins, John. *The Art of Writing, Reduced to a Plain and Easy System: On a Plan Entirely New: In Seven Books*. Printed in Boston: by Isaiah Thomas and Ebenezer T. Andrews, 1791.

———. *The Art of Writing, Reduced to a Plain and Easy System : On a Plan Entirely New, in Seven Books*. Cambridge, MA: Printed for the author, 1813.

Jombert, Charles Antoine. *Nouvelle methode pour apprendre à dessiner sans maître*. À Paris: Chez Charles Antoine Jombert, 1740.

Neveu, François-Marie. "Dessin." In *Journal polytechnique ou Bulletin du travail fair à l'École central des travaux public publié par le consel d'isntruction et administration de cette École*, Vol. 1. Paris: L'Imprimerie de la république, 1794.

Peale, Rembrandt. *Graphics: A Manual of Drawing and Writing, for the Use of Schools and Families*. New York: J. P. Peaslee, 1835.

Smith, John Rubens. *Key to the Art of Drawing the Human Figure*. Philadelphia: S.M. Stewart, 1831.

———. *The Juvenile Drawing Book*. New York: The Author, 1822.

Additional Primary Sources

Adams, Cindy, and J. Thomas Russell, eds. *The West Point Thayer Papers*. West Point, NY: Association of Graduates, 1965.

Alcott, William A. *Lectures on Life and Health; Or, the Laws and Means of Physical Culture.* Boston: Phillips, Sampson, and Company, 1853.

———. *The Structure, Uses and Abuses of the Human Hand.* Boston: Massachusetts Sabbath School Society, 1856.

An act fixing the military peace establishment of the United States, Statute I § 27 (1802).

Bentham, Jeremy. *Chrestomathia*. Edited by W.H. Burston and M.J. Smith. Oxford; New York: Clarendon Press; Oxford University Press, 1983.

Brewster, Walter. "The Mechanic on Taxation." *Norwich Packet*, April 4, 1792.

Carlyle, Thomas. "Signs of the Times (1829)." In *The Philosophy of Manufactures: Early Debates over Industrialization in the United States*, 1:259–80.

Documents in American Industrial History. Cambridge, MA; London: MIT Press, 1982.

Clinton, DeWitt. *A Discourse, Delivered before the American Academy of the Arts*. New-York: Printed and published by T. & W. Mercein, printers to the Academy, 1816.

Comenius, Johann Amos. *The Orbis Pictus of John Amos Comenius*. Edited by C. W. Bardeen. Syracuse, NY: C.W. Bardeen, 1887.

Condillac, Etienne Bonnot de. *The Logic of Condillac, Translated by Joseph Neef, as an Illustration of the Plan of Education Established at His School near Philadelphia*. Philadelphia: [unknown], 1809.

———. *Traité Des Sensations*. Paris: Bure l'Aîné, Quay des Augustins, 1754.

Cooper, Thomas. "The Disadvantage of Machinery (1823)." In *The Philosophy of Manufactures: Early Debates over Industrialization in the United States*, 1:255–57. Documents in American Industrial History. Cambridge, MA; London: MIT Press, 1982.

Darwin, Erasmus. *A Plan for the Conduct of Female Education*. Derby: J. Drewry for J. Johnson, London, 1797.

Diderot, Denis and Jean Le Rond d'Alembert. *Encyclopédie, Ou Dictionnaire Raisonné Des Sciences, Des Arts et Des Métiers, Etc.* Paris: Briasson, David, Le Breton & Durand, 1751-1752.

"Destruction of the General Post-Office, City Post-Office, and Patent-Office." *Columbian Register*. December 24, 1836.

Du Pont de Nemours, Pierre Samuel, and B.G. Du Pont. *National Education in the United States*. Translated from the Second French Edition of 1812. Newark, DE: University of Delaware Press, 1923.

Dunlap, William. *History of the Rise and Progress of the Arts of Design in the United States*. New York: G.P. Scott, printers, 1834.

Eliot, John. *The Dying Speeches of Several Indians*. Cambridge, Mass.: Printed by Samuel Green?, 1685.

Emerson, William. *The Principles of Mechanics*. London: Printed for G.G. and J. Robinson, in Pater Noster-Row, 1794.

Félibien, André. *Conferences de l'Academie royale de peinture et de sculpture pendant l'année 1667.* Paris: Chez Frederic Leonard, 1669.

Ferguson, John. *Lectures on Select Subjects in Mechanics, Hydrostatics, Pneumatics, and Optics*. London: Printed for A. Millar, in the Strand, 1764.

Franklin, Benjamin. *Proposals Relating to the Education of Youth in Pensilvania*. Philadelphia: [Benjamin Franklin], 1749.

———. *The Works of Benjamin Franklin: Containing Several Political and Historical Tracts Not Included in Any Former Edition, and Many Letters, Official and Private, Not Hitherto Published; with Notes and a Life of the Author*. Edited by Jared Sparks. Boston: Whittemore, Niles, and Hall, 1856.

"Friendship Esteems as Valuable Even the Most Distant Likeness of a Friend." *Philadelphia Repository*, January 1, 1803.

Fulton, Robert. *A Treatise on the Improvement of Canal Navigation; Exhibiting the Numerous Advantages to Be Derived from Small Canals.* London: I. & J. Taylor, 1796.

Fulton, Robert, Edmund Cartwright, and W. Powell Jones. "New Light on Fulton's Submarine." *Huntington Library Quarterly* 4, no. 4 (July 1941).

Gilbreth, Frank. *Motion Study*. New York: D. Van Nostrand Co., 1911.

Gimbrede, Thomas. "Lecture." *Journal of American Arts and Sciences* 21, no. 2 (January 1832).

Hamilton, Alexander. "*Report on the Subject of Manufactures (1791)*." In *The Philosophy of Manufactures: Early Debates over Industrialization in the United States*, edited by Michael Folsom and Steven D. Lubar, 81–94. Cambridge, MA; London: MIT Press, 1982.

James Watt and Company. *Directions for Using the Machine for Copying Letters and Other Writings.: Invented and Made by James Watt and Company, of Birmingham.* Birmingham, 1780.

Jefferson, Thomas. *Notes on the State of Virginia*. Richmond, VA: J.W. Randolph, 1853.

———. *The Papers of Thomas Jefferson*. Edited by J. Jefferson Looney. Vol. 6. Princeton: Princeton University Press, 2009. Founders Online, National Archives. http://founders.archives.gov/documents/Jefferson.

Johnson, Walter R. "On the Utility of Visible Instruction." *American Annals of Education and Instruction* 3, no. 3 (1833): 97–112.

La Mettrie, Julien Offray de. *Man a Machine*. Edited by Gertrude Carman Bussey. Chicago: The Open Court Publishing Co., 1912.

Latrobe, Benjamin Henry. "First Report of Benjamin Henry Latrobe, to the American Philosophical Society, Held at Philadelphia: In Answer to the Enquiry of the Society of Rotterdam, 'Whether Any, and What Improvements Ahve Been Made in the Construction of Steam-Engines in America?'" *Transactions of the American Philosophical Society* 6 (1809): 89–98.

Lavater, Johann Caspar. *Essays on Physiognomy*. Translated by Thomas Holcroft. 8th ed. London: Tegg, 1853.

Le Corbusier. *Towards a New Architecture*. Translated by Frederick Etchells. New York: Dover Publications, 1986.

Locke, John. *An Essay Concerning Human Understanding*. Edited by Kenneth P. Winkler. Indianapolis: Hackett Publishing Company, Inc., 1996.

———. "Some Thoughts Concerning Education." In Some Thoughts Concerning Education *and* Of the Conduct of the Understanding, edited by Ruth W. Grant and Nathan Tarcov, 1–162. Indianapolis: Hackett Publishing Company, Inc., 1996.

"Maelzel's Exhibition." *Boston Traveler*. August 5, 1835.

Malortie de Martemont, C. *Instructions for Officers on Military Plan-Drawing*. London: Printed by J. Barfield, 1805.

Marx, Karl. "*Capital*." In *The Craft Reader*, edited by Glenn Adamson, 69–77. Oxford; New York: Berg Publishers, 2010.

"[Mr Sheriff; Language; Gentleman; Mess. Braidwood; London; Deaf; Dumb]." *Boston Gazette*. August 15, 1803.

"[No Title]." *The Philadelphia Gazette & Universal Daily Advertiser*, August 14, 1795.

The Packard Humanities Institute. "The Papers of Benjamin Franklin." Accessed May 10, 2017. http://franklinpapers.org/franklin//.

Poe, Edgar Allan. "Maelzel's Chess-Player." *Southern Literary Messenger* 2 (April 1836): 318–26.

Reynolds, Joshua. *The Literary Works of Sir Joshua Reynolds: First President of the Royal Academy*. London; Edinborough: T. Cadell, 1835.

Rousseau, Jean-Jacques. *Emile, or On Education*. Translated by Allan Bloom. New York: Basic Books, 1979.

———. "Scène Lyrique." In *Œuvres complètes*, edited by Bernard Gagnebin and Marcel Raymond. Paris: Gallimard, 1959.

Rush, Benjamin. *A Plan for the Establishment of Public Schools and the Diffusion of Knowledge in Pennsylvania: To Which Are Added Thoughts upon the Mode of Education, Proper in a Republic: Addressed to the Legislature and Citizens of the State.* Philadelphia: Printed for Thomas Dobson, in Second-Street, two doors above Chesnut-Street, 1786.

———. “Address to the People of the United States.” *The American Museum: Or Repository of Ancient and Modern Fugitive Pieces* 1, no. 1 (1787): 8–11.

Ryland, John. *An Easy Introduction to Mechancis, Geometry, Plane Trigonometry, Measuring Heights and Distances, Optics, Astronomy*. London: Printed for Edward and Charles Dilly, in the Polutry, 1768.

Shakespeare, William. “A Midsummer Night’s Dream.” In *The Yale Shakespeare*, edited by Wilbur L. Cross and Tucker Brooke. New York: Barnes and Noble Books and Yale University Press, 1993.

Shelley, George. *The Penman’s Magazine, or a New Copy Book of the English, French, and Italian Hands*. London: Sold by R. Parker, under the Piazza Royal-Exchange; J. Holland; B. Lintott; J. Dewell, 1705.

“To the Electors.” *The Independent Chronicle and the Univeral Advertiser*, May 9, 1790.

Todd, Charles Burr. *Life and Letters of Joel Barlow, LL.D., Poet, Statesman, Philosopher: With Extracts from His Works and Hitherto Unpublished Poems*. G.P. Putnam’s Sons, 1886.

Townsend, Reginald. “The Magic of Motion Study.” *The World’s Work*, July 1916, 321–36.

United States Congress. *American State Papers, Class V, Military Affairs*. Vol. II. Washington: Gales and Seaton, 1834.

U.S. Census Bureau. *Statistical View of the United States...Being a Compendium of the Seventh Census*. Washington, D.C.: Beverley Tucker, Senate Printer, 1854.

U.S. Department of State. *Return of the Whole Number of Persons within the Several Districts of the United States, According to “An Act Providing for the Enumeration of the Inhabitants of the United States,” Passed March the First, One Thousand Seven Hundred and Ninety-One.* Philadelphia: J. Phillips, George-Yard, Lombard-Street, 1793.

Washington, George, and Jared Sparks. “Speech to Both Houses of Congress, December 7th, 1796.” In *The Writings of George Washington*, XII:65–74. Boston: American Stationers’ Company, 1837.

Webster, Noah. *Dissertations on the English Language*. Boston: Isaiah Thomas and Company, 1789.

West, Benjamin. *A Discourse, Delivered to the Students of the Royal Academy, on the Distribution of the Prizes, December 10, 1792, by the President. Humbly Inscribed by Permission to His Majesty.* London: Printed by Thomas Cadell, printer to the Royal Academy, 1793.

Woodcroft, Bennett. *Patents of Invention: From March 2, 1617 (14 James I) to October 1, 1852 (16 Victoriae)*. London: Queen's Printing Office, 1854.

Wrifford, Anson. *A New Plan of Writing Copies: With Accompanying Explanations and Remarks*. Boston: Printed by W. Hooker, 1810.

Zophyrus. "On Physiognomy. No. III." *The Companion and Weekly Miscellany* 2, no. 21 (March 22, 1806): 162.

Secondary Sources

Adamson, Glenn. *The Invention of Craft*. London: Bloomsbury, 2013.

Adamson, Glenn, ed. *The Craft Reader.* New York: Berg, 2010.

Alder, Ken. "Innovation and Amnesia: Engineering Rationality and the Fate of Interchangeable Parts Manufacturing in France." *Technology and Culture* 38, no. 2 (1997): 273–311.

———. "Making Things the Same: Representation, Tolerance and the End of the Ancien Régime in France." *Social Studies of Science* 28, no. 4 (August 1998): 499–545.

Alpers, Svetlana. *The Art of Describing: Dutch Art in the Seventeenth Century*. Chicago: University of Chicago Press, 1983.

Altick, Richard Daniel. *The Shows of London*. Cambridge, Mass.: Belknap Press, 1978.

Ambrose, Stephen E. *Duty, Honor, Country: A History of West Point*. Baltimore: Johns Hopkins University Press, 1966.

Anderson, Marvin J. "The Architectural Education of Nineteenth-Century American Engineers: Dennis Hart Mahan at West Point." *Journal of the Society of Architectural Historians* 67, no. 2 (2008): 222–47.

Arrington, Joseph. "John Maelzel, Master Showman of Automata and Panoramas." *The Pennsylvania Magazine of History and Biography* 84, no. 1 (1960): 56–92.

Artz, Frederick Binkerd. *The Development of Technical Education in France, 1500-1850*. Cleveland: Society for the History of Technology, 1966.

Ashwin, Clive. "Pestalozzi and the Origins of Pedagogical Drawing." *British Journal of Educational Studies* 29, no. 2 (June 1981): 138–51.

Bailyn, Bernard. *The Ideological Origins of the American Revolution*. Cambridge, MA: The Belknap Press of Harvard University Press, 2017.

Baker, William Spohn. *Character Portraits of Washington as Delineated by Historians, Orators and Divines: Selected and Arranged in Chronological Order with Biographical Notes and References*. R.M. Lindsay, 1887.

Baptist, Edward E. *The Half Has Never Been Told: Slavery and the Making of American Capitalism*. New York: Basic Books, 2014.

Barthes, Roland. "The Plates of the Encyclopedia." In *New Critical Essays*, translated by Richard Howard. New York: Hill and Wang, 1980.

Barzman, K.-E. "The Florentine Accademia Del Disegno: Liberal Education and the Renaissance Artist." In *Academies of Art between Renaissance and Romanticism*, edited by Anton W.A. Boschloo et al., 14–32. 's-Gravenhage: SDU Uitgeverij, 1989.

Beamish, Richard. *Memoir of the Life of Sir Marc Isambard Brunel*. London: Longman, Green, Longman, and Roberts, 1862.

Bedford, C.P. "Collier and His Revolvers." *American Society of Arms Collectors Bulletin*, no. 24 (Fall 1971): 10–21.

Belhoste, Bruno. *La formation d'une technocratie: l'École polytechnique et ses élèves de la Révolution au Second Empire*. Paris: Belin, 2003.

Belhoste, Bruno, Antoine Picon, and Joêl Sakarovitch. "Les exercices dans les écoles d'ingénieurs sous l'ancien régime et la révolution." *Histoire de l'education* 46 (May 1990): 53–109.

Bellion, Wendy. *Citizen Spectator: Art, Illusion, and Visual Perception in Early National America*. Chapel Hill: Published for the Omohundro Institute of Early American History and Culture by the University of North Carolina Press, 2011.

———. "Heads of State: Profiles and Politics in Jeffersonian America." In *New Media, 1740-1915*, edited by Lisa Gitelman and Geoffrey B. Pingree, 31–60. Media in Transition. Cambridge, Mass.: MIT Press, 2003.

Bender, John B., and Michael Marrinan. *The Culture of Diagram*. Stanford: Stanford University Press, 2010.

Benes, Peter. "Machine-Assisted Portraiture and Profile Making in New England after 1803." *Annual Proceedings/Dublin Seminar for New England Folklife* 19 (1994): 138–50.

Benjamin, Walter. "The Work of Art in the Age of Its Technological Reproducibility: Second Version." In *The Work of Art in the Age of Its Technological Reproducibility and Other Writings on Media*, edited by Michael W. Jennings, Brigid Doherty, and Thomas Y. Levin, translated by Edmund Jephcott, 19–55. Cambridge: Belknap Press of Harvard University Press, 2008.

Benson, Richard. *The Printed Picture*. New York: The Museum of Modern Art, 2008.

Berg, Maxine, ed. "Reflections on Joel Mokyr's *Gifts of Athena*." Special Issue, *History of Science* 45, no. 2 (June 2007).

Berg, Maxine. *The Age of Manufactures, 1700-1820 : Industry, Innovation, and Work in Britain*. 2nd ed. London; New York: Routledge, 1994.

Bermingham, Ann. *Learning to Draw: Studies in the Cultural History of a Polite and Useful Art*. New Haven: Published for the Paul Mellon Centre for Studies in British Art by Yale University Press, 2000.

Biagioli, Mario. "Patent Specification and Political Representation: How Patents Became Rights." In *Making and Unmaking Intellectual Property: Creative Production in Legal and Cultural Perspective*, edited by Mario Biagioli, Peter Jaszi, and Martha Woodmansee, 25–40. Chicago: University of Chicago Press, 2011.

Bowden, Witt. *Industrial Society in England towards the End of the Eighteenth Century*. New York: The Macmillan Company, 1925.

Bredekamp, Horst, Vera Dünkel, and Birgit Schneider, eds. *The Technical Image: A History of Styles in Scientific Imagery*. Chicago: The University of Chicago Press, 2015.

Breen, T. H. *The Marketplace of Revolution: How Consumer Politics Shaped American Independence*. Oxford; New York: Oxford University Press, 2004.

———. "The Meaning of 'Likeness': Portrait-Painting in an Eighteenth-Century Consumer Society." In *The Portrait in Eighteenth-Century America*, edited by Ellen G. Miles. The American Arts Series/University of Delaware Press Books. Newark, DE: University of Delaware Press, 1993.

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

Briggs, Robert. "History of the Steam Engine in America." *Journal of the Franklin Institute* 72, no. 1 (July 1876): 253–68.

Brockett, L. P. *The Silk Industry in America: A History: Prepared for the Centennial Exposition*. New York: Silk Association of America, 1876.

Brown, Theodore. "From Mechanism to Vitalism in Eighteenth-Century English Physiology." *Journal of the History of Biology* 7, no. 2 (1974): 179–216.

Brückner, Martin. *The Geographic Revolution in Early America : Maps, Literacy, and National Identity*. Chapel Hill: Published for the Omohundro Institute of Early American History and Culture by University of North Carolina Press, 2006.

Buchloh, Benjamin H. D. “Painting as Diagram: Five Notes on Frank Stella’s Early Paintings, 1958–1959.” *October* 143 (2013): 126–144.

Burstein. “Immortalizing the Founding Fathers: The Excesses of Public Eulogy.” In *Mortal Remains: Death in Early America*, edited by Nancy Isenberg and Andrew Burstein. Philadelphia: University of Pennsylvania Press, 2003.

Bushman, Richard L. *The Refinement of America: Persons, Houses, Cities*. 1st ed. New York: Knopf : Distributed by Random House, 1992.

Carr, J. “Pygmalion and the ‘Philosophes.’” *Journal of the Warburg and Courtauld Institutes* 23, no. 3 (1960): 239–55.

Caws, Peter, George Bugliarello, and Dean B. Doner. “Praxis and Techne.” In *The History and Philosophy of Technology*, 227–38. Urbana: University of Illinois Press, 1979.

Ceramics in America 2007. Milwaukee, WI; Hanover, NH: Chipstone Foundation, Distributed by University Press of New England, 2007.

Certeau, Michel de. “Walking in the City.” In *The Practice of Everyday Life*, 91–110. Berkeley: University of California Press, 1984.

Christen, Richard S. “John Jenkins and The Art of Writing: Handwriting and Identity in the Early American Republic.” *The New England Quarterly* 85, no. 3 (September 2012): 491–525.

Clark, John R. “Early Latin Handwriting and Plautus’ ‘Pseudolus.’” *The Classical Journal* 97, no. 2 (December 2001): 183–89.

Clifford, James. “On Ethnographic Allegory.” In *Writing Culture: The Poetics and Politics of Ethnography: A School of American Research Advanced Seminar*, edited by James Clifford and George E. Marcus, 98–121. Berkeley: University of California Press, 1986.

Cohen, Alexis. “Domestic Utility and Useful Lines: Jean-Charles Krafft’s and Thomas Hope’s Outlines.” *Journal of Art Historiography*, no. 9 (2013): AHC1–AHC20.

Colden, Cadwallader D. *The Life of Robert Fulton*. New York: Kirk & Mercein New York, 1817.

Coleman, D., and H. Fraser. *Minds, Bodies, Machines, 1770-1930*. New York: Palgrave Macmillan, 2011.

Cottom, Daniel. “The Work of Art in the Age of Mechanical Digestion.” *Representations* 66, no. 1 (1999): 52–74.

Crackel, Theodore J. “Jefferson, Politics, and the Army: An Examination of the Military Peace Establishment Act of 1802.” *Journal of the Early Republic* 2, no. 1 (1982): 21–38.

Crain, Patricia. *The Story of A: The Alphabetization of America from The New England Primer to The Scarlet Letter*. Stanford: Stanford University Press, 2000.

Crary, Jonathan. “Géricault, the Panorama, and Sites of Reality in the Early Nineteenth Century.” *Grey Room*, no. 9 (2002): 5–25.

———. *Suspensions of Perception: Attention, Spectacle, and Modern Culture*. Cambridge, MA: MIT Press, 1999.

———. *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century*. Cambridge, MA: MIT Press, 1992.

Craven, Wayne. *Colonial American Portraiture: The Economic, Religious, Social, Cultural, Philosophical, Scientific, and Aesthetic Foundations*. Cambridge, UK; New York: Cambridge University Press, 1986.

Curti, Merle. “America at the World Fairs, 1851-1893.” *The American Historical Review* 55, no. 4 (1950): 833–856.

Custis, John Trevor. *The Public Schools of Philadelphia: Historical, Biographical, Statistical*. Philadelphia: Burk & McFetridge Co, 1897.

Daston, Lorraine. “Fear & Loathing of the Imagination in Science.” *Daedalus* 134, no. 4 (2005): 16–30.

———. “Objectivity and the Escape from Perspective.” *Social Studies of Science* 22, no. 4 (1992): 597–618.

———. “The Physicalist Tradition in Early Nineteenth Century French Geometry.” *History and Philosophy of Science Part A* 17, no. 3 (1986): 269–95.

Daston, Lorraine, and Peter Galison. *Objectivity*. New York: Zone Books, 2007.

———. “The Image of Objectivity.” *Representations* 40, no. 1 (1992): 81–128.

Davis, Elliot Bostwick. “Training the Eye and the Hand: Drawing Books in Nineteenth-Century America.” Dissertation, Columbia University, 1992.

De Man, Paul. “Self (Pygmalion).” In *Allegories of Reading: Figural Language in Rousseau, Nietzsche, Rilke, and Proust*, 160–87. New Haven: Yale University Press, 1979.

Dear, Peter. “A Mechanical Microcosm: Bodily Passions, Good Manners, and Cartesian Mechanism.” In *Science Incarnate: Historical Embodiments of Natural Knowledge*, edited by Christopher Lawrence and Steven Shapin, 51–82. Chicago: University of Chicago Press, 1998.

Degenaar, Marjolein. *Molyneux’s Problem: Three Centuries of Discussion on the Perception of Forms*. Translated by Michael J. Collins. Dordrecht: Kluwer Academic Publishers, 1996.

Deutsch, Davida Tennenbaum. “Washington Memorial Prints.” *Antiques* 111, no. 2 (1977): 324–332.

Dobyns, Kenneth W. *A History of the Early Patent Offices: The Patent Office Pony*. Fredericksburg, VA: Sergeant Kirkland’s Museum and Historical Society, 1997.

Drucker, Johanna. *The Alphabetic Labyrinth: The Letters in History and Imagination*. London: Thames and Hudson, 1995.

Dutton, H. I. *The Patent System and Inventive Activity during the Industrial Revolution, 1750-1852*. Dover, NH: Manchester University Press, 1984.

Edmonds, Franklin Spencer. *History of the Central High School of Philadelphia*. Philadelphia: J.B. Lippincott Co., 1902.

Evans, Dorinda. *Benjamin West and His American Students*. Washington, D.C.: Published for the National Portrait Gallery by the Smithsonian Institution Press, 1980.

Evans, Robin. *The Projective Cast: Architecture and Its Three Dimensions*. Cambridge, MA: MIT Press, 1995.

Fahlman, Betsy. *John Ferguson Weir, the Labor of Art*. The American Arts Series. Newark, DE: University of Delaware Press, 1997.

Ferguson, Eugene S. “The Mind’s Eye: Nonverbal Thought in Technology.” *Science* 197 (1977): 827.

Flatley, Jonathan. “Like: Collecting and Collectivity.” *October*, no. 132 (Spring 2010): 71–98.

Foley, Michael. *Laws, Men and Machines: Modern American Government and the Appeal of Newtonian Mechanics*. London; New York: Routledge, 1990.

Fox, Celina. *The Arts of Industry in the Age of Enlightenment*. New Haven; London: Yale University Press for The Paul Mellon Centre for Studies in British Art, 2009.

Fried, Michael. *Absorption and Theatricality: Painting and Beholder in the Age of Diderot*. Chicago: University of Chicago Press, 1988.

Fuchs, Thomas. *The Mechanization of the Heart: Harvey and Descartes*. Rochester Studies in Medical History. Rochester, NY: University of Rochester Press, 2001.

Gaudio, Michael. *Engraving the Savage: The New World and Techniques of Civilization*. Minneapolis: University of Minnesota Press, 2008.

———. "Magical Pictures; Or, *Observations on LIghting and Thunder, Occasion'd by a Portrait of Dr. Franklin*." In *Picturing*, edited by Rachael DeLue, 84–111. Chicago; Paris: University of Chicago Press for Terra Foundation for American Art, 2016.

Gee, Brian. "The Newtons of Chancery Lane and Fleet Street Revisited, Part II: The Fleet Street Business and Other Geneaology." *Bulletin of the Scientific Instrument Society*, no. 36 (1993): 12–14.

Gell, Alfred. "The Enchantment of Technology and the Technology of Enchantment." In *Anthropology, Art and Aesthetics*, edited by Jeremy Coote and Anthony Shelton. New York: Oxford University Press, 1992.

George Eastman House. "Before Photography." https://www.youtube.com/watch?v=me5ke7agyOw&list=PL4F918844C147182A,.

Gilmore, Paul. "Republican Machines and Brackenridge's Caves: Aesthetics and Models of Machinery in the Early Republic." *Early American Literature* 39, no. 2 (2004): 299–322.

Goldberg, Jonathan. *Writing Matter: From the Hands of the English Renaissance*. Stanford: Stanford University Press, 1990.

Goldstein, Carl. *Teaching Art: Academies and Schools from Vasari to Albers*. Cambridge; New York: Cambridge University Press, 1996.

Goody, Jack. *Literacy in Traditional Societies*. Cambridge: Cambridge University Press, 1975.

Graff, Frederick. "Notice of the Earliest Steam Engines Used in the United States." *Journal of the Franklin Institute* 55, no. 4 (1853): 269–71.

Greenhalgh, Adam. "'Not a Man but a God.' The Apotheosis of Gilbert Stuart's Athenaeum Portrait of George Washington." *Winterthur Portfolio* 41, no. 4 (2007): 269–304.

Guerlac, Henry. "Science and War in the Old Regime: The Development of Science in an Armed Society." Dissertation, Harvard University, 1941.

Guignard, Philippe. *Notice historique sur la vie et les travaux de M. Fevret de Saint-Mémin*. Dijon: Imprimerie Loireau-Feuchot, 1853.

Gusdorf, George. *Les Sciences Humaines et La Pensée Occidentale*. Paris: Payot, 1973.

Gutman, Herbert. “Work, Culture and Society in Industrializing America, 1815-1919.” In *Work, Culture and Society in Industrializing America: Essays in American Working Class History*. New York: Vintage Books, 1976.

Haraway, Donna Jeanne. “A Cyborg Manifesto: Science, Technology, and Socialist Feminism in the Late Twentieth Century.” In *Manifestly Haraway*, 5–90. Minneapolis: University of Minnesota Press, 2016.

Hayles, N. Katherine. *How We Became Posthuman: Virtual Bodies in Cybernetics, Literature, and Informatics*. Chicago: University of Chicago Press, 1999.

Heaton, Herbert. “The Industrial Immigrant in the United States, 1783-1812.” *Proceedings of the American Philosophical Society* 95, no. 5 (10): 519–27.

Hellman, Mimi. “The Joy of Sets: The Uses of Seriality in the French Interior.” In *Furnishing the Eighteenth Century: What Furniture Can Tell Us about the European and American Past*, edited by Dena Goodman and Kathryn Norberg, 129–54. New York: Routledge, 2007.

Hennequin, René. In *Un “photographe” de l’époque de la révolution et l’empire, Edme Quenedey des Riceys (Aube), portraitiste au physionotrace*, 2:77–86. Troyes: J.L. Paton, 1926.

Hilaire-Perez, Liliane. “Technology as Public Culture in the Eighteenth Century: The Artisan’s Legacy.” *History of Science* 45, no. 2 (2007): 135–53.

Hindle, Brooke. *Emulation and Invention*. New York: New York University Press, 1981.

———. *Engines of Change: The American Industrial Revolution, 1790-1860*. Washington, D.C.: Smithsonian Institution Press, 1986.

Honour, Hugh. *Romanticism*. New York: Harper & Row, 1979.

Hope, Ian C. *A Scientific Way of War: Antebellum Military Science, West Point, and the Origins of American Military Thought*. Studies in War, Society, and the Military. Lincoln, NB: University of Nebraska Press, 2015, 2015.

Horkheimer, Max, and Theodor W. Adorno. *Dialectic of Enlightenment: Philosophical Fragments*. Edited by Gunzelin Schmid Noerr. Translated by Edmund Jephcott. Stanford: Stanford University Press, 2002.

Howell, William Huntting. *Against Self-Reliance: The Arts of Dependence in the Early United States*. Philadelphia: University of Pennsylvania Press, 2015.

Howell, William Huntting. “Spirits of Emulation: Readers, Samplers, and the Republican Girl, 1787-1810.” *American Literature* 81, no. 3 (2009): 497–526.

Hudson, Nicholas. *Writing and European Thought 1600-1830*. Cambridge: Cambridge University Press, 1994.

Hunt, Margaret R. *The Middling Sort: Commerce, Gender, and the Family in England, 1680-1780*. Berkeley: University of California Press, 1996.

Hunter, Robert F. *Claudius Crozet, French Engineer in America, 1790-1864*. Charlottesville: University Press of Virginia, 1989.

Hutchinson, Elizabeth. “‘The Dress of His Nation.’ Romney’s Portrait of Joseph Brant.” *Winterthur Portfolio* 45, no. 2/3 (2011): 209–228.

Impériali, Marcelle. *François Devosge. Créateur de l’École de Dessin et du Musée de Dijon, 1732-1811*. Dijon: Rebourseau, 1927.

Institute of Western American Art and Denver Art Museum. *West Point, Points West*. Denver: Institute of Western American Art, Denver Art Museum, 2002.

Ivins, William Mills. *On the Rationalization of Sight, with an Examination of Three Renaissance Texts on Perspective*. New York: Da Capo Press, 1973.

Jacob, Margaret C. *The First Knowledge Economy: Human Capital and the European Economy, 1750-1850*. Cambridge: Cambridge University Press, 2014.

Jacobs, Phoebe Lloyd. “John James Barralet and the Apotheosis of George Washington.” *Winterthur Portfolio* 12 (1977): 115–137.

Jaffee, David. *A New Nation of Goods: The Material Culture of Early America*. Philadelphia: University of Pennsylvania Press, 2010.

Jay, Martin. *Downcast Eyes: The Denigration of Vision in Modern Thought*. Berkeley: University of California Press, 1993.

Jeremy, David J. *Transatlantic Industrial Revolution: The Diffusion of Textile Technologies between Britain and America, 1790-1830s*. Cambridge, MA: MIT Press, 1981.

Johns, Elizabeth. “Drawing Instruction at Central High School and Its Impact on Thomas Eakins.” *Winterthur Portfolio* 15, no. 2 (1980): 139–49.

Jones, Caroline A. *Machine in the Studio: Constructing the Postwar American Artist*. Chicago: University of Chicago Press, 1996.

Joselit, David. “Dada’s Diagrams.” In *The Dada Seminars, CASVA Seminar Papers I*, edited by Leah Dickerman and Matthew S. Witkovsky, 221–39. Washington, D.C.: The National Gallery of Art for the Center for Advanced Study in the Visual Arts, 2005.

Kang, Minsoo. “From the Man-Machine to the Automaton-Man: The Enlightenment Origins of the Mechanistic Imagery of Humanity.” In *Vital Matters: Eighteenth-Century Views of Conception, Life, and Death*, edited by Mary Terrall and Helen Deutsch, 148–73. Toronto: University of Toronto Press, 2012.

Kasson, John F. *Civilizing the Machine : Technology and Republican Values in America, 1776-1900*. New York: Hill and Wang, 1999.

Kimball, Fiske. “Joseph Wright and His Portraits of Washington: Sculpture.” *Antiques* 17 (January 1930): 34–39.

Klingender, F. D. *Art and the Industrial Revolution,*. Edited by Arthur Elton. London: Evelyn, Adams & Mackay, 1968.

Knipe, Penley. “Paper Profiles: American Portrait Silhouettes.” *Journal of the American Institute for Conservation* 41, no. 3 (2002): 203–223.

Knox, Katharine McCook. *The Sharples, Their Portraits of George Washington and His Contemporaries: A Diary and an Account of the Life and Work of James Sharples and His Family in England and America*. New Haven; London: Yale University Press; Oxford University Press, 1930.

Kornfeld, Eve. “Encountering ‘the Other’: American Intellectuals and Indians in the 1790s.” *The William and Mary Quarterly* 52, no. 2 (1995): 287–314.

Kurke, Leslie. *Coins, Bodies, Games, and Gold: The Politics of Meaning in Archaic Greece*. Princeton: Princeton University Press, 1999.

Laderman, Gary. “Locating the Dead: A Cultural History of Death in the Antebellum, Anglo-Protestant Communities of the Northeast.” *Journal of the American Academy of Religion* 63, no. 1 (1995): 27–52.

———. *The Sacred Remains: American Attitudes toward Death, 1799-1883*. New Haven: Yale University Press, 1996.

Landes, Joan. “The Anatomy of Artificial Life: An Eighteenth-Century Perspective.” In *Genesis Redux: Essays in the History and Philosophy of Artificial Life*, edited by Jessica Riskin, 96–115. Chicago: University of Chicago Press, 2007.

Lajer-Burcharth, Ewa. “Pompadour’s Touch: Difference in Representation.” *Representations* 73, no. 2 (2001): 54–88.

Lambert-Beatty, Carrie. *Being Watched: Yvonne Rainer and the 1960s*. Cambridge: MIT Press, 2008.

Lanmon, Dwight P., and Arlene M. Palmer. "The Background of Glass Production in America." *Journal of Glass Studies* 18 (1976): 14–19.

Latour, Bruno. "A Collection of Humans and Nonhumans: Following Daedalus's Labyrinth." In *Pandora's Hope: Essays on the Reality of Science Studies*, 174–215. Cambridge, MA: Harvard University Press, 1999.

———. *Reassembling the Social : An Introduction to Actor-Network-Theory*. Clarendon Lectures in Management Studies. Oxford ; New York: Oxford University Press, 2005.

———. "Visualisation and Cognition: Drawing Things Together." In *Knowledge and Society Studies in the Sociology of Culture Past and Present*, edited by H. Kulick, 6:1–40. Greenwich, CT: JAI Press, 1986.

Leben, Ulrich. *Object Design in the Age of Enlightenment: The History of the Royal Free Drawing School in Paris*. Los Angeles: The J. Paul Getty Museum, 2004.

Lepore, Jill. *A Is for American : Letters and Other Characters in the Newly United States*. 1st ed. New York: Alfred A. Knopf, 2002.

Levitt, Theresa. *The Shadow of Enlightenment: Optical and Political Transparency in France, 1789-1848*. Oxford: Oxford University Press, 2009.

Lichtenstein, Jacqueline. *The Eloquence of Color: Rhetoric and Painting in the French Classical Age*. Berkeley: University of California Press, 1993.

Linker, Jessica. "Souvenir of a 'Splendid Exhibition': Cupid as Drawn by Maelzel's Automaton, the Juvenile Artist." *Massachusetts Historical Society: Online Collections*. Accessed May 2, 2017. http://www.masshist.org/objects/2012january.php.

Long, Pamela O. "Invention, Authorship, 'Intellectual Property,' and the Origin of Patents: Notes toward a Conceptual History." *Technology and Culture* 32, no. 4 (1991): 846–884.

———. *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance*. Baltimore: Johns Hopkins University Press, 2003.

Lovell, Margaretta M. *Art in a Season of Revolution: Painters, Artisans, and Patrons in Early America*. Philadelphia: University of Pennsylvania Press, 2005.

Lubar, Steven. "Representation and Power." *Technology and Culture* 36, no. 2 (1995): S54–82.

Lukasik, Christopher J. *Discerning Characters: The Culture of Appearance in Early America*. Philadelphia: University of Pennsylvania Press, 2011.

Marsden, Ben. *Watt's Perfect Engine: Steam and the Age of Invention*. New York: Columbia University Press, 2002.

Marshall, Jennifer Jane. "In Form We Trust: Neoplatonism, the Gold Standard, and the Machine Art Show, 1934." *The Art Bulletin* 90, no. 4 (2008): 597–615.

———. *Machine Art, 1934*. Chicago ; London: The University of Chicago Press, 2012.

Marx, Leo. *The Machine in the Garden: Technology and the Pastoral Ideal in America*. New York: Oxford University Press, 2000.

Marzio, Peter C. *The Art Crusade: An Analysis of American Drawing Manuals, 1820-1860*. Washington, D.C.: Smithsonian Institution Press, 1976.

Masten, Jeffrey, Peter Stallybrass, and Nancy Vickers, eds. *Language Machines: Technologies of Literacy and Cultural Production*. New York: Routledge, 1997.

Matsuura, Jeffrey H. *Jefferson vs. the Patent Trolls: A Populist Vision of Intellectual Property Rights*. Charlottesville: University of Virginia Press, 2008.

Mayr, Otto. *Authority, Liberty, & Automatic Machinery in Early Modern Europe*. Baltimore: Johns Hopkins University Press, 1986.

McGill, Meredith L. "The Duplicity of the Pen." In *Language Machines: Technologies of Literary and Cultural Production*, edited by Jeffrey Masten, Peter Stallybrass, and Nancy Vickers. New York: Routledge, 1997.

McLuhan, Marshall. *Understanding Media: The Extensions of Man*. New York: McGraw-Hill, 1964.

Miles, Ellen G. *Saint-Mémin and the Neoclassical Profile Portrait in America*. Washington D.C.: National Portrait Gallery : Smithsonian Institution Press, 1994.

———. "Saint-Mémin's Portraits of American Indians, 1804-1807." *American Art Journal* 20, no. 4 (1988): 3–33.

Millburn, John R. "Patent Agents and the Newtons in 19th-Century London." *Bulletin of the Scientific Instrument Society*, no. 20 (1989): 3–6.

Mokyr, Joel. *The Gifts of Athena: Historical Origins of the Knowledge Economy*. Princeton: Princeton University Press, 2002.

Molloy, Peter Michael. "Technical Education and the Young Republic: West Point as America's École Polytechnique, 1802-1833." Dissertation, Brown University, 1975.

Morton, Alan Q. “Concepts of Power: Natural Philosophy and the Uses of Machines in Mid-Eighteenth-Century London.” *The British Journal for the History of Science* 28, no. 1 (March 1995): 16.

Moss, Michael E., ed. *Robert W. Weir of West Point : Illustrator, Teacher and Poet*. USMA Library, Occasional Papers 4. West Point, NY: United States Military Academy, 1976.

Mossoff, Adam. “Who Cares What Thomas Jefferson Thought about Patents? Reevaluating the Patent ‘Privilege’ in Historical Context.” *Cornell Law Review* 92, no. 5 (2007): 953–1012.

Muller, Kevin R. “From Palace to Longhouse. Portraits of the Four Indian Kings in a Transatlantic Context.” *American Art* 22, no. 3 (2008): 26–49.

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

Nesbit, Molly. “Ready-Made Originals: The Duchamp Model.” *October* 37 (1986): 53.

Nielsen, Wendy C. “Rousseau’s Pygmalion and Automata in the Romantic Period.” In *Romanticism, Rousseau, Switzerland: New Prospects*, edited by Angela Esterhammer, Diane Piccitto, and Patrick H. Vincent, 68–83. Palgrave Studies in the Enlightenment, Romanticism and Cultures of Print. New York: Palgrave Macmillan, 2015.

Nye, David E. *American Technological Sublime*. Cambridge, MA: MIT Press, 1994.

Oliver, Andrew. *Portraits of John Quincy Adams and His Wife*. Cambridge, MA: The Belknap Press of Harvard University Press, 1970.

O’Neal, John C. *The Authority of Experience: Sensationist Theory in the French Enlightenment*. University Park, PA: The Pennsylvania State University Press, 1996.

Ong, Walter. “Writing Is a Technology That Restructures Thought.” In *The Written Word: Literacy in Transition*, edited by Gerd Baumann. Oxford: Clarendon, 1986.

“Organic and Mechanical Metaphors in Late Eighteenth-Century American Political Thought.” *Harvard Law Review* 110, no. 8 (1997): 1832–1849.

Palmer, Arlene. “Glass Production in Eighteenth-Century America: The Wistarburgh Enterprise.” *Winterthur Portfolio* 11 (1976): 75–101.

Parker, Patricia. “Rude Mechanicals.” In *Subject and Object in Renaissance Culture*, edited by Margreta de Grazia and Peter Stallybrass, 43–82. Cambridge, UK: Cambridge University Press, 1996.

Petherbridge, Deanna. *The Primacy of Drawing: Histories and Theories of Practice*. New Haven: Yale University Press, 2010.

Phelan, Peggy. *Unmarked: The Politics of Performance*. London; New York: Routledge, 1993.

Philip, Cynthia Owen. *Robert Fulton, a Biography*. New York: F. Watts, 1985.

Pittenger, Elizabeth. "Explicit Ink." In *Premodern Sexualities*, edited by Louise Fradenburg and Carla Freccero. New York: Routledge, 2013.

Pointon, Marcia R. *Hanging the Head: Portraiture and Social Formation in Eighteenth-Century England*. New Haven: Published for the Paul Mellon Centre for Studies in British Art by Yale University Press, 1993.

Polanyi, Michael. "Skills." In *Personal Knowledge: Towards a Post-Critical Philosophy*. Chicago: University of Chicago Press, 1958.

Posner, Donald. "Concerning the 'Mechanical' Parts of Painting and the Artistic Culture of Seventeenth-Century France." *Art Bulletin* 75, no. 4 (1993): 583–98.

Post, David. "The Continuing Saga of Thomas Jefferson and the Internet." Lecture presented at the "Unfinished Constitution" series, The David Library of the American Revolution, Washington Crossing, PA, October 13, 2011.

Pratt, Stephanie. "Warfare, Diplomacy, and Visual Representation, Ca. 1700-1760." In *American Indians in British Art, 1700-1840*, 30–52. Norman, OK: University of Oklahoma Press, 2005.

Prown, Jules David. "Mind in Matter: An Introduction to Material Culture Theory and Method." *Winterthur Portfolio* 17, no. 1 (1982): 1–19.

Puetz, Anne. "Design Instruction for Artisans in Eighteenth-Century Britain." *Journal of Design History* 12, no. 3 (1999): 217–239.

Pursell, Carroll W. *Early Stationary Steam Engines in America; a Study in the Migration of a Technology*. Washington: Smithsonian Institution Press, 1969.

———. *The Machine in America: A Social History of Technology*. Baltimore: Johns Hopkins University Press, 1995.

———. "Thomas Digges and William Pearce: An Example of the Transit of Technology." *The William and Mary Quarterly* 21, no. 4 (1964): 551–560.

Quarré, Pierre. *Un Descendant d'une grande famille de parlementaires bourguignons, Charles-Balthazar-Julien Févret de Saint-Mémin*. Dijon: Le Musée (impr. Darantière), 1965.

Rabinbach, Anson. *The Human Motor: Energy, Fatigue, and the Origins of Modernity*. Berkeley: University of California Press, 1992.

Reaves, Wendy Wick. *George Washington, an American Icon: The Eighteenth-Century Graphic Portraits*. Washington, D.C.; Charlottesville: National Portrait Gallery, Smithsonian Institution, Distributed by the University Press of Virginia, 1982.

Rebora, Carrie. "Robert Fulton's Art Collection." *American Art Journal* 22, no. 3 (1990): 41–63.

Reel, David M. "The Drawing Curriculum at the U.S. Military Academy in the Nineteenth Century." In *West Point, Points West*, edited by David M. Reel. Denver: Denver Art Museum, 2002.

Reid, Martine, and Nigel Turner, eds. "Boundaries: Writing/Drawing." *Yale French Studies* 84 (1994).

Reynolds, Terry S. "The Engineer in 19th-Century America." In *The Engineer in America: A Historical Anthology from Technology and Culture*. Chicago: University of Chicago Press, 1991.

Rigal, Laura. *The American Manufactory: Art, Labor, and the World of Things in the Early Republic*. Princeton: Princeton University Press, 1998.

Riskin, Jessica. *The Restless Clock: A History of the Centuries-Long Argument over What Makes Living Things Tick*. Chicago: University of Chicago Press, 2016.

———. *Science in the Age of Sensibility: The Sentimental Empiricists of the French Enlightenment*. Chicago: University of Chicago Press, 2002.

Roberts, John. "Labor, Emancipation, and the Critique of Craft-Skill." *The Journal of Modern Craft* 5, no. 2 (2012): 137–148.

———. *The Intangibilities of Form: Skill and Deskilling in Art After the Readymade*. New York: Verso, 2007.

Roberts, Lissa, Simon Schaffer, and Peter Dear, eds. *The Mindful Hand: Inquiry and Invention from the Late Renaissance to Early Industrialisation*. Amsterdam: Koninkliijke Nederlandse Akademie van Wetenschappen, 2007.

Robinson, Eric H. "The Early Diffusion of Steam Power." *The Journal of Economic History* 34, no. 1 (1974): 91–107.

Rosaldo, Renato. *Culture & Truth: The Remaking of Social Analysis*. Boston: Beacon Press, 1989.

Rosand, David. *Drawing Acts: Studies in Graphic Expression and Representation*. Cambridge: Cambridge University Press, 2002.

Rosenblum, Robert. “The Origin of Painting: A Problem in the Iconography of Romantic Classicism.” *The Art Bulletin* 39, no. 4 (1957): 279–290.

Rule, John. “The Property of Skill in the Period of Manufacture.” In *The Historical Meanings of Work*, 99–118. Cambridge: Cambridge University Press, 1987.

Said, Edward W. *Culture and Imperialism*. New York: Knopf, Distributed by Random House, 1994.

Sakarovitch, Jöel. *Epures d’architecture: de la coupe des pierres à la géométrie descriptive XVIe-XIXe siècles*. Basel; Boston: Birkhäuser, 1998.

Sakarovitch, Joël. “The Teaching of Stereotomy in Engineering Schools in France in the XIIth and XIXth Centuries: An Application of Geometry, an ‘Applied Geometory,’ or a Construction Technique?” In *Entre Mécanique et Architecture/Between Mechanics and Architecture*, 205–20. Basel: Birkhäuser Basel, 1995.

Sale, Kirkpatrick. *The Fire of His Genius: Robert Fulton and the American Dream*. New York: Free Press, 2001.

Schofield, Robert E. *Mechanism and Materialism; British Natural Philosophy in an Age of Reason*. Princeton: Princeton University Press, 1970.

Schorsch, Anita. “Mourning Art: A Neoclassical Reflection in America.” *American Art Journal* 8, no. 1 (1976): 5–15.

Schultz, Ronald. *The Republic of Labor: Philadelphia Artisans and the Politics of Class, 1720-1830*. New York: Oxford University Press, 1993.

Seybolt, Robert Francis. *The Evening School in Colonial America.* New York: Arno Press, 1971.

Shalhope, Robert E. “Toward a Republican Synthesis: The Emergence of an Understanding of Republicanism in American Historiography.” *The William and Mary Quarterly* 29, no. 1 (1972): 49–80.

Shallat, Todd A. *Structures in the Stream: Water, Science, and the Rise of the U.S. Army Corps of Engineers*. Austin: University of Texas Press, 1994.

Shapin, Steven. *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. Princeton: Princeton University Press, 2011.

Shaw, Gwendolyn Dubois. "'Moses Williams, Cutter of Profiles': Silhouettes and African American Identity in the Early Republic." *Proceedings of the American Philosophical Society* 149, no. 1 (2005): 22–39.

Sheriff, Mary D. "Passionate Spectators: On Enthusiasm, Nymphomania, and the Imagined Tableau." *Huntington Library Quarterly* 60, no. 1/2 (1997): 51–83.

Simons, Lao G. "Short Stories in Colonial Geometry." *Osiris* 1 (January 1936): 584–605.

Sizer, Theodore R. "The Academies: An Interpretation." In *The Age of Academies*, edited by Theodore R. Sizer. Classics in Education. New York: Bureau of Publications, Teachers College, Columbia University, 1964.

Sloan, Douglas. *The Scottish Enlightenment and the American College Ideal*. New York: Teachers College Press, 1971.

Smith, Merritt Roe. "Eli Whitney and the American System of Manufacturing." In *Technology in America: A History of Individuals and Ideas*, edited by Carroll W. Pursell. Cambridge, MA: The MIT Press, 1981.

Smith, Pamela H. *The Body of the Artisan : Art and Experience in the Scientific Revolution*. Chicago: University of Chicago Press, 2004.

Smith, Pamela H., Amy R.W. Meyers, and Harold J. Cook, eds. "Introduction: Making and Knowing." In *Ways of Making and Knowing: The Material Culture of Empirical Knowledge*, 1–16. The Bard Graduate Center Cultural Histories of the Material World. Ann Arbor: University of Michigan Press, 2014.

Sohn-Rethel, Alfred. *Intellectual and Manual Labour: A Critique of Epistemology*. Critical Social Studies. London: Macmillan, 1978.

Stafford, Barbara Maria. "'Peculiar Marks': Lavater and the Countenance of Blemished Thought." *Art Journal* 46, no. 3 (1987): 185–192.

Staiti, Paul. "Character and Class." In *John Singleton Copley in America*, edited by Carrie Rebora Barratt, Paul Staiti, Erica E. Hirshler, Theodore E. Stebbins, Jr., and Carol Troyen, 53–78. New York: Metropolitan Museum of Art, Distributed by H.N. Abrams, 1995.

Stapleton, Darwin H. "The Engineering Practice of Benjamin Henry Latrobe." In *The Engineering Drawings of Benjamin Henry Latrobe*, edited by Darwin H. Stapleton. New Haven: Published for the Maryland Historical Society by Yale University Press, 1980.

———. *The Transfer of Early Industrial Technologies to America*. Memoirs of the American Philosophical Society ; v. 177. Philadelphia: American Philosophical Society, 1987.

Stevens, Edward. *The Grammar of the Machine: Technical Literacy and Early Industrial Expansion in the United States*. New Haven: Yale University Press, 1995.

Stevens, Edward W. "Technology, Literacy, and Early Industrial Expansion in the United States." *History of Education Quarterly* 30, no. 4 (Winter 1990): 523–44.

Stevens, Laura. "The Christian Origins of the Vanishing Indian." In *Mortal Remains: Death in Early America*, edited by Nancy Isenberg and Andrew Burstein, 17–30. Philadelphia: University of Pennsylvania Press, 2003.

Stevens, Laura M. *The Poor Indians: British Missionaries, Native Americans, and Colonial Sensibility*. Early American Studies. Philadelphia: University of Pennsylvania Press, 2004.

Stewart, Larry R. *The Rise of Public Science: Rhetoric, Technology, and Natural Philosophy in Newtonian Britain, 1660-1750*. Cambridge; New York: Cambridge University Press, 1992.

Strazdes, Diana. "The Amateur Aesthetic and the Draughtsman in Early America." *Archives of American Art Journal* 19, no. 1 (January 1): 15–23.

Sutcliffe, Alice Crary. *Robert Fulton and the "Clermont": The Authoritative Story of Robert Fulton's Early Experiments, Persistent Efforts, and Historic Achievements. Containing Many of Fulton's Hitherto Unpublished Letters, Drawings, and Pictures*. New York: The Century Co., 1909.

Terrell, Colleen E. "'Republican Machines': Franklin, Rush, and the Manufacture of Civic Virtue in the Early Republic." *Early American Studies* 1, no. 2 (Fall 2003): 100–132.

Thomas, George. *The Founders and the Idea of a National University*. New York: Cambridge University Press, 2015.

Thompson, E.P. *The Making of the English Working Class*. New York: Vintage Books, 1963.

Thornton, Tamara Plakins. *Handwriting in America: A Cultural History*. New Haven: Yale University Press, 1996.

Tobin, Beth Fowkes. "Cultural Cross-Dressing in British North America." In *Picturing Imperial Power: Colonial Subjects in Eighteenth-Century British Painting*, 81–109. Durham, NC: Duke University Press, 1999.

Tresch, John. *The Romantic Machine: Utopian Science and Technology after Napoleon*. Chicago; London: University of Chicago Press, 2012.

Truettner, William H. *Painting Indians and Building Empires in North America, 1710-1840*. Berkeley: University of California Press, 2010.

Turner, Ella May. *James Rumsey: Pioneer in Steam Navigation*. Scottdale, PA: Mennonite Publishing House, 1930.

United States Military Academy, Edward S Holden, and W. L Ostrander. *The Centennial of the United States Military Academy at West Point, New York. 1802-1902.* Washington, D.C.: Government Printing Office, 1904.

Wagoner, Jr., Jennings L., and Christine Coalwell McDonald. "An Educational Interpretation." In *Thomas Jefferson's Military Academy: Founding West Point*, edited by Robert M.S. McDonald, 118–53. Charlottesville: University of Virginia Press, 2004.

Warner, Michael. *The Letters of the Republic: Publication and the Public Sphere in Eighteenth-Century America*. Cambridge, MA: Harvard University Press, 1990.

Wartofsky, Marx W. "Diderot and the Development of Materialist Monism." In *Models: Representation and the Scientific Understanding*, 297–337. Boston Studies in the Philosophy of Science; v. 48. Dordrecht; Boston: D. Reidel Publishing Company, 1979.

Williams, James M. "Antique Mechanical Computers, Part 2: 18th and 19th Century Mechanical Marvels." *Byte* 3, no. 8 (August 1978): 96–107.

Williams, Robert. "Without a Borrowed Hand: The Beginnings of American Penmanship." *Society of Scribes Journal*, Fall 2000, 3–11.

Winterer, Caroline. "From Royal to Republican: The Classical Image in Early America." *The Journal of American History* 91, no. 4 (2005): 1264–1290.

———. *The Culture of Classicism: Ancient Greece and Rome in American Intellectual Life, 1780-1910*. Baltimore: Johns Hopkins University Press, 2002.

Wood, Denis. *The Power of Maps*. New York: The Guilford Press, 1992.

Wood, Gordon S. *The Creation of the American Republic, 1776-1787*. Chapel Hill: Published for the Institute of Early American History and Culture by the University of North Carolina Press, 1969.

———. *The Radicalism of the American Revolution*. New York: A.A. Knopf, 1992.

Woodbury, Robert. "The Legend of Eli Whitney and Interchangeable Parts." *Technology and Culture* 1 (Summer 1960): 235–53.

Woolrich, A.P. "John Farey, Jr., Technical Author and Draughtsman: His Contribution to Rees's Cyclopedia." *Industrial Archaeology Review* 20 (1998): 49–67.

Figure 0.1 Automaton drawing of Cupid, 29 April 1835. Ink on paper. Minot family papers, Massachusetts Historical Society.

Figure 0.2 Henri Maillardet, “Draughtsman-Writer,” ca. 1800. Brass, steel, and painted wood. Franklin Institute.

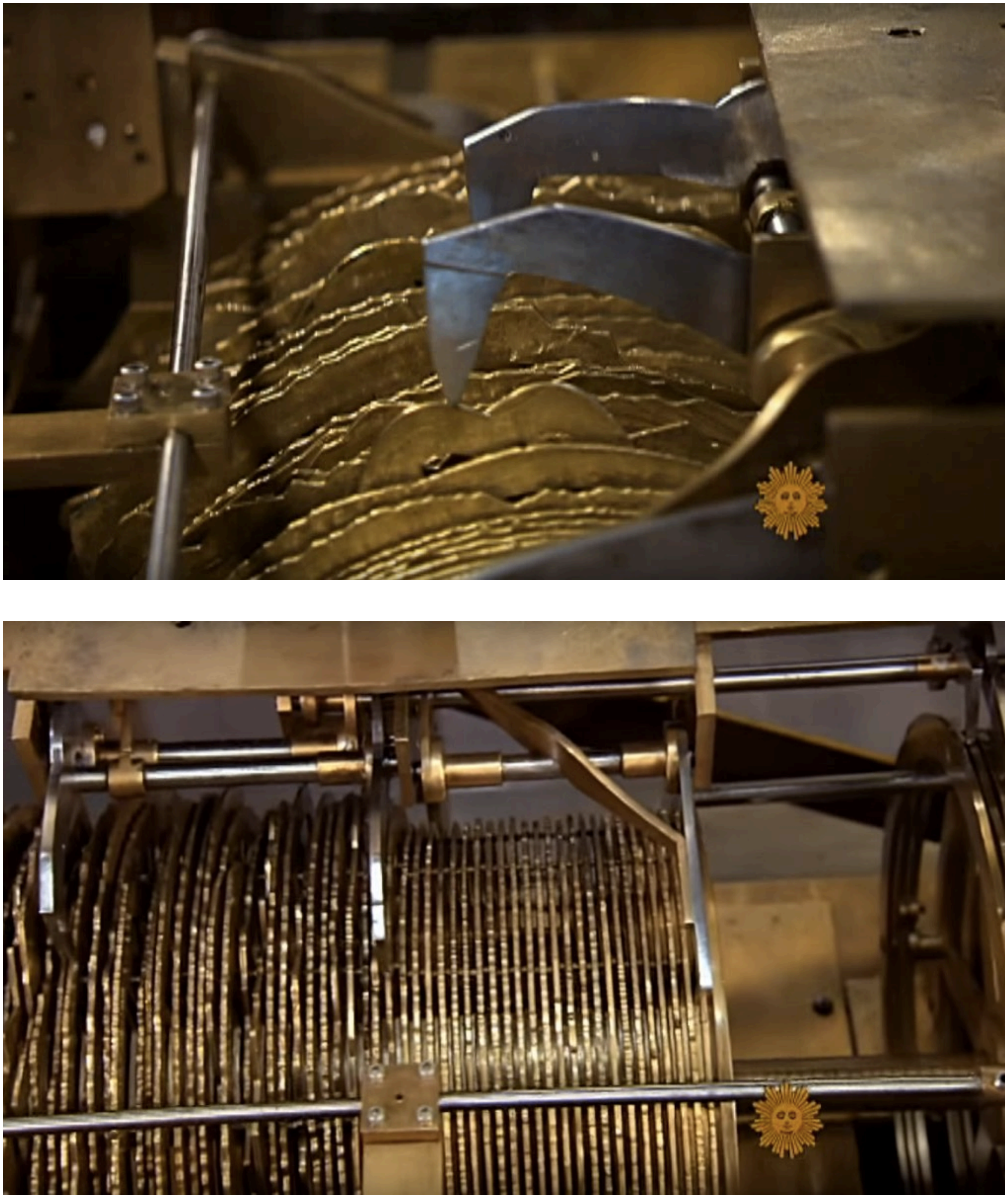


Figure 0.3 Details of the inner-workings of the "Juvenile Artist," [Stills from CBS Sunday Morning, "LostArt of Automatons Alive Again"], January 29, 2012. https://www.youtube.com/watch?v=C7oSFNKIlaM, accessed on January 30, 2016.

Figure 0. 4 Six additional designs programmed into the "Juvenile Artist," [date unknown]. Ink on paper. Franklin Institute.

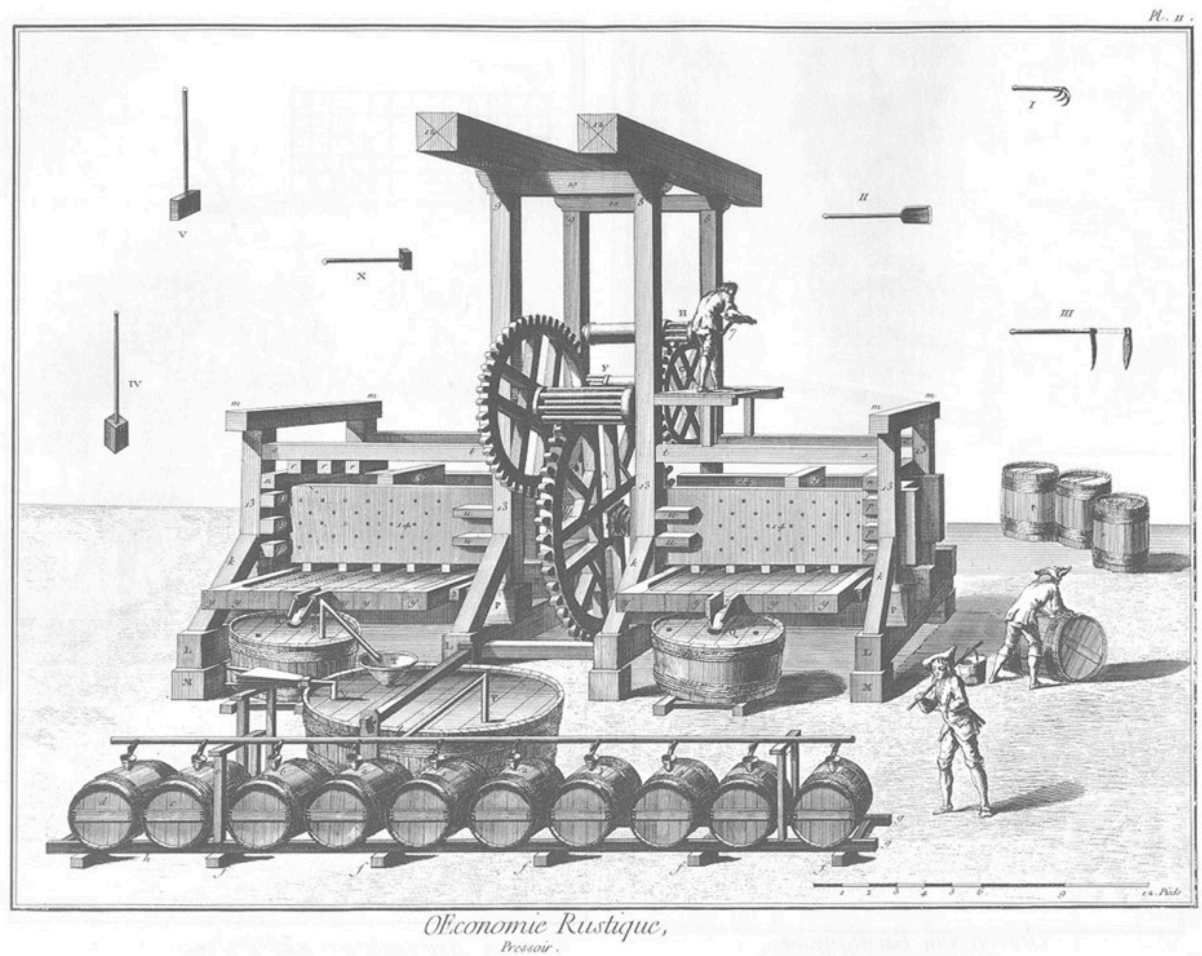


Figure 0.5 “Pressoir à double coffre,” plate II of “Agriculture et Economie Rustique, Pressoirs,” in Denis Diderot and Jean le Rond d’Alembert, eds., *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.,* vol. 1 (plates). (Paris: Briasson, David, Le Breton, & Durand, 1762).

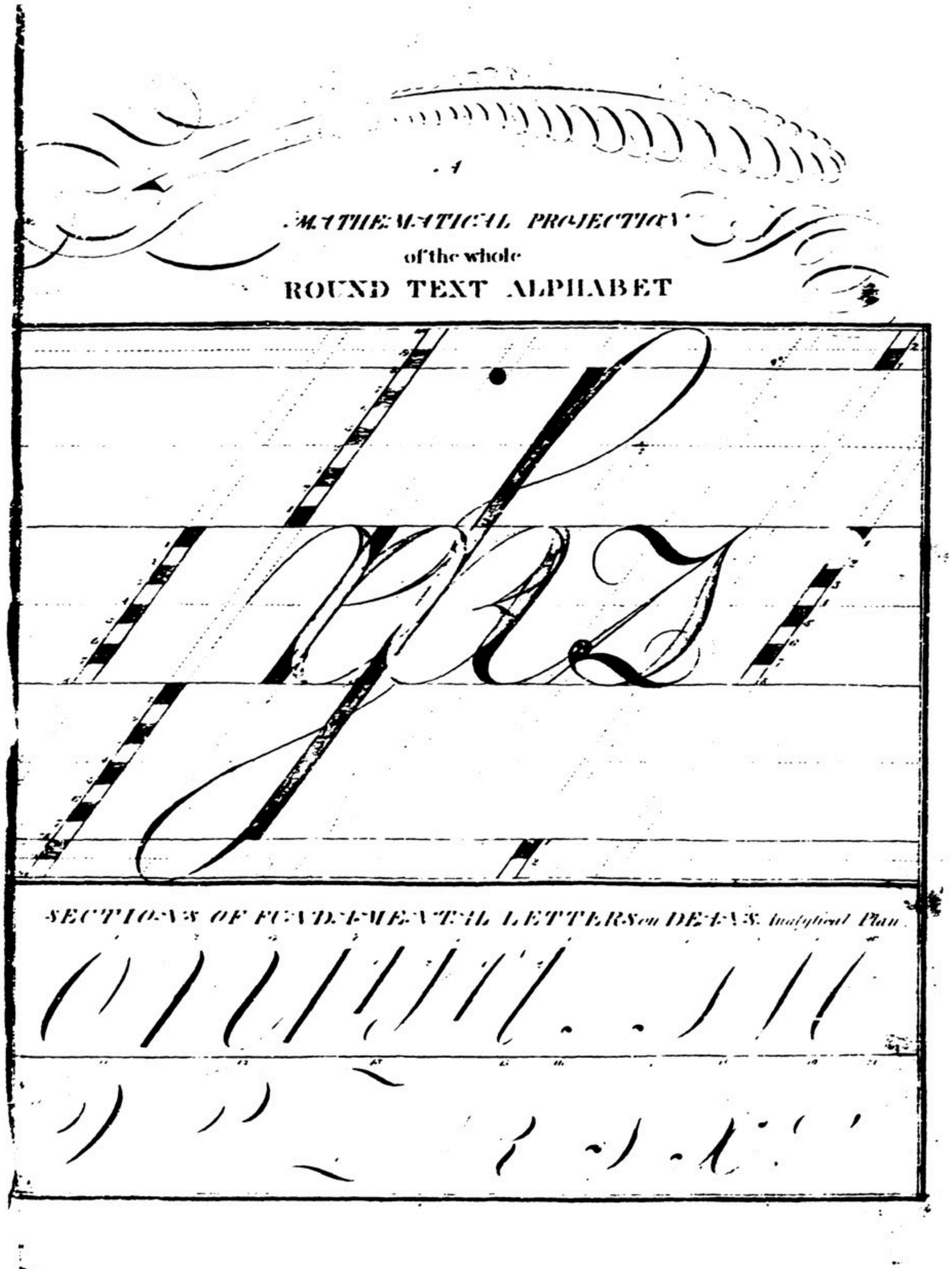


Figure 0.6 Henry Dean, "A Mathematical Projection of the Whole Round Text Alphabet," in *The Printers Academical Companion*. (Salem, MA: Printed for the author, 1806).

Figure 0.7 Richard Delafield, selections from cadet drawing book, 1818. Ink and wash on paper. West Point Library, Special Collections and Archives.

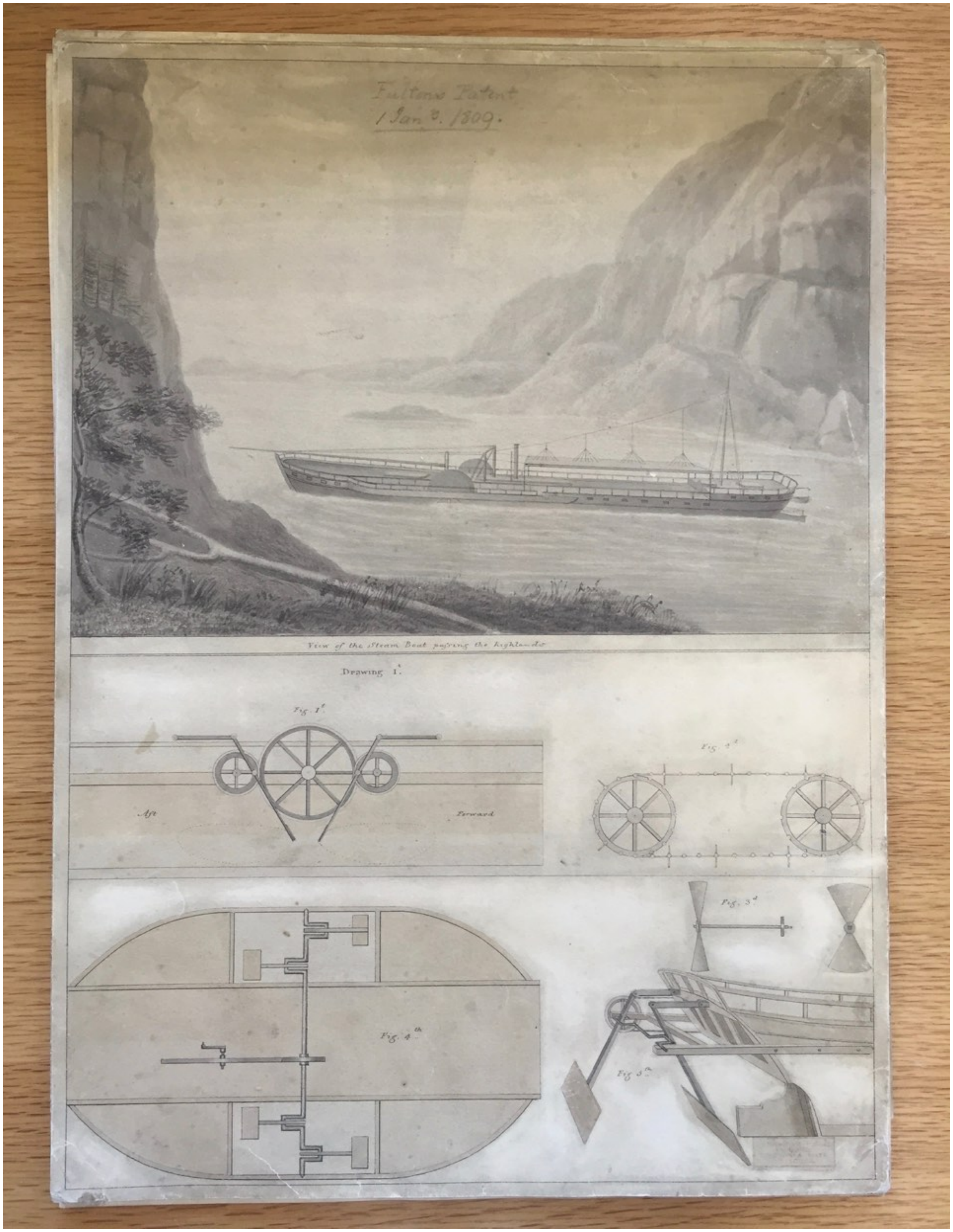


Figure 0.8 Boulton and Watt Drawing Office, page 1 of "Fulton's 1809 specification," ca. 1815. Graphite, ink, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

Figure 0.9 Charles Balthazar Julien Févret de Saint-Mémin, *Payouska*, 1804-1807. Chalk on tinted paper. New-York Historical Society.

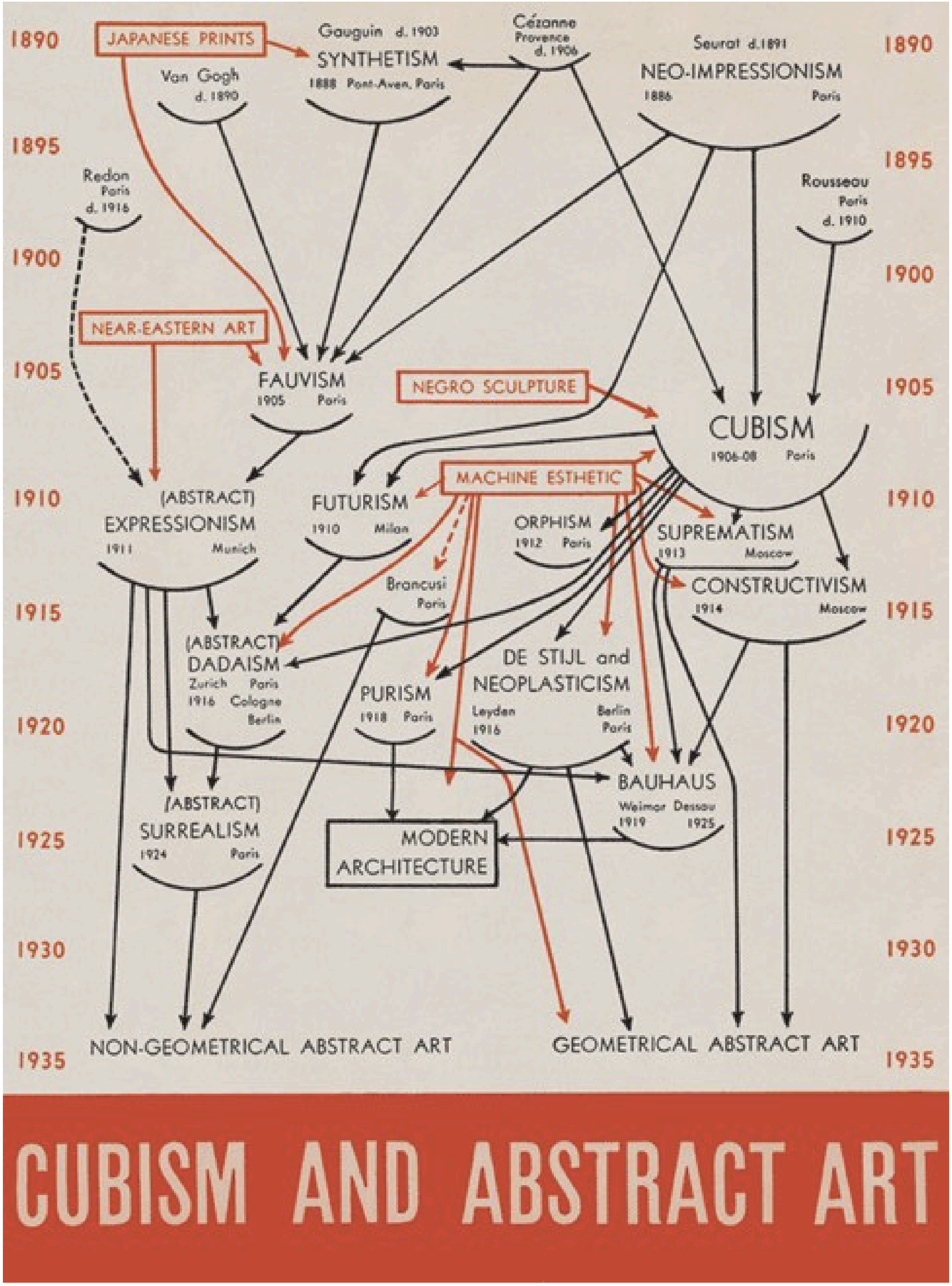
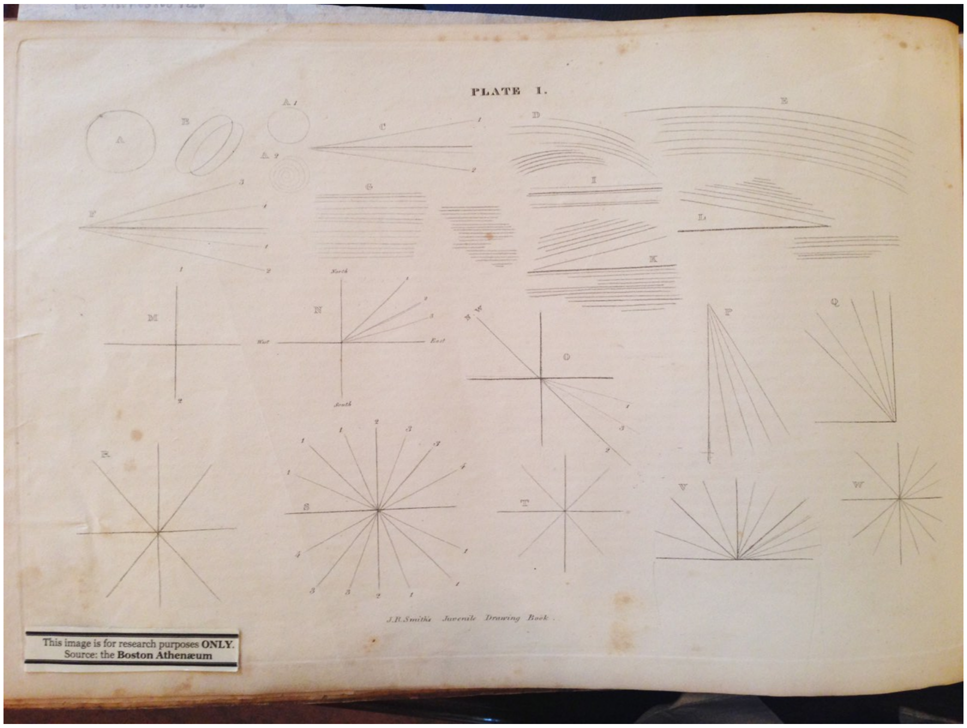


Figure 0.10 Exhibition catalogue cover from Alfred Barr, *Cubism and Abstract Art.* (New York: The Museum of Modern Art, 1936).



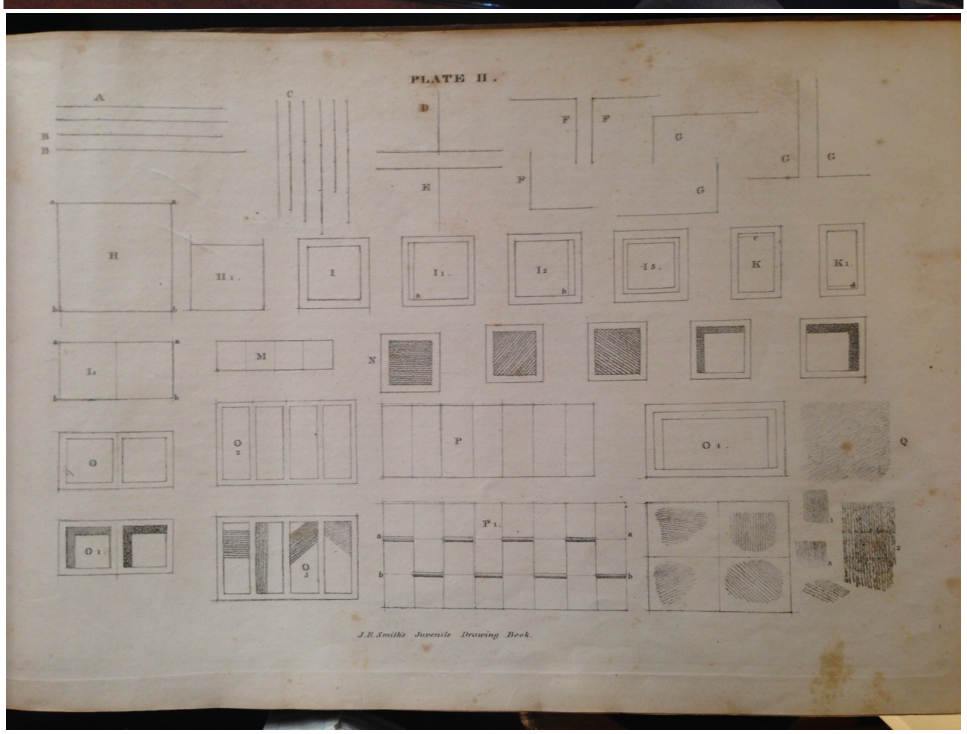
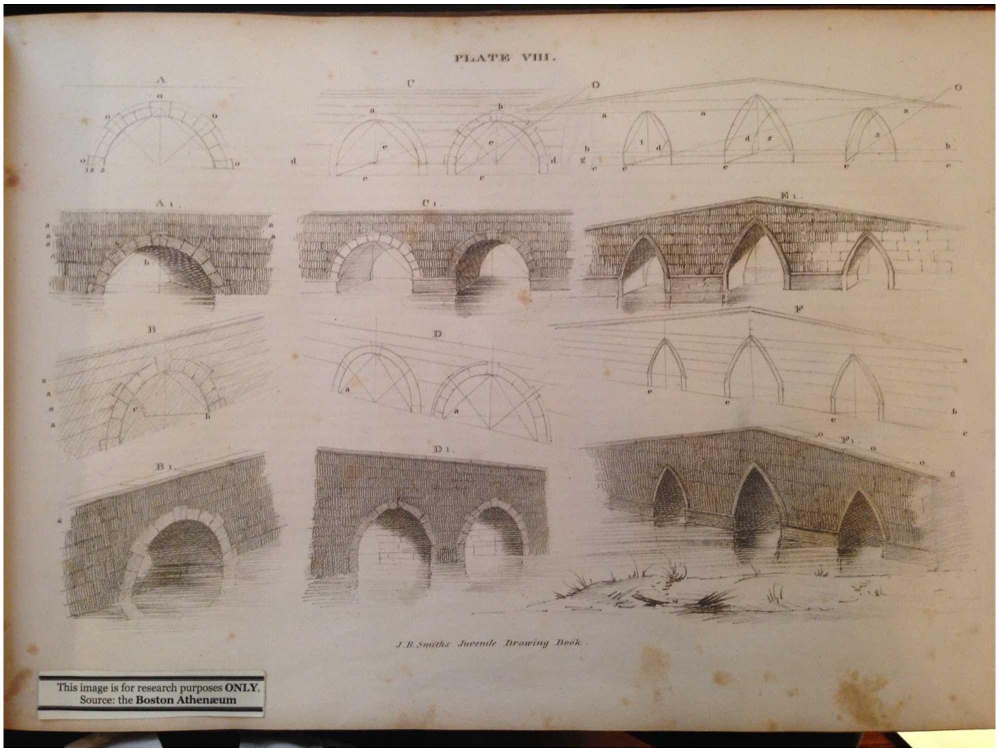


Figure 1.1 Plates 1 & 2 in John Rubens Smith, *The Juvenile Drawing Book: Being the Rudiments of the Art, Explained in a Series of Easy Progressive Lessons, Adapted to the Studies and Pursuits of Young Ladies and Gentlemen*. (New York: J.R. Smith, 1822). Boston Athenaeum.



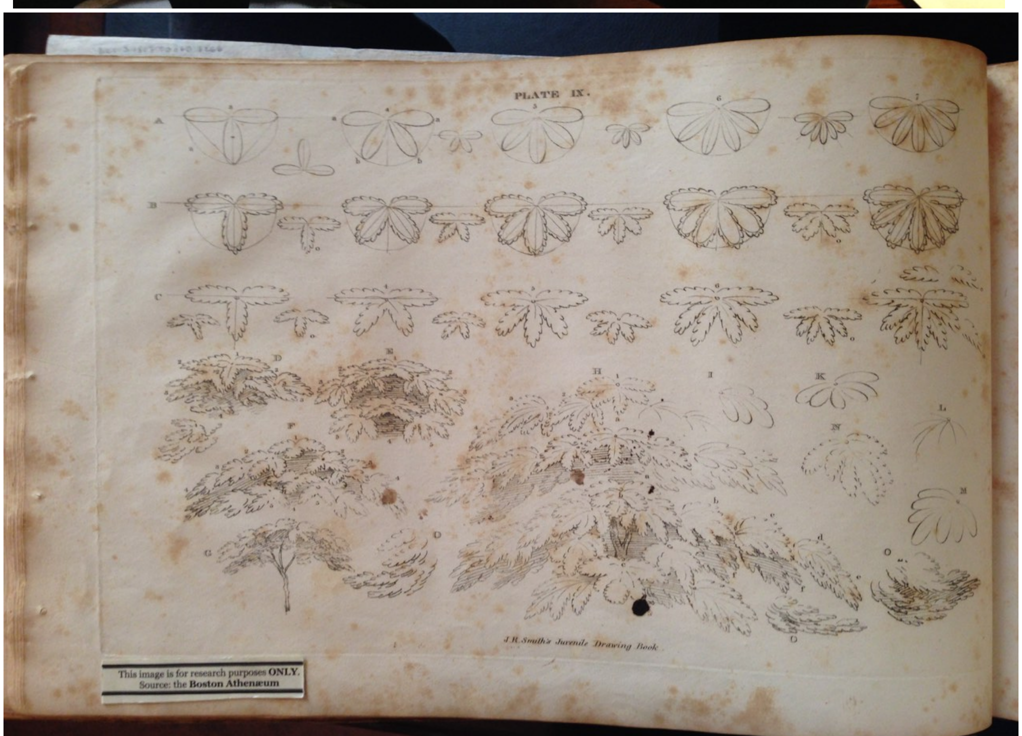


Figure 1.2 Plates 5 & 9 in John Rubens Smith, *The Juvenile Drawing Book: Being the Rudiments of the Art, Explained in a Series of Easy Progressive Lessons, Adapted to the Studies and Pursuits of Young Ladies and Gentlemen*. (New York: J.R. Smith, 1822). Boston Athenaeum.

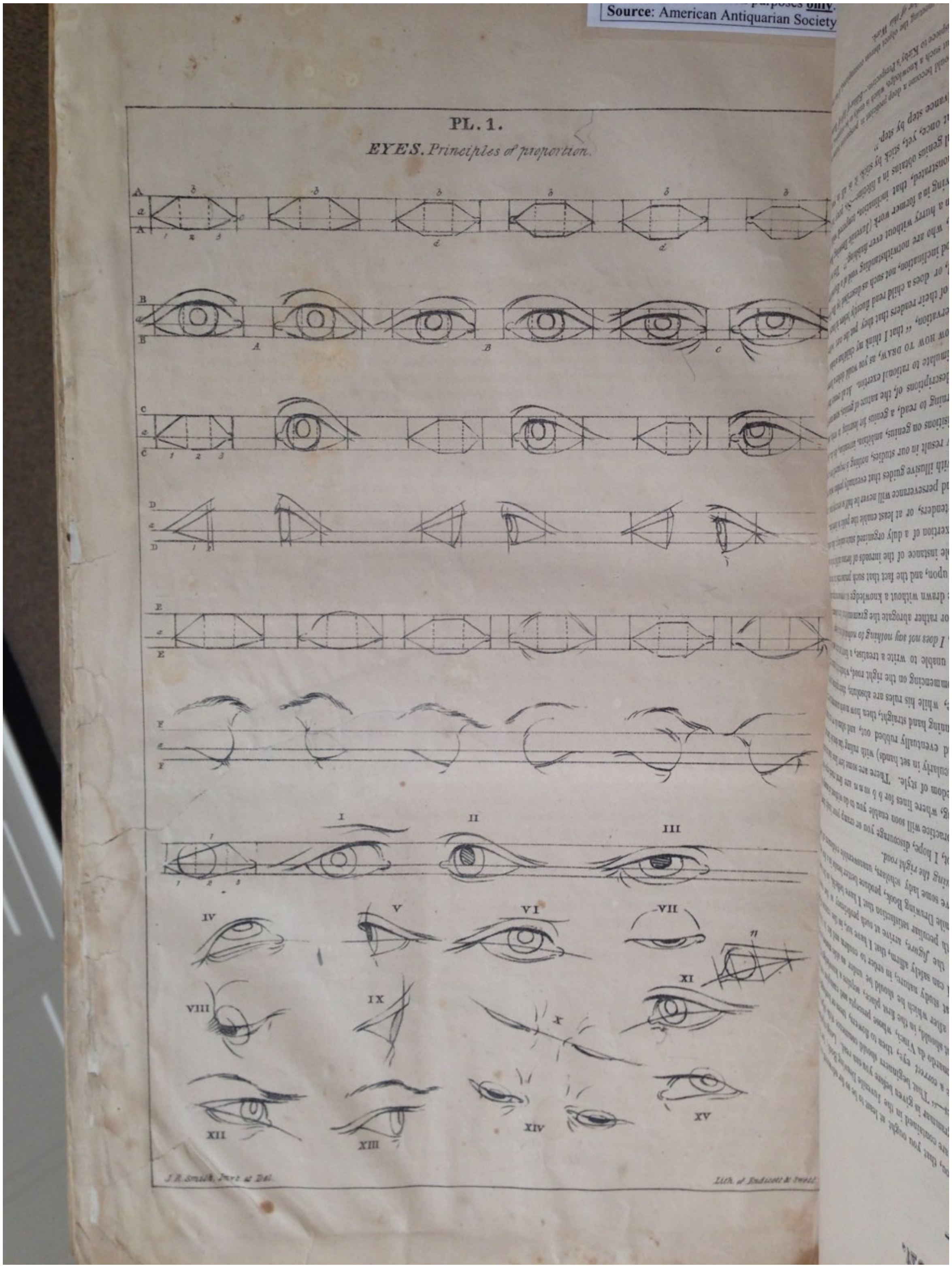
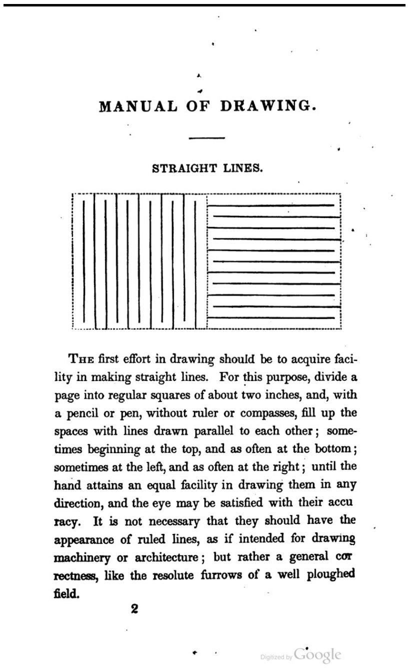


Figure 1.3 Plate 1 in John Rubens Smith, *A Key to the Art of Drawing the Human Figure*. (Philadelphia: Published by Samuel M. Stewart, 1831). American Antiquarian Society.

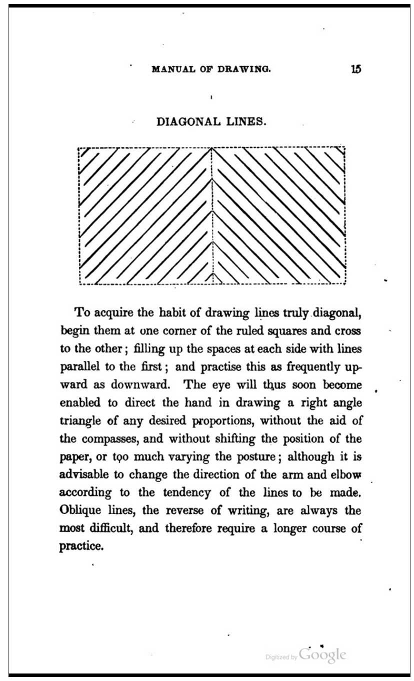


MANUAL OF DRAWING.

STRAIGHT LINES.

THE first effort in drawing should be to acquire facility in making straight lines. For this purpose, divide a page into regular squares of about two inches, and, with a pencil or pen, without ruler or compasses, fill up the spaces with lines drawn parallel to each other; sometimes beginning at the top, and as often at the bottom; sometimes at the left, and as often at the right; until the hand attains an equal facility in drawing them in any direction, and the eye may be satisfied with their accuracy. It is not necessary that they should have the appearance of ruled lines, as if intended for drawing machinery or architecture; but rather a general correctness, like the resolute furrows of a well ploughed field.

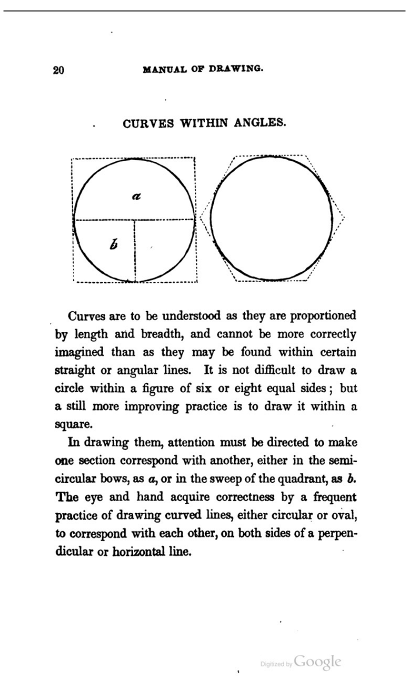
2



MANUAL OF DRAWING. 15

DIAGONAL LINES.

To acquire the habit of drawing lines truly diagonal, begin them at one corner of the ruled squares and cross to the other; filling up the spaces at each side with lines parallel to the first; and practise this as frequently upward as downward. The eye will thus soon become enabled to direct the hand in drawing a right angle triangle of any desired proportions, without the aid of the compasses, and without shifting the position of the paper, or too much varying the posture; although it is advisable to change the direction of the arm and elbow according to the tendency of the lines to be made. Oblique lines, the reverse of writing, are always the most difficult, and therefore require a longer course of practice.

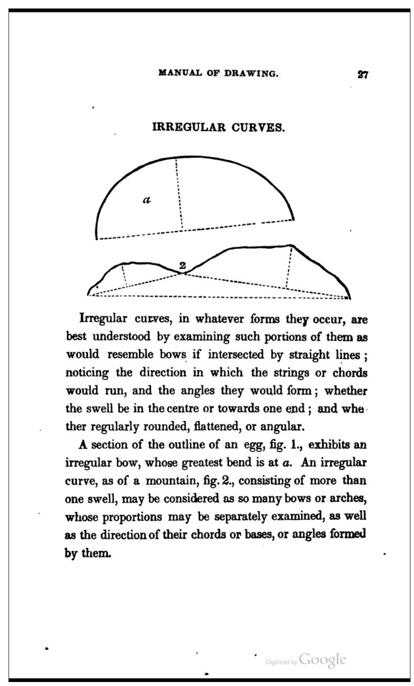


20 MANUAL OF DRAWING.

CURVES WITHIN ANGLES.

Curves are to be understood as they are proportioned by length and breadth, and cannot be more correctly imagined than as they may be found within certain straight or angular lines. It is not difficult to draw a circle within a figure of six or eight equal sides; but a still more improving practice is to draw it within a square.

In drawing them, attention must be directed to make one section correspond with another, either in the semicircular bows, as *a*, or in the sweep of the quadrant, as *b*. The eye and hand acquire correctness by a frequent practice of drawing curved lines, either circular or oval, to correspond with each other, on both sides of a perpendicular or horizontal line.



MANUAL OF DRAWING. 27

IRREGULAR CURVES.

Irregular curves, in whatever forms they occur, are best understood by examining such portions of them as would resemble bows if intersected by straight lines; noticing the direction in which the strings or chords would run, and the angles they would form; whether the swell be in the centre or towards one end; and whether regularly rounded, flattened, or angular.

A section of the outline of an egg, fig. 1., exhibits an irregular bow, whose greatest bend is at *a*. An irregular curve, as of a mountain, fig. 2., consisting of more than one swell, may be considered as so many bows or arches, whose proportions may be separately examined, as well as the direction of their chords or bases, or angles formed by them.

Figure 1.4 Pages 2, 15, 20 & 27 in Rembrandt Peale. *Graphics: A Manual of Drawing and Writing, for Schools and Families*. (New York: J.P. Peaslee, 1835). Harvard College Library.

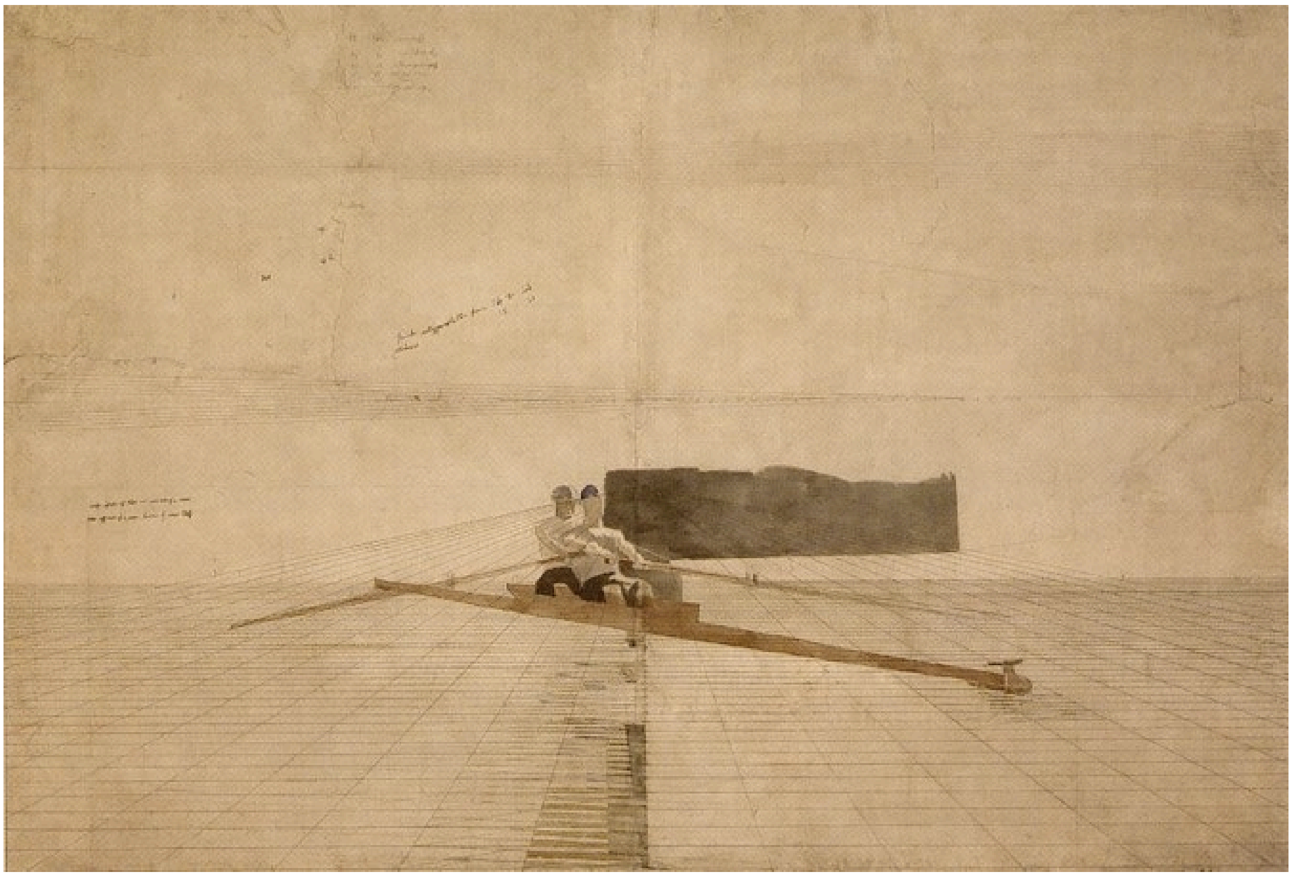


Figure 1.5 Thomas Eakins, *Perspective Drawing for The Pair-Oared Shell*, 1872. Graphite, ink, and watercolor on paper. Philadelphia Museum of Art.

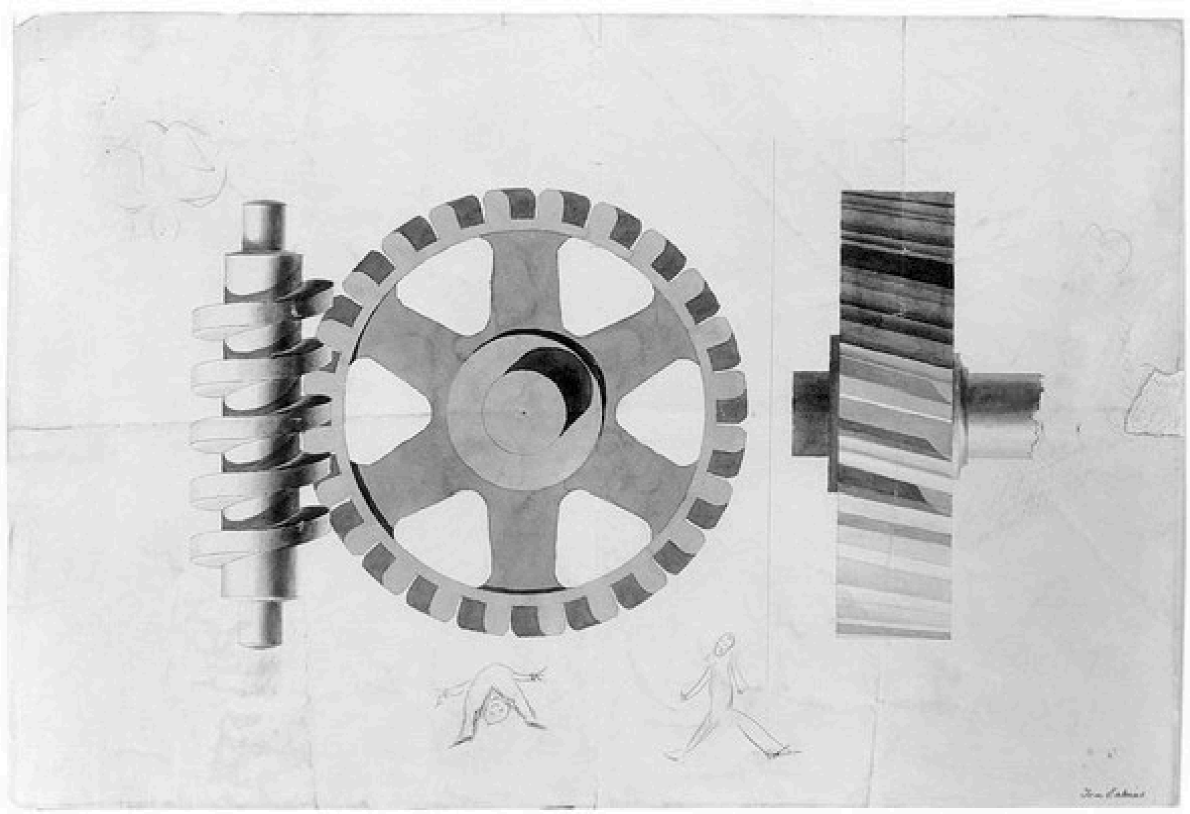


Figure 1.6 Thomas Eakins, *Drawing of Gears*, 1860. Pen, ink, and watercolor on paper. Hirshorn Museum and Sculpture Garden, Smithsonian Institution.

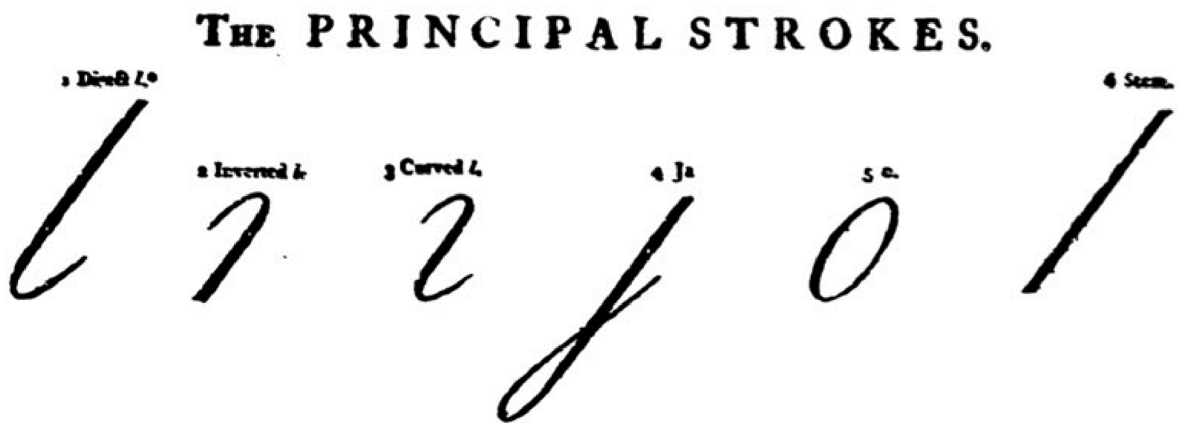


Figure 1.7 Page 12 in John Jenkins, *The Art of Writing, Reduced to a Plain and Easy System: On a Plan Entirely New*. (Boston: Isaiah Thomas and Ebenezer T. Andrews, 1791).

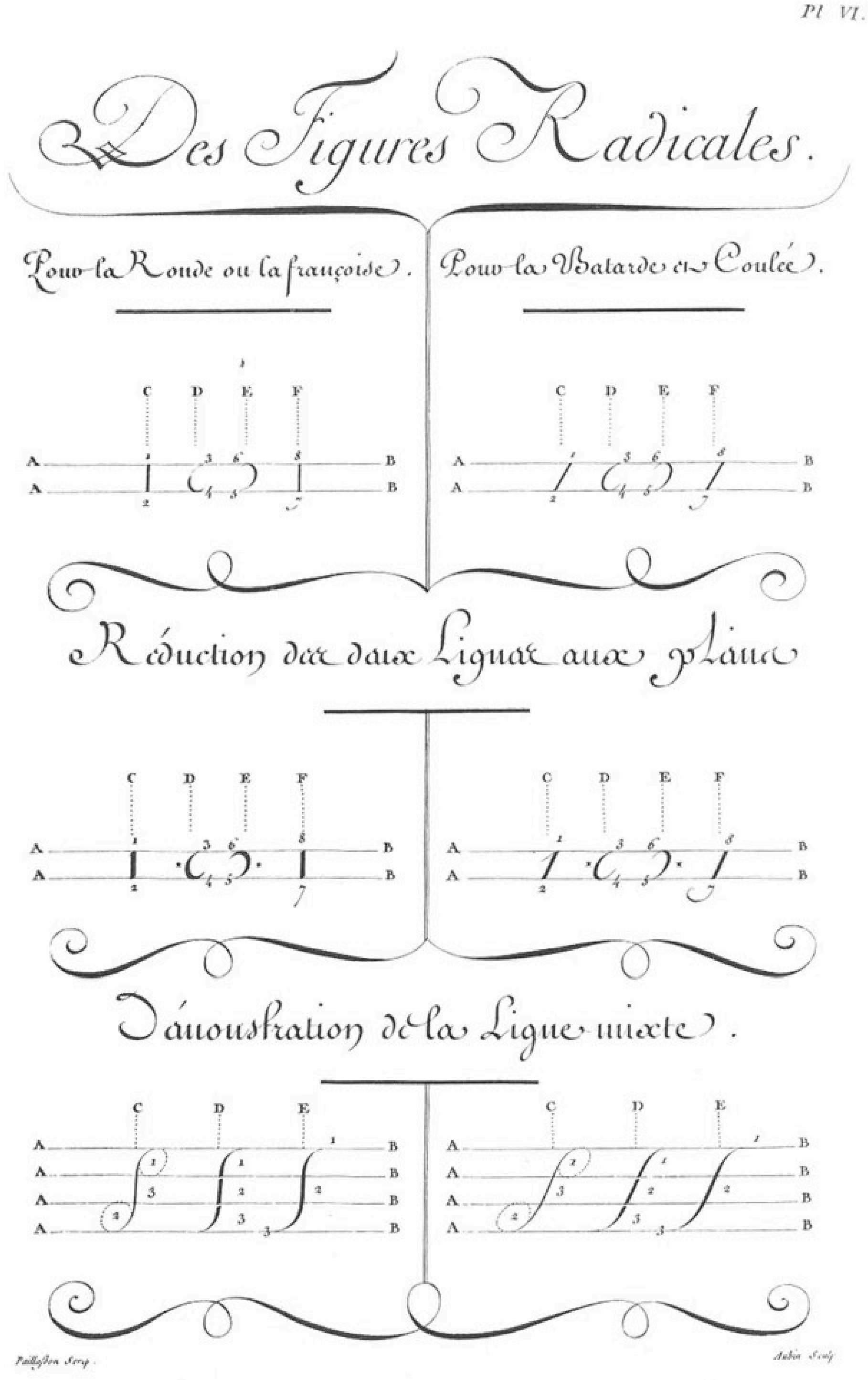
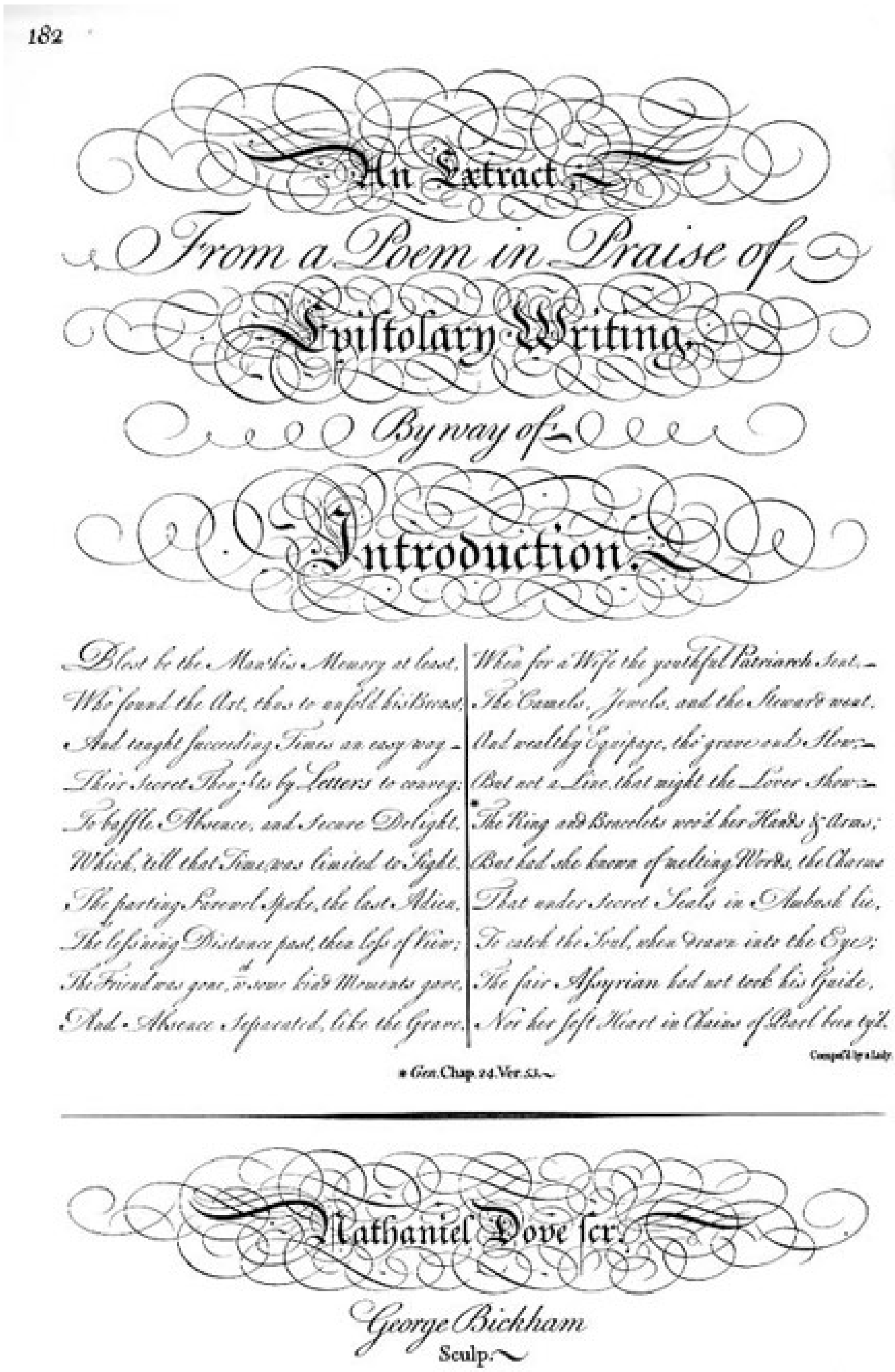


Figure 1.8 "Des Figures Radicales," plate VI of "Ecritures," in Denis Diderot and Jean le Rond d'Alembert, eds., *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.,* vol. 2. (plates), (Paris: Briasson, David, Le Breton, & Durand, 1763).



182

An Extract
From a Poem in Praise of
Epistolary Writing,
By way of
Introduction.

Blest be the Man his Memory at least,
Who found the Art, thus to unfold his Breast,
And taught succeeding Times an easy way
Their secret Thoughts by Letters to convey;
To baffle Absence, and secure Delight,
Which, till that Time, was limited to Sight.
The parting Farewel spoke, the last Adieu,
The lessning Distance past, then loss of View;
The Friend was gone, or some kind Moments gave,
And Absence separated, like the Grave.

When for a Wife the youthful Patriarch sent,
The Camels, Jewels, and the Steward went,
And wealthy Equipage, tho' grave and slow;
But not a Line, that might the Lover shew:
* The Ring and Bracelets woo'd her Hands & Arms;
But had she known of melting Words, the Charms
That under secret Seals in Ambush lie,
To catch the Soul, when drawn into the Eye;
The fair Assyrian had not took his Guide,
Nor her soft Heart in Chains of Pearl been ty'd.

Compos'd by a Lady.

* Gen. Chap. 24. Ver. 53.

Nathaniel Dove scr.

George Bickham
Sculp.

Figure 1.9 Nathaniel Dove (scribe) and George Bickham (engraver), "From a Poem in Praise of Epistolary Writing" in *The Universal Penman*. (London: Printed for the author, 1733-1739).

Figure 1.10 George Bickham (engraver) and William Molineux, (draftsman), [Penmanship example from Boston South Writing School], 1753 and 1763. Engraving and hand-lettered text. American Antiquarian Society.

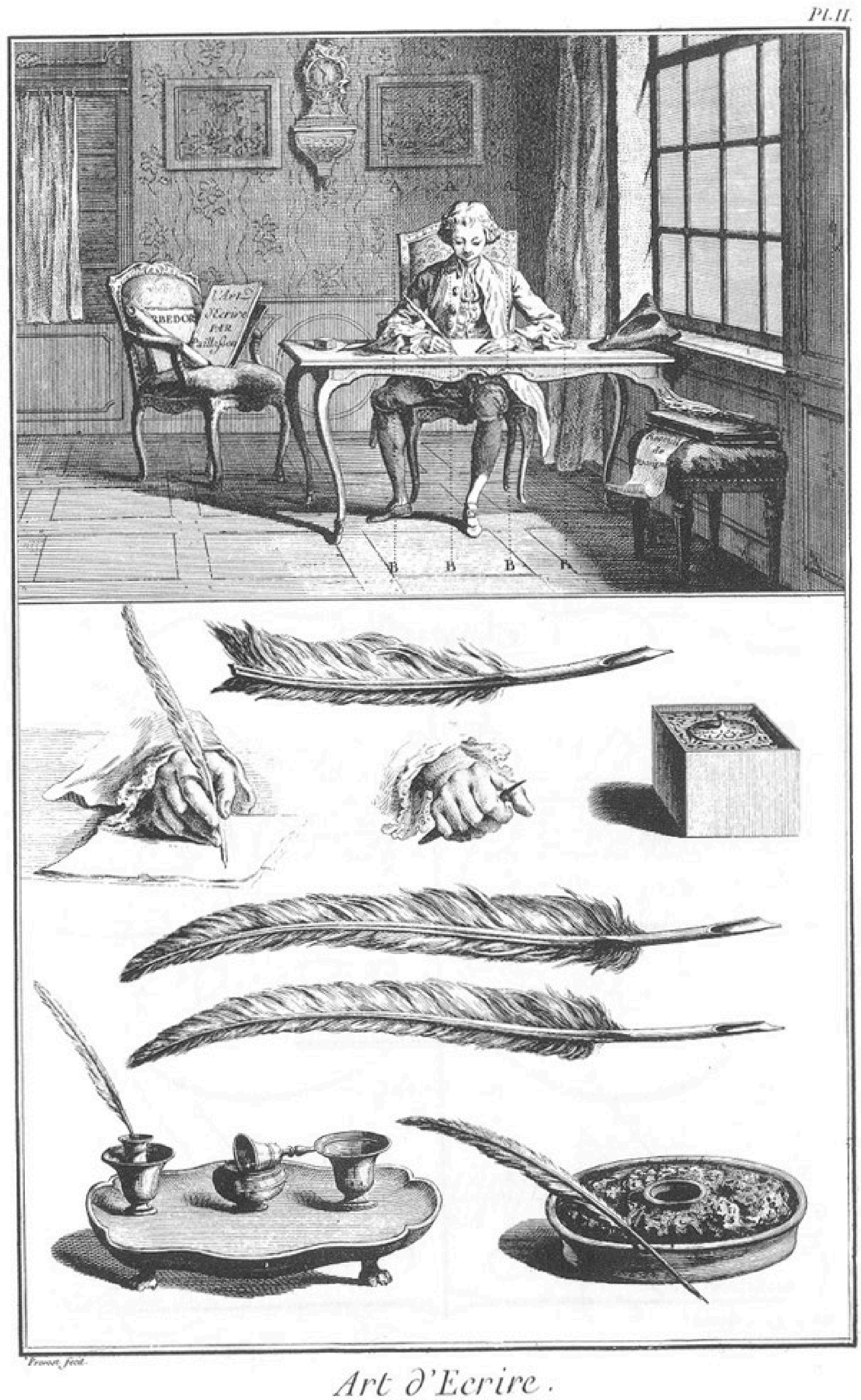


Figure 1.11 "Art d'Ecrire," plate II of "Ecritures," in *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc*. in Denis Diderot and Jean le Rond d'Alembert, eds., *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.,* vol. 2 (plates). (Paris: Briasson, David, Le Breton, & Durand, 1763).

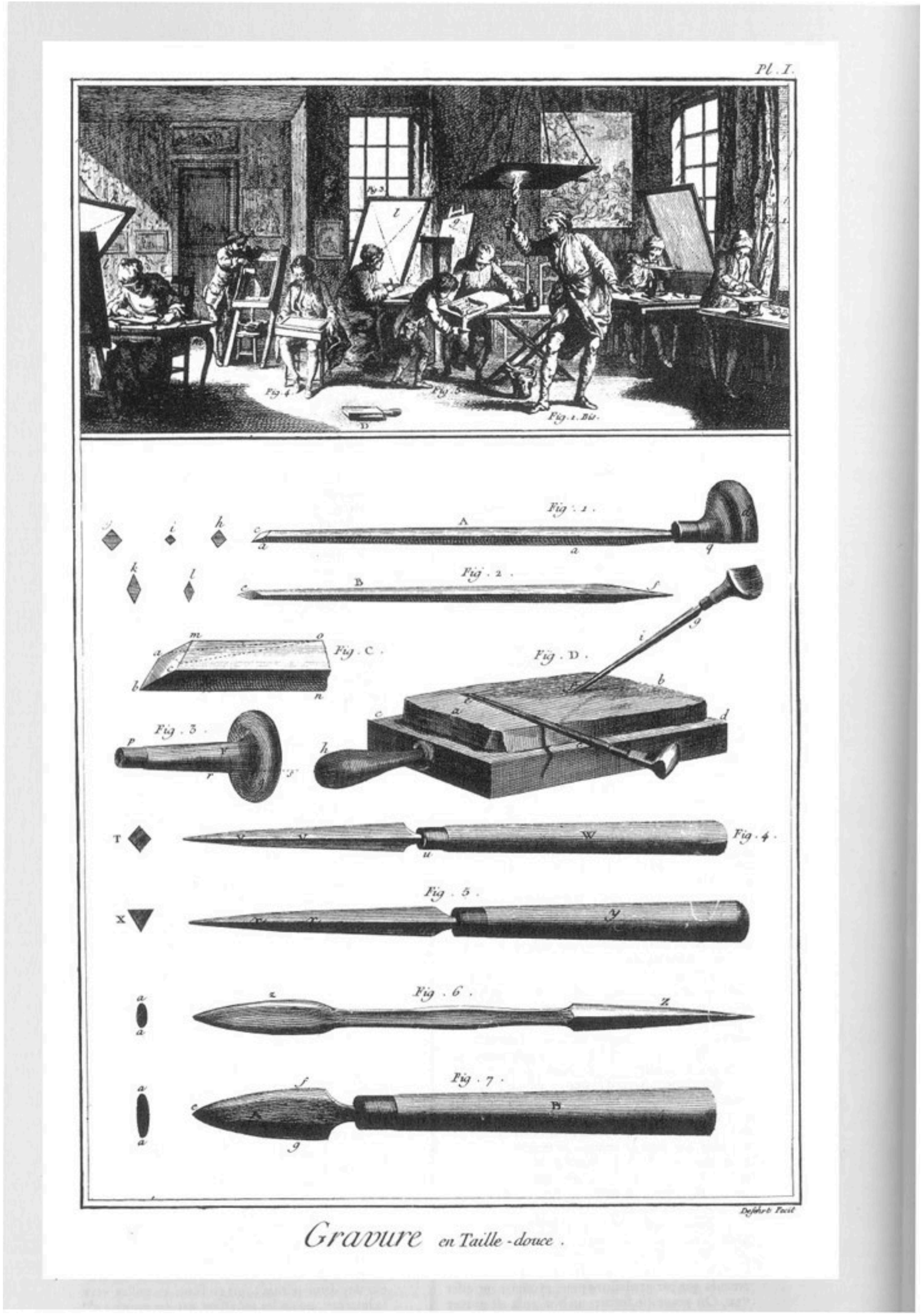
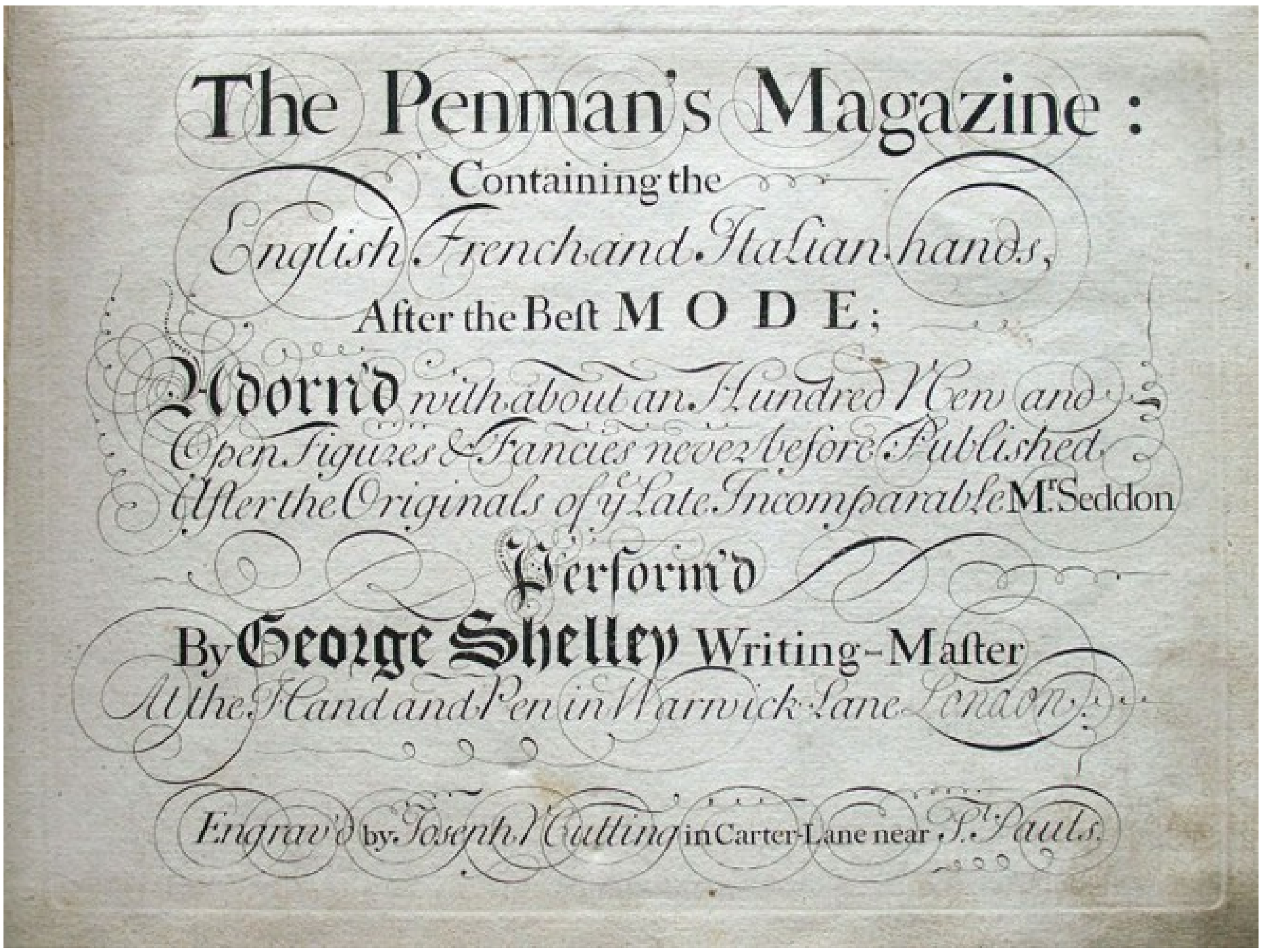
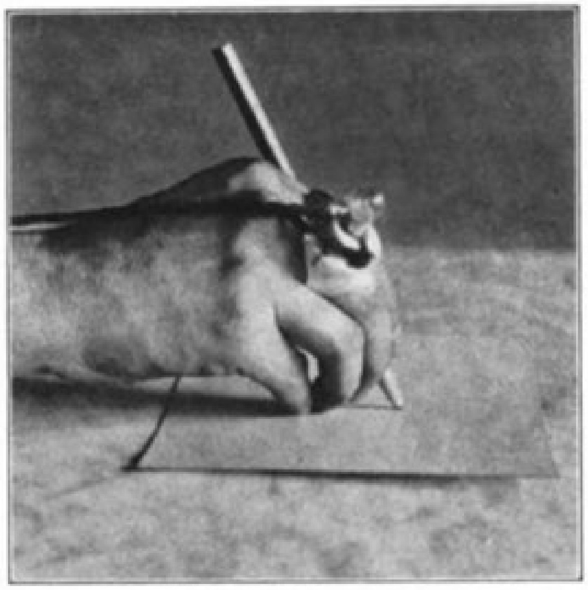


Figure 1.12 "Gravure en Taille-douce," plate I of "Gravure en Taille-Douce," in Denis Diderot and Jean le Rond d'Alembert, eds., *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.,* vol. 4 (plates). (Paris: Briasson, David, & Le Breton, 1767).



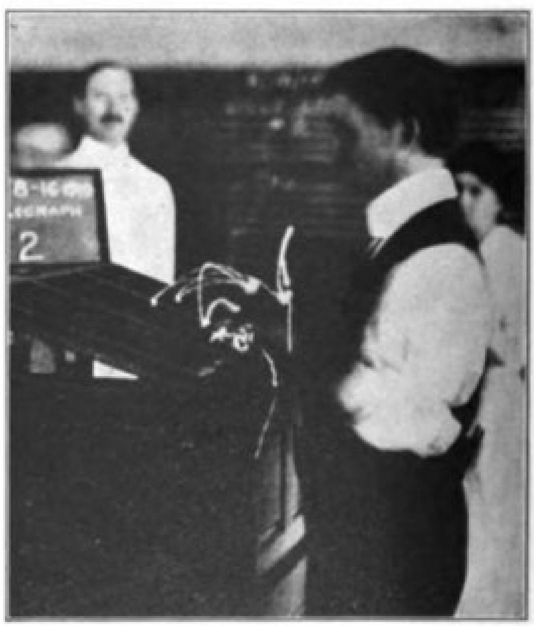
The Penman's Magazine:
Containing the
English French and Italian hands,
After the Best MODE;
Adorn'd with about an Hundred New and
Open Figures & Fancies never before Published
After the Originals of ye Late Incomparable Mr. Seddon
Perform'd
By George Shelley Writing-Master
At the Hand and Pen in Warwick Lane London.
Engrav'd by Joseph Cutting in Carter-Lane near St. Pauls.

Figure 1.13 George Shelley (scribe) and Joseph Cutting (engraver), frontispiece, George Shelley and John Seddons, *The Penman's Magazine*. (London: Printed by J. Holland, 1709). Princeton University Library, Graphic Arts Collection.



TRACING A MOTION

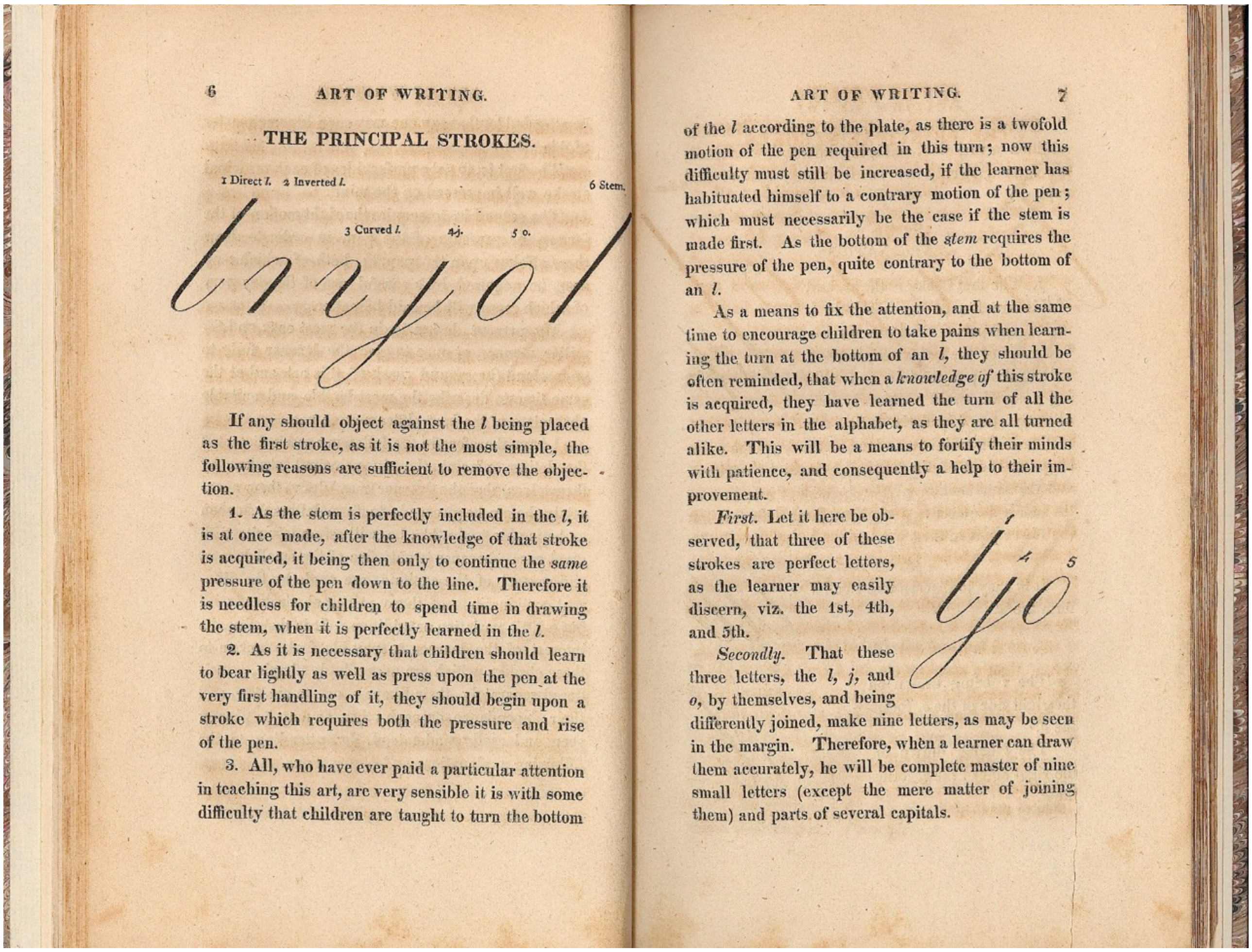
By means of an electric light attached to the hand, or other working member of the body, the path of motions made in performing an act can be traced on a photograph



SETTING TYPE

Through a similar photograph it was found that the typesetter's left hand failed to coöperate with his right hand in filling a type stick

Figure 1.14 Images of Frank and Lilian Gilbreth's motion studies, from Reignald Townsend, "The Magic of Motion Study," *The World's Work* (July 1916): 321-336.



6 ART OF WRITING.

THE PRINCIPAL STROKES.

1 Direct *l*. 2 Inverted *l*. 3 Curved *l*. 4 j. 5 o. 6 Stem.

If any should object against the *l* being placed as the first stroke, as it is not the most simple, the following reasons are sufficient to remove the objection.

1. As the stem is perfectly included in the *l*, it is at once made, after the knowledge of that stroke is acquired, it being then only to continue the *same* pressure of the pen down to the line. Therefore it is needless for children to spend time in drawing the stem, when it is perfectly learned in the *l*.

2. As it is necessary that children should learn to bear lightly as well as press upon the pen at the very first handling of it, they should begin upon a stroke which requires both the pressure and rise of the pen.

3. All, who have ever paid a particular attention in teaching this art, are very sensible it is with some difficulty that children are taught to turn the bottom

ART OF WRITING. 7

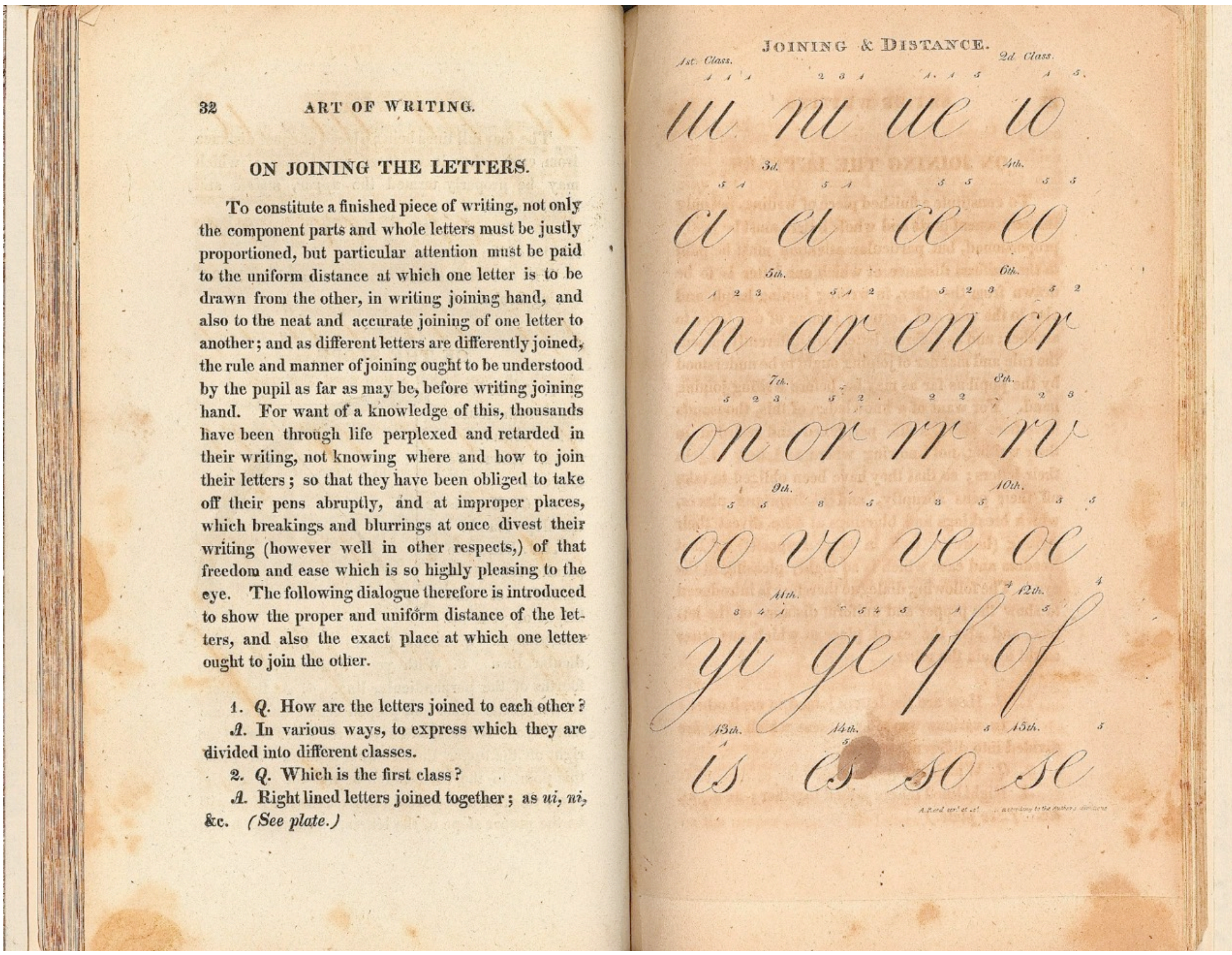
of the *l* according to the plate, as there is a twofold motion of the pen required in this turn; now this difficulty must still be increased, if the learner has habituated himself to a contrary motion of the pen; which must necessarily be the case if the stem is made first. As the bottom of the *stem* requires the pressure of the pen, quite contrary to the bottom of an *l*.

As a means to fix the attention, and at the same time to encourage children to take pains when learning the turn at the bottom of an *l*, they should be often reminded, that when a *knowledge of* this stroke is acquired, they have learned the turn of all the other letters in the alphabet, as they are all turned alike. This will be a means to fortify their minds with patience, and consequently a help to their improvement.

First. Let it here be observed, that three of these strokes are perfect letters, as the learner may easily discern, viz. the 1st, 4th, and 5th.

Secondly. That these three letters, the *l*, *j*, and *o*, by themselves, and being differently joined, make nine letters, as may be seen in the margin. Therefore, when a learner can draw them accurately, he will be complete master of nine small letters (except the mere matter of joining them) and parts of several capitals.

Figure 1. 15 Pages 6 & 7 from John Jenkins, *The Art of Writing, Reduced to a Plain and Easy System, of a Plan Entirely New*. (Cambridge, MA: Printed for the author, 1813).

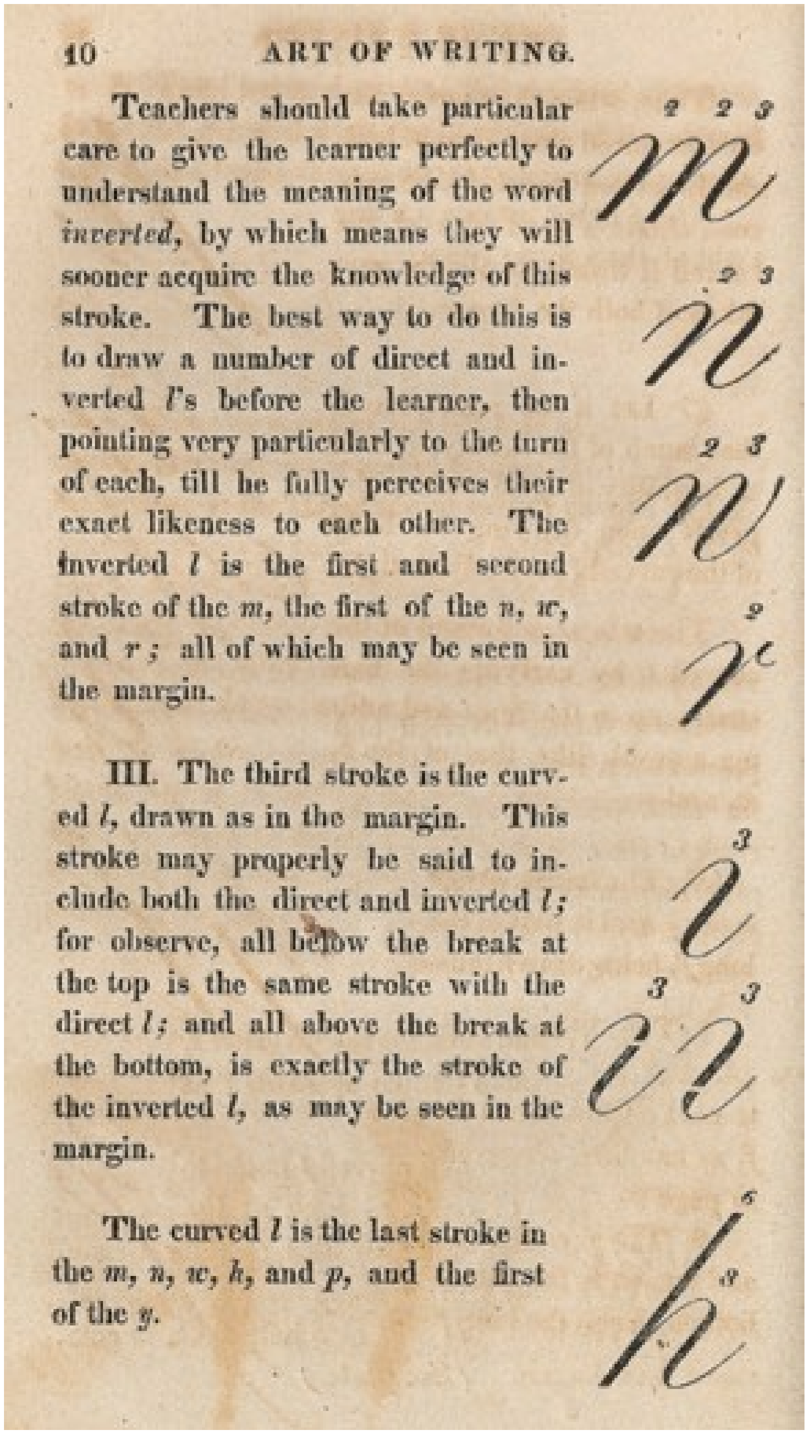

32 ART OF WRITING.

ON JOINING THE LETTERS.

To constitute a finished piece of writing, not only the component parts and whole letters must be justly proportioned, but particular attention must be paid to the uniform distance at which one letter is to be drawn from the other, in writing joining hand, and also to the neat and accurate joining of one letter to another; and as different letters are differently joined, the rule and manner of joining ought to be understood by the pupil as far as may be, before writing joining hand. For want of a knowledge of this, thousands have been through life perplexed and retarded in their writing, not knowing where and how to join their letters; so that they have been obliged to take off their pens abruptly, and at improper places, which breakings and blurrings at once divest their writing (however well in other respects,) of that freedom and ease which is so highly pleasing to the eye. The following dialogue therefore is introduced to show the proper and uniform distance of the letters, and also the exact place at which one letter ought to join the other.

1. *Q.* How are the letters joined to each other?
A. In various ways, to express which they are divided into different classes.
2. *Q.* Which is the first class?
A. Right lined letters joined together; as *ui, ni*, &c. *(See plate.)*

Figure 1. 16 Diagrams on joining and spacing letters from John Jenkins, *The Art of Writing, Reduced to a Plain and Easy System, of a Plan Entirely New*. (Cambridge, MA: Printed for the author, 1813).



10 ART OF WRITING.

Teachers should take particular care to give the learner perfectly to understand the meaning of the word *inverted*, by which means they will sooner acquire the knowledge of this stroke. The best way to do this is to draw a number of direct and inverted *l*'s before the learner, then pointing very particularly to the turn of each, till he fully perceives their exact likeness to each other. The inverted *l* is the first and second stroke of the *m*, the first of the *n*, *w*, and *r*; all of which may be seen in the margin.

III. The third stroke is the curved *l*, drawn as in the margin. This stroke may properly be said to include both the direct and inverted *l*; for observe, all below the break at the top is the same stroke with the direct *l*; and all above the break at the bottom, is exactly the stroke of the inverted *l*, as may be seen in the margin.

The curved *l* is the last stroke in the *m*, *n*, *w*, *h*, and *p*, and the first of the *y*.

Figure 1. 17 Page 10 from John Jenkins, *The Art of Writing, Reduced to a Plain and Easy System, of a Plan Entirely New*. (Cambridge, MA: Printed for the author, 1813).

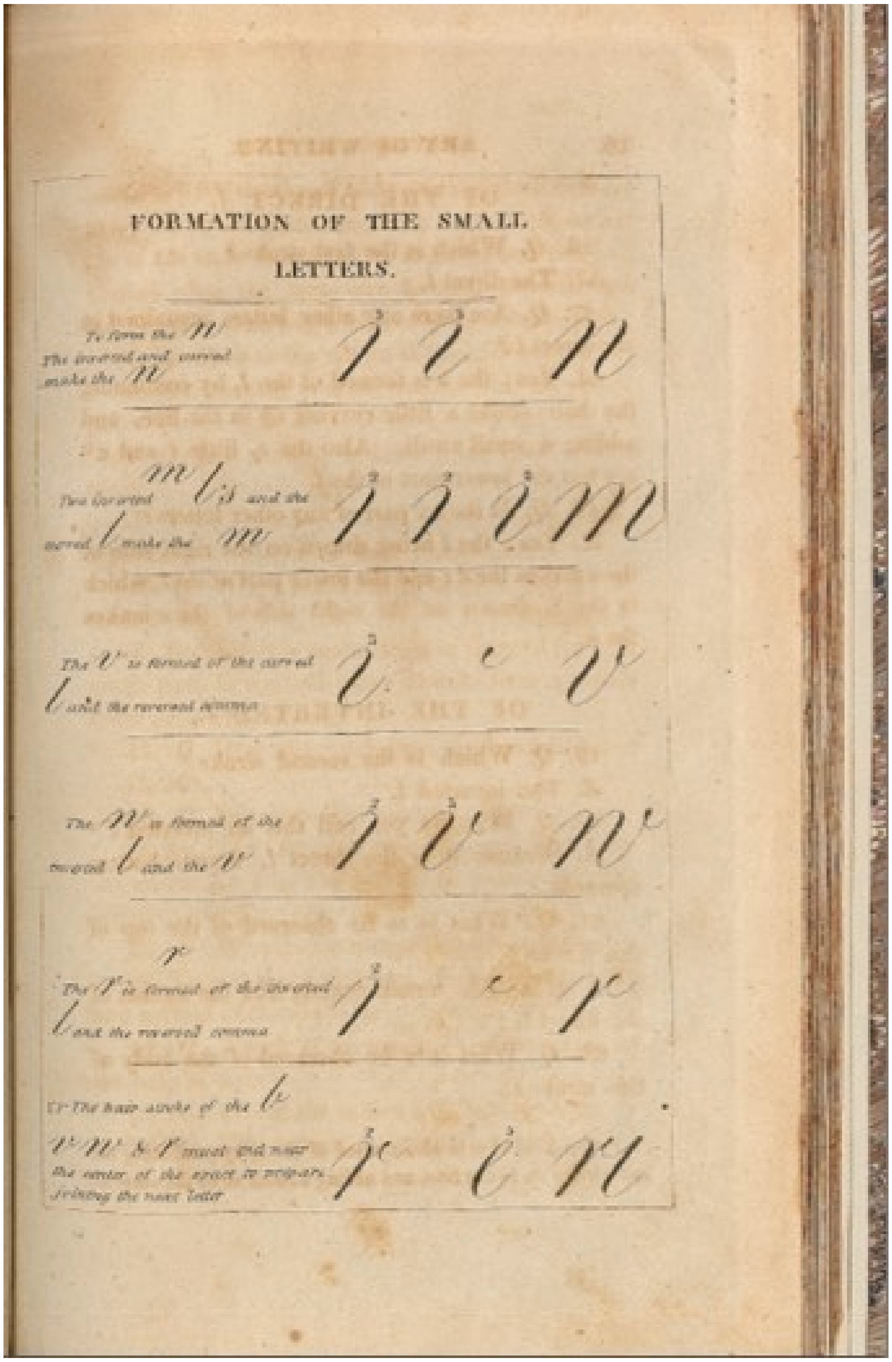


Figure 1. 18 “Formation of the Small Letters” from John Jenkins, *The Art of Writing, Reduced to a Plain and Easy System, of a Plan Entirely New*. (Cambridge, MA: Printed for the author, 1813).

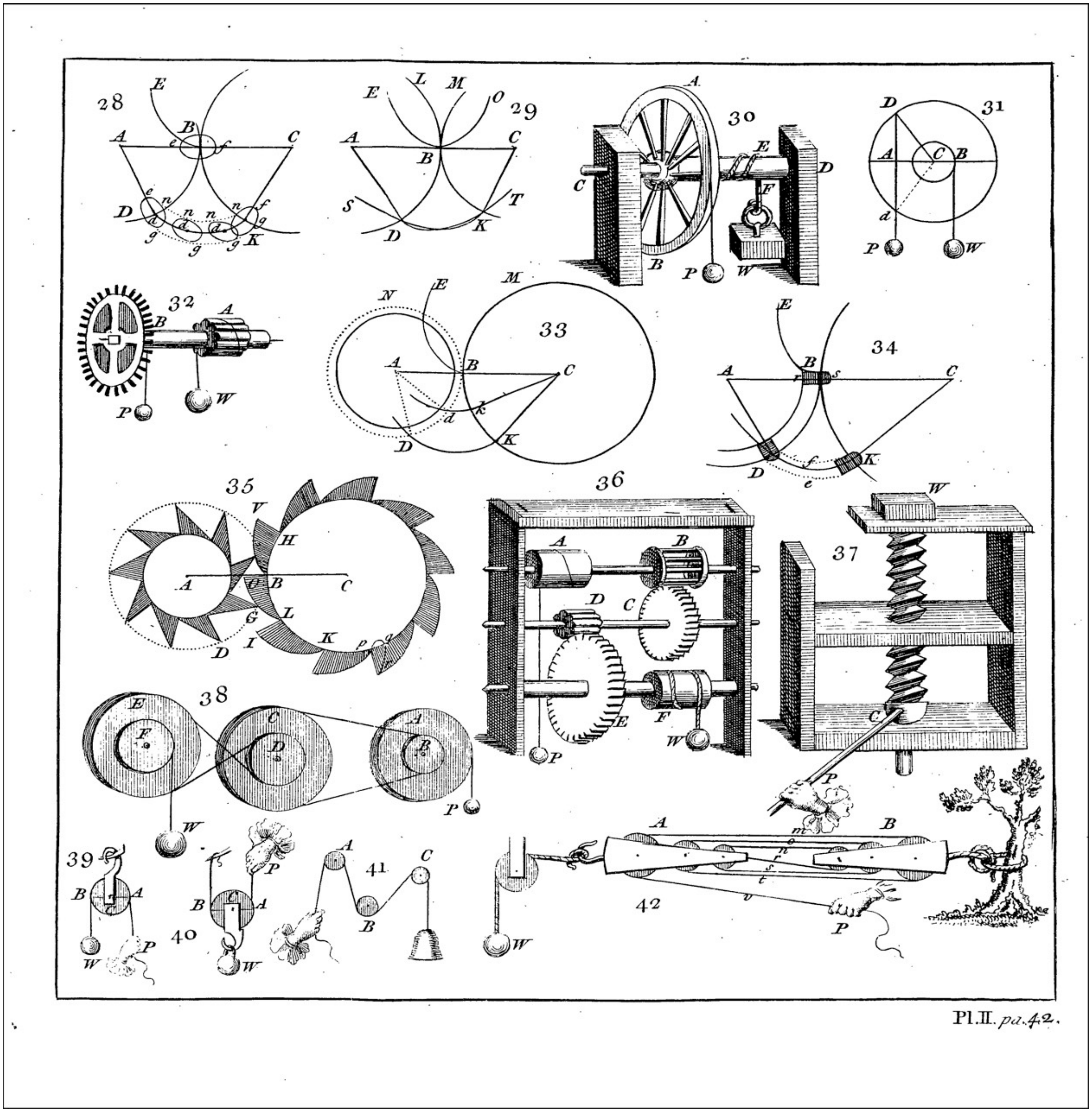
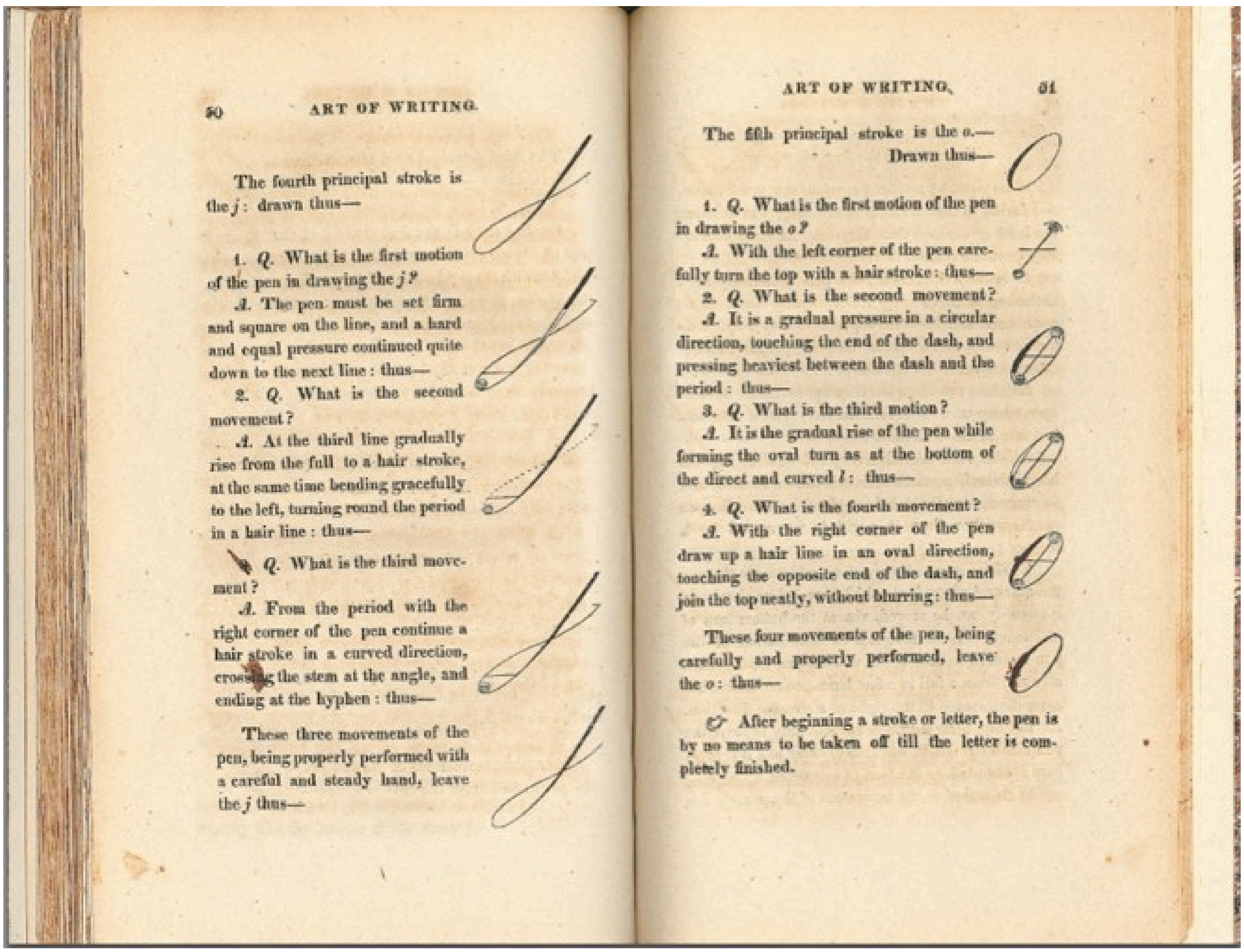


Figure 1. 19 Plate II from William Emerson, *The principles of mechanics*. (London: Printed for G.G. and J. Robinson, 1794).


50 ART OF WRITING.

The fourth principal stroke is the *j*: drawn thus—

1. *Q.* What is the first motion of the pen in drawing the *j*?

A. The pen must be set firm and square on the line, and a hard and equal pressure continued quite down to the next line: thus—

2. *Q.* What is the second movement?

A. At the third line gradually rise from the full to a hair stroke, at the same time bending gracefully to the left, turning round the period in a hair line: thus—

3. *Q.* What is the third movement?

A. From the period with the right corner of the pen continue a hair stroke in a curved direction, crossing the stem at the angle, and ending at the hyphen: thus—

These three movements of the pen, being properly performed with a careful and steady hand, leave the *j* thus—

ART OF WRITING. 51

The fifth principal stroke is the *o*.— Drawn thus—

1. *Q.* What is the first motion of the pen in drawing the *o*?

A. With the left corner of the pen carefully turn the top with a hair stroke: thus—

2. *Q.* What is the second movement?

A. It is a gradual pressure in a circular direction, touching the end of the dash, and pressing heaviest between the dash and the period: thus—

3. *Q.* What is the third motion?

A. It is the gradual rise of the pen while forming the oval turn as at the bottom of the direct and curved *l*: thus—

4. *Q.* What is the fourth movement?

A. With the right corner of the pen draw up a hair line in an oval direction, touching the opposite end of the dash, and join the top neatly, without blurring: thus—

These four movements of the pen, being carefully and properly performed, leave the *o*: thus—

☞ After beginning a stroke or letter, the pen is by no means to be taken off till the letter is completely finished.

Figure 1. 20 Pages 50-51 from John Jenkins, *The Art of Writing, Reduced to a Plain and Easy System, of a Plan Entirely New*. (Cambridge, MA: Printed for the author, 1813).

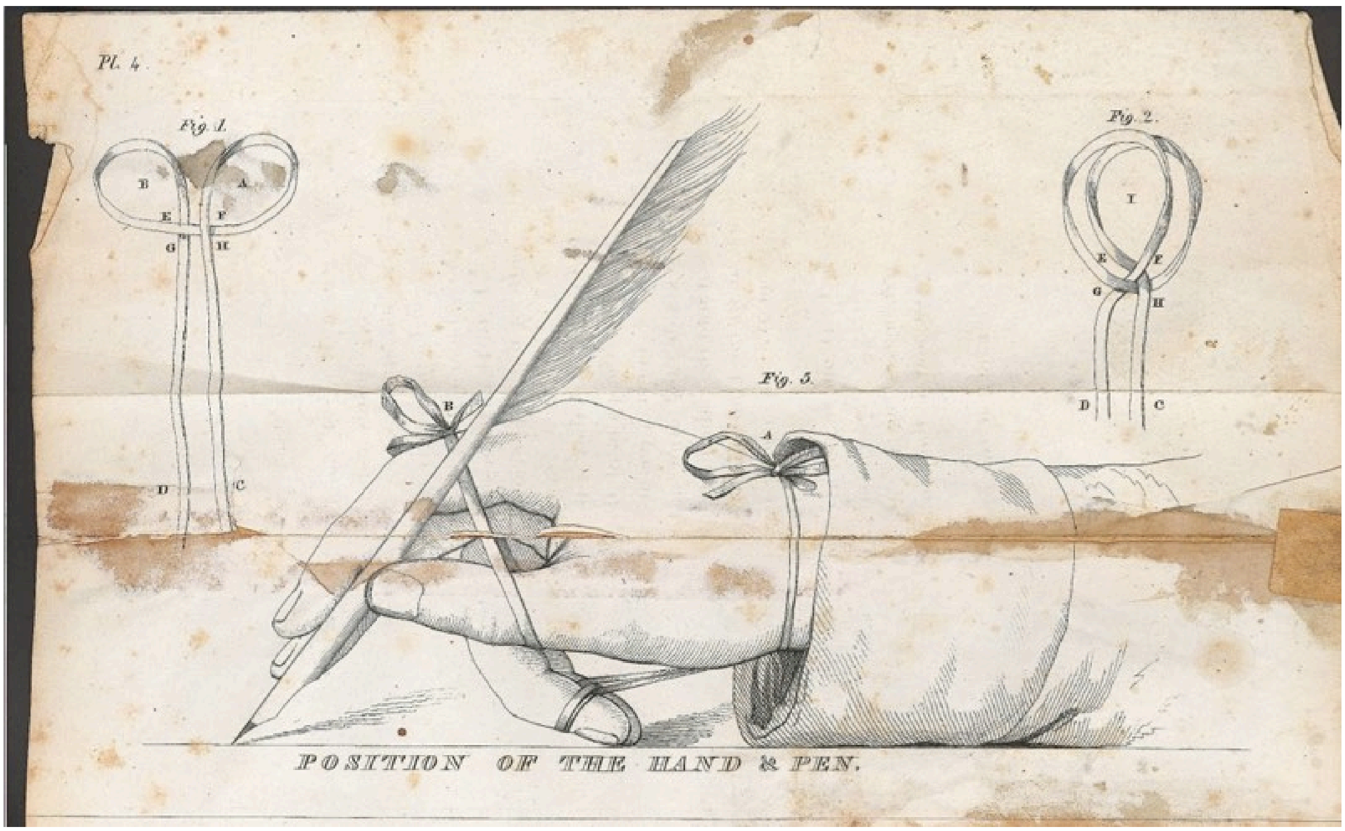


Figure 1. 21 Plate 4 from Benjamin Franklin Foster, *Practical Penmanship: Being a Development of the Carstairian System.* (Albany, NY: Little and Cummings, 1830).

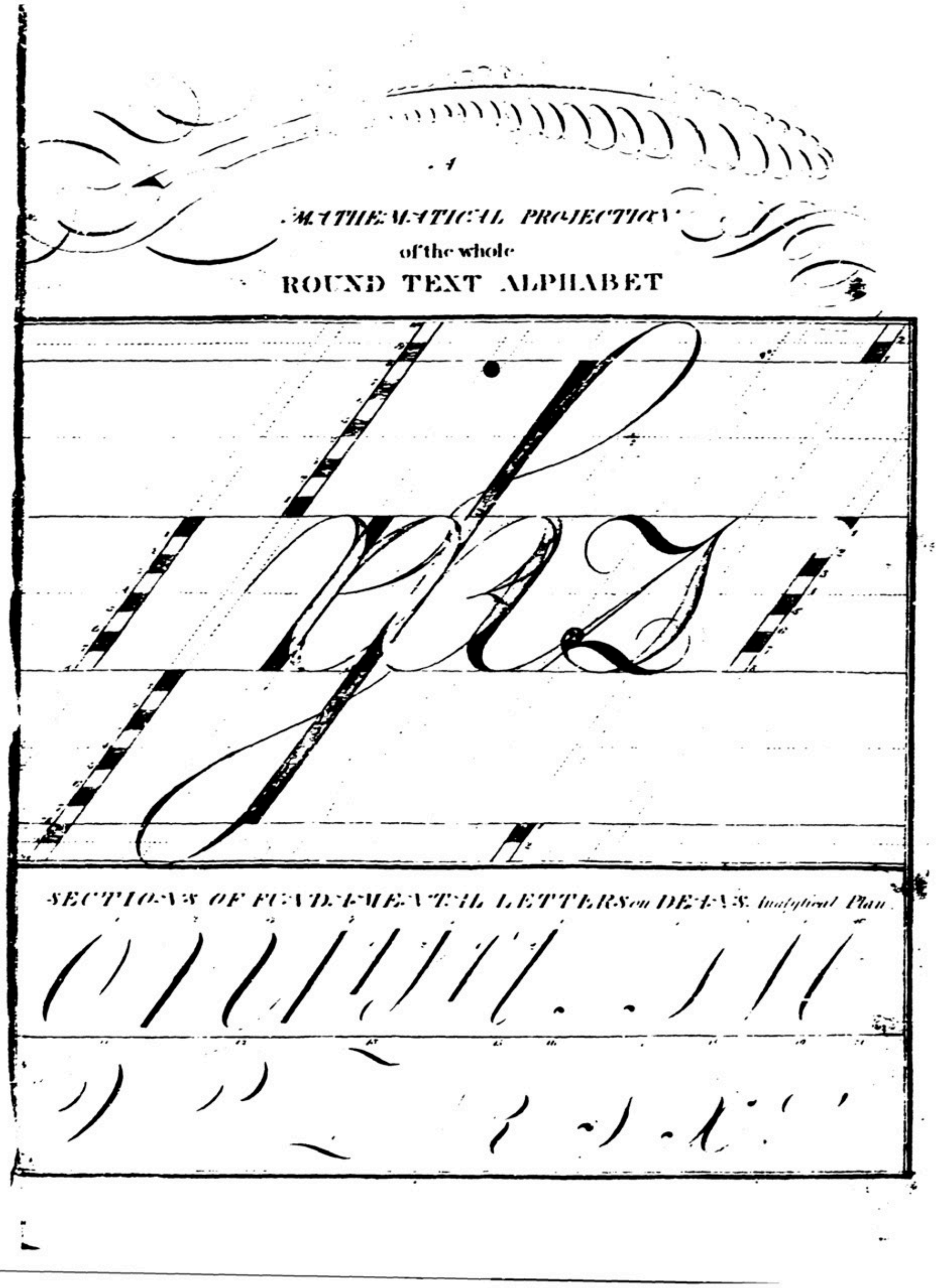
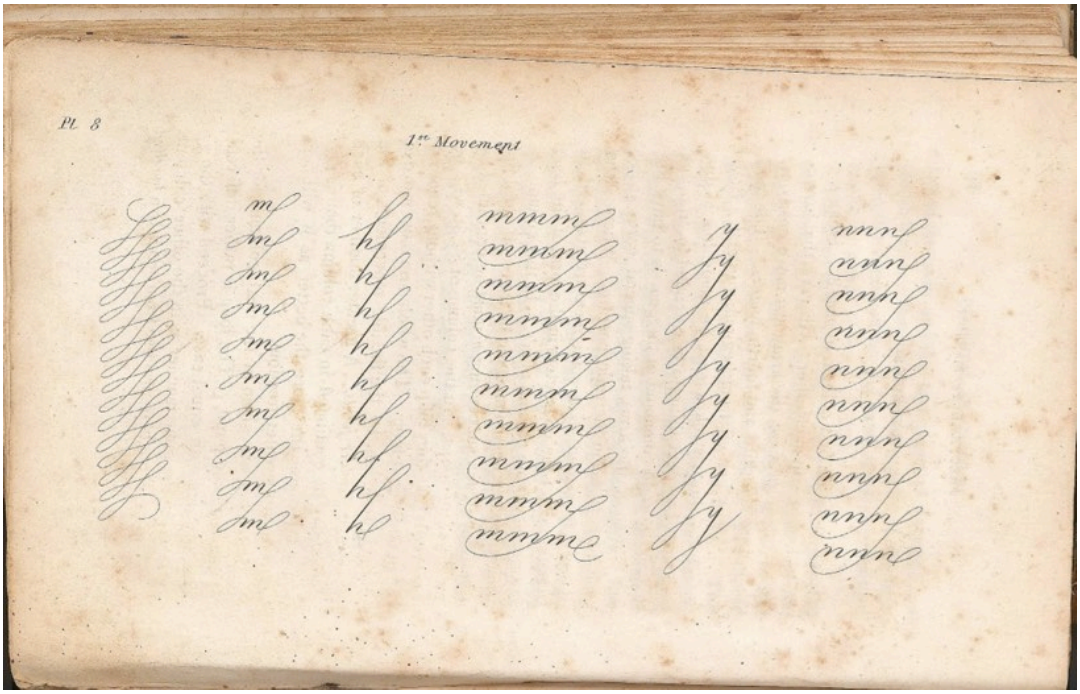


Figure 1.22 Henry Dean, "A Mathematical Projection of the Whole Round Text Alphabet," in *The Printers Academical Companion*. (Salem, MA: Printed for the author, 1806).



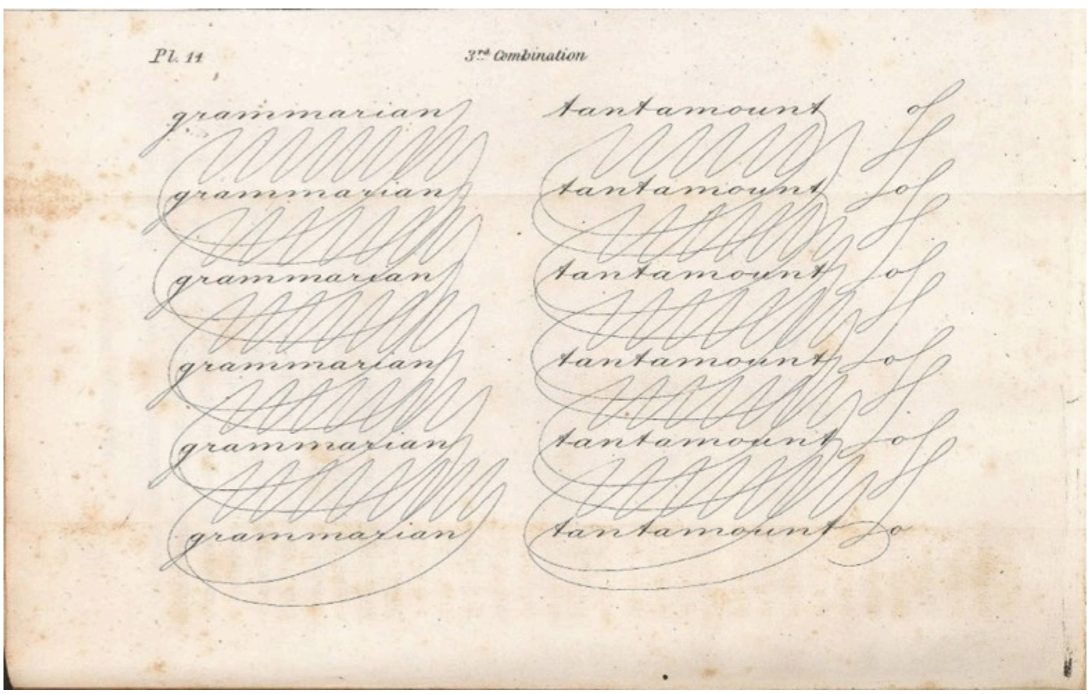
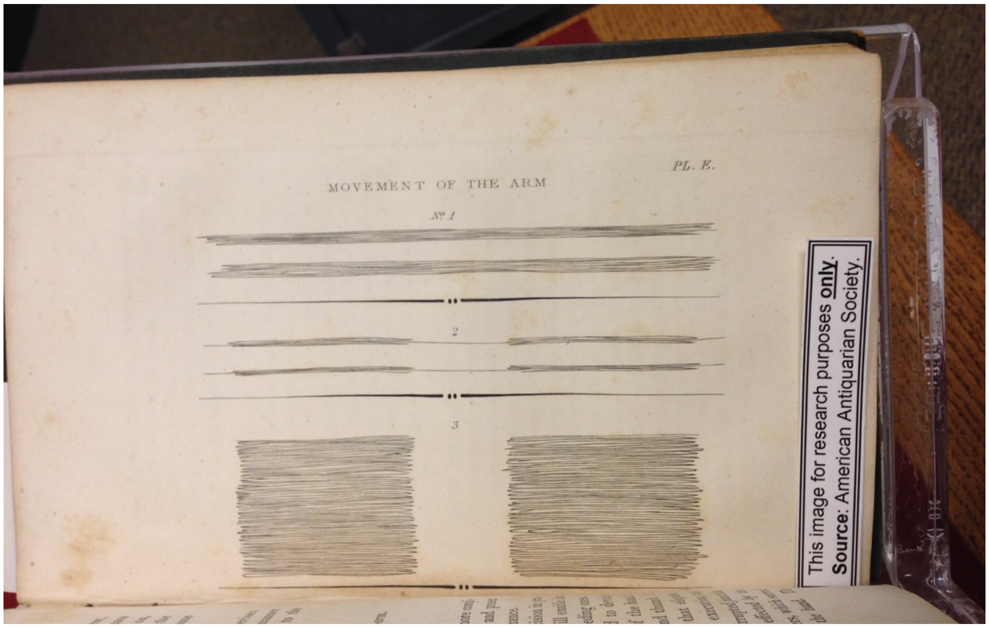
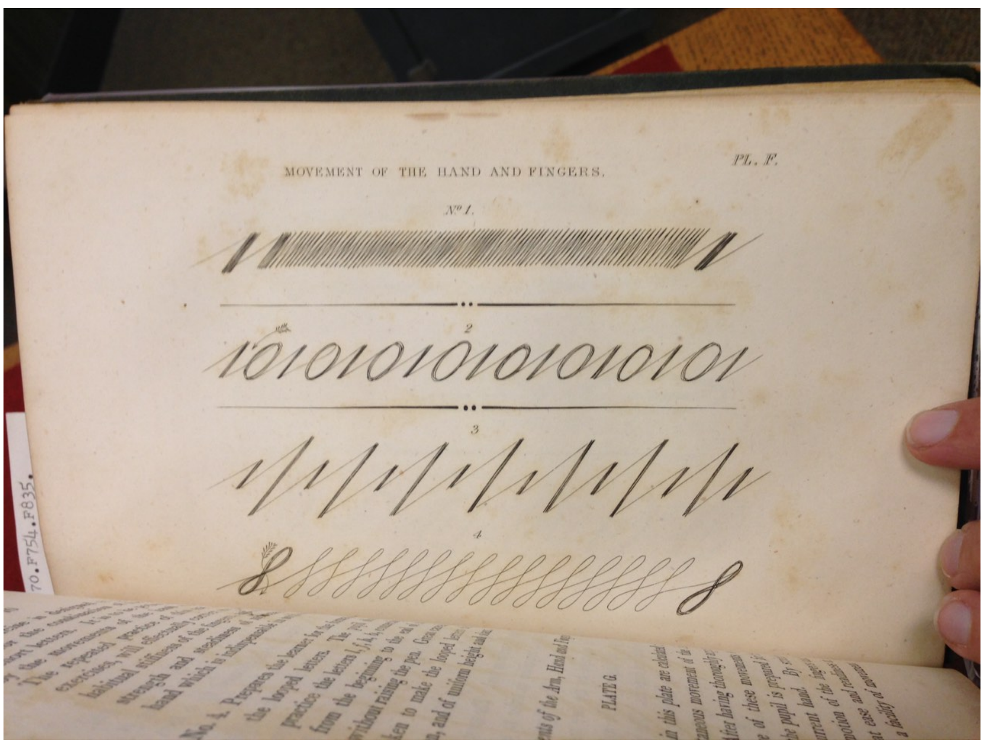


Figure 1.23 Plates 8 & 14 from Benjamin Franklin Foster, *Practical Penmanship: Being a Development of the Carstairian System.* (Albany, NY: Little and Cummings, 1830).

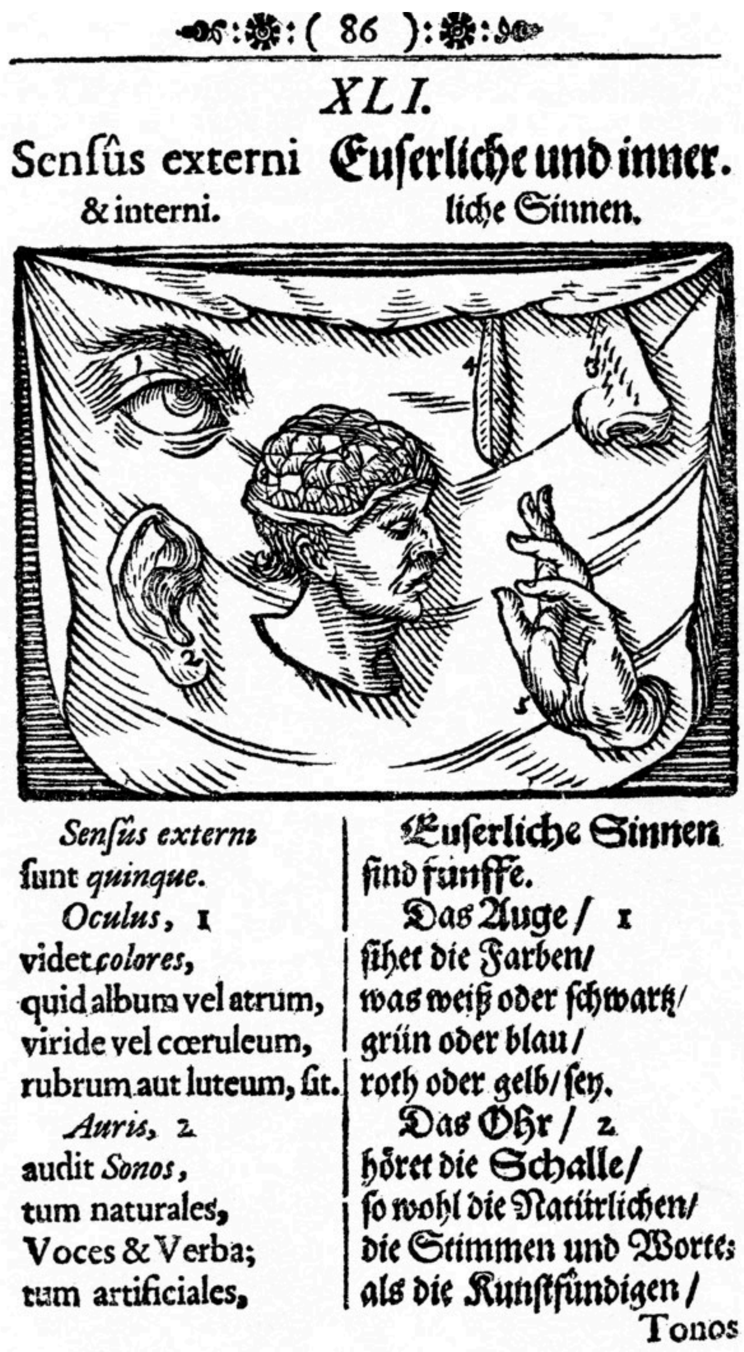


A



B

Figure 1. 24 Plates E & F from *Foster's System of Penmanship, or, The Art of Rapid Writing Illustrated and Explained: To Which is Added the Angular and Anti-angular Systems: Exemplified with Plates*. (Boston: Published by Perkins, Marving & Co., 1835).



(86)

XLI.

Sensûs externi & interni. | Euserliche und innerliche Sinnen.

Sensûs externi	Euserliche Sinnen
sunt *quinque.*	sind fünffe.
Oculus, 1	Das Auge / 1
videt *colores,*	sihet die Farben /
quid album vel atrum,	was weiß oder schwartz /
viride vel cœruleum,	grün oder blau /
rubrum aut luteum, sit.	roth oder gelb / sey.
Auris, 2	Das Ohr / 2
audit *Sonos,*	höret die Schalle /
tum naturales,	so wohl die Natürlichen /
Voces & Verba;	die Stimmen und Worte;
tum artificiales,	als die Kunstfündigen /

Tonos

Figure 2.1 Plate LXI from Johann Amos Comenius, *Orbis Sensualium Pictus. Die Sichtbare Welt*. (Nuremberg: Michael Endter, 1658).

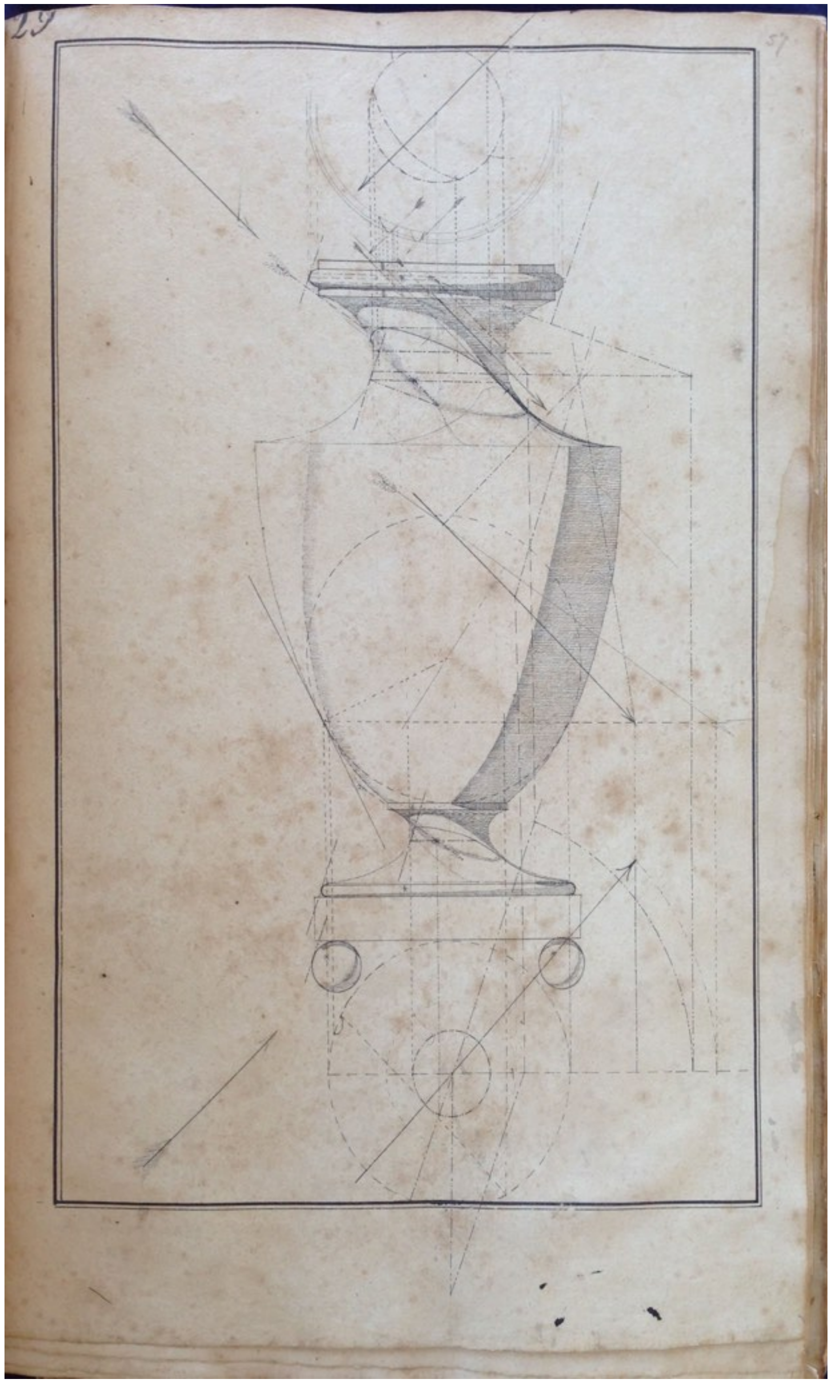


Figure 2.2 Richard Delafield, [selections from cadet drawing book],1818. Ink on paper. West Point Library, Special Collections and Archives.

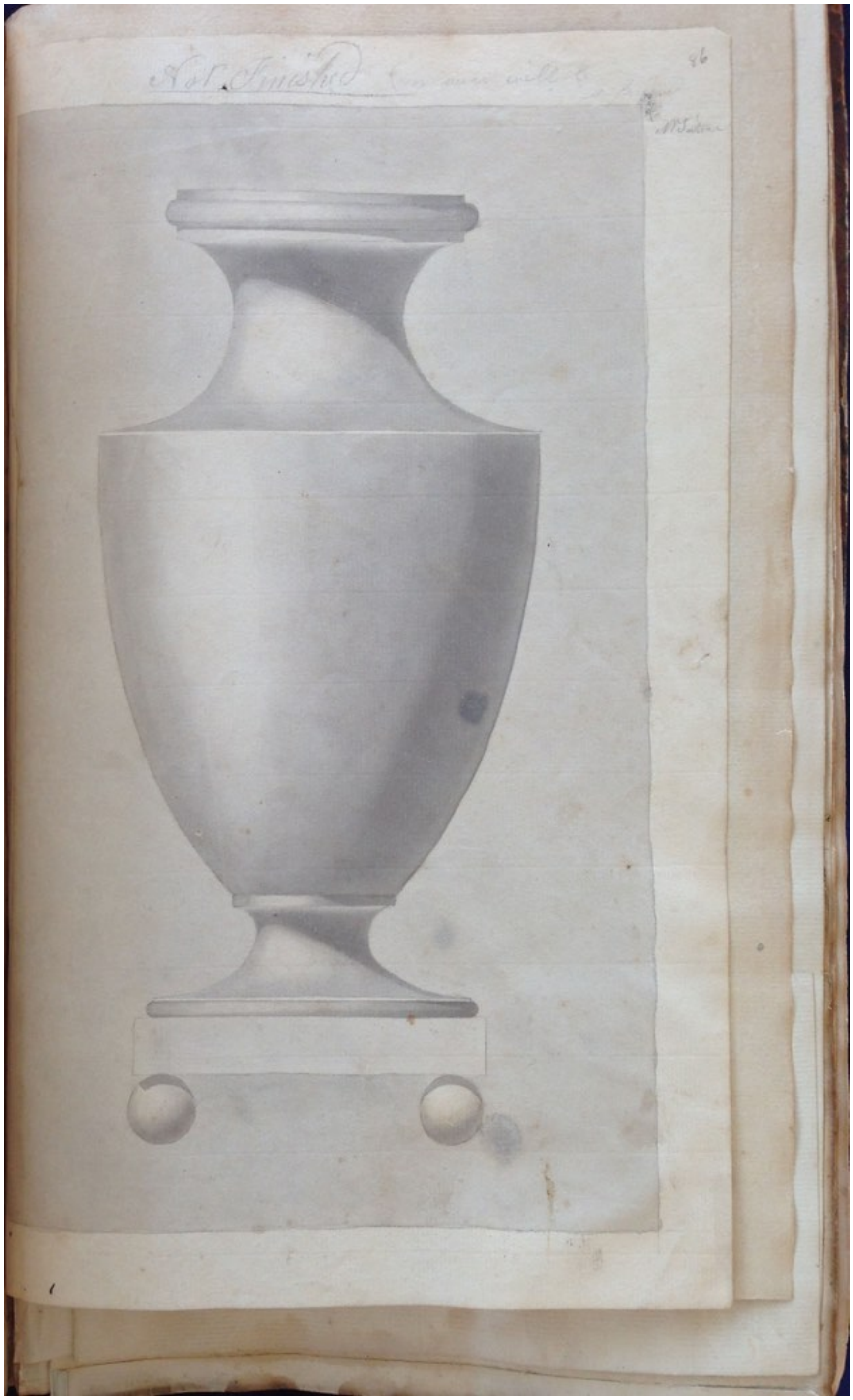
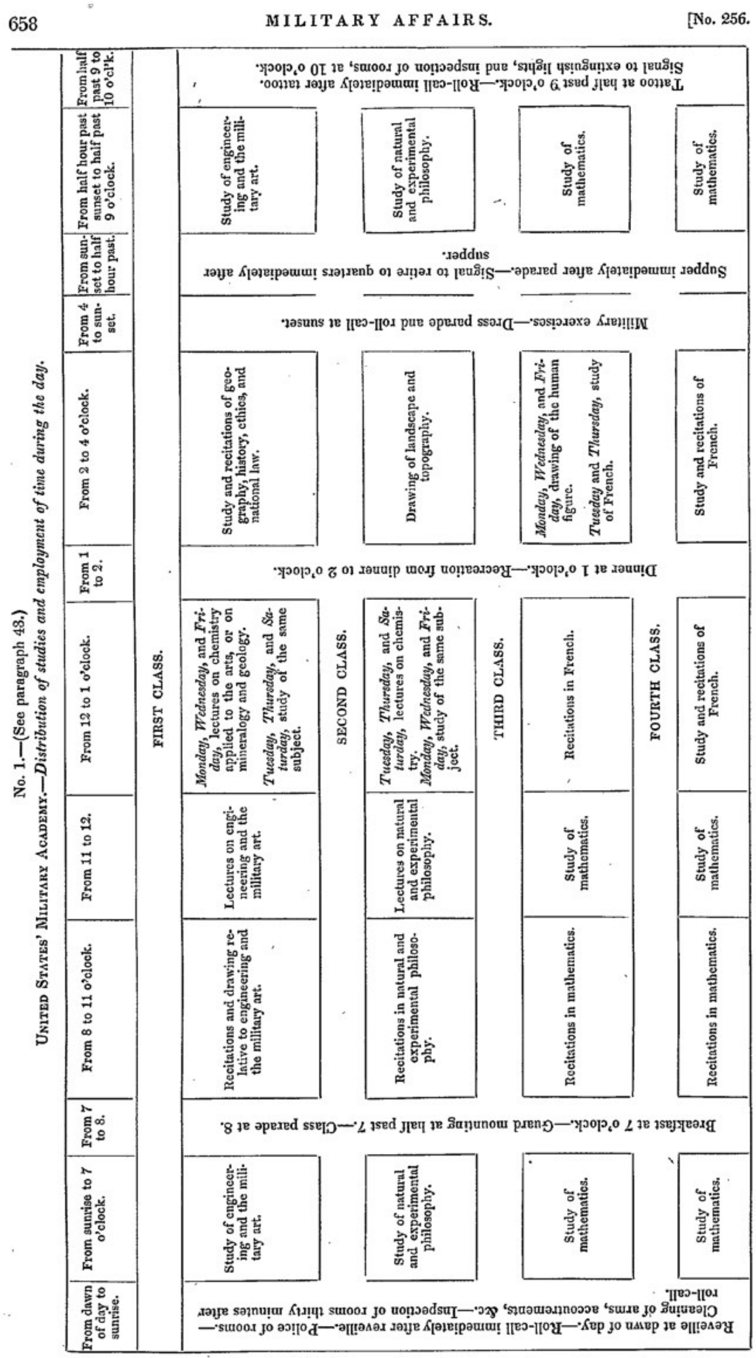


Figure 2.3 Richard Delafield, [selections from cadet drawing book],1818. Ink on paper. West Point Library, Special Collections and Archives.

Figure 2.4 Plan of Forts, Batteries and Post at West Point from François Barbe-Marbois, *Complot d'Arnold et de Sir Henry Clinton Contre les États-Unie d'Amérique et Contre le Général Washington, Septembre 1780*. (Paris: P. Didot, l'aîné, 1831).



No. 1.—(See paragraph 43.)

UNITED STATES' MILITARY ACADEMY.—*Distribution of studies and employment of time during the day.*

From dawn of day to sunrise.	From sunrise to 7 o'clock.	From 7 to 8.	From 8 to 11 o'clock.	From 11 to 12.	From 12 to 1 o'clock.	From 1 to 2.	From 2 to 4 o'clock.	From 4 to sunset.	From sunset to half hour past.	From half hour past sunset to half past 9 o'clock.	From half past 9 to 10 o'cl'k.
FIRST CLASS.											
Reveille at dawn of day.—Roll-call immediately after reveille.—Police of rooms.—Cleaning of arms, accoutrements, &c.—Inspection of rooms thirty minutes after roll-call.	Study of engineering and the military art.	Breakfast at 7 o'clock.—Guard mounting at half past 7.—Class parade at 8.	Recitations and drawing relative to engineering and the military art.	Lectures on engineering and the military art.	*Monday, Wednesday,* and *Friday,* lectures on chemistry applied to the arts, or on mineralogy and geology. *Tuesday, Thursday,* and *Saturday,* study of the same subject.	Dinner at 1 o'clock.—Recreation from dinner to 2 o'clock.	Study and recitations of geography, history, ethics, and national law.	Military exercises.—Dress parade and roll-call at sunset.	Supper immediately after parade.—Signal to retire to quarters immediately after supper.	Study of engineering and the military art.	Tattoo at half past 9 o'clock.—Roll-call immediately after tattoo. Signal to extinguish lights, and inspection of rooms, at 10 o'clock.
SECOND CLASS.											
	Study of natural and experimental philosophy.		Recitations in natural and experimental philosophy.	Lectures on natural and experimental philosophy.	*Tuesday, Thursday,* and *Saturday,* lectures on chemistry. *Monday, Wednesday,* and *Friday,* study of the same subject.		Drawing of landscape and topography.			Study of natural and experimental philosophy.	
THIRD CLASS.											
	Study of mathematics.		Recitations in mathematics.	Study of mathematics.	Recitations in French.		*Monday, Wednesday,* and *Friday,* drawing of the human figure. *Tuesday* and *Thursday,* study of French.			Study of mathematics.	
FOURTH CLASS.											
	Study of mathematics.		Recitations in mathematics.	Study of mathematics.	Study and recitations of French.		Study and recitations of French.			Study of mathematics.	

Figure 2.5 "Distribution of Studies and Employment of Time During the Day" from "Condition of the Military Academy at West Point" in *American State Papers, Class V. Military Affairs*, vol. 2. (Washington: Published by Gales and Seaton, 1834).

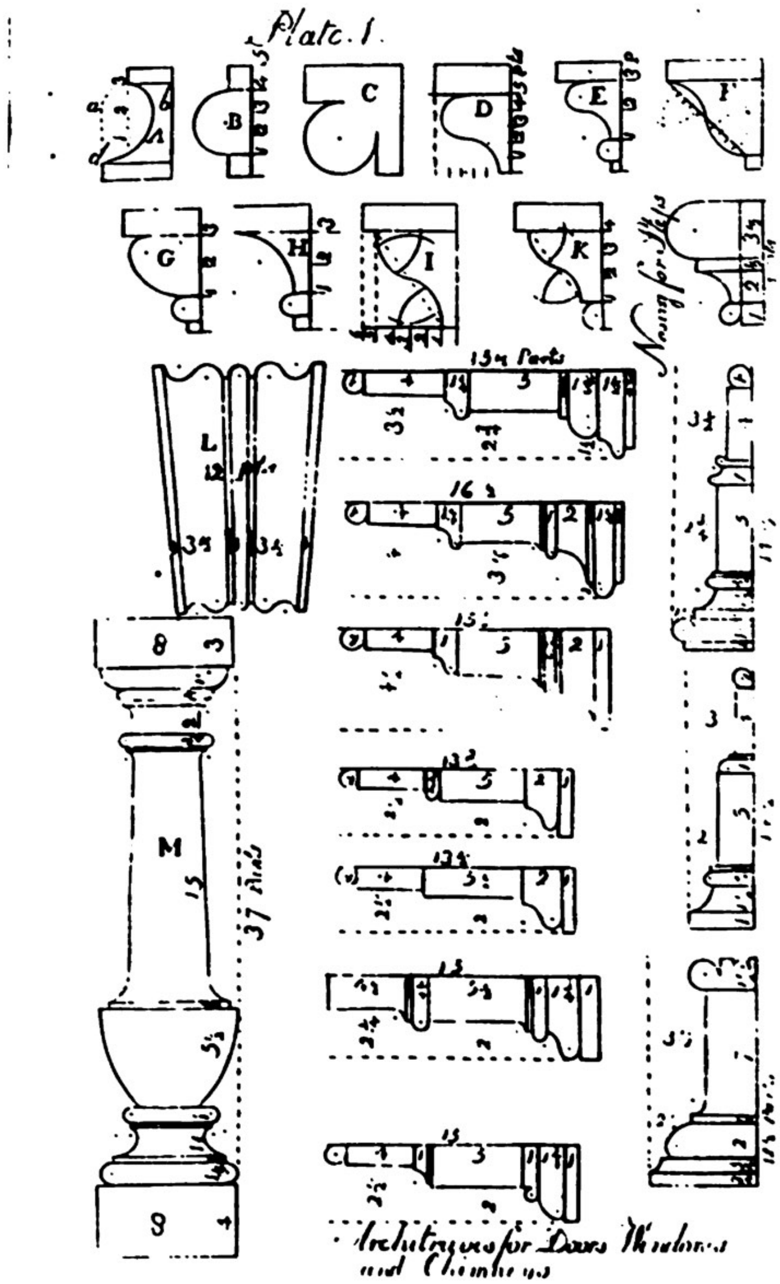


Figure 2.6 Plate I from Asher Benjamin, *The Country Builder's Assistant*. (Greenfield, MA: Thomas Dickman, 1797).

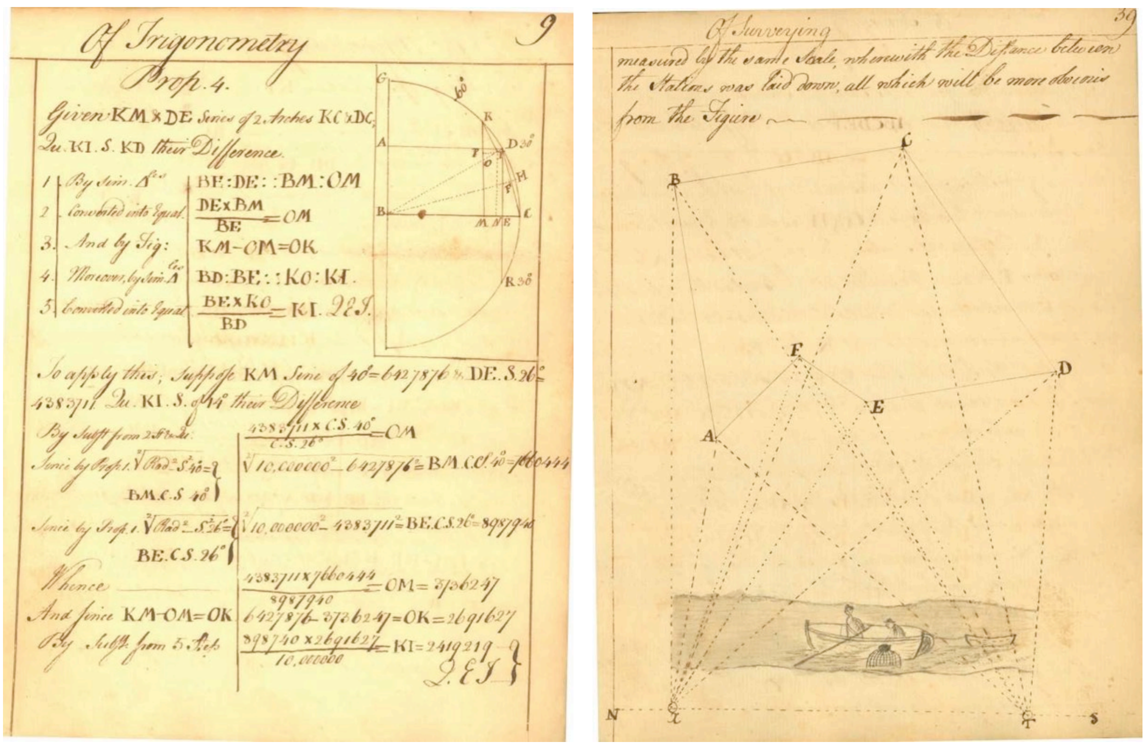


Figure 2.7 Jasper Yeates, [selections from student notebook, "Trigonometry, Plain Sailing, Surveying, With Heights and Distances. Collected from the most approved Writers on each Subject"], May 1, 1760. University of Pennsylvania, Archives General.

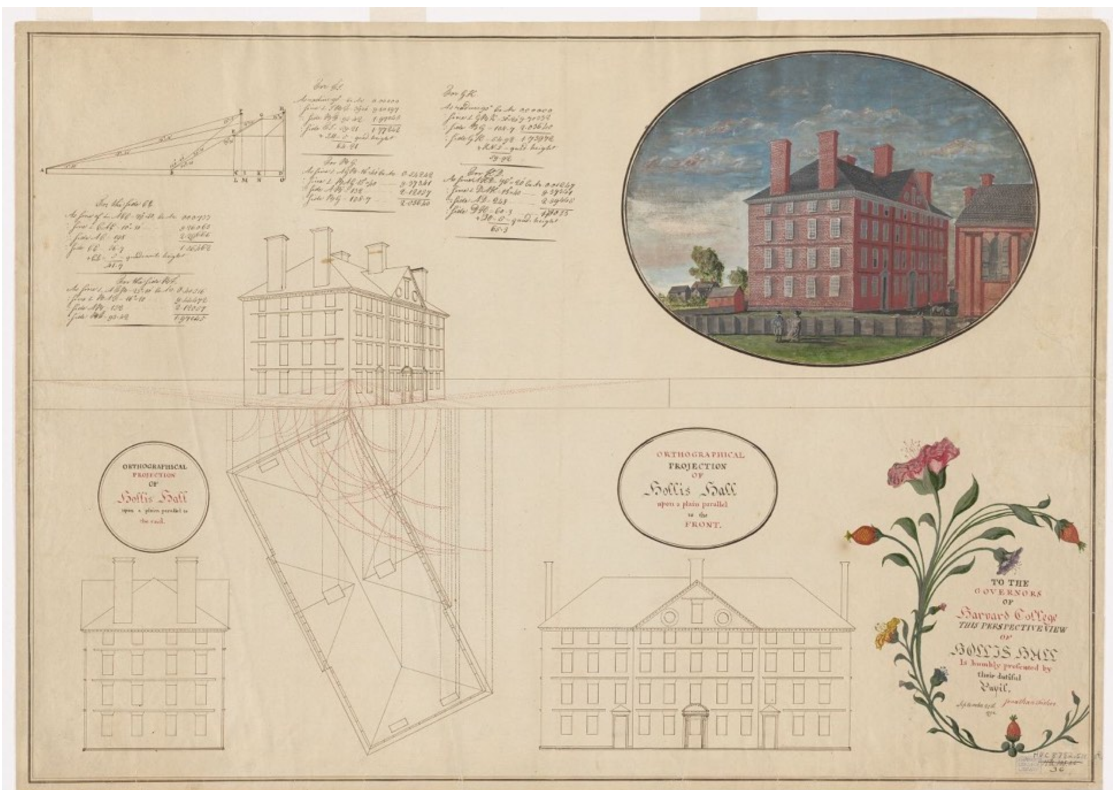


Figure 2.8 Jonathan Fisher, "Orthographical Projection of Hollis Hall, etc. Front View, End View, and Perspective View with part of Holden Chapel and Buildings East of Hollis Hall," September 27, 1791. Harvard University Archives.

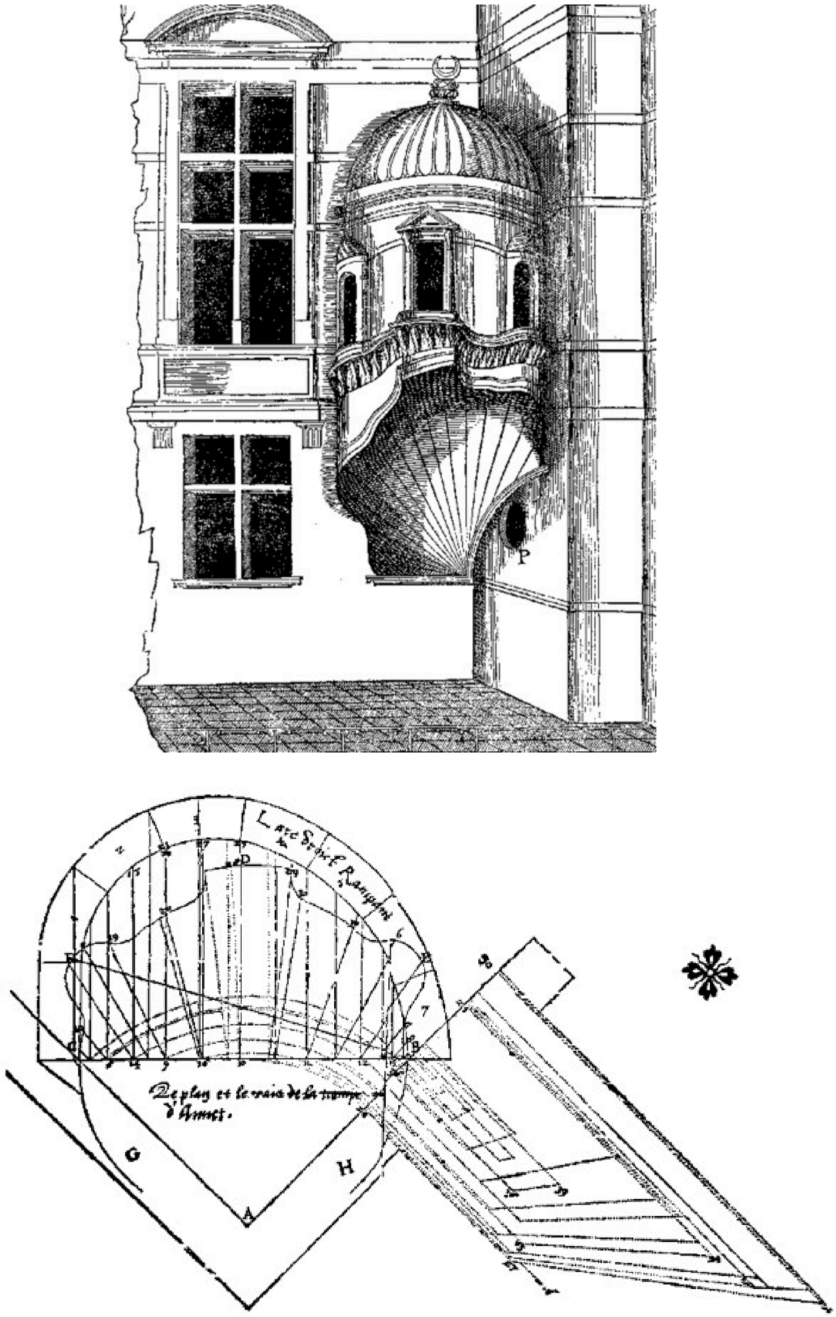


Figure 2.9 Philibert de l'Orme, (above) Trompe d'Anet and (below) Trait of the Trompe d'Anet, both from *Le Premier Tome de l'Architecture de Philibert de l'Orme*. (Paris: Frederic Morel, 1567).

Figure 2.10 A. Brockenboroguh, [fictive topographic landscape], 1816. Ink and watercolor wash. West Point Museum.

Figure 2.11 Detail. "Military Sketch" from Charles Stanislas de Malortie de Martemont, *Instructions for Officers on Military Plan-Drawing*, (London: [unknown publisher], 1805). Library Company of Philadelphia.

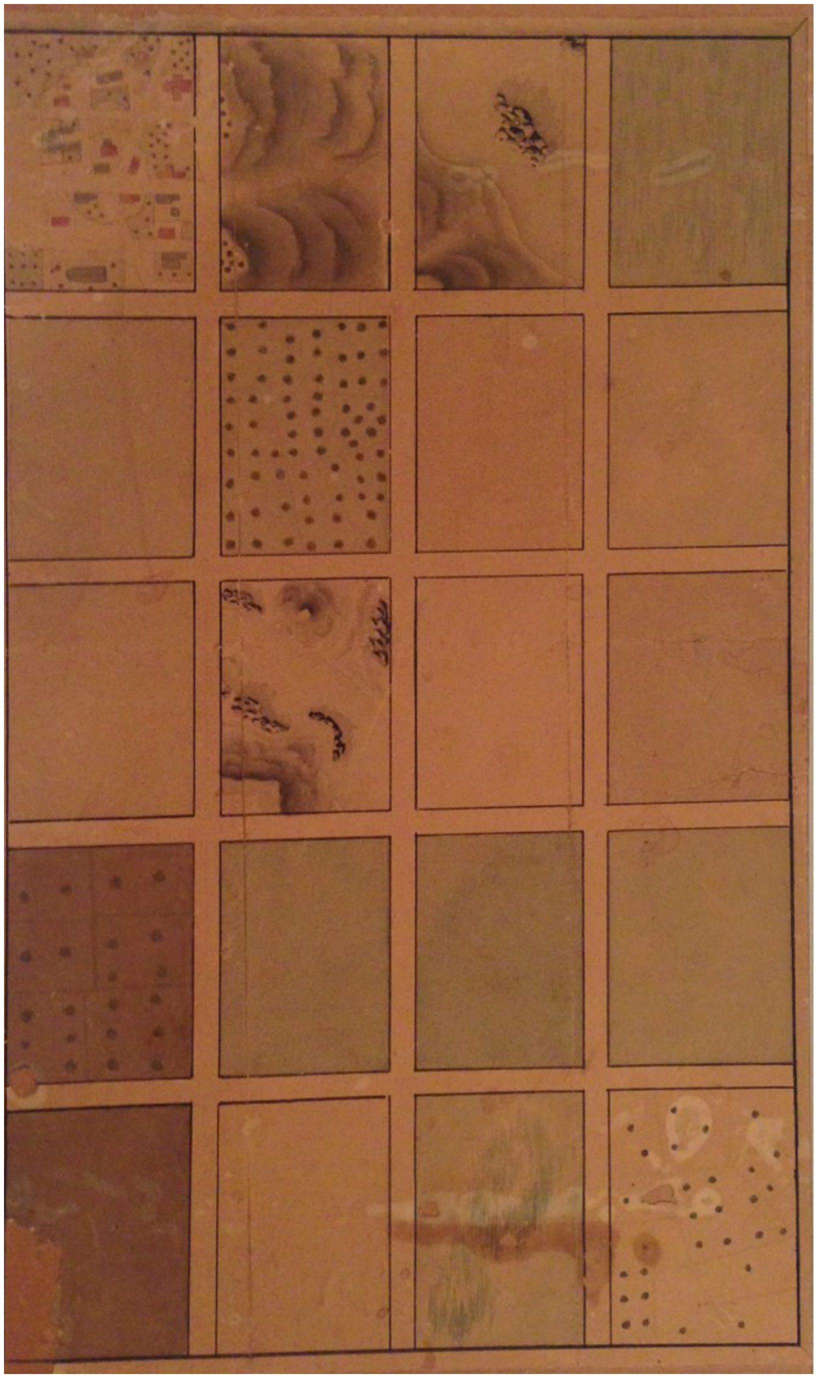


Figure 2.12 Cadet Brockenborough, [landscape samples], 1816. Ink and watercolor on paper. West Point Museum.

Figure 2.13 Richard Delafield, [landscape samples from cadet drawing book], 1818. Ink and watercolor on paper. West Point Library. Special Collections and Archives.

Figure 2.14 Edward Deering Mansfield, [fictive topographic lansdcape], before 1819. Ink on paper. West Point Museum.

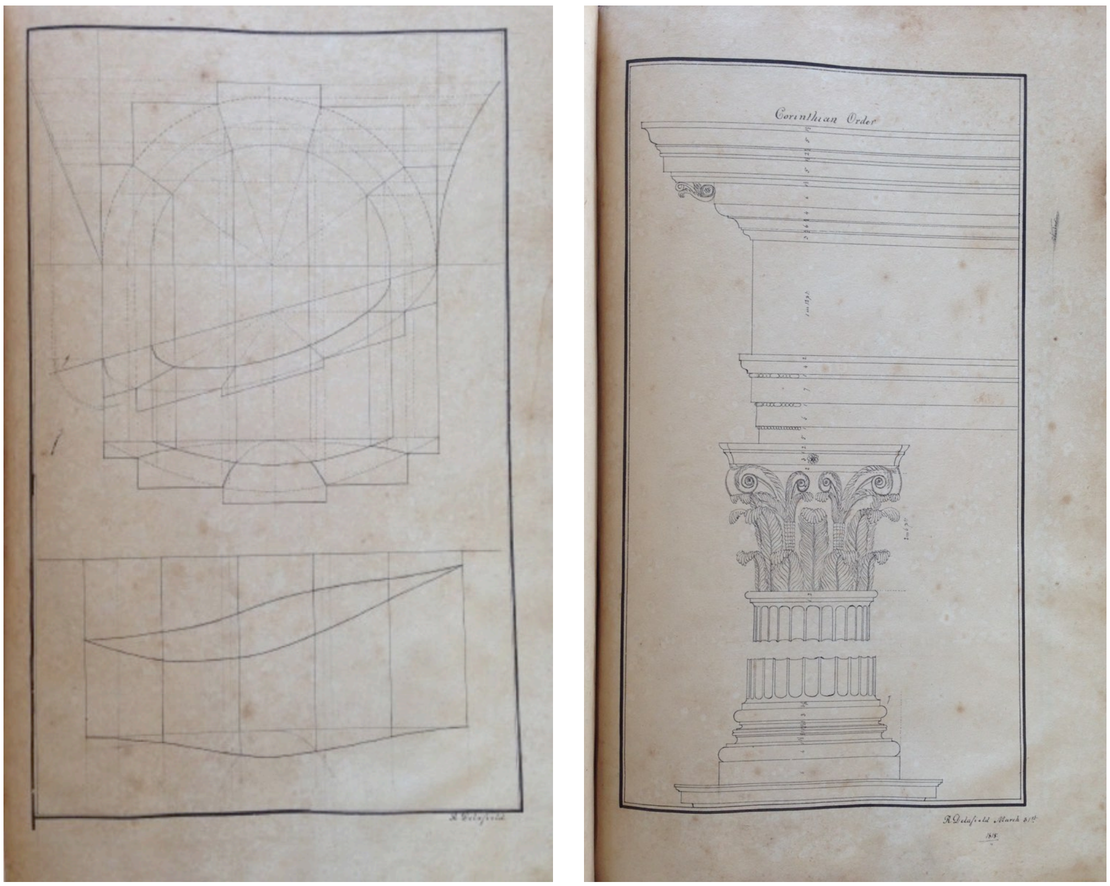


Figure 2.15 Richard Delafield, [selections from cadet drawing book], 1818. Ink on paper. West Point Library, Special Collections and Archives.

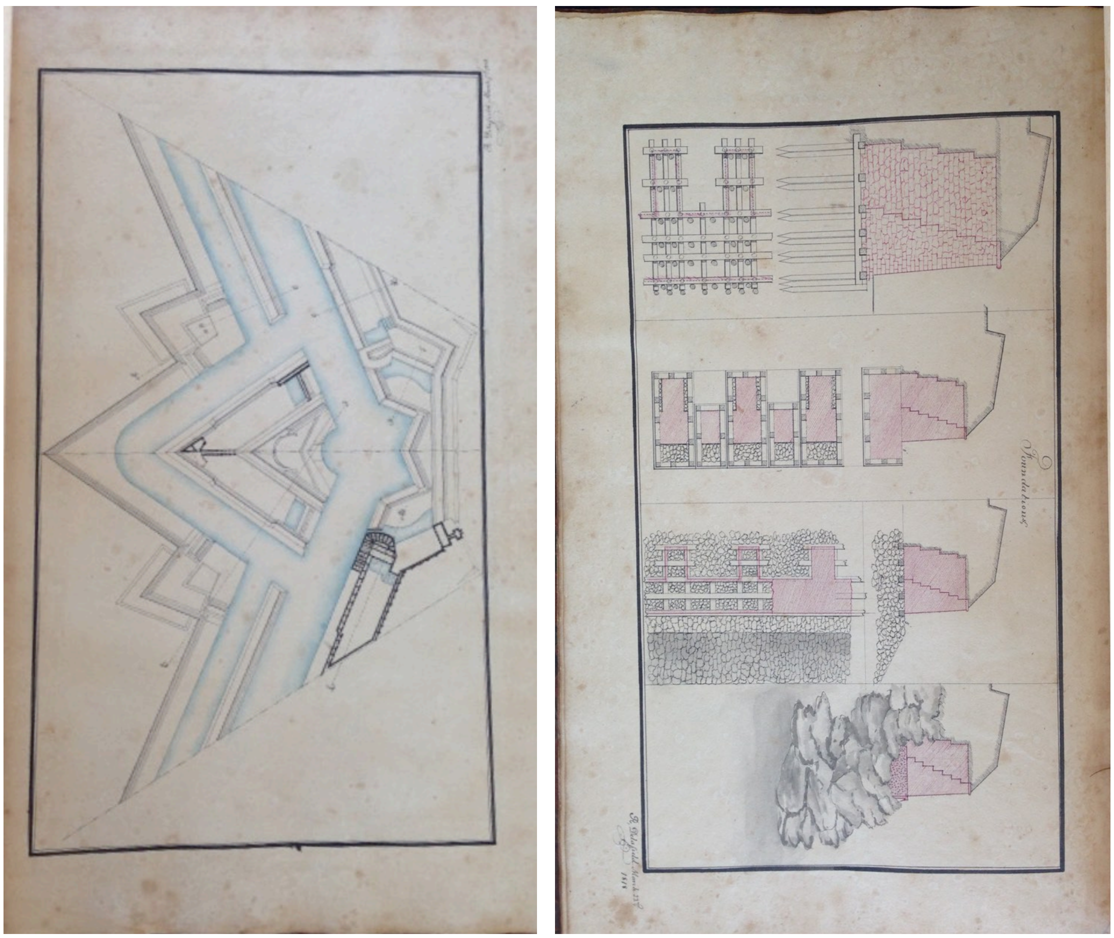


Figure 2.16 Richard Delafield, [selections from cadet drawing book],1818. Ink on paper. West Point Library, Special Collections and Archives.

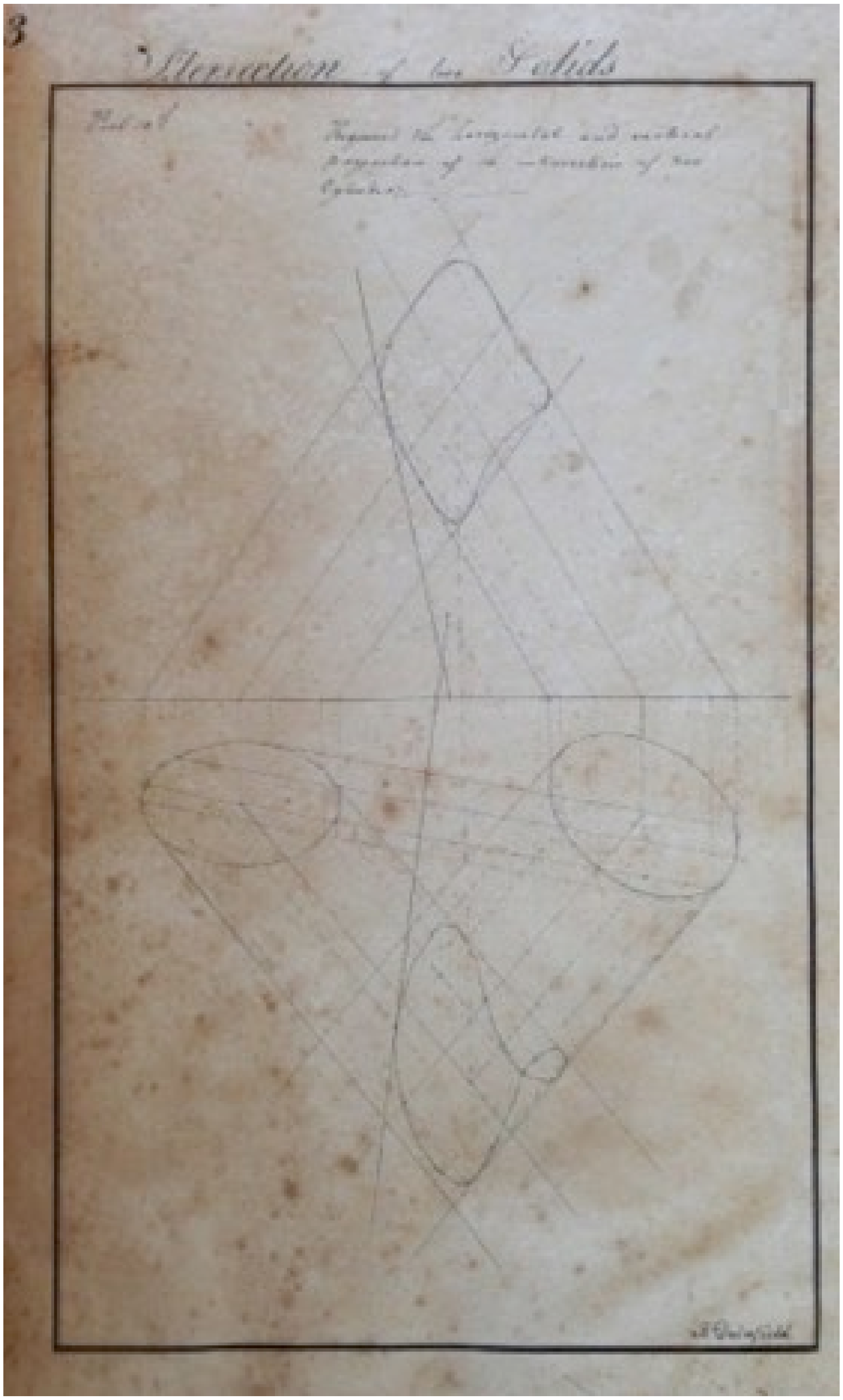


Figure 2.17 Richard Delafied, [descriptive geometry exercise], 1818, ink on paper. West Point Library, Special Collections and Archives.

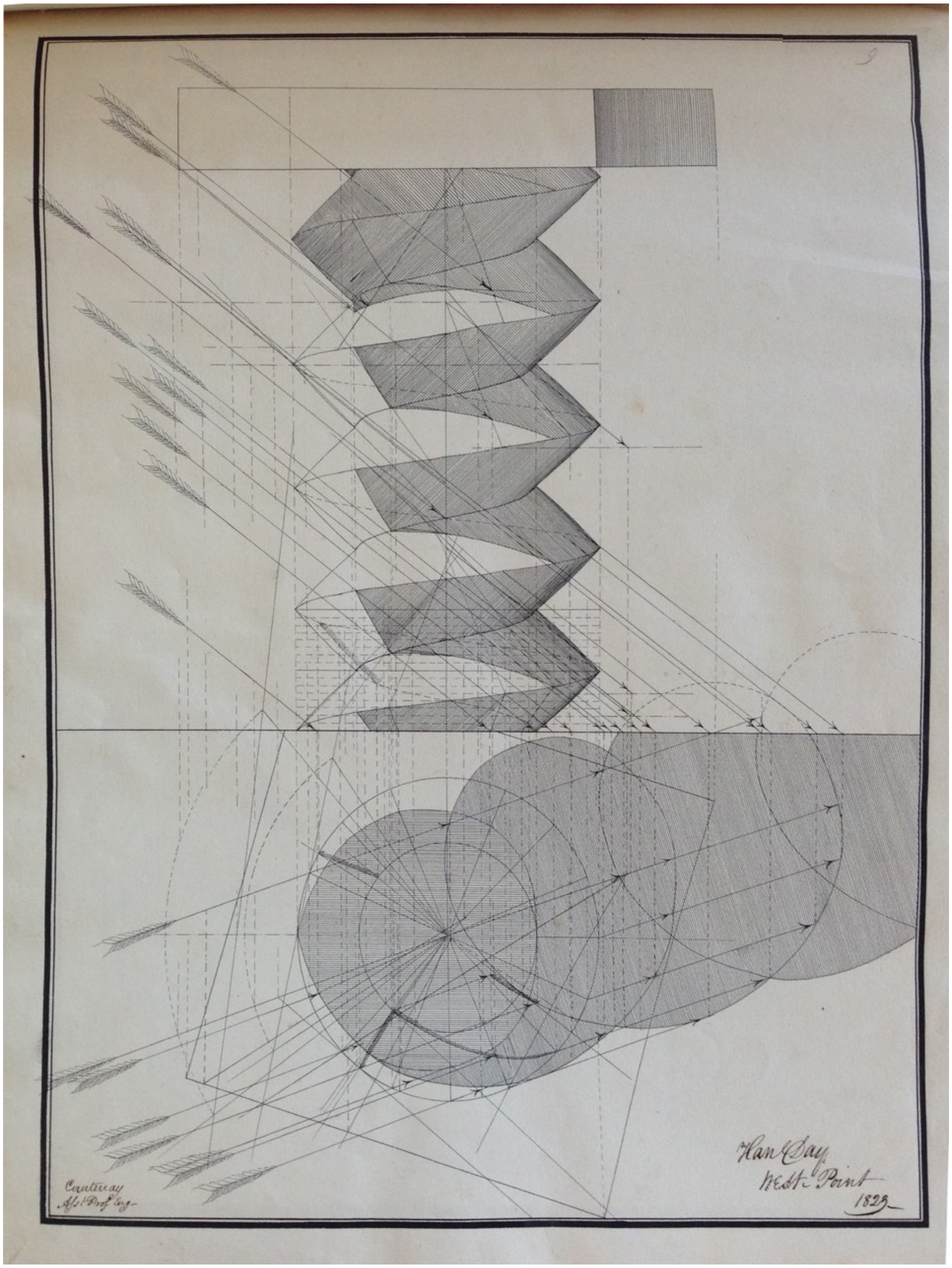


Figure 2.18 Hannibal Day, [selection from cadet drawing book], 1823. Ink on paper. West Point Library, Special Collections and Archives.

Figure 2.19 Ecole Polytechnique Bureau des Dessinateurs, [two-dimensional models for figure drawing], undated. (Left) red chalk on paper, (right) ink on paper. Bibliothèque de l’Ecole Polytechnique.

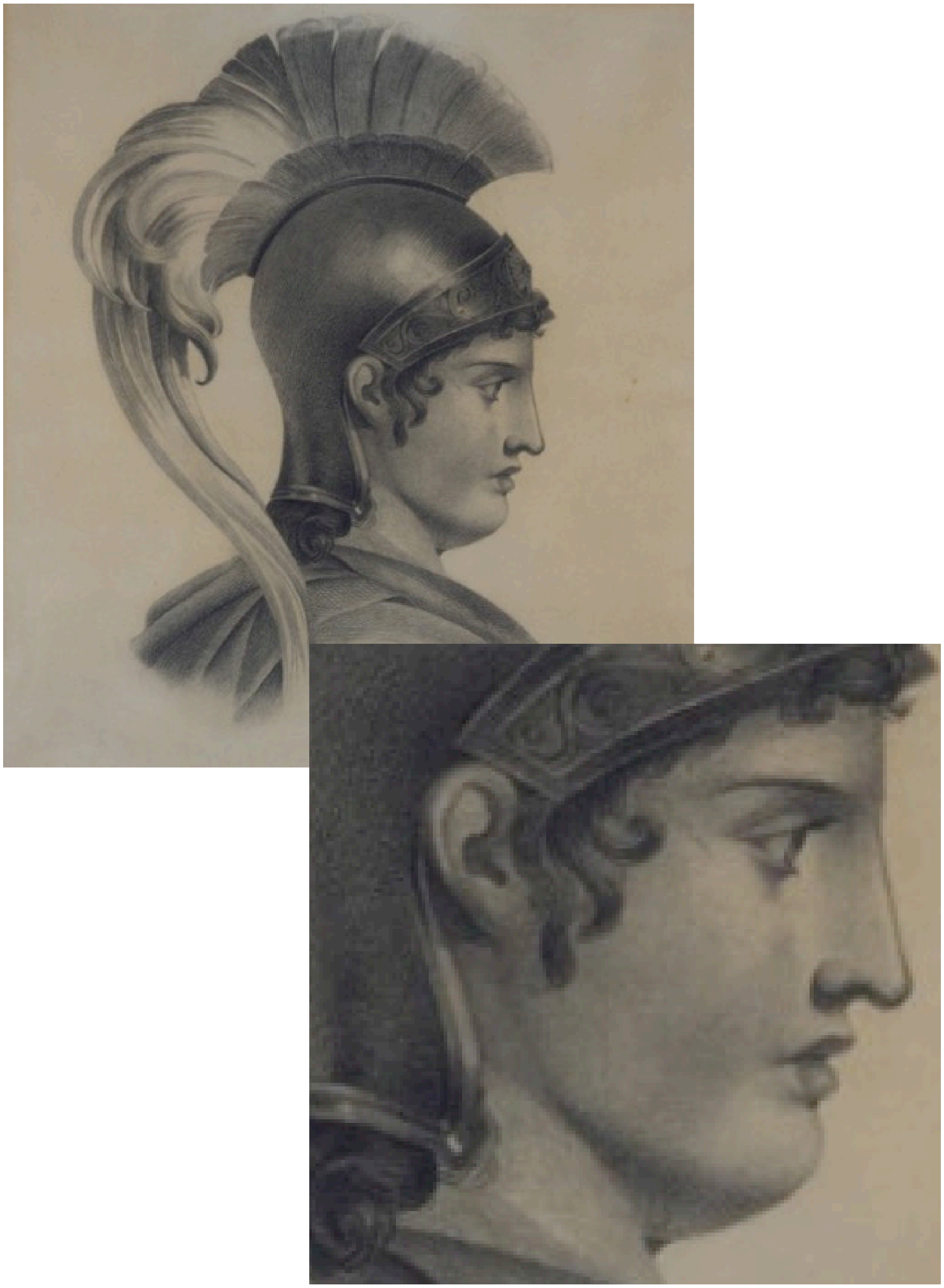


Figure 2.20 Jefferson Davis, [untitled profile of helmeted warrior], 1826. Graphite on paper. West Point Museum.

Figure 2.21 James Duncan, [untitled torso rear view], 1831-32. Graphite on paper. West Point Museum.

Figure 3.1 Benjamin West, *Robert Fulton*, 1806. Oil on canvas. Fenimore Art Museum.

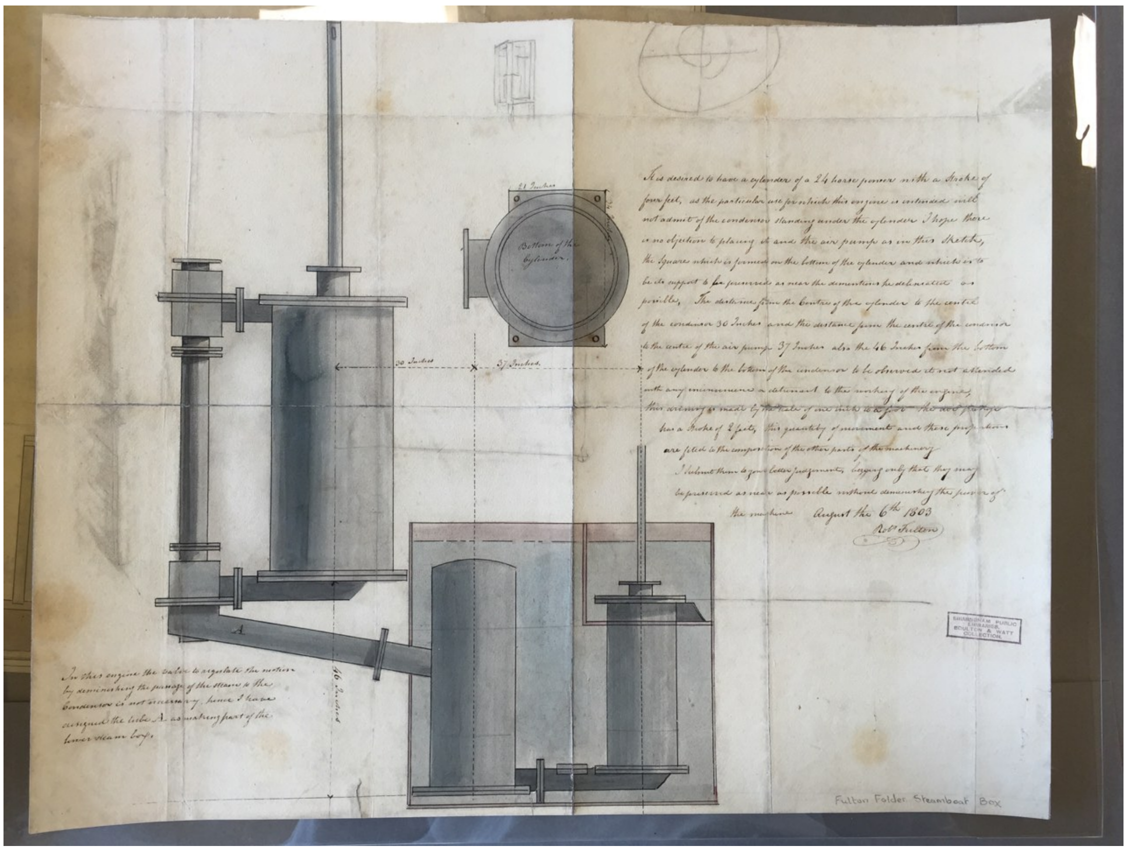


Figure 3.2 Robert Fulton to Matthew Boulton and James Watt, [enclosed drawing], August 6, 1803. Ink, graphite, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

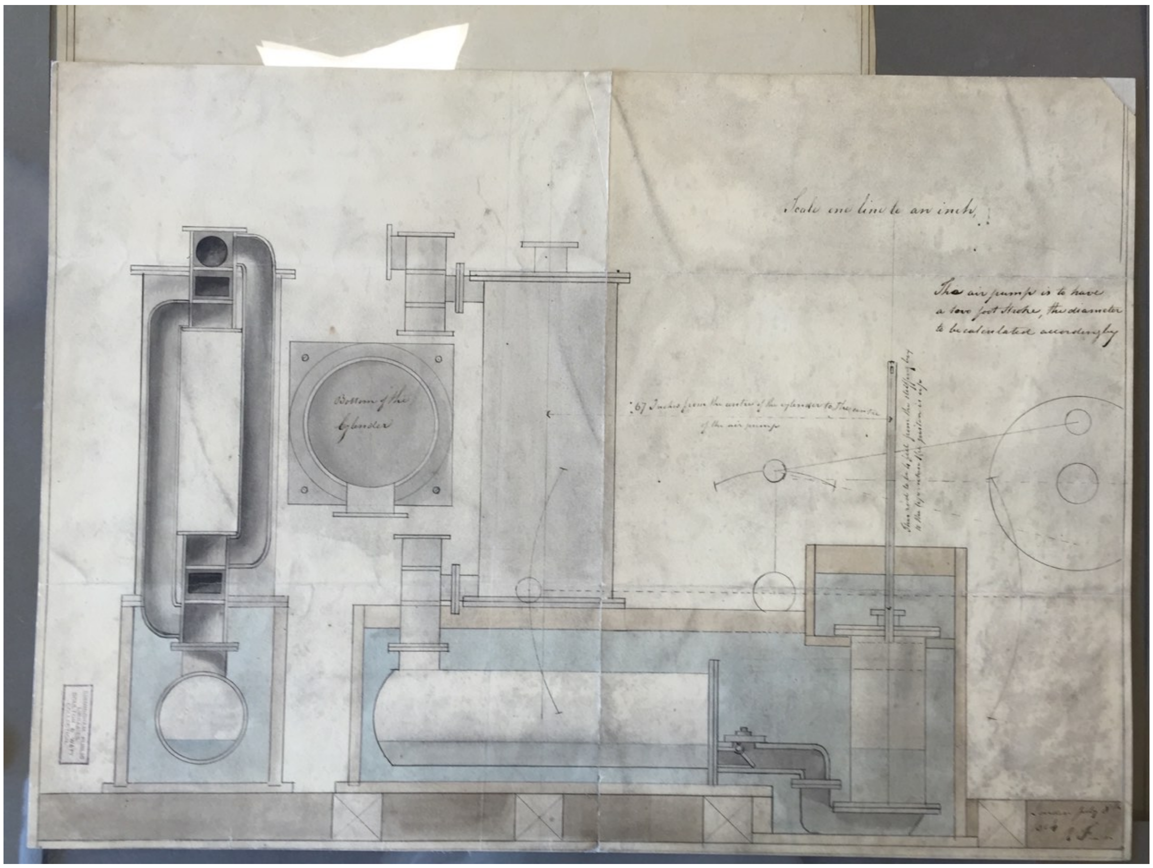


Figure 3.3 Robert Fulton to Matthew Boulton and James Watt, [enclosed drawing], July 13, 1804. Ink, graphite, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

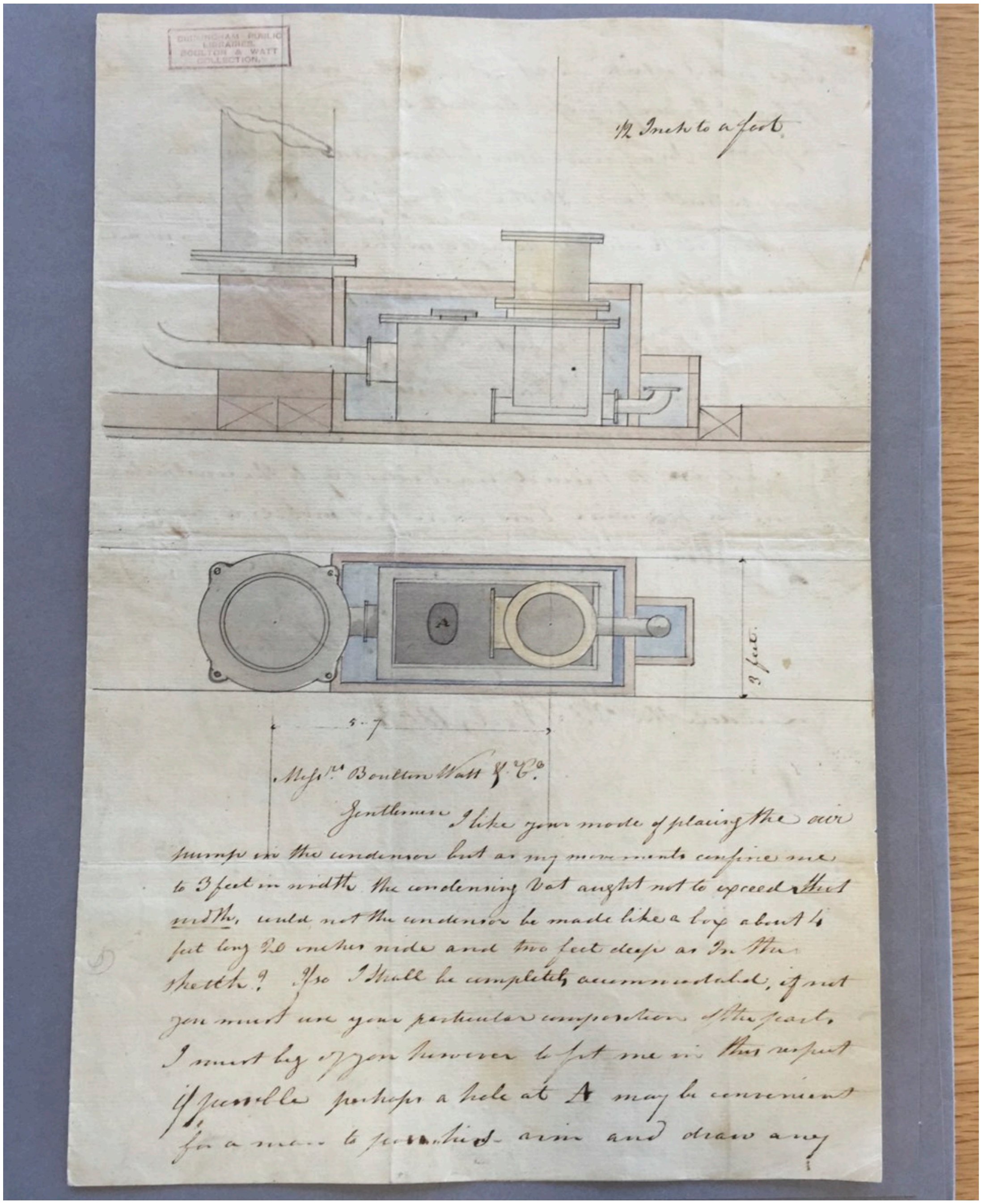


Figure 3.4 Robert Fulton to Matthew Boulton and James Watt, [enclosed drawing], July 23, 1804. Ink, graphite, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

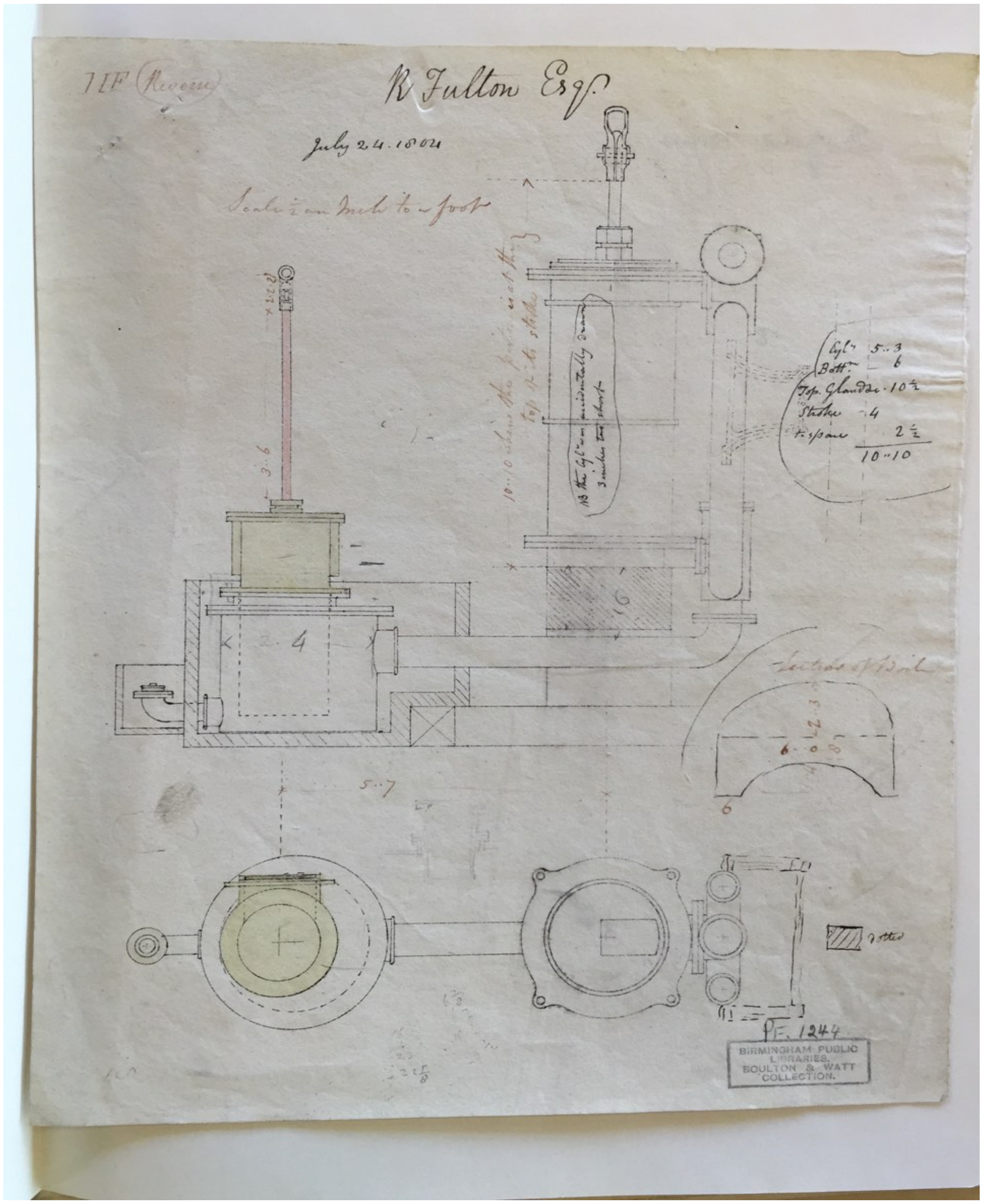


Figure 3.5 Boulton and Watt Drawing Office, [housing and air pump for Fulton's engine], July 24, 1804. Ink, graphite, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

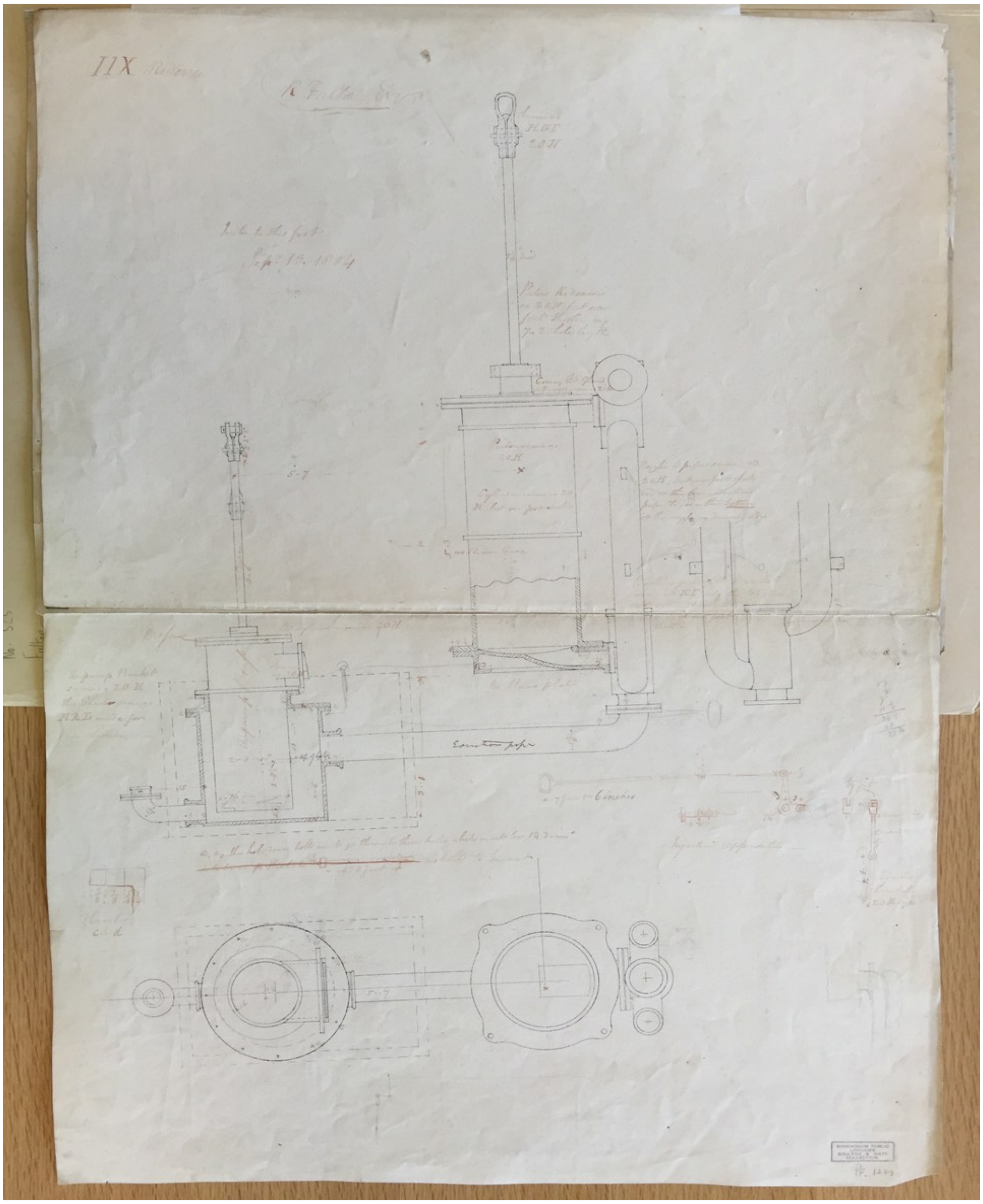


Figure 3.6 Bouton and Watt Drawing Office, [plan and section of the cylinder for Fulton’s engine], September 13, 1804. Ink and graphite on paper. Ink, graphite, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

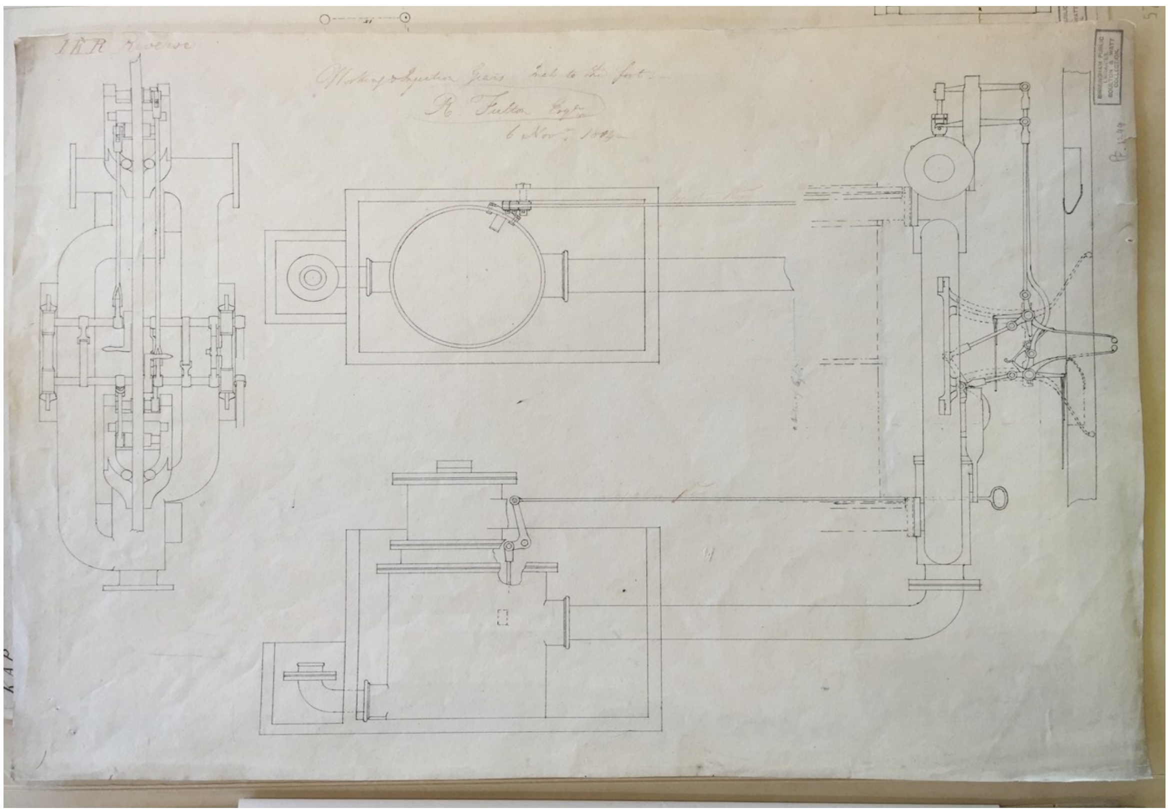


Figure 3.7 Boulton and Wat, [working and injection gear for Fulton's engine], November 6, 1804. Ink and watercolor wash on paper. Archives of Soho, Library of Birmingham.

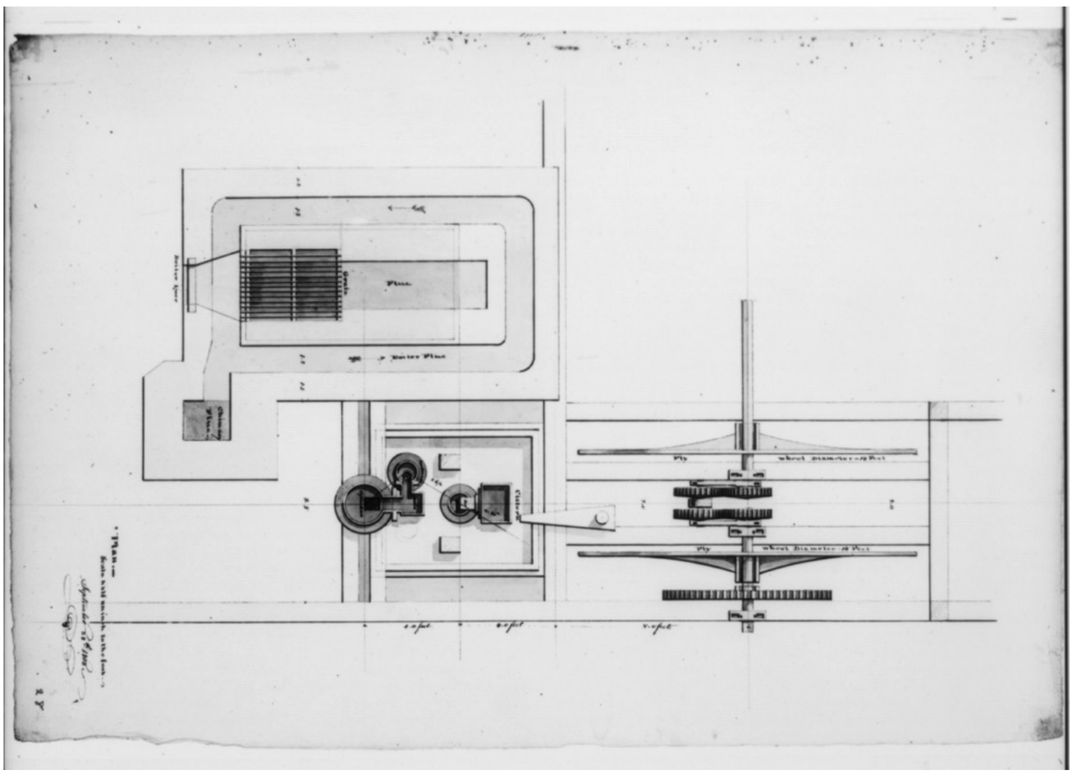


Figure 3.8 James Smallman, [steam engine, Washington Navy Yard, Washington, D.C., plan—flue, fly wheel, cistern, etc.]. September 29, 1808. Ink, graphite, and watercolor wash on paper. Library of Congress, Prints and Photographs Division.

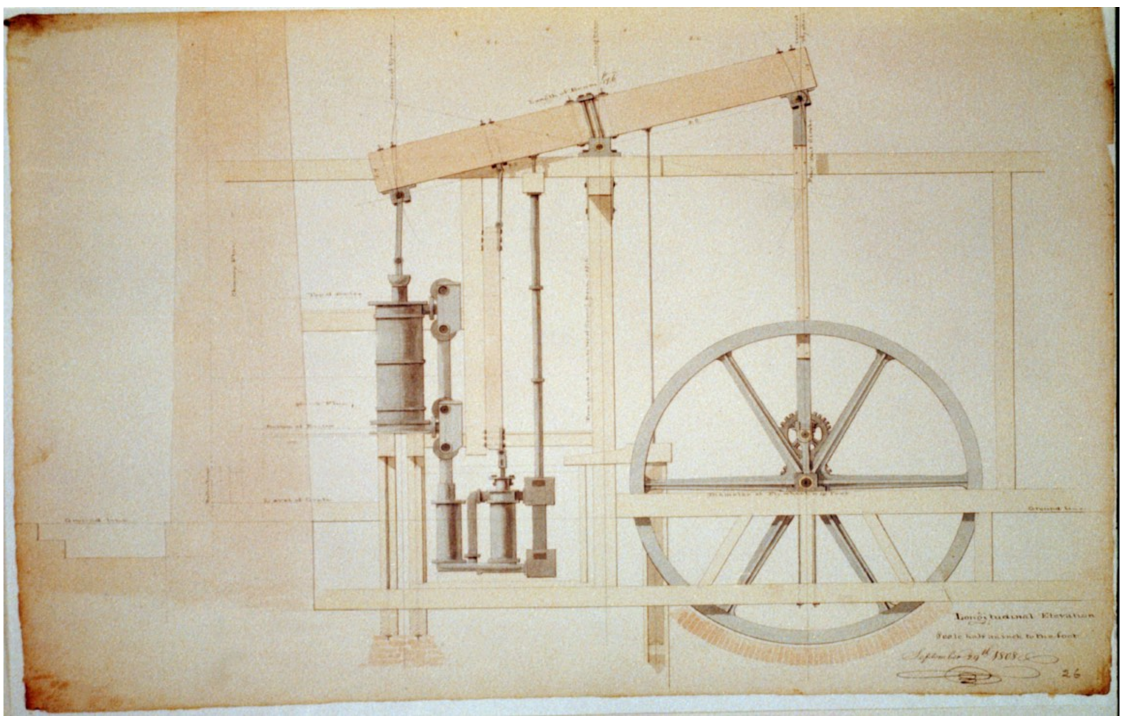


Figure 3.9 James Smallman, [steam engine, Washington Navy Yard, Washington, D.C., longitudinal elevation], September 29, 1808. Ink, graphite, and watercolor wash on paper. Library of Congress, Prints and Photographs Division.

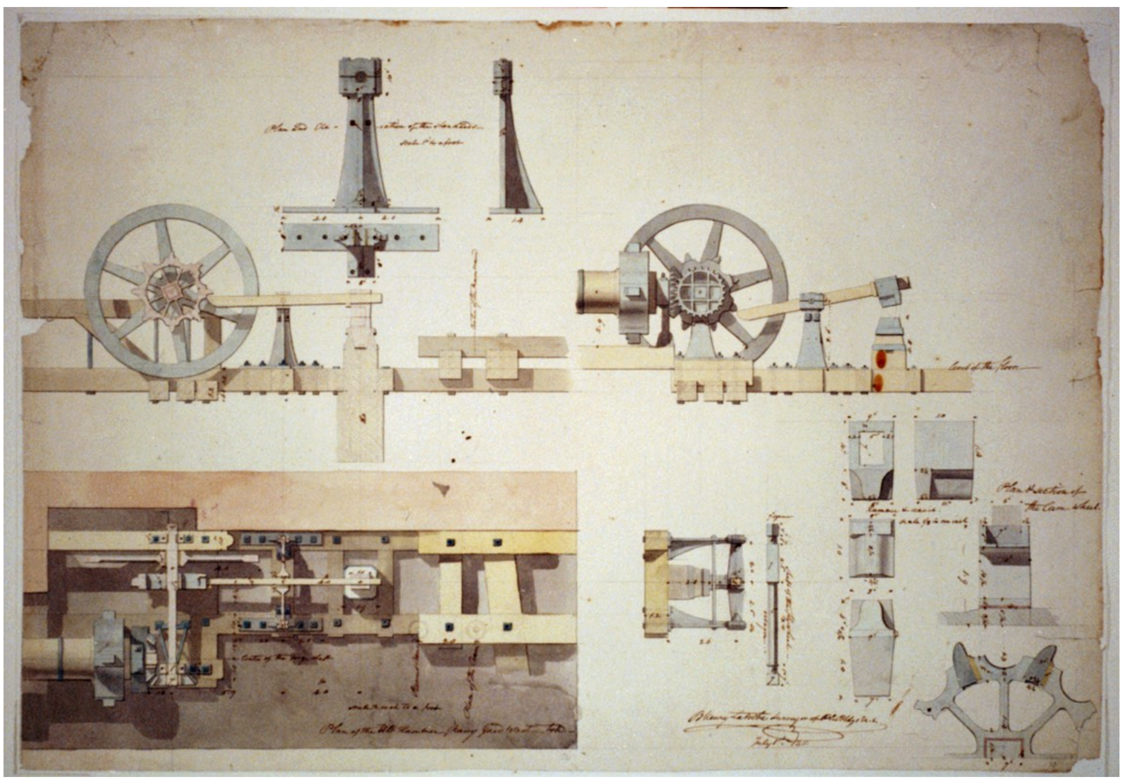


Figure 3.10 Benjamin Henry Latrobe, [steam engine, Washington Navy Yard, Washington, D.C., plan of the forge tilt hammer], September 29, 1808. Library of Congress, Prints and Photographs Division.

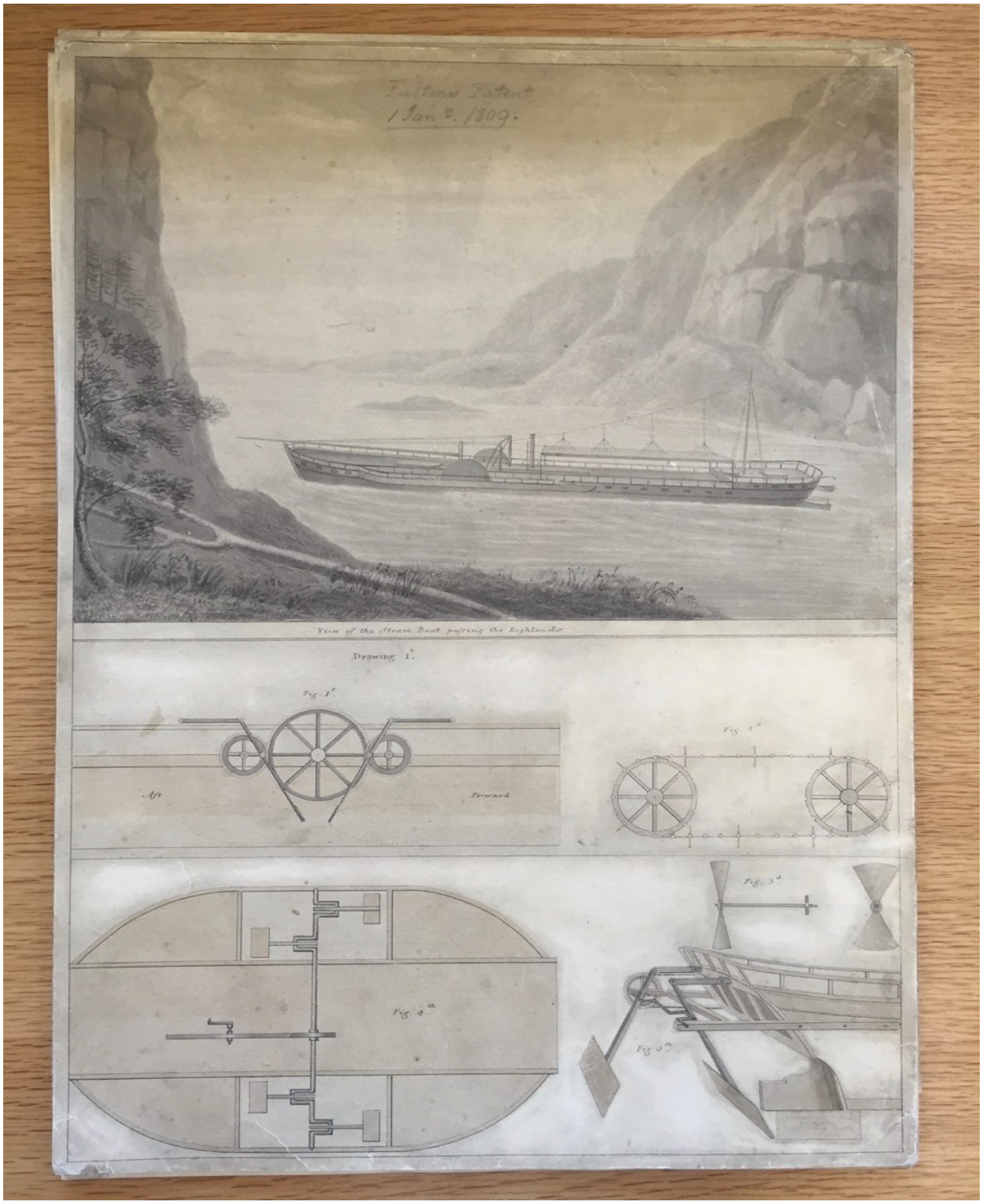


Figure 3.11 Boulton and Watt Drawing Office, page 1 of "Fulton's 1809 specification," ca. 1815. Graphite, ink, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

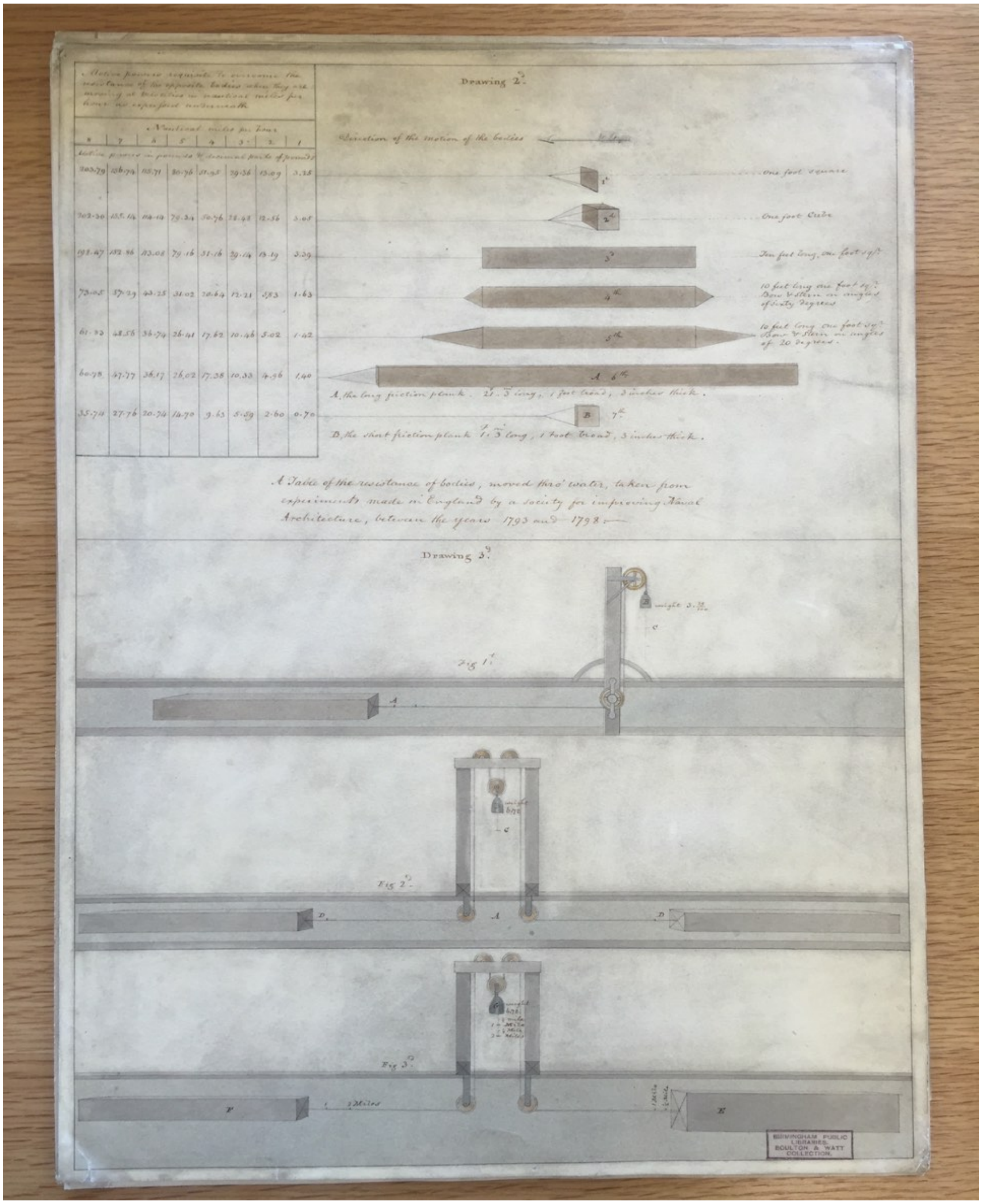


Figure 3.12 Boulton and Watt Drawing Office, page 2 of "Fulton's 1809 specification," ca. 1815. Graphite, ink, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

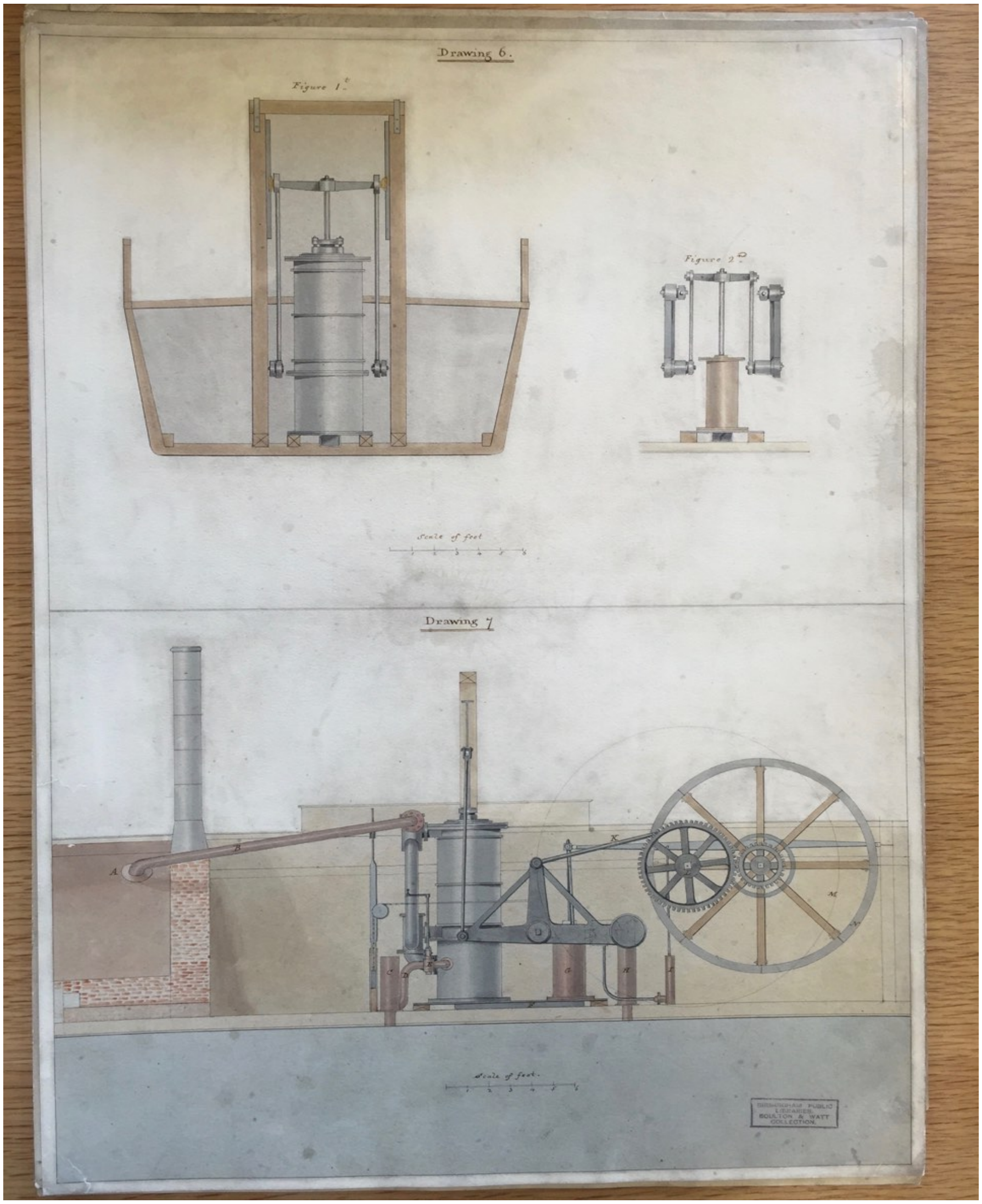


Figure 3.13 Boulton and Watt Drawing Office, page 4 of "Fulton's 1809 specification," ca. 1815. Graphite, ink, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

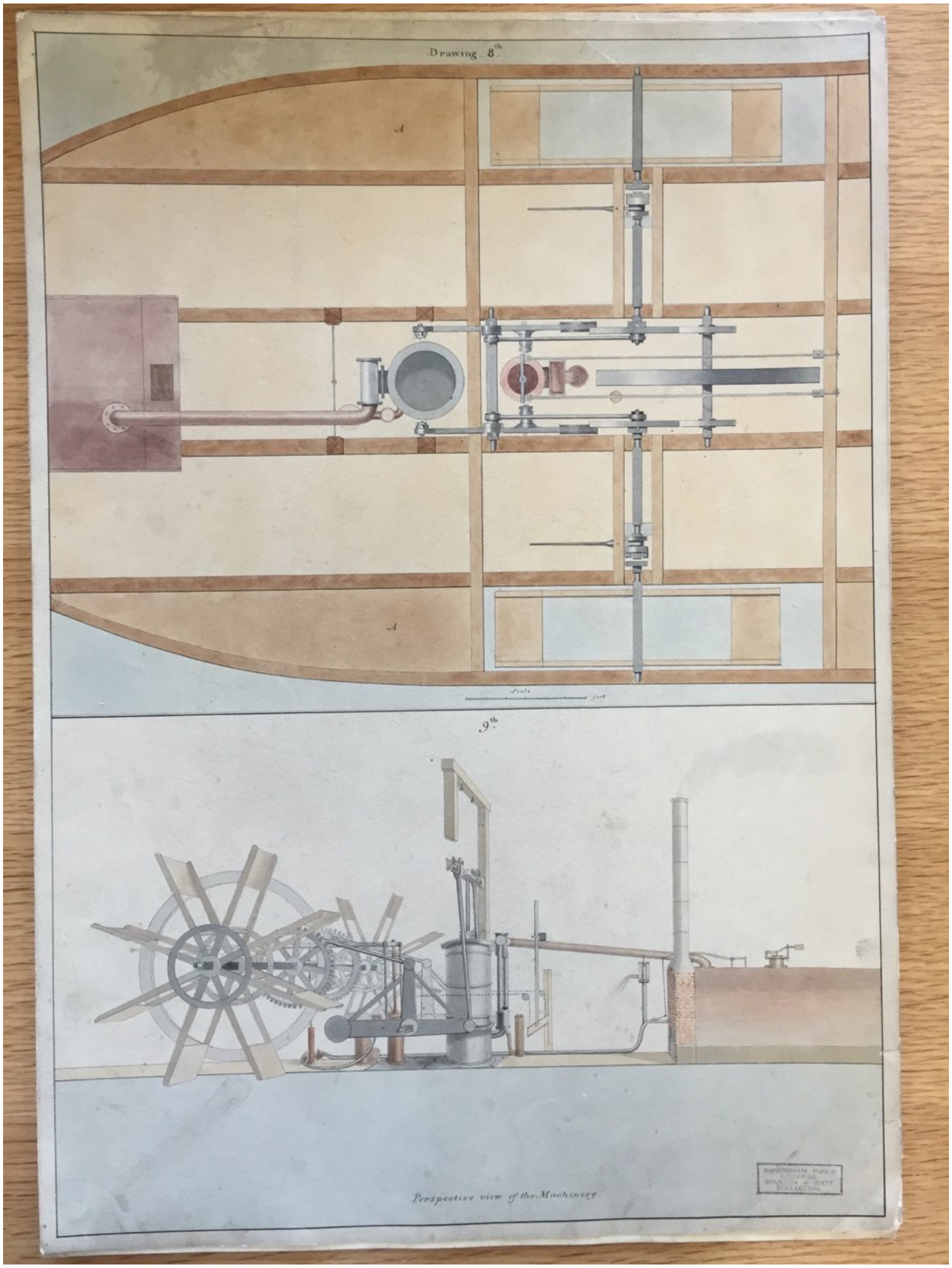


Figure 3.14 Boulton and Watt Drawing Office, page 5 of “Fulton’s 1809 specification,” ca. 1815. Graphite, ink, and watercolor wash on paper. Archives of Soho, Library of Birmingham.

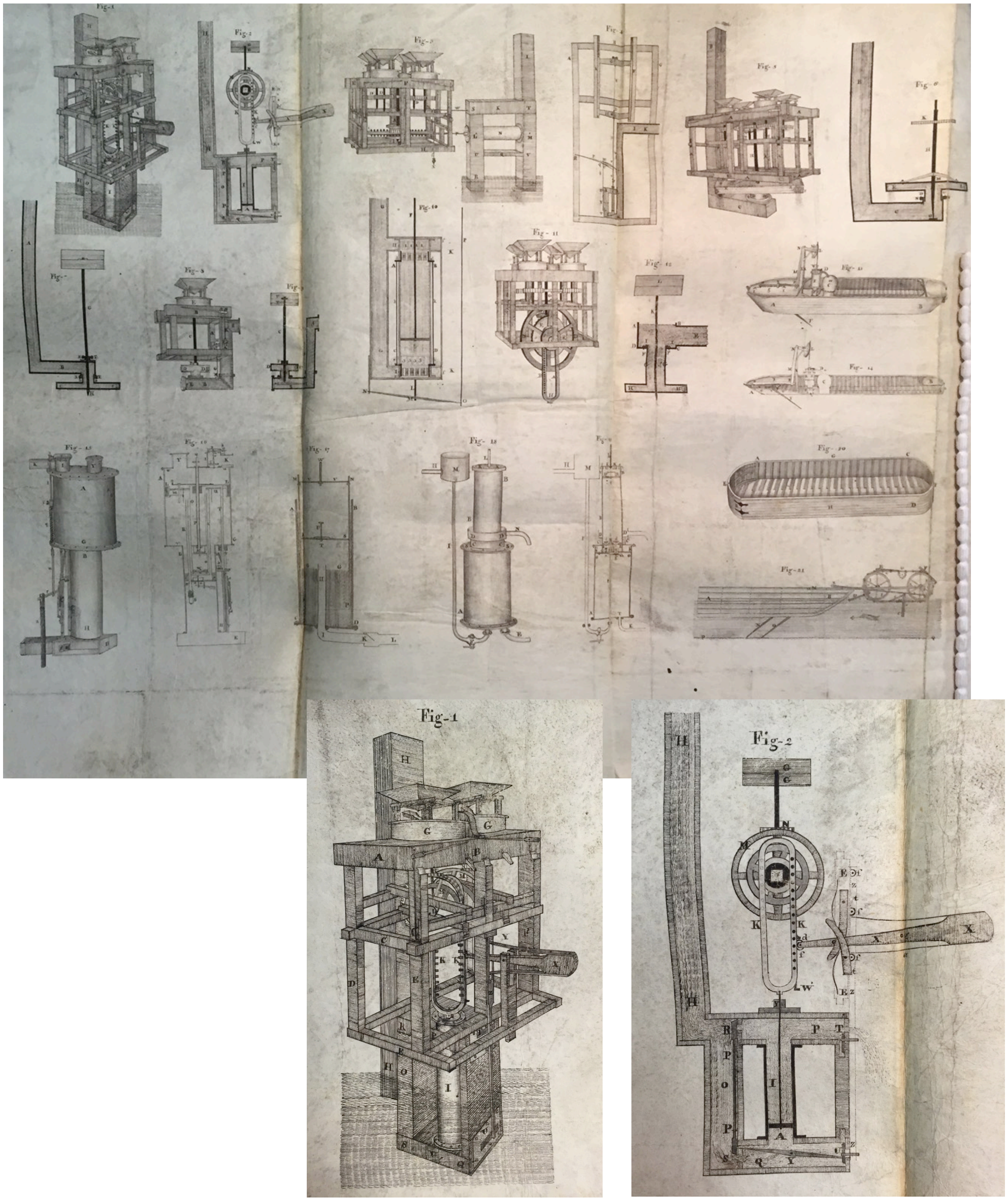
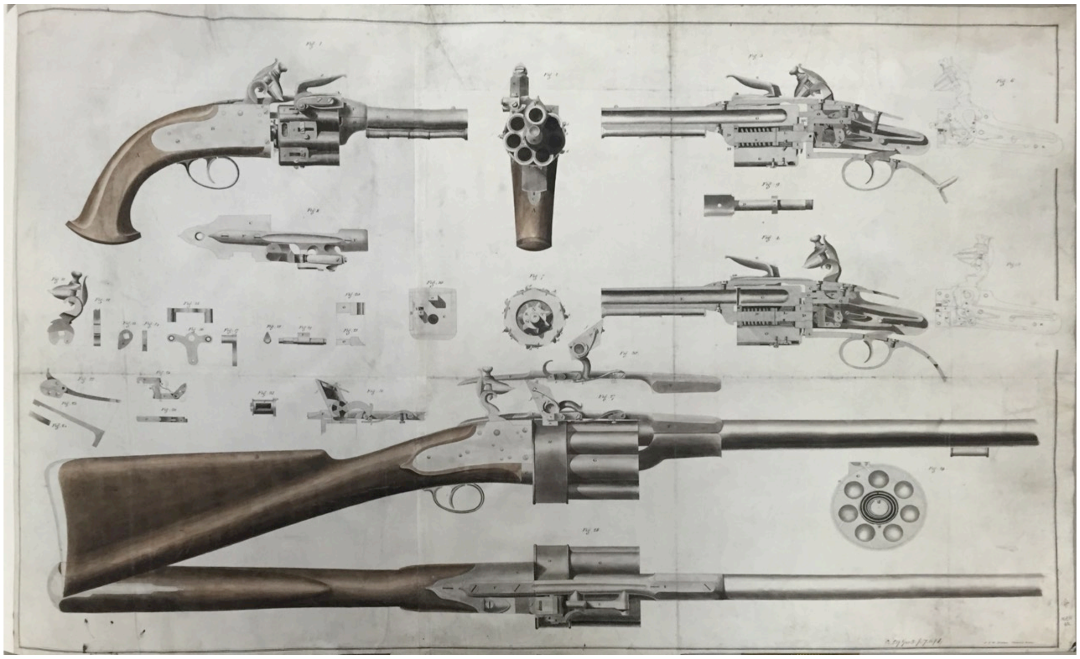


Figure 3.15 James Rumsey, [specification drawing to secure a patent on "New improved and certain methods of applying the power of water of air and of steam either separately or together…"], 1789. Ink on vellum. National Archives United Kingdom.



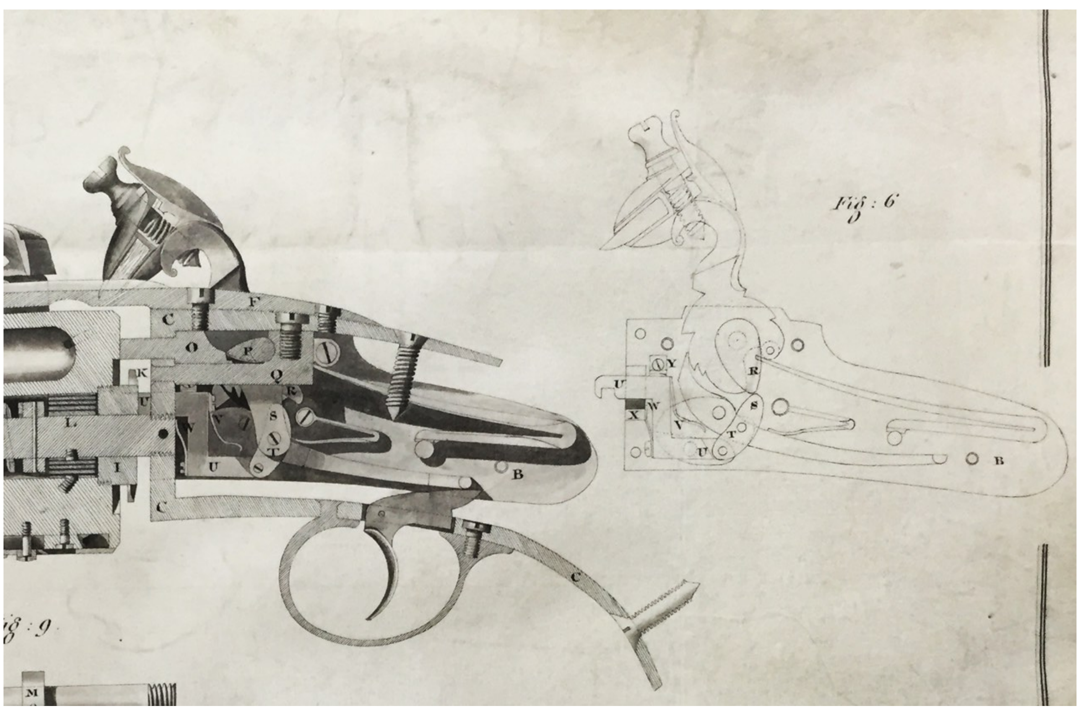


Figure 3.16 J. & W. Newton (patent agents), J. Elisha Haydon Collier (patentee), [specification drawing to secure patent on "Improvements in firearms of various descriptions"], 1819. Ink and watercolor wash on vellum. National Archives United Kingdom.

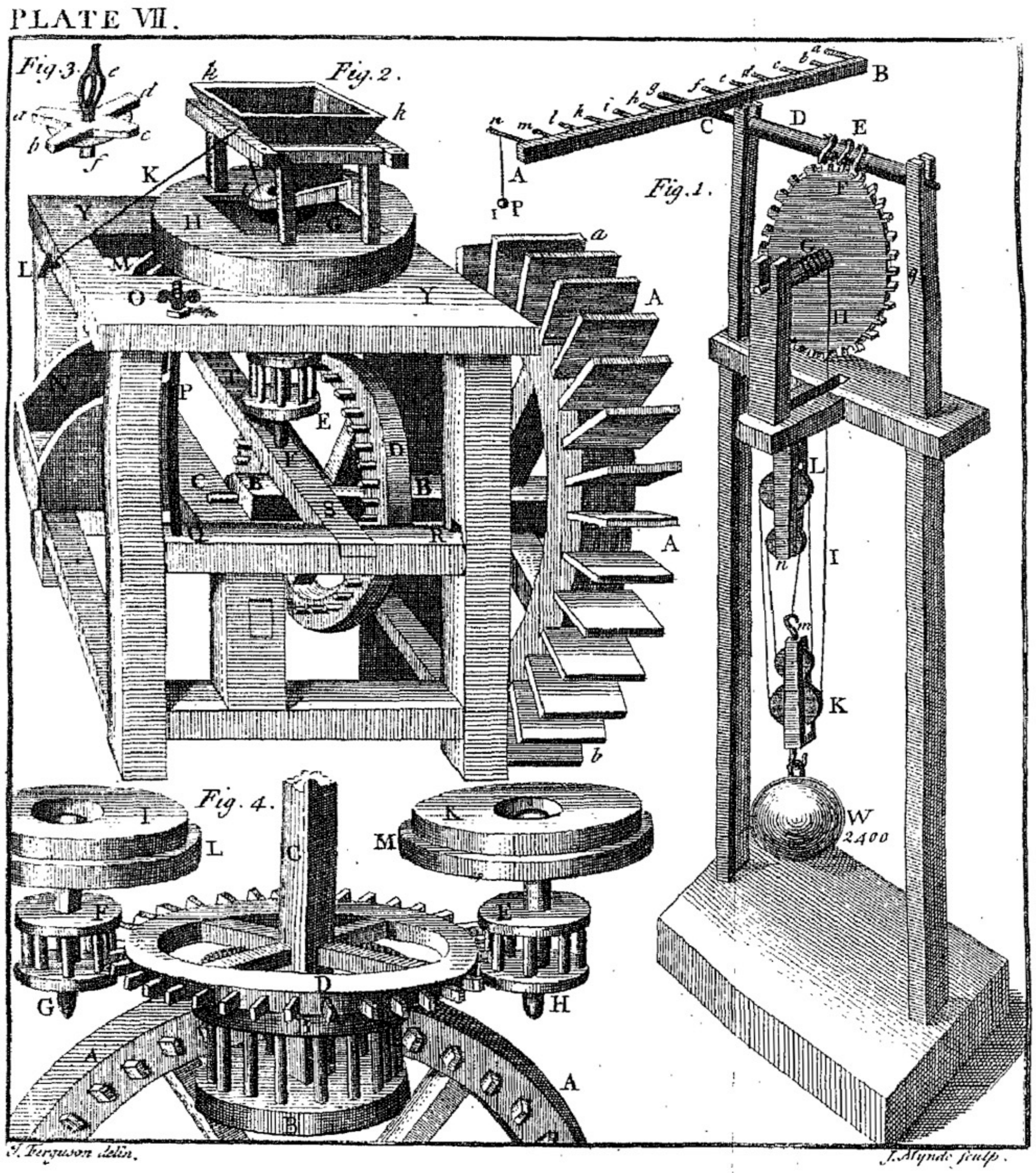


Figure 3.17 Plate VII from James Ferguson, *Lectures on Select Subjects in Mechanics, Hydrostatics, Pneumatics, and Optics*. (London: Printed for A. Millar, in the Strand, 1764).

PLATE IX.

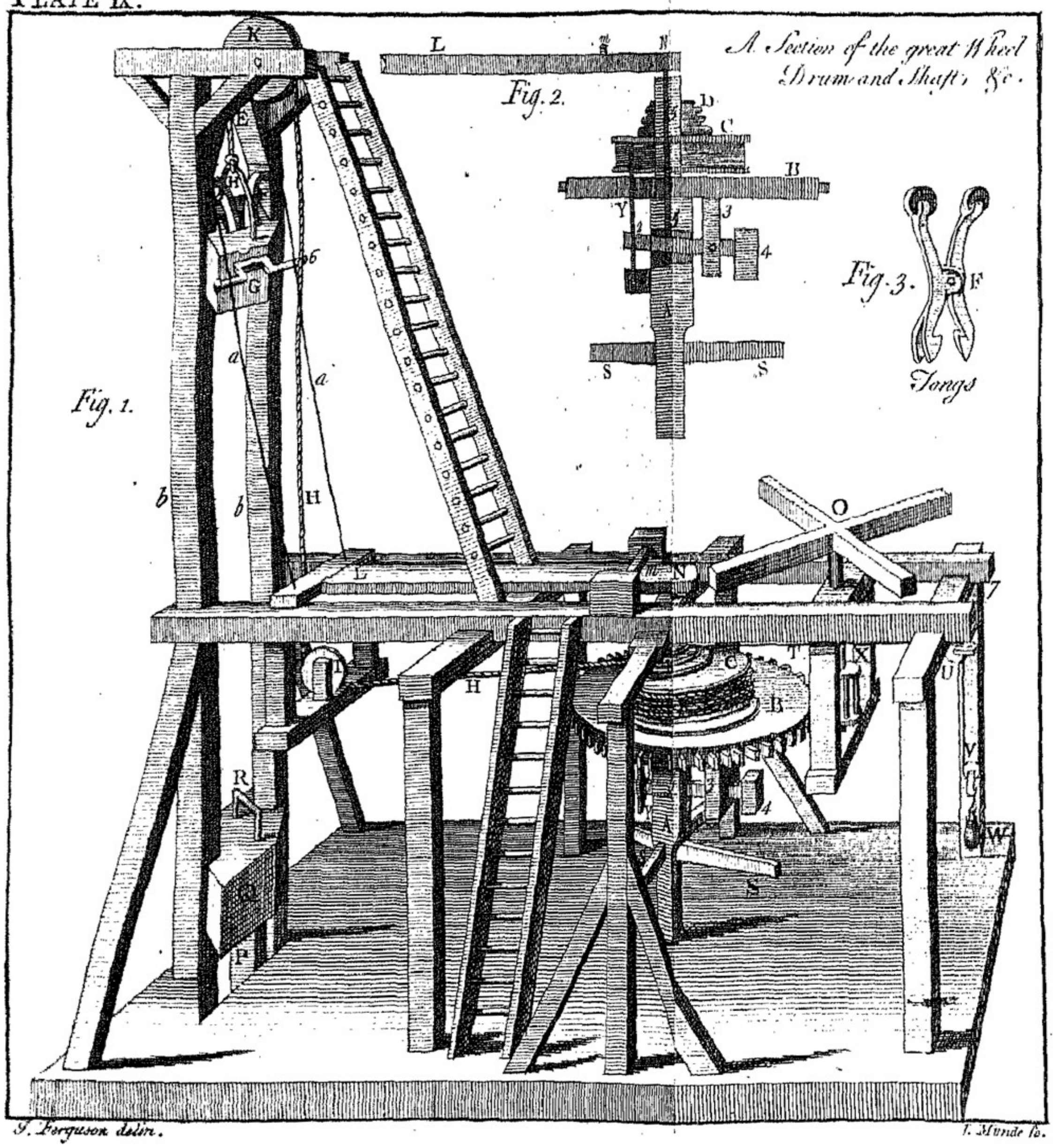


Figure 3.18 Plate IX from James Ferguson, *Lectures on Select Subjects in Mechanics, Hydrostatics, Pneumatics, and Optics*. (London: Printed for A. Millar, in the Strand, 1764).

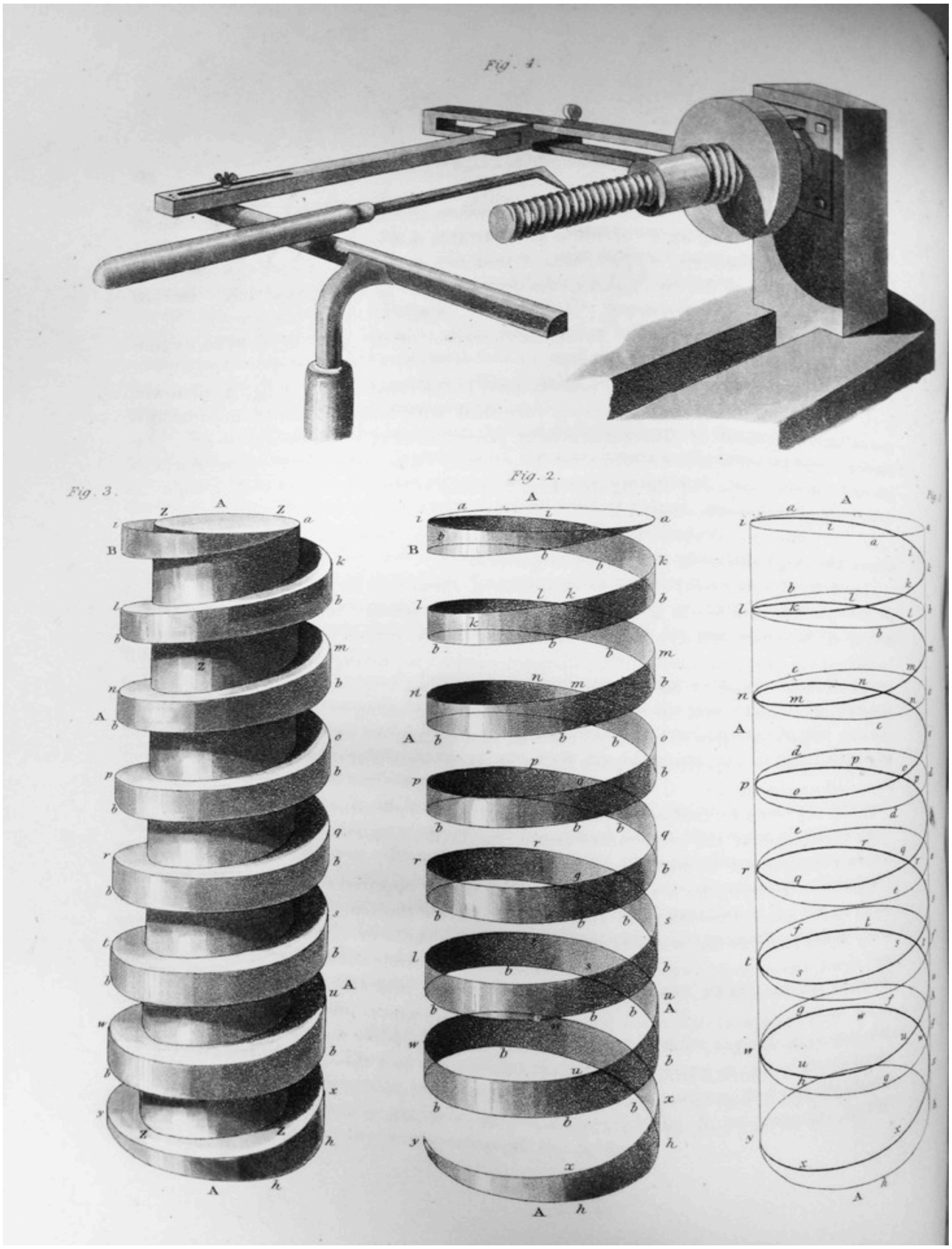


Figure 3.19 Plate 17 from Charles Blunt, *An Essay on Mechanical Drawing*. (London: Printed for R. Ackerman, 1811).

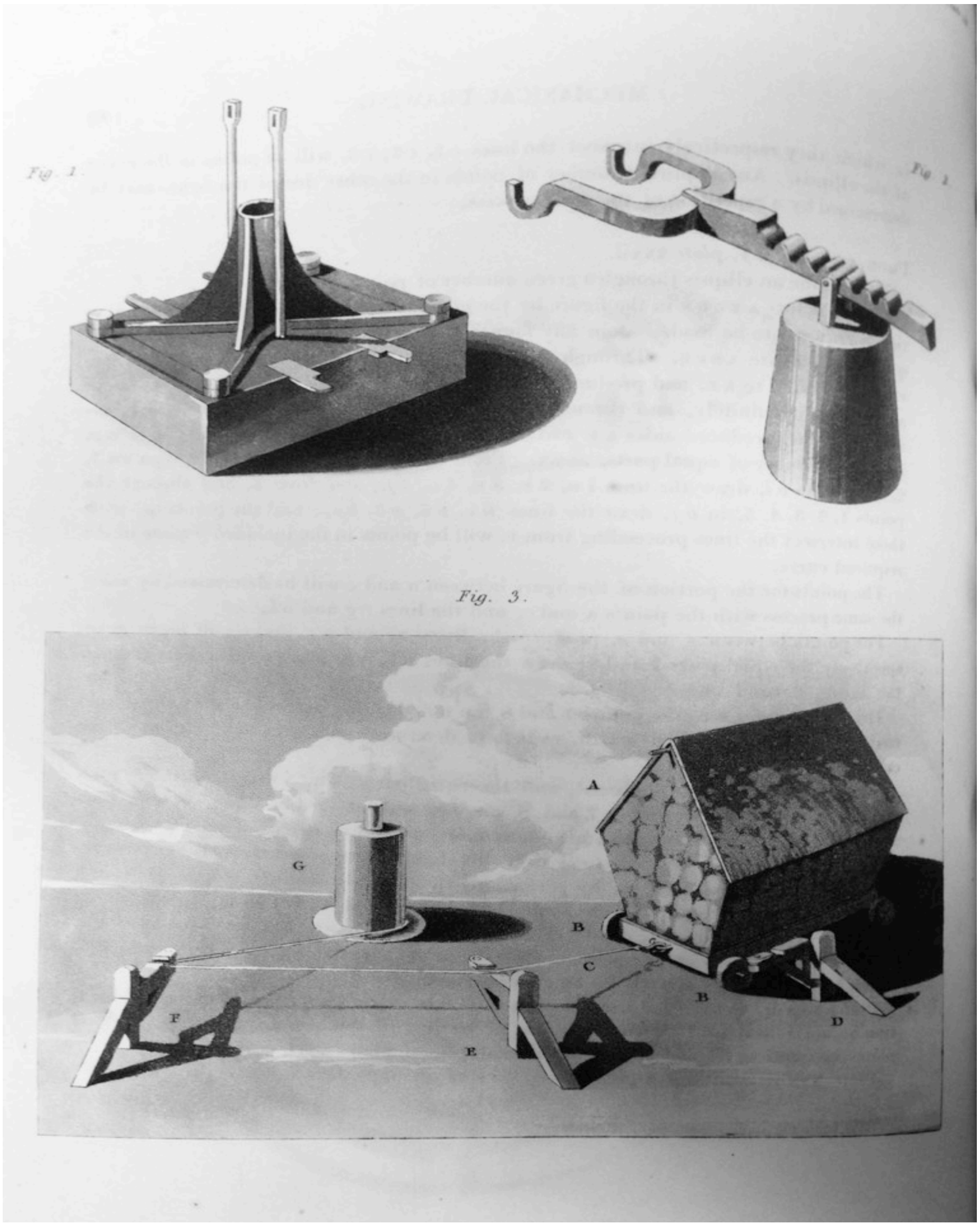
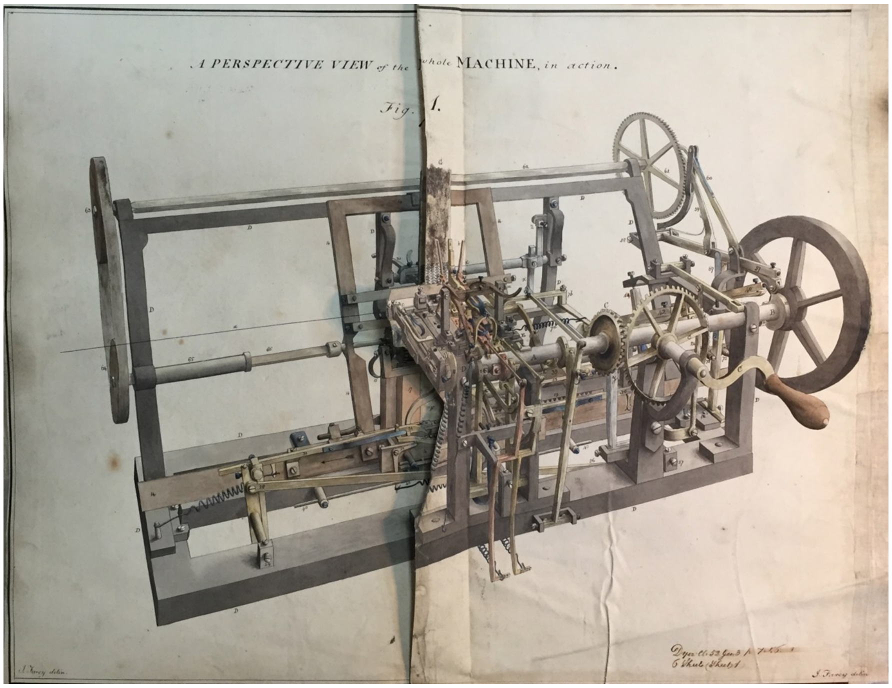


Figure 3.20 Plate 39 from Charles Blunt, *An Essay on Mechanical Drawing*. (London: Printed for R. Ackerman, 1811).



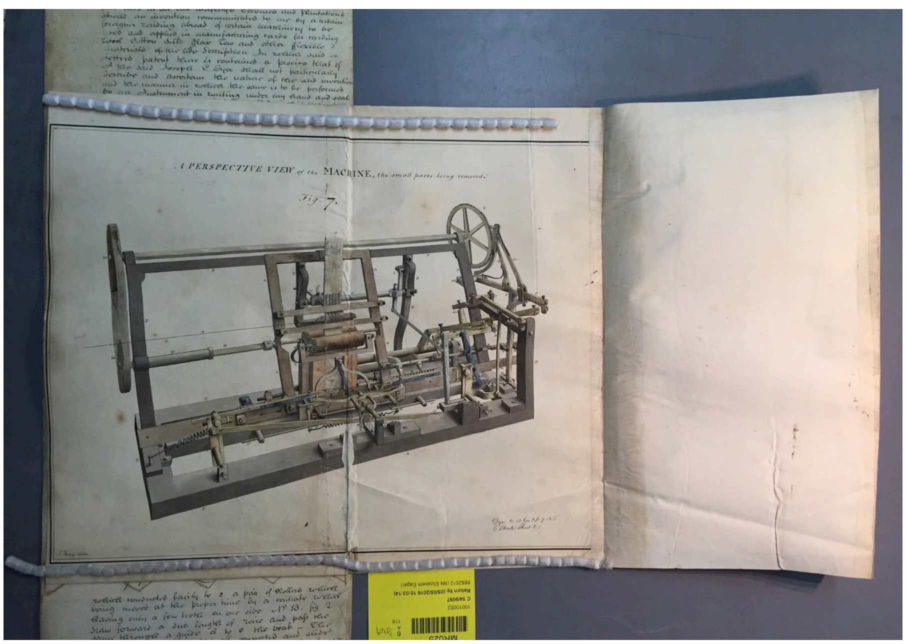


Figure 3.21 John Farey (patent agent), Joseph Chessborough Dyer (patentee), [drawing for specification to secure patent for a “Certain machinery to be used and applied in manufacturing cards”], 1811. Ink and watercolor wash on paper. National Archives United Kingdom.

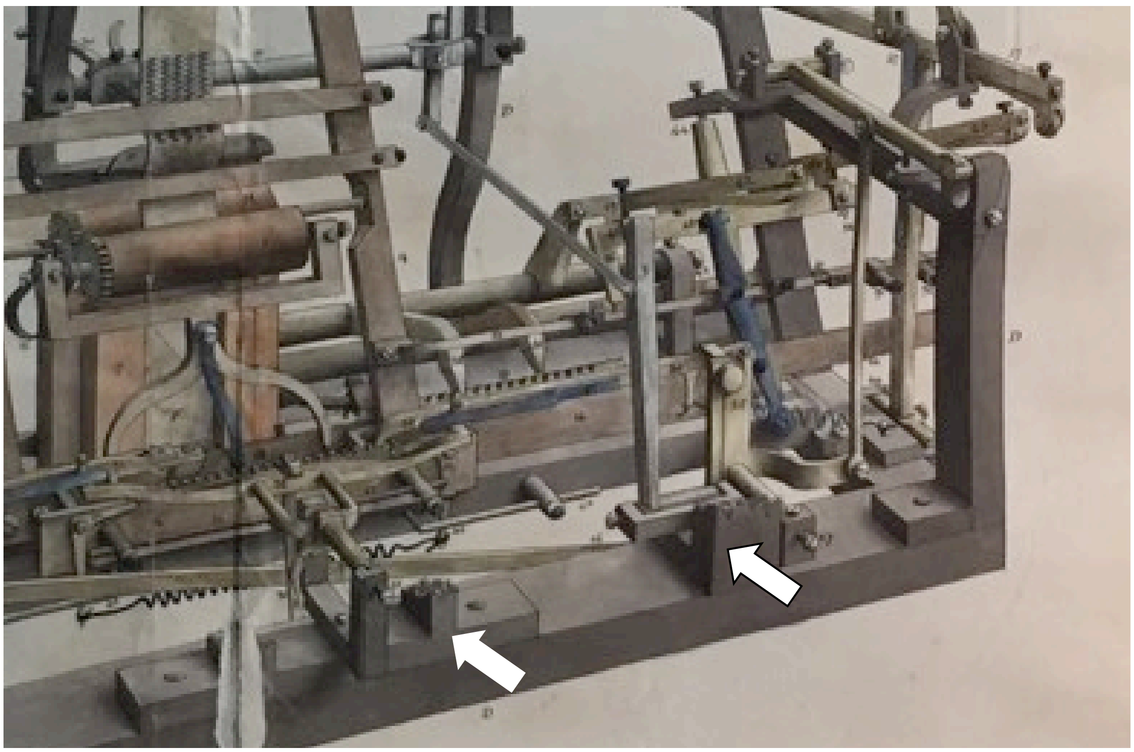


Figure 3.22 Detail. John Farey (patent agent), Joseph Chessborough Dyer (patentee), [specification drawing to secure patent for a "Certain machinery to be used and applied in manufacturing cards"], 1811. Ink and watercolor wash on paper. National Archives United Kingdom.

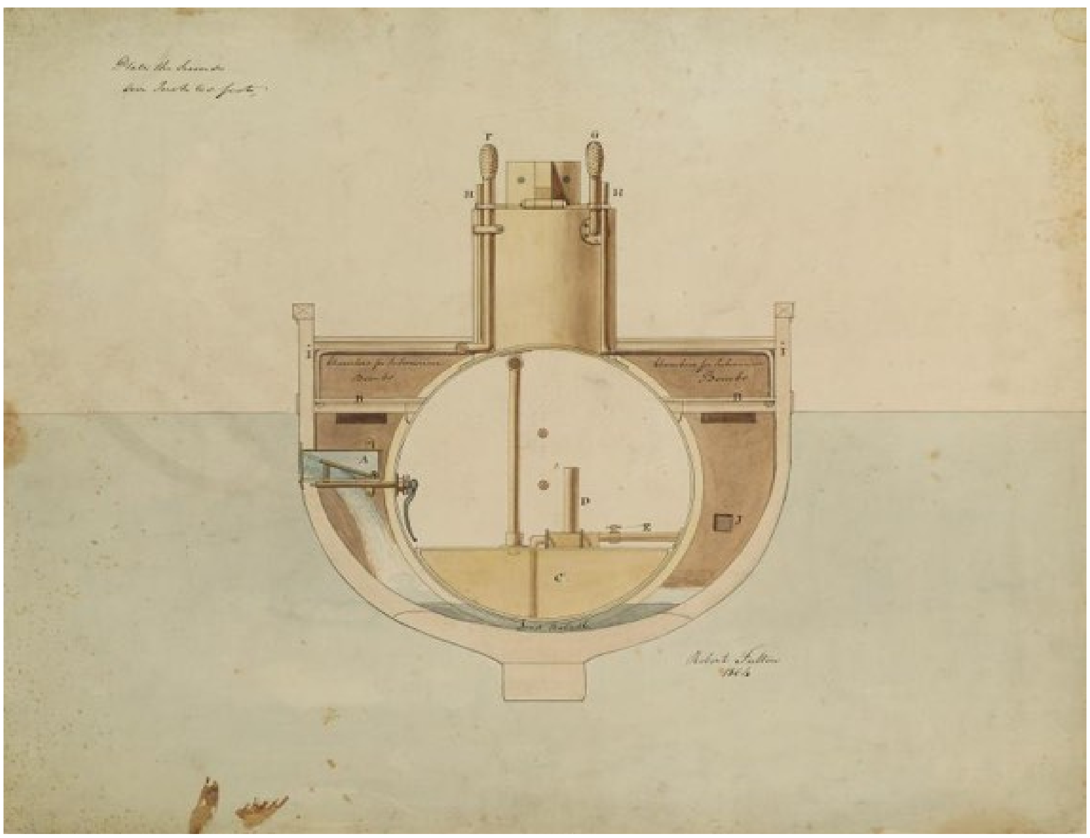


Figure 3.23 Robert Fulton, [submarine and torpedo drawings – plate 2], 1804. Ink and watercolor wash on paper. New York Public Library, William Barclay Parsons Collection of Robert Fulton Manuscripts.

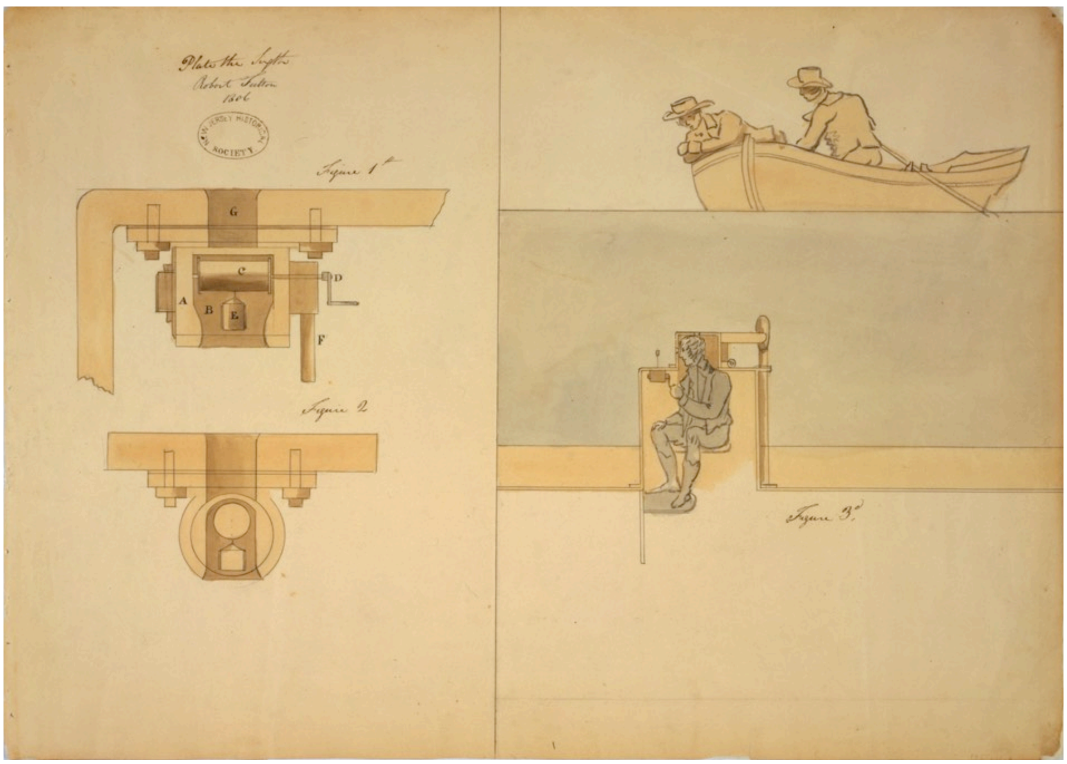


Figure 3.24 Detail. Robert Fulton, [submarine and torpedo drawings – plate 6], 1806. Ink and watercolor wash on paper. New York Public Library, William Barclay Parsons Collection of Robert Fulton Manuscripts.

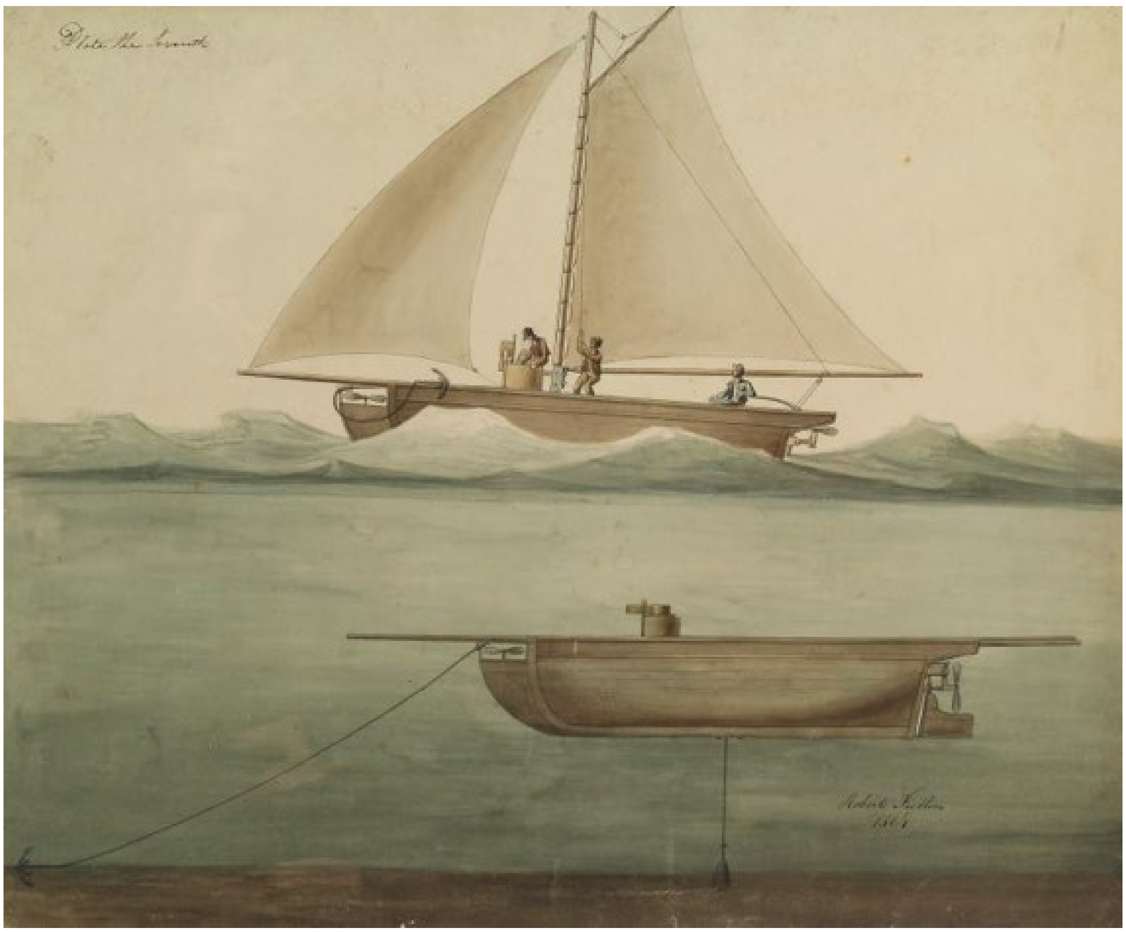


Figure 3.25 Robert Fulton, [submarine and torpedo drawings – plate 7], 1804. Ink and watercolor wash on paper. New York Public Library, William Barclay Parsons Collection of Robert Fulton Manuscripts.

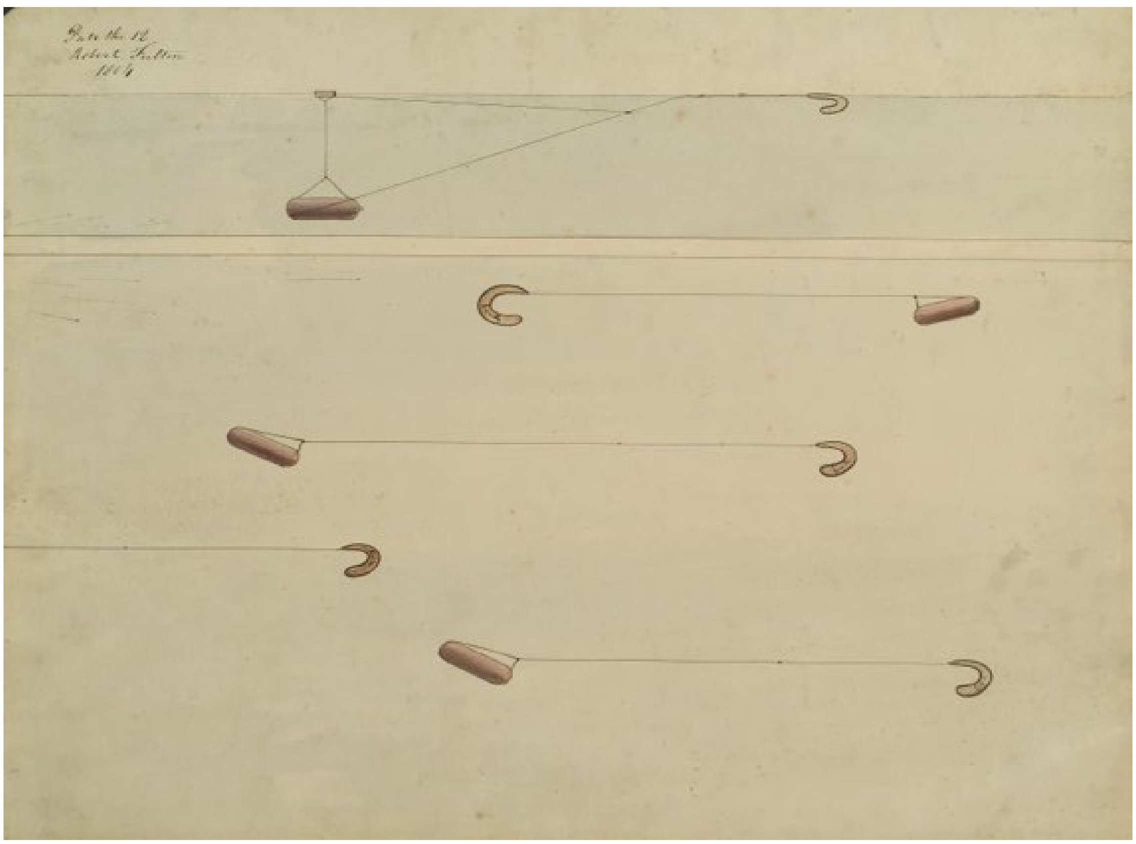


Figure 3.26 Robert Fulton, [submarine and torpedo drawings – plate 12], 1804. Ink and watercolor wash on paper. New York Public Library, William Barclay Parsons Collection of Robert Fulton Manuscripts.

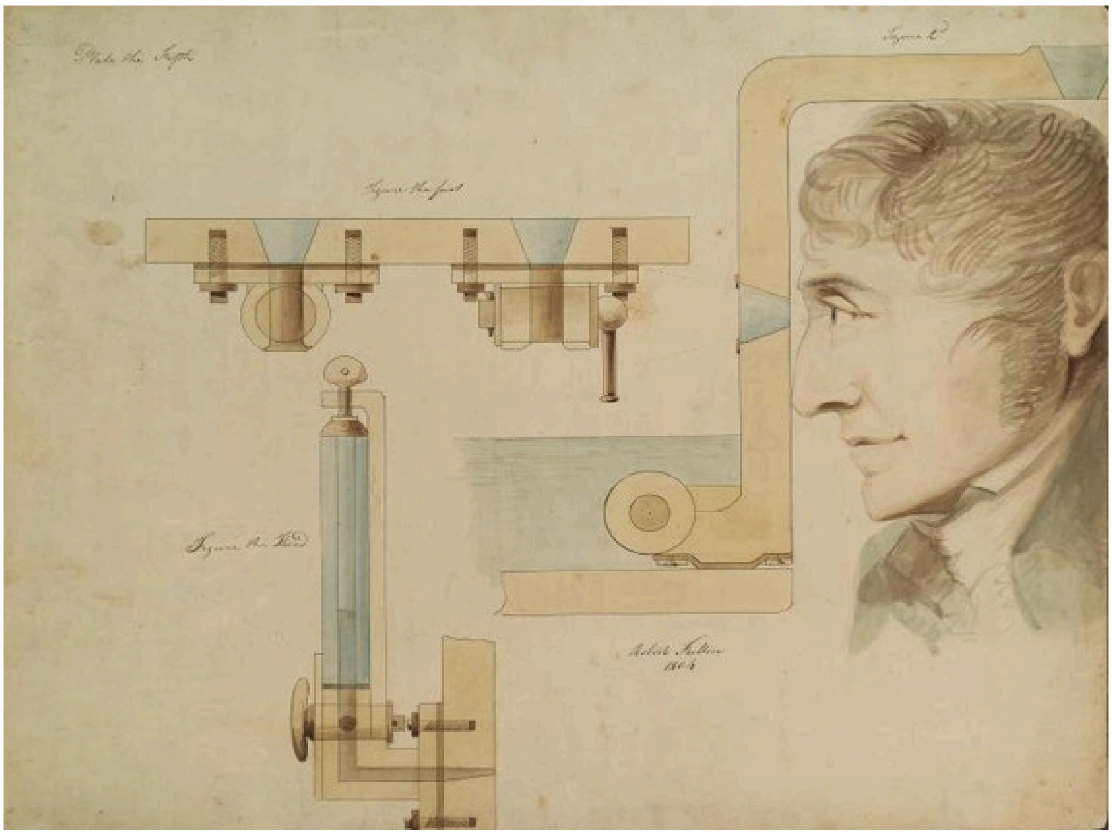


Figure 3.27 Robert Fulton, plate 5, [submarine and torpedo drawings – plate 5], 1804. Ink and watercolor wash on paper. New York Public Library, William Barclay Parsons Collection of Robert Fulton Manuscripts.

Figure 3.28 Robert Fulton, *Mrs. Manigault Heyward (Susan Hayne Simmons)*, ca. 1813. Watercolor on ivory. Metropolitan Museum of Art.

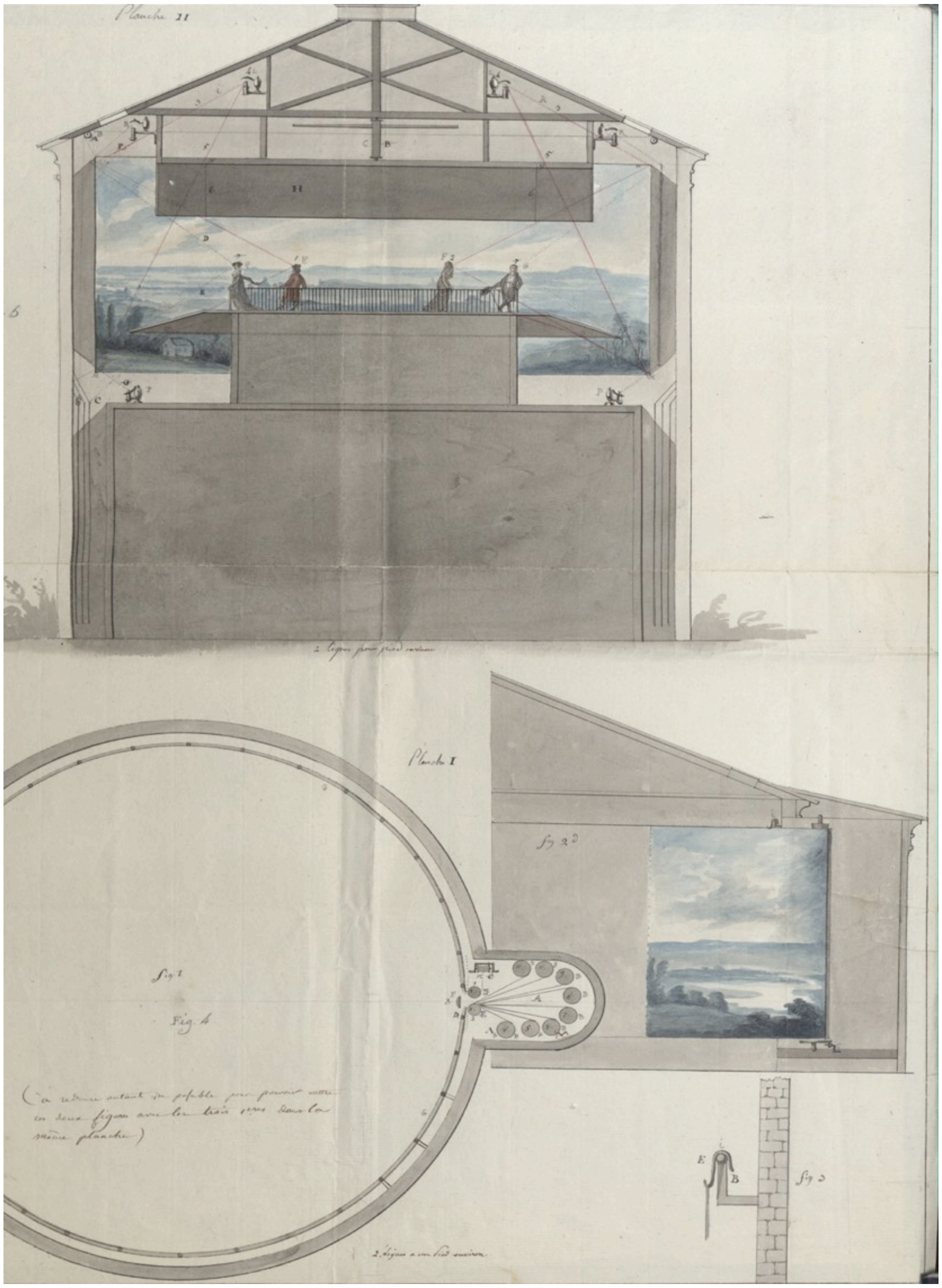


Figure 3.29 Robert Fulton, [preparatory drawings for French patent on the panorama – plate 1], 1799. Ink, graphite and watercolor on paper. Archives Institut National de la Propriété Industrielle.

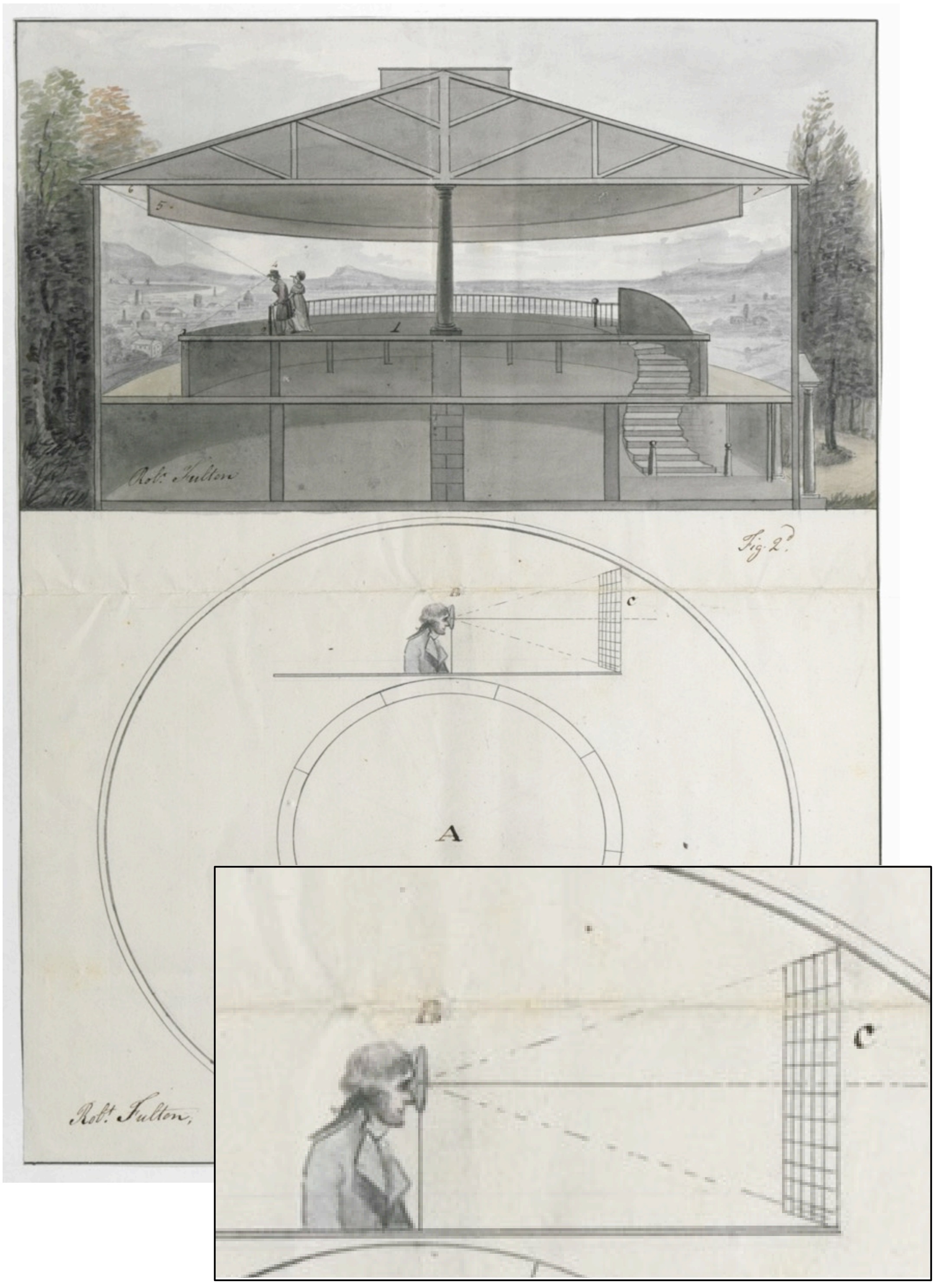


Figure 3.30 Robert Fulton, [preparatory drawings for French patent on the panorama – plate 2], 1799. Ink, graphite and watercolor on paper. Archives Institut National de la Propriété Industrielle.

Figure 3.31 Mason Chamberlin, *Portrait of Benjamin Franklin*, 1762. Oil on canvas. Philadelphia Museum of Art.

Figure 3.32 Benjamin West, *Benjamin Franklin Drawing Electricity from the Sky,* ca. 1816. Oil on slate, Philadelphia Museum of Art.

Figure 3.33 Details. Benjamin West, *Robert Fulton*, 1806. Oil on canvas. Fenimore Art Museum.

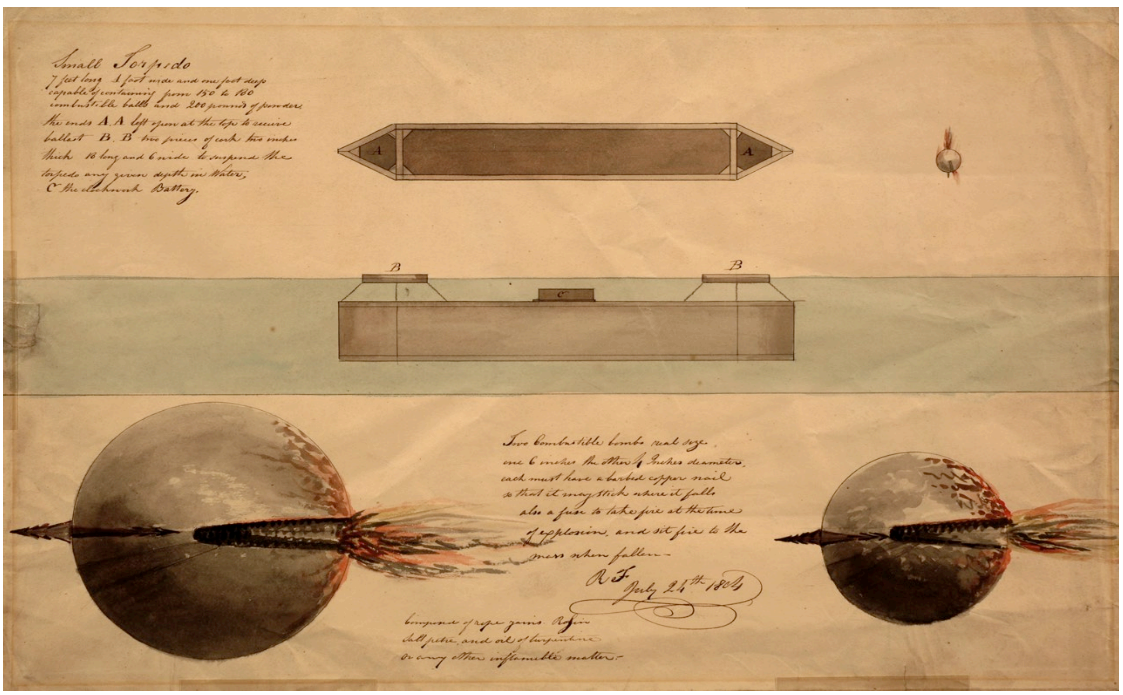


Figure 3.34 Robert Fulton, [small torpedo], July 24, 1804. Ink and wash. Lehigh University Libraries, Special Collections.

Figure 3.35 Philip James de Loutherbourg, *Coalbrookdale by Night*, 1801. Oil on canvas. Science Museum, London.

Figure 3.36 John Sell Cotman, *Bedlam Furnace (In the Black Country)*, ca. 1802-1803. Watercolor. Private collection.

Figure 3.37 James Ward (engraver) after Robert Fulton, *Lady Jane Grey the Night Before Her Execution*, 1793. Engraving. Metropolitan Museum of Art.

Figure 3.38 James Ward (engraver) after Robert Fulton, *Mary Queen of Scotts, Under Confinement*, 1793. Engraving. Metropolitan Museum of Art.

Figure 3.39 Joseph Wright of Derby, *Iron Forge*, 1772. Oil on canvas. Tate Britain.

Figure 4.1 Charles-Balthazar-Julien Févret de Saint-Mémin, *George Washington*, ca. 1800. Black and white chalk on paper. Library of Congress, Prints and Photographs Division.

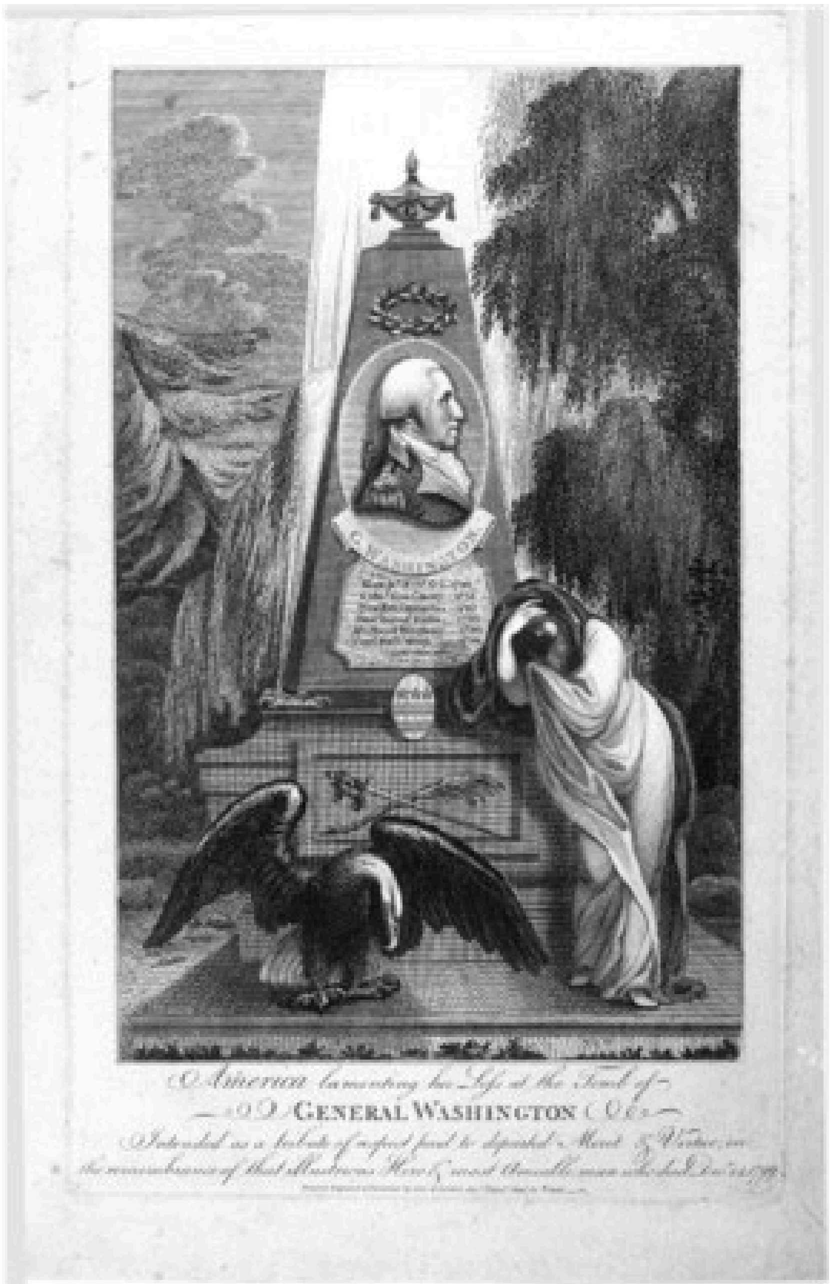


Figure 4.2 James Akin and William Harrison, Jr., *American Lamenting Her Loss at the Tomb of General Washington*, 1800. Engraving. Historical Society of Pennsylvania.

Figure 4.3 Samuel Folwell and Ann Elizabeth Folwell, [Memorial to George Washington, "Sacred to the Memory of the Illustrious Washington"], ca. 1805. Silk, ink, and paint on silk. Colonial Williamsburg.

Figure 4.4 Pitcher, [“Washington in Glory,”], 1800-1820. Creamware. The National Museum of American History.

Figure 4.5 John James Barralet, *Apotheosis of Washington*, 1800-1802. Engraving and etching. Metropolitan Museum of Art.

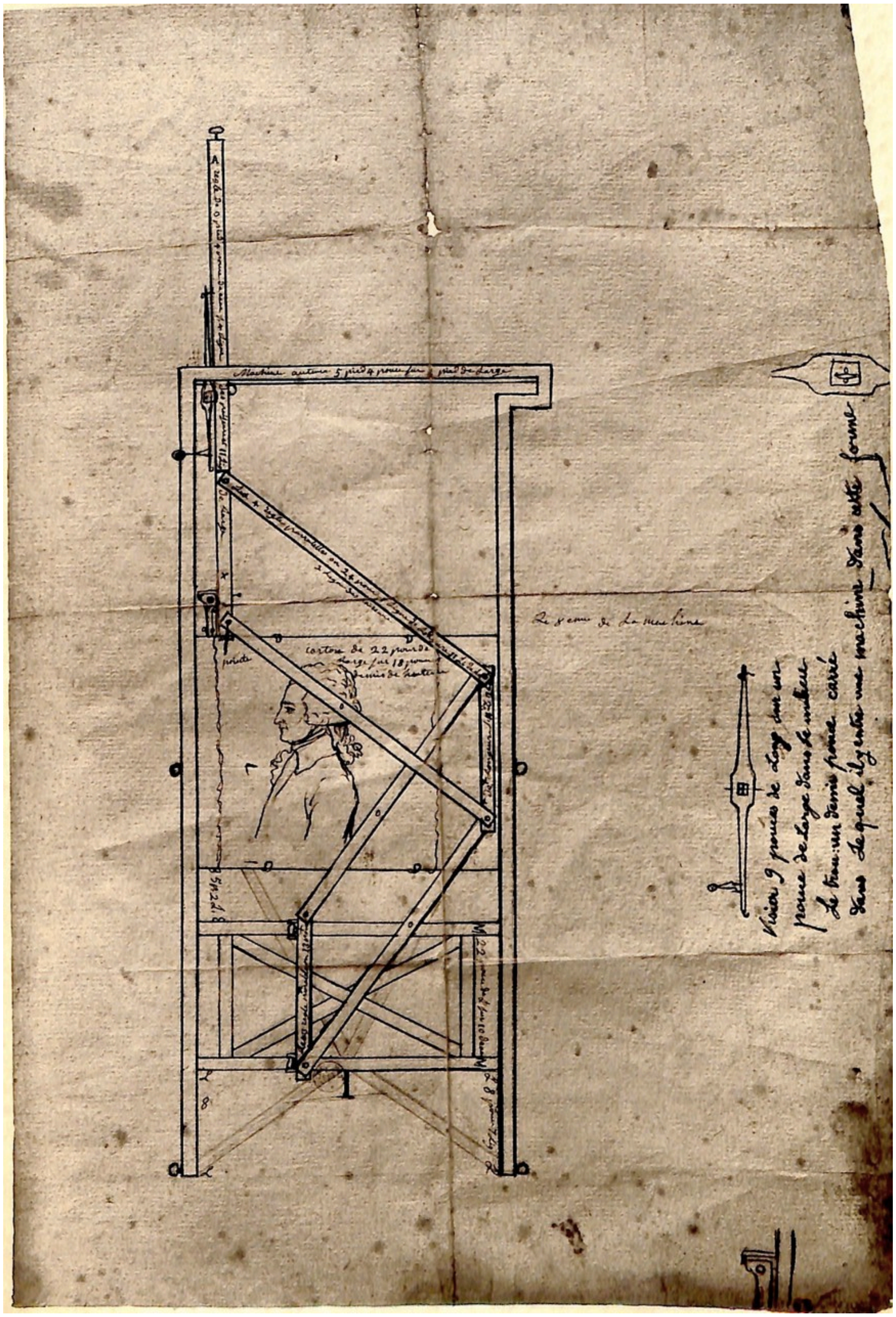


Figure 4.6 Edme Quenedey, diagram for the “physionotrace,” ca. 1786. Ink on paper. Bibliothèque National de France.

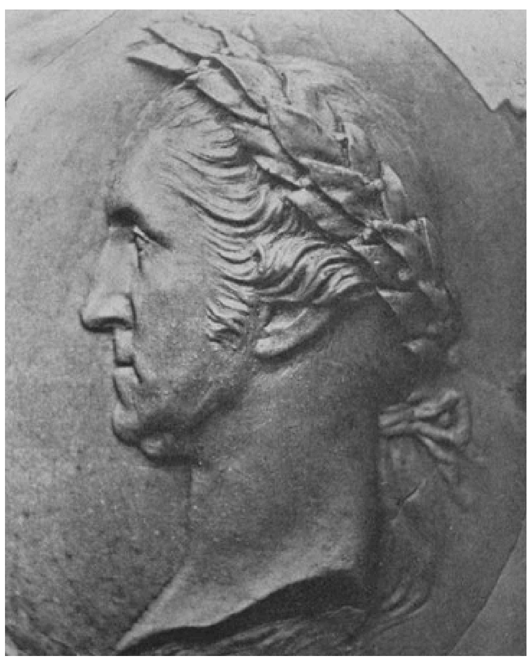


Figure 4.7 Joseph Wright, (above) *George Washington*, ca. 1784-1785. Plaster. Private collection; (below) *George Washington*, ca. 1784-1785. Wax. Private collection.

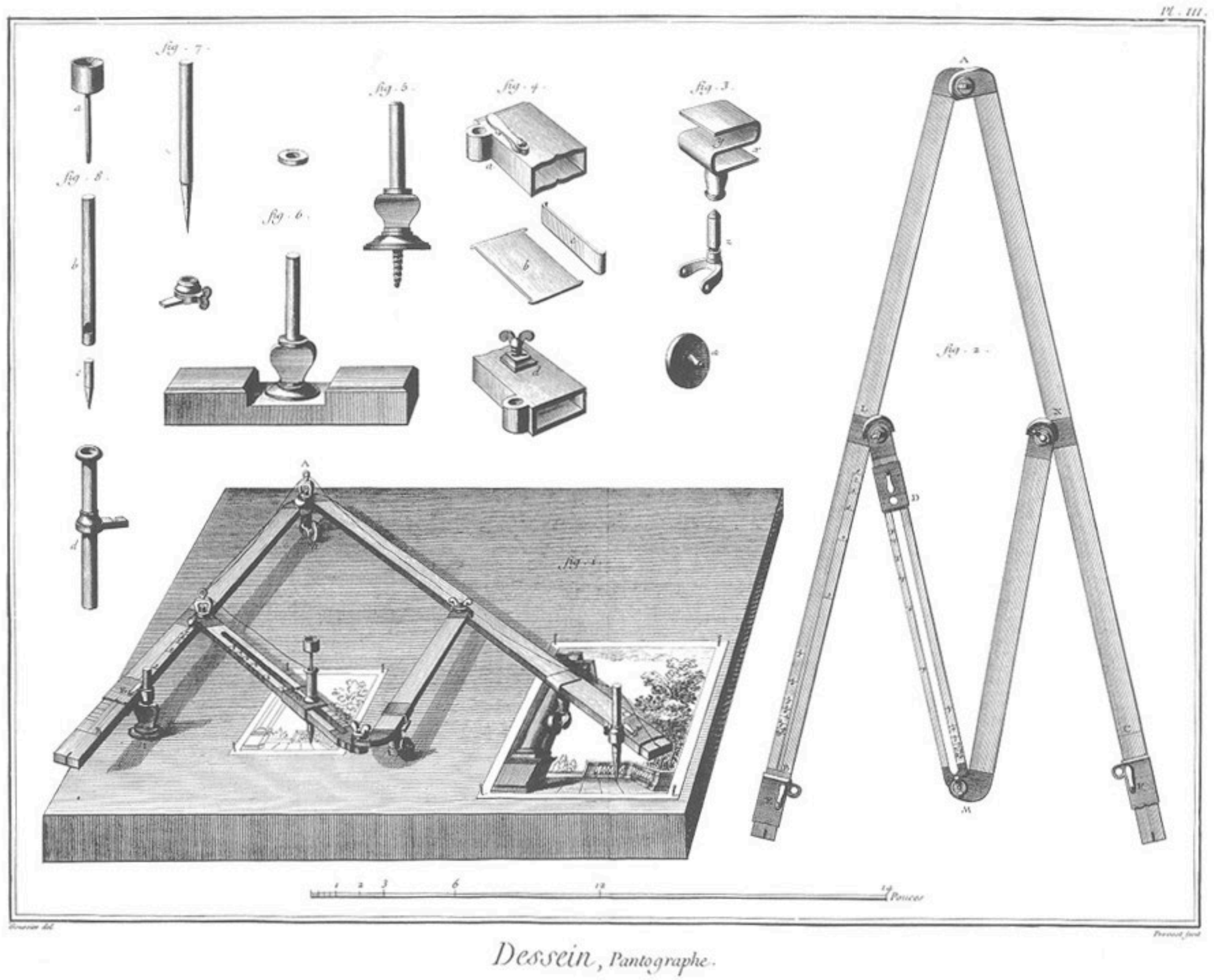


Figure 4.8 “Dessein, pantographe,” plate III of “Dessein,” in Denis Diderot and Jean le Rond d’Alembert, eds., *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.,* vol. 3 (plates). (Paris: Briasson, David, Le Breton, & Durand, 1763).

Figure 4.9 Gilles-Louis Chrétien, *William Richardson Davie*, 1800. Graphite and chalk on paper. University of North Carolina at Chapel Hill, Wilson Library, North Carolina Collection.

Figure 4.10 “A Sure and Convenient Machine for Drawing Silhouettes” from Johann Caspar Lavater, *The Whole Works of Lavater on Physiognomy*. (London: Printed for W. Butters, [1800?]).

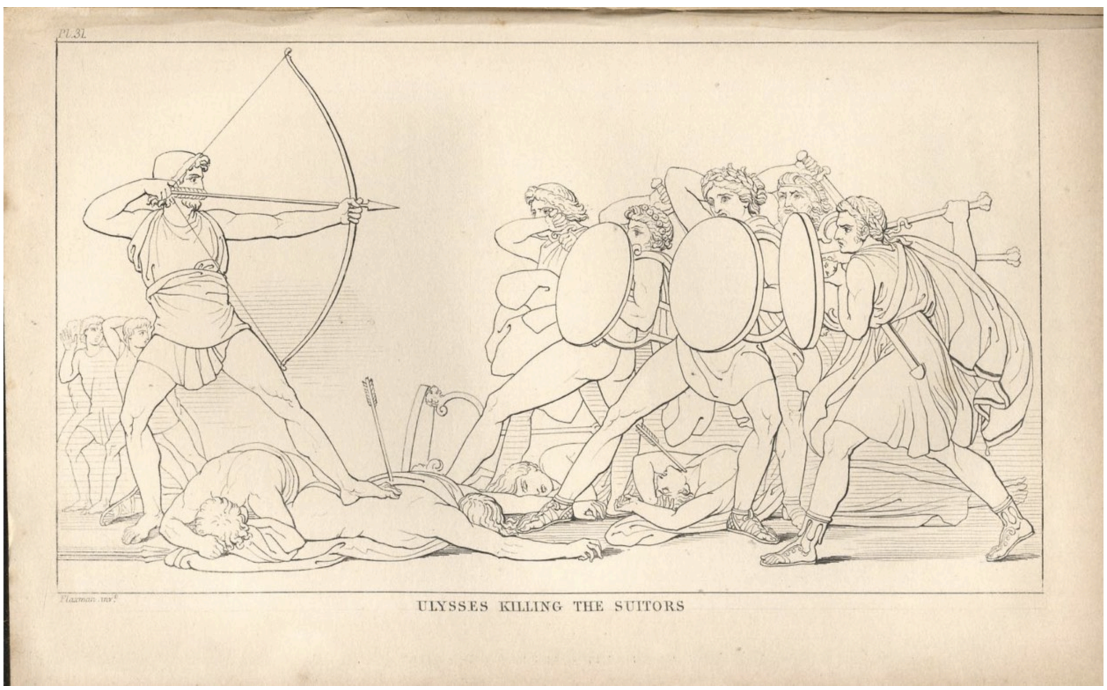


Figure 4.11 John Flaxman, "Ulysses Killing the Suitors" from *The Odyssey of Homer* (London: Longman, Hurst, Rees & Orme, 1805). Tate Museum.

Figure 4.12 Plates LXXVII & LXXIX from Johann Kaspar Lavater, *Essays on Physiognomy*, 8th edition. (London: William Tegg and Co., 1853).

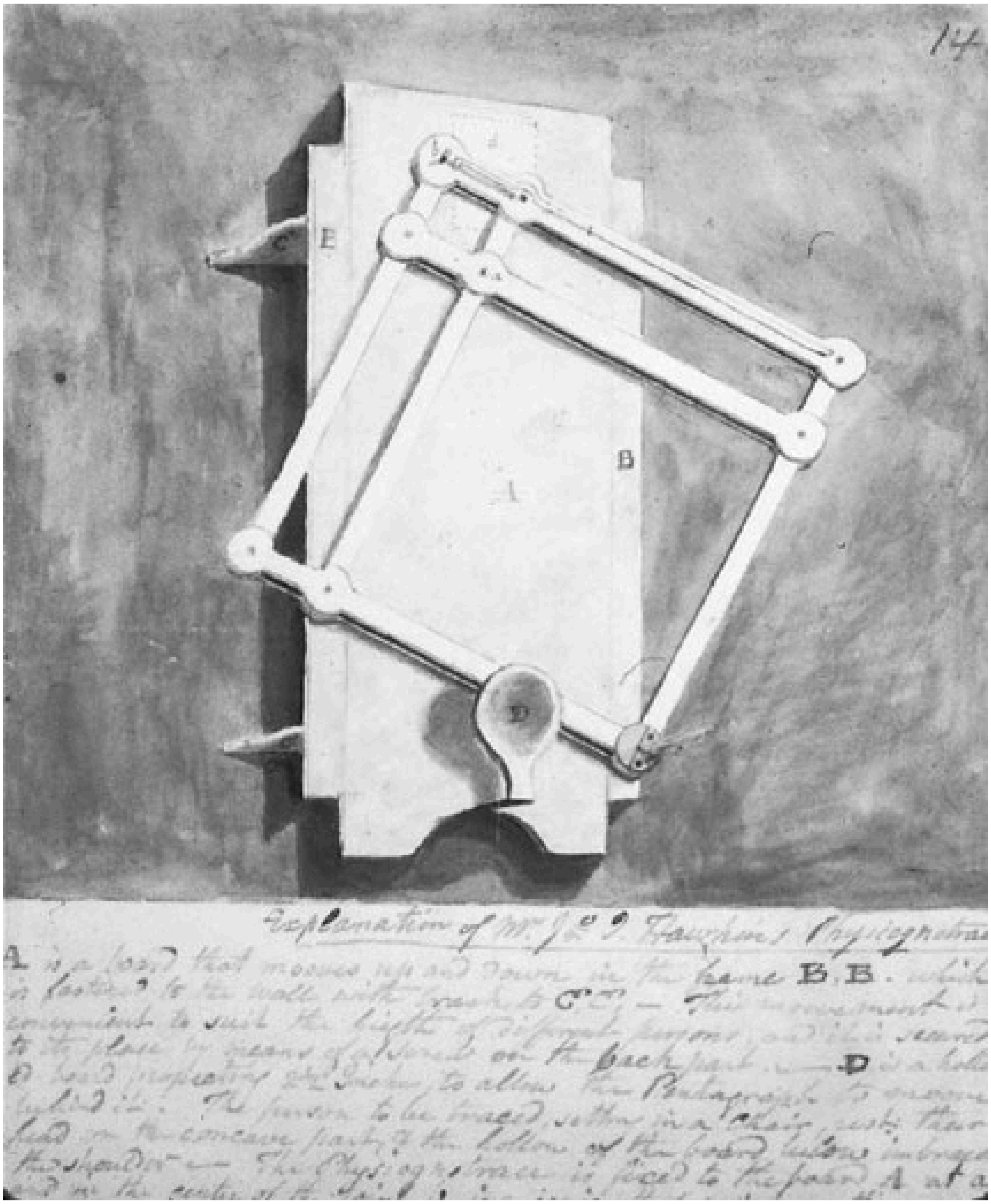
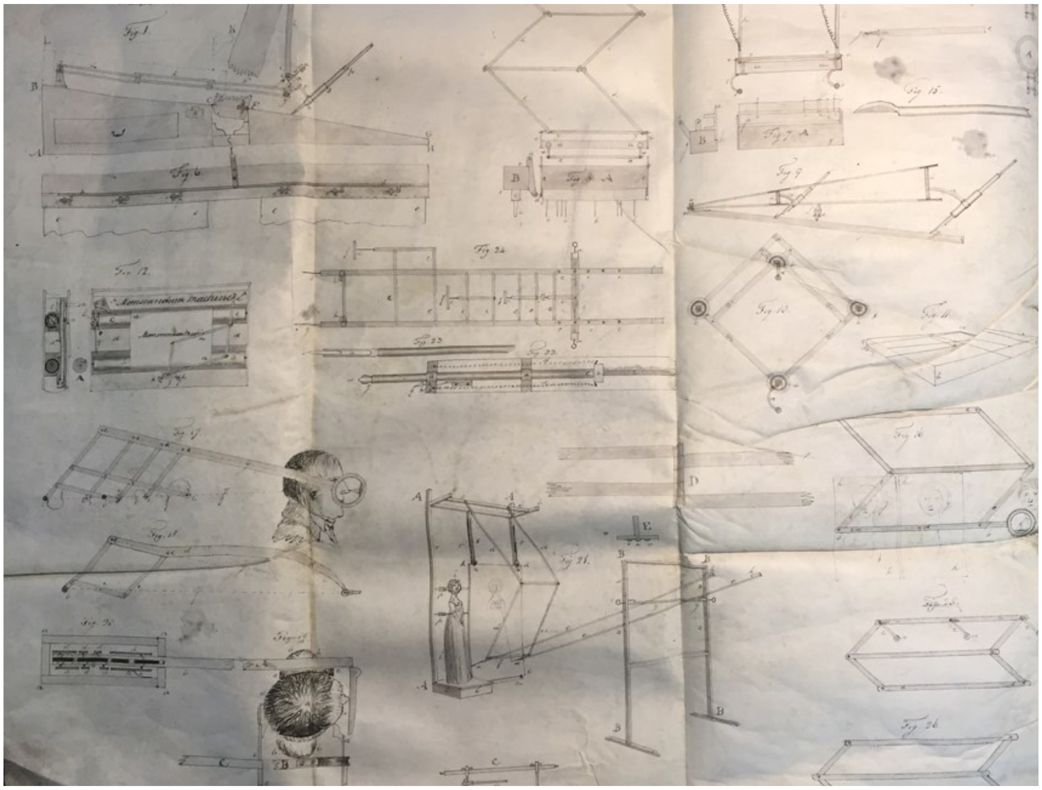


Figure 4.13 Charles Willson Peale to Thomas Jefferson [enclosed drawing, John Isaac Hawkins's physiognotrace], January 28, 1803. Thomas Jefferson Papers, Library of Congress.



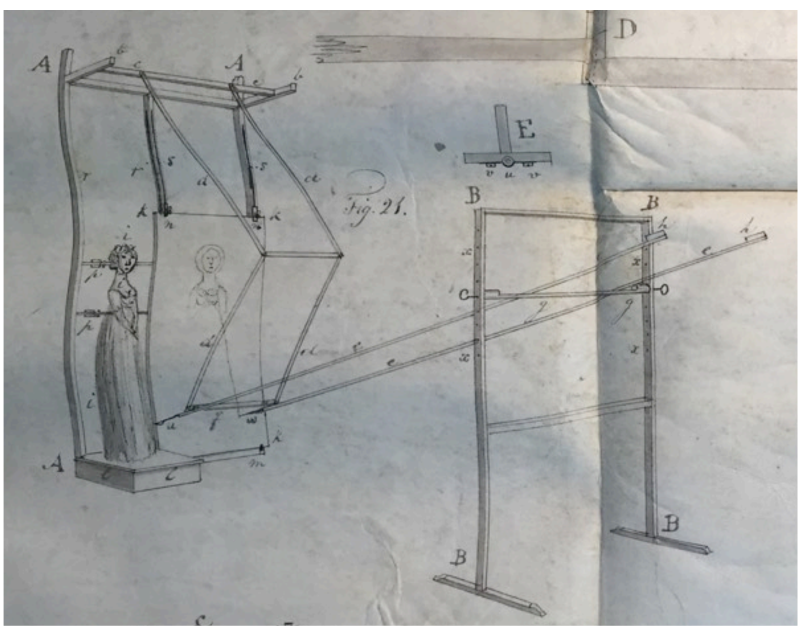


Figure 4.14 John Isaac Hawkins, [specification drawing to pursue a patent on “new Machinhery for Writing, painting Drawing ruling lines and other things…”], September 24, 1803. Ink and wash on vellum. National Archives United Kingdom.

Figure 4.15 Charles-Balthazar-Julien Févret de Saint-Mémin, *Les Trois Graces*, date unknown. Graphite and ink on wove paper. Musée des Beaux Arts Dijon.

Figure 4.16 Charles-Balthazar-Julien Févret de Saint-Mémin. [Unititled study], date unknown. Red chalk on wove paper. Musée des Beaux Arts Dijon.

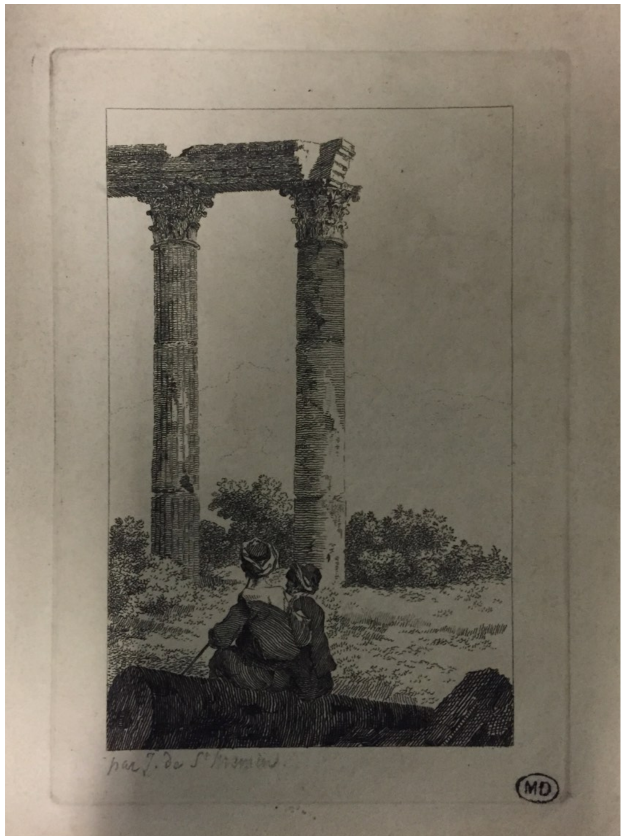


Figure 4.17 Examples of Saint-Mémin’s engraving. Charles-Balthazar-Julien Févret de Saint-Mémin (engraver), Peter Mourgeon (printer), 1793-1796. Engraving and etching. Musée des Beaux Arts, Dijon.

Figure 4.18 Thomas Bluget de Valdenuit. [Portrait of a Man], c. 1796. Pencil, black chalk, and wash, heightened with white on paper. Private collection.

Figure 4.19 Charles-Balthazar-Julien Févret de Saint-Mémin, *Paul Wheelock*, 1798-1803. Black chalk heightened with white on pink prepared paper. Museum of Fine Arts, Boston.

Figure 4.20 Charles-Balthazar-Julien Févret de Saint-Mémin, *John Adams*, 1800-1801. Conté crayon, charcoal (?), and white-chalk heightening on off-white laid paper coated with gouache. Metropolitan Museum of Art.

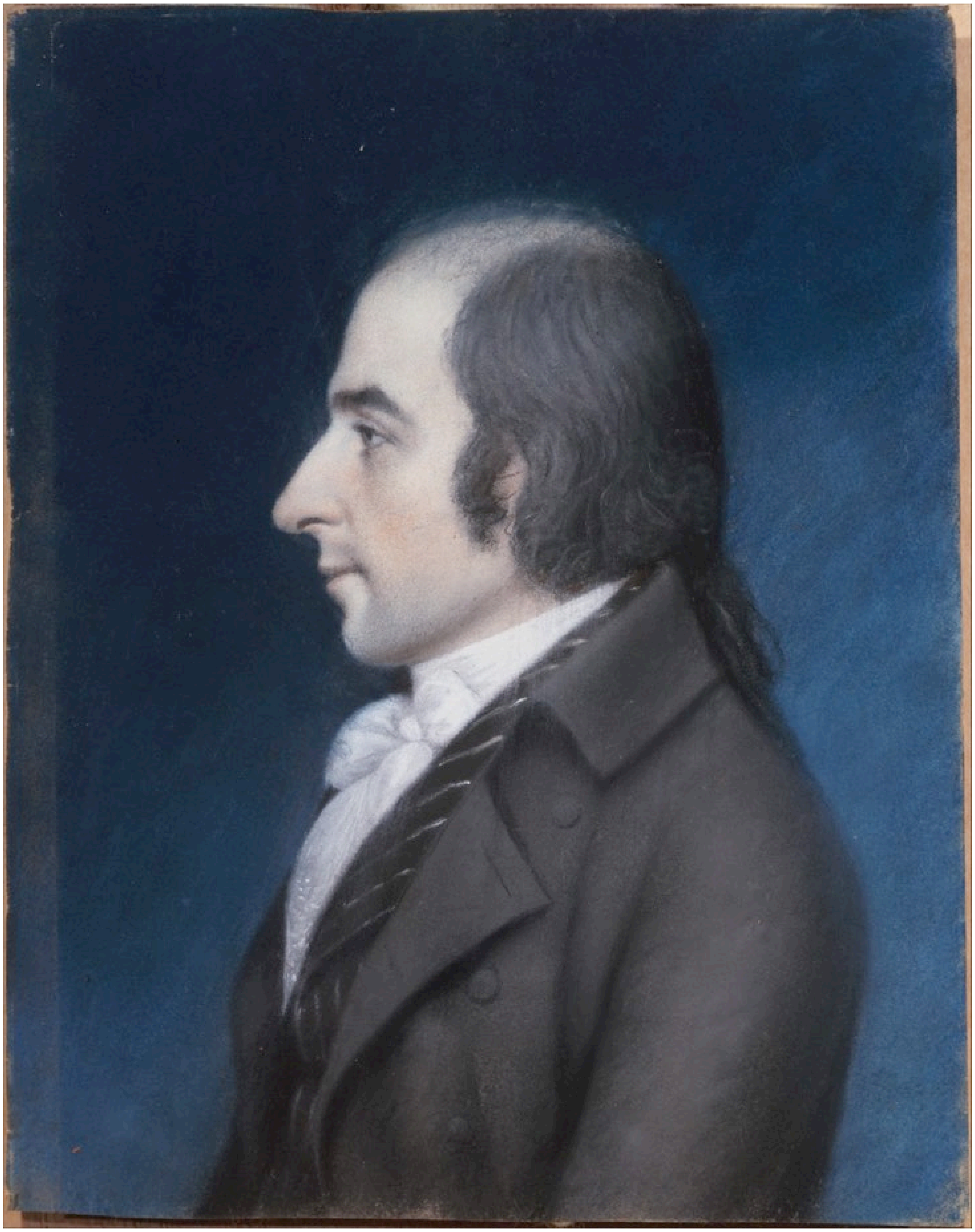


Figure 4.21 James Sharples, *Albert Gallatin*, c. 1797. Pastel on light gray wove paper. Metropolitan Museum of Art

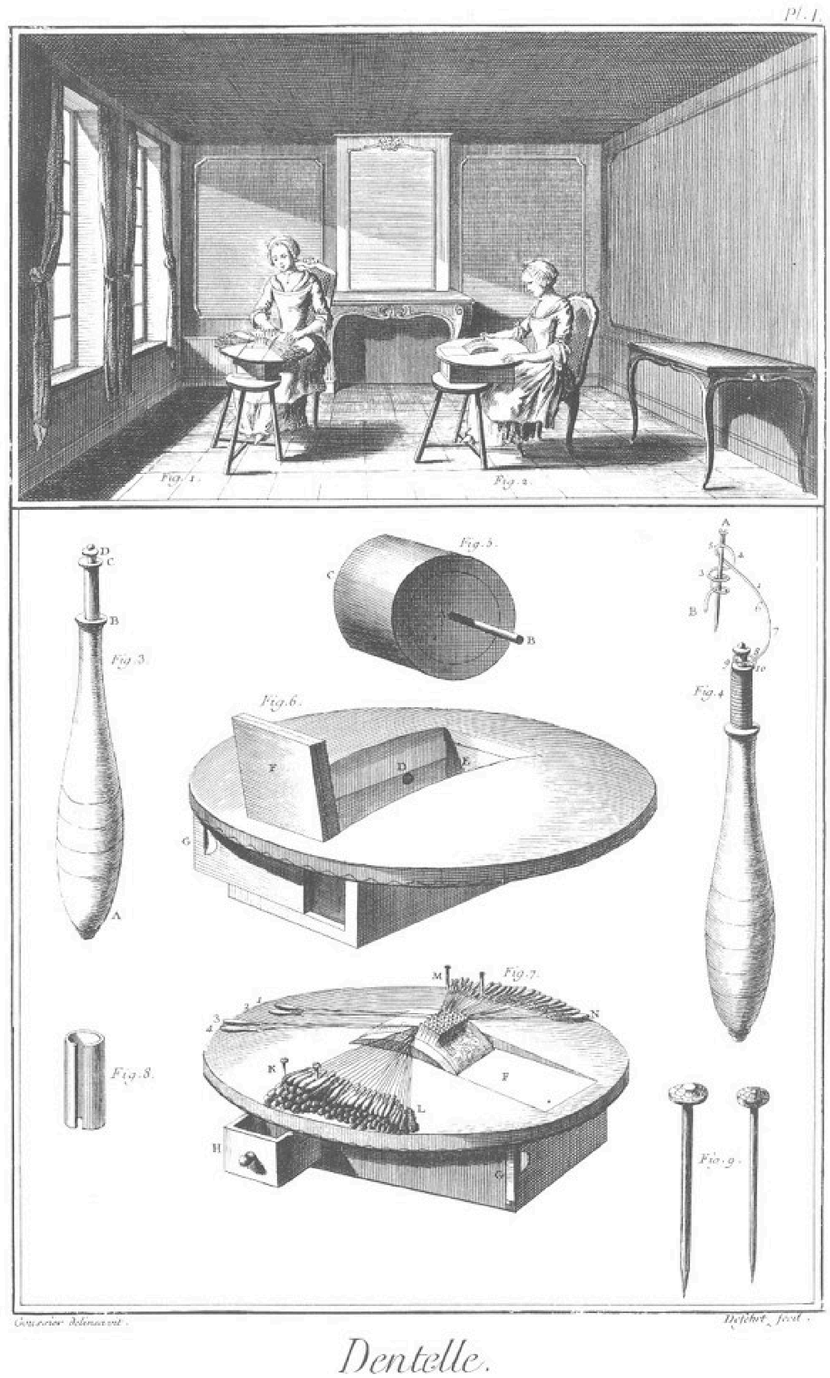


Figure 4.22 “Dentelle,” plate I of “Dentelle et Façon du Point,” in Denis Diderot and Jean le Rond d’Alembert, eds., *Encyclopédie, ou dictionnaire raisonné des sciences, des arts et des métiers, etc.,* vol. 3 (plates). (Paris: Briasson, David, Le Breton, & Durand, 1763).

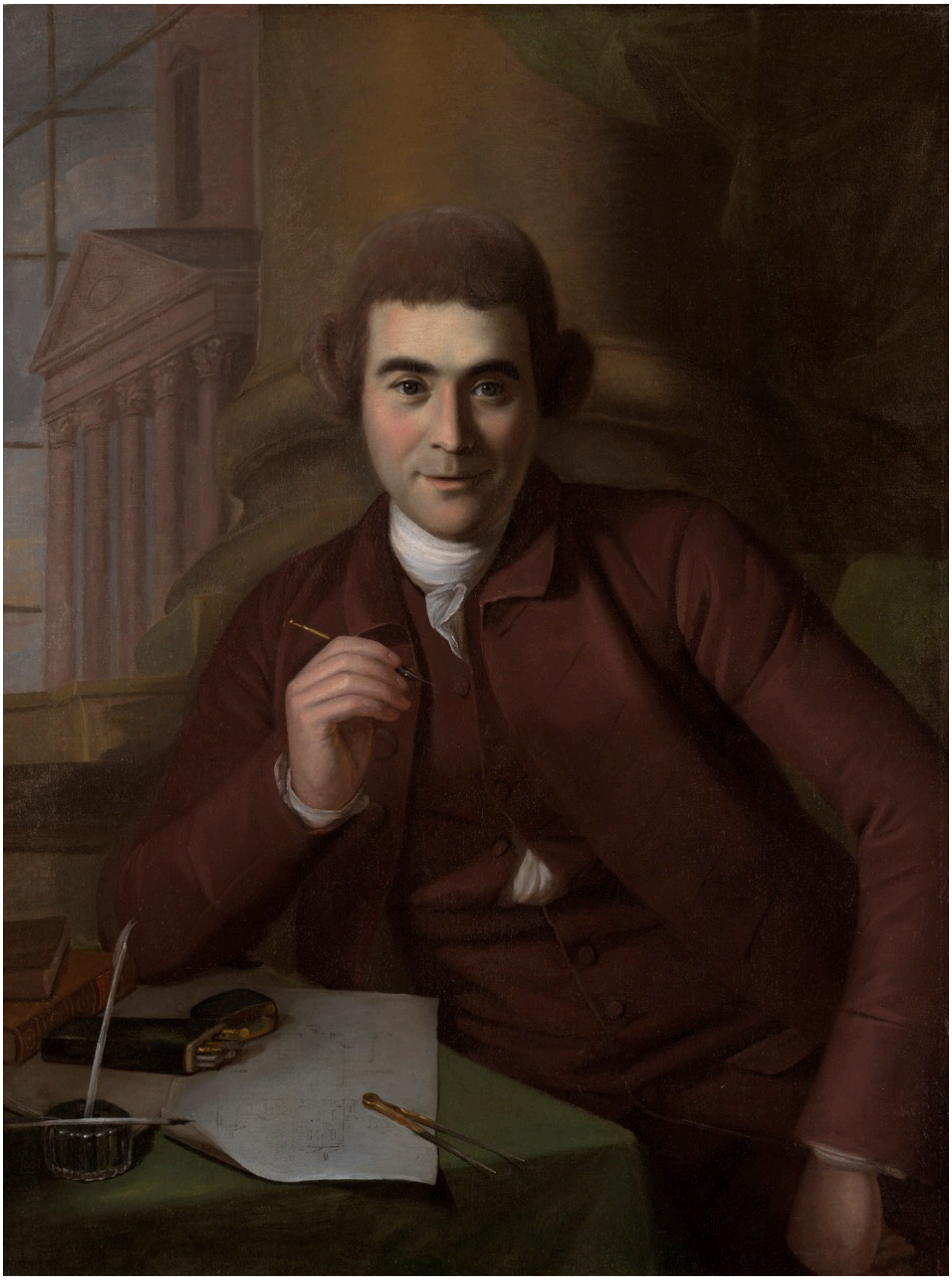


Figure 4.23 Charles Willson Peale, *William Buckland*, 1774 & 1789. Oil on canvas. Yale University Art Gallery.

Figure 4.24 Charles-Balthazar-Julien Févret de Saint-Mémin, *Thomas Jefferson*, 1804. Charcoal and black, white and gray chalk drawing on cream wove paper prepared with pink background. Worcester Art Museum.

Figure 4.25 Raphaelle Peale, *Thomas Jefferson*, 1804. Cut paper. Thomas Jefferson Foundation.

Figure 4.26 Charles-Balthazar-Julien Févret de Saint-Mémin, (top to bottom, left to right) *Payouska; Chief of the Little Osage (Soldat du Chêne)*; *Cachusinghia*; *Osage Chief*; *Osage Warrior*; *Mandan King (Possibly Shahaka)*; *Mandan Queen (possibly Yellow Corn)*; *Lenape Indian (possibly Montgomery Montour)*, 1804-1807. Chalk on tinted paper. New-York Historical Society.

Figure 4.27 Charles-Balthazar-Julien Févret de Saint-Mémin, *Payouska*, 1804-1807. Chalk on tinted paper. New-York Historical Society.

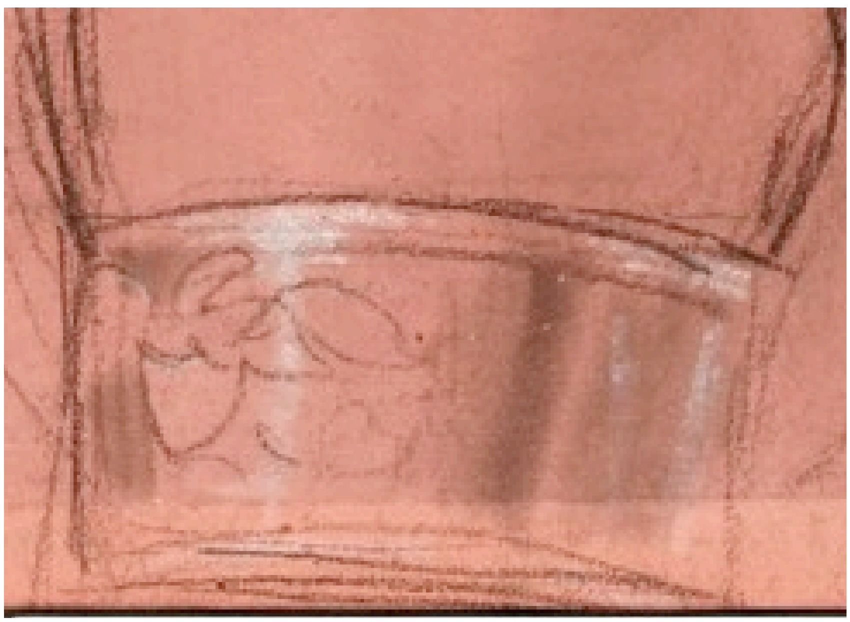


Figure 4.28 Detail. Charles-Balthazar-Julien Févret de Saint-Mémin, *Payouska*, 1804-1807. Chalk on tinted paper. New-York Historical Society.

Figure 4.29 Charles-Balthazar-Julien Févret de Saint-Mémin, *Osage Warrior*, 1804-1807. Chalk on tinted paper. New-York Historical Society

Figure 4.30 Jan Verelst, (left to right, top to bottom) *Etow Oh Koam*, *Sa Ga Yeath Qua Pieth Tow*, *Ho Nee Yeath Taw No Row*, and *Tee Yee Neen Ho Ga Row*, 1710. Oil on canvas with original japanned frames. National Archives of Canada.

Figure 4.31 George Romney, *Thayendanegea (Joseph Brant)*, 1776. Oil on canvas. National Gallery of Canada.