The Craft of Premodern (European) History of Technology: Past and Future Practice

By

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The occasion for this paper, the fiftieth anniversary of the Society for the History of Technology, provides an opportunity to cast a critical eye both backward and forward concerning methodologies and approaches to the history of technology. My own discussion concerns that history in the European premodern centuries, especially from about 500 to 1650 c.e., excluding the ancient world as well as the late 17th and 18th centuries, both areas of highly active scholarship that are to some extent beyond my competence. My assessment is necessarily personal, that is, made from my own disciplinary point of view which is medieval and late medieval/Renaissance European history. It is from the point of view of a historian—not an engineer or economist—and one whose approach has been shaped by intellectual and cultural history and by the history of science as well as by the history of technology. This intellectual background is by no means particularly idiosyncratic, but it is perhaps germane to a contextual methodology that sees technology as embedded within a broader cultural and social history.

Any contextual history must be, to some extent at least, based on an investigation of the local. Technologies developed and were used in particular places and at particular times, at the behest of specific individuals, groups, and institutions. Traditional technologies deserve the same level of serious investigation as inventions, especially because novel technologies rarely, if ever, arose or were used in isolation from traditional ones. A contextual methodology also suggests that while the survey and/or synthesis always has its place, it should interact with and compliment more specialized investigations based on primary source research, including the investigation of archival records. Such research is focused on particular locales and technologies

or groups of technologies that exist in specific times and places. The necessity for stating such a (for historians) obvious methodological principle comes about because the historiography of the history of technology has been disproportionately dominated by the histories of invention and innovation. David Edgerton's discussion of the persistence of traditional technologies that accompany novelties could just as easily be applied to the twelfth century or to the fifteenth as to the twentieth.[1]

While the creation of SHOT in 1958 was certainly important, an earlier event marked the intellectual foundation of the discipline of the history of technology in the twentieth century, namely the publication of the 1935 issue of the *Annales d'histoire économique et sociale* devoted to "*Les techniques, l'histoire et la vie*," edited and in part authored by Marc Bloch and Lucien Febvre. Bloch and Febvre's interest in technology and technique was part of their broader program to reform the study of history, taking it beyond the (then) traditional focus on war, politics, diplomacy, and great men. Instead, they wanted to create a history of ordinary people and daily life, and to create stronger analytical frameworks for social and economic history. As is well known, the *Annales* program transformed the study of history in the twentieth century in permanent and indelible ways.[2]

In the special issue of the *Annales* mentioned above, Febvre made a programmatic statement of methodology for the new history of technology. His tripartite approach called first, for the study of techniques themselves, their development across time and space, and their

[1] David Edgerton, *The Shock of the Old: Technology and Global History since 1900* (Oxford, 2007).
[2] Introductions to the Annales School include Peter Burke, *The French Historical Revolution: The Annales School, 1929-1989* (Stanford, CA, 1990); Hervé Coutau-Bégarie, *Le phénomène nouvelle histoire: Grandeur et decadence de l'école des Annales*, 2nd ed. (Paris, 1989); Georg G. Iggers, *Historiography in the Twentieth Century: From Scientific Objectivity to the Postmodern Challenge* (Hannover, MA), 1997), 51-64; and Traian Stoianovich, *French Historical Method: The Annales Paradigm*, Forward by Fernand Braudel (Ithaca, NY, 1976). A second issue of the *Annales* dedicated to the history of techniques appeared in 1998, edited by Yves Cohen and Dominique Pestre—*Annales, Histoire, Sciences Sociales* 53 (1998).

grounding in the general social, economic, and political conditions in which they were used and transmitted. Second, Febvre believed that historians should study the "progress" of techniques, including both incremental and precipitous changes or "revolutions" that create radically new situations. A key problem concerned the complex reciprocal relationships of theory and practice, by which he meant the role of science in technical accomplishments and the role of technical accomplishments in science. Third was the relationship of techniques to other activities, both individual and collective, including art, religion, politics, and military matters. A fundamental issue for modern research was to explain how techniques and "what one can call general history" have influenced one another.[3]

Certain aspects of the program as outlined by Febvre no longer bear scrutiny. One is his belief that the history of techniques should be written by technicians. Notwithstanding the great value of experimental history of technology in recreating historical practices,[4] as well as the value of practical technical experience in the study of the history of particular technologies, the craft of history itself remains paramount to the discipline, including explication of particular technologies and their relationships to broader historical issues. A second aspect of Febvre's outlook that at least requires modification is his call for a study of the relationships of "science" and "technology." While this may still be desirable, the history of science itself has undergone radical changes since the 1930s, and now includes intensive study of laboratory and other

[3] Lucien Febvre, "Réflexions sur l'histoire des techniques," *Annales d'histoire économique et sociale* 7 (November 1935), 531-35. For a discussion of this entire *Annales* issue on which the present paragraphs are based, see Pamela O. Long, "Classics Revisited: The *Annales* and the History of Technology: *Annales d'histoire économique et sociale* 7 (November 1935), *Les techniques, l'histoire, et la vie*," *Technology and Culture* 46 (January 2005): 177-186.
[4] Examples include a study of harnessing by G. Raepsaet, *Attelages et techniques de transport dans le monde gréco-romaine* (Brussels, 2002); and a study of the trebuchet—W. T. S. Tarver, "The Traction Trebuchet: A Reconstruction of an Early Medieval Siege Engine," *Technology and Culture* 36 (1995): 136-67.

technical practices, making a strict division between the history of "science" and the history of "technology" much more problematic now than it was then.[5]

Nevertheless, Febvre's view of the importance of the relationship of techniques to other aspects of history remains an important principle. Its use was demonstrated in a classic article in the same issue by Marc Bloch on the use of the watermill in medieval France. "The Advent and Triumph of the Watermill in Medieval Europe" aimed to establish the origins of the mill and its development from antiquity until the eleventh century. Bloch discussed early stone-roller and mortar-and-pestle mills and then, later mills requiring a revolving millstone powered by men or animals, invented in the Mediterranean basin in the third or second century B.C.E. Investigating evidence for the water mill in ancient times, he hypothesized that it was a development from the noria, a wheel used to scoop water and lift it into canals or other receptacles. For Bloch, effective progress in transforming the idea of the watermill to a practical reality was something which could only take place under the pressure of social forces. Those forces emerged when seigneurial lords began to use water powered mills as instruments to obtain and maintain monopolies on grinding grain. Bloch pointed to the hand mill, often hidden in peasant houses, as the peasant's defense against such monopolies.[6]

Bloch's discussion of the watermill represented one part of his long interest in agricultural and technological history. He had already completed his classic work on medieval agriculture, first delivered as lectures in Oslo, on the character of medieval French agriculture.

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[5] See Jan Golinski, *Making Natural Knowledge: Constructivism and the History of Science* (Cambridge: Cambridge University Press, 1998), esp. 133-161; Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts* (Princeton, N.J., 1986); Domenico Bertoloni Meli, *Thinking with Objects: The Transformation of Mechanics in the Seventeenth Century* (Baltimore, 2006); Bruce Moran, *Distilling Knowledge: Alchemy, Chemistry, and the Scientific Revolution* (Harvard: Harvard University Press, 2005); and Andrew Pickering, *The Mangle of Practice: Time, Agency, and Science* (Chicago, 1995);

[6] Marc Bloch, "Avènement et conquêt du Moulin à eau," *Annales* 7: 538-63, which has been translated by J. E. Anderson as "The Advent and Triumph of the Watermill," in *Land and Work in Mediaeval Europe: Seleceted Papers by Marc Bloch* (New York, 1969).

Published as a book in 1931, Bloch had rejected the legal and institutional orientation of the agricultural history of his day, while expanding beyond this traditional subject matter. One aspect of his research entailed a study of patterns of settlement and field cultivation. It is to Bloch that can be attributed the first understanding that plowing in long strips (open field farming) is characteristic of the use of the heavy plow in the north, while square fields were found closer to the Mediterranean and are associated with the much older, lighter plow.[7]

Bloch's influence was highly significant for the history of technology. Most notably, Lynn White Jr. dedicated his own massively influential *Medieval Technology and Social Change* (1962) to Bloch. The dedication served undoubtedly as a homage to the great historian and resistance fighter, who was shot by a firing squad in 1944, but also as an acknowledgement of influence. Lynn White began his professional life as a medieval historian and eventually served as president of SHOT. He used some of the approaches developed by Bloch and the *Annales*, including, for example, linguistic analysis used as an investigative tool for the study of technological developments. Perhaps most important, White took and expanded Bloch's classic discussion of French agriculture. He also retained and indeed expanded the initial *Annales* interest in innovation and invention, focusing on the profound importance of medieval inventions. This included the introduction of the stirrup, which he argued, brought about feudalism. In addition, he argued that an agricultural revolution occurred by means of inventions such as the heavy plow, new harnessing systems for draft animals, and the change from two-field to three field crop rotation.[8]

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[7] See Marc Bloch, *French Rural History: An Essay on Its Basic Characteristics*, Foreword by Bryce Lyon, trans. Janet Sondheimer (Berkeley and Los Angeles, 1966). Lyon's forward provides a useful introduction and further bibliography.

[8] Lynn White Jr., *Medieval Technology and Social Change* (Oxford, 1962). For a succinct discussion of the state of the history of medieval technology and it's major contributors from the 1930s, see White, "The Study of Medieval

White's emphasis on invention and technological revolution was shared by numerous other historians and popular writers in the subsequent two decades. In addition to the agricultural "revolution," a variety of scholars and writers expounded a medieval industrial revolution (Jean Gimpel and others);[9] a commercial revolution;[10] a "green" revolution, referring to the adoption of new crops across the Mediterranean from Iran to al-Andalus in the west,[11] and a revolution in time.[12] For a somewhat later period, other scholars proposed further revolutions, such as the "military revolution,"[13] and the "print revolution."[14]

A parallel to the focus on revolutions was a tendency to study inventions in isolation from their surroundings, including the traditional technologies with which they coexisted and/or from which they emerged. This focus on invention was general among earlier historians of technology and economic historians. Technological history was often discussed exclusively in terms of important inventions—the heavy plow, new harnessing systems, and new kinds of crop

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Technology, 1924-1974: Personal Reflections," *Technology and Culture* 16 (1975): 519-530; and his 1940 assessment, "Technology and Invention in the Middle Ages," *Speculum* (15 (1940): 141-159, both reprinted in Lynn White, jr., *Medieval Religion and Technology* (Berkeley and Los Angeles, 1986), xi-xxiv and 1-22 respectively. For an assessment of Lynn White's career, see esp. Bert S. Hall, "Lynn Townsend White, Jr. (1907-1987)," *Technology and Culture* 30 (1989): 194-213. A full review of the critiques of *Medieval Technology and Social Change* is beyond the scope of this essay. However, for the stirrup and feudalism thesis, which has been decisively rejected, see especially Kelly DeVries, *Medieval Military Technology* (Peterborough, Ontario, 1992), 95-110, and the key article, Bernard Bachrach, "Charles Martel, Mounted Shock Combat, the Stirrup, and Feudalism," *Studies in Medieval and Renaissance History* 7 (1970): 49-75. More recent critiques of the book as a whole, as well as of particular aspects include Bert Hall, "Lynn White's *Medieval Technology and Social Change* After Thirty Years," and Richard Holt, "Medieval Technology and the Historians: The Evidence for the Mill," both in *Technological Change: Methods and Themes in the History of Technology*, ed. Robert Fox (Amsterdam, 1996), 85-101 and 103-121, respectively.

[9] Especially, White, *Medieval Technology*; and Jean Gimpel, *The Medieval Machine: The Industrial Revolution of the Middle Ages* (New York, 1976).

[10] Robert S. Lopez, *The Commercial Revolution of the Middle Ages, 950-1350* (Cambridge, 1976).

[11] Andrew M. Watson, *Agricultural Innovation in the Early Islamic World: The Diffusion of Crops and Farming Technologies, 700-1100* (Cambridge, 1983).

[12] David S. Landes, *Revolution in Time: Clocks and the Making of the Modern World* (Cambridge, Mass., 1983).

[13] Geoffrey Parker, *The Military Revolution: Military Innovation and the Rise of the West*, 2d ed. (Cambridge, 1996).

[14] Elizabeth Eisenstein, *The Printing Press as an Agent of Change*, 2 vols. (Cambridge, 1979).

rotation; or new systems of irrigation; the adoption of water power mills; or the mechanical clock, gun powder artillery; the printing press, and the telescope, to name just a few. [15]

More recently many scholars have questioned whether the technological changes involved merit the term "revolution." In the first place, the traditional view of the ancient world as technologically static has been revised.[16] Concerning the medieval period, extensive empirical investigations have produced complex pictures of the role of particular technologies in medieval economic and social life. This scholarship has entailed not only a serious review of the literature, but also exhaustive studies of primary sources for particular locales and technologies such as windmills or types of draft animals employed.[17] As a result, the heavy plow, for example, has been shown to have been a gradual development from late antiquity, rather than an invention that appeared suddenly in the Middle Ages.[18] Similarly, heavy, water-driven mills have been shown to be gradual and variable, depending on a number of factors, including location.[19] Gunpowder artillery was a centuries' long development which occurred in the context of other forms of

[15] In addition to the references in notes 9-14 above, see Joel Mokyr, *A Lever of Riches: Technological Creativity and Economic Progress* (Oxford, 1990); and for the telescope, Mario Biagioli, *Galileo's Instruments of Credit: Telescopes, Images, Secrecy* (Chicago, 2006).

[16] See especially Kevin Greene, "Perspectives on Roman Technology," *Oxford Journal of Archaeology* 9 (1990): 209-219; Greene, "Technological Innovation and Economic Progress in the Ancient World: M. I. Finley Re-considered," *Economic History Review* 53 (2000): 29-59; and Örjan Wikander, *Exploitation of Water-Power or Technological Stagnation? A Reappraisal of the Productive Forces in the Roman Empire* (Lund, 1984).

[17] For example, Grenville Astill and John Langdon, eds. *Medieval Farming and Technology: The Impact of Agricultural Change in Northwest Europe* (Leiden, 1997); Richard Holt, *The Mills of Medieval England* (Oxford, 1988); Adam Lucas, *Wind, Water, Work: Ancient and Medieval Milling Technology* (Leiden, 2006), esp. 201-231; and John Langdon, *Horses, Oxen, and Technological Innovation: The Use of Draught Animals in English Farming from 1066 to 1500* (Cambridge, 1986).

[18] Georges Raepsaet, "The Development of Farming Implements between the Seine and the Rhine from the second to the Twelfth Centuries," in *Medieval Farming*, ed. Astill and Langdon, 40-68.

[19] Lucas, *Wind, Water* (n. 16 above); Lucas, "Industrial Milling in the Ancient and Medieval Worlds: A Survey of the Evidence for an Industrial Revolution in Medieval Europe," *Technology and Culture* 46 (2005): 1-30; Holt, *Mills of Medieval England* (n. 16 above); and John Langdon, *Mills in the Medieval Economy: England, 1300-1540* (Oxford, 2004).

weaponry, both traditional and innovative.[20] Other scholars argue that there was far more continuity between manuscript and print culture than would justify the term "revolution."[21]

Bloch's work had a direct influence on Lynn White Jr., whose writings in turn influenced numerous other historians of technology as well as the general public. Two other authors who wrote influential books well before the creation of SHOT in 1958 also influenced the history of medieval and Renaissance European technology. Both became energetic supporters of the new Society for the History of Technology. They were the economic historian, Abbot Payson Usher, and the wide-ranging public intellectual and architectural critic, Lewis Mumford.

Abbot Payson Usher, who spent most of his working life teaching at Harvard, wrote a book on the industrial history of England, published in 1920, and then turned to the study of technology in order to understand better the relationships between economic growth and technical innovation. The result was *A History of Mechanical Inventions*, published in 1929. As Arthur Molella has put it, the book "covered in exquisite detail an extraordinary range of basic technologies," including great attention to machines important to the medieval period, such as waterwheels, windmills, clocks, and printing. In addition, the book included an important chapter on Leonardo da Vinci that emphasized the importance of his mechanical inventions at a time when this aspect of Leonardo's work was little recognized. Molella lucidly explicates Usher's holistic vision of human invention which was influenced by Gestalt psychology—a vision

[20] Bert S. Hall, "Essay Review: The Military Revolution Revisited," *Technology and Culture* 31 (1990): 500-507; and Hall, *Weapons and Warfare in Renaissance Europe* (Baltimore, 1997).
[21] Adrian Johns, *The Nature of the Book: Print and Knowledge in the Making* (Chicago, 2000), esp. 1-57; and see Anthony Grafton, Elizabeth L. Eisenstein, and Adrian Johns, "AHR Forum: How Revolutionary was the Print Revolution," American Historical Review 107 (2002): 84-128; and http://www.historycooperative.org/journals/ahr/107.1/ah0102000084.html (last accessed Sept. 4, 2007).

largely lost on most of Usher's subsequent readers who focused instead on his brilliant chapters explicating particular machines.[22]

While Abbot Payson Usher was writing his *History of Mechanical Inventions*, his contemporary Lewis Mumford was at work on a similar subject conceived in a very different way. In an insightful essay, Rosalind Williams describes Mumford as primarily a writer and a "public intellectual" whose prolific output often included books that focused on technology and its relationships to human culture. For historians of technology, Mumford's most influential book was undoubtedly *Technics and Civilization*. First published in 1934, it was subsequently widely read by the general public, and as well, was assigned to numerous introductory courses in the history of technology. Mumford's lasting contribution was to explore the relationships between the development of machines, and human culture and psychology. Following his mentor Patrick Geddes, Mumford divided western civilization into phases—paleotechnic, referring to an eighteenth century industrial age based on coal and iron; and neotechnic, referring to the modern age based on electricity and alloys. However, to Geddes' two phases, he added a third "preparatory" phase, the eotechnic, characterized by wood and water, which he placed between 1100 and 1750. This period that encompassed medieval and late medieval Europe was the time during which "all the key inventions were either invented or foreshadowed." Mumford outlined those inventions such as the clock, the printing press, and the blast furnace. Beyond that, a key characteristic of ecotechnic culture, in Mumford's view, was an expansion of the senses, "a more acute response to external stimuli." While Mumford's vast canvas of generalization now seems

[22] Abbott Payson Usher, *An Introduction to the Industrial History of England* (Boston, 1920); Usher, *A History of Mechanical Inventions*, Rev. ed. (Cambridge, Mass., 1962); and Arthur P. Molella, "Classics Revisited: The Long Durée of Abbott Payson Usher: A. P. Usher, *A History of Mechanical* Inventions," Technology and Culture 46 (2005): 779-796, citation on 781; and Molella, "The First Generation: U sher, Mumford, and Giedion," in *In Context: History and the History of Technology: Essays in Honor of Melvin Kranzberg*, ed. Stephen H. Cutcliffe and Robert C. Post (Bethlehem, Penn., 1989), 88-105.

problematic, his central insight concerning the significance of the relationships of machines and tools to cultural, psychological, and symbolic life remains important. It shows, as Williams has noted, "an awareness of the importance in technics of symbolic representations of worldly reality."[23]

In the early years of SHOT in the 1960s Mel Kranzberg and the other founders promoted a discipline conceived very broadly both in terms of methodology and chronology. Influenced by Mumford, they decided that the newly founded journal be focused explicitly on technology and culture, not just technology per se. The history of technology should be explored, they thought, not in isolation from the individuals, society, and culture that produced and used it. And indeed, as John Staudenmaier in particular has shown, the studies produced in the new journal became increasingly oriented to contextual studies.[24]

As is well known, Kransberg vigorously encouraged studies in the history of technology, including those pertaining to premodern times. The scholars who worked with him, including Lynn White, Jr., Abbott Payson Usher, Lewis Mumford, and Eugene Ferguson, among others, made significant contributions to medieval and Renaissance history of technology. These individuals, drawing on their own respective spheres of influence, drew in others working on premodern technologies in diverse areas.[25] While SHOT was certainly not the sole player, it

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[23] Lewis Mumford, *Technics and Civilization* with new introduction (New York,1962), esp. 107-150, citation on 150; Rosalind Williams, "Classics Revisited: Lewis Mumford's *Technics and Civilization*," *Technology and Culture* 43 (2002): 139-149, citation on 145. See also Thomas P. Hughes and Agatha C. Hughes eds., *Lewis Mumford: Public Intellectual* (New York, 1989); and Donald L. Miller, *Lewis Mumford: A Life* (New York, 1989). Recent discussions of Mumford's intellectual context, which place him more firmly in the context of early 20th century throught, include Adam Green, "Matter and Psyche: Lewis Mumford's Appropriation of Marx and Jung in his Appraisal of the Condition of Man in Technological Civilization ," *History of the Human Sciences* 19 (2006): 33-64; and Gregory Morgan Swer, "Technics and (para)praxis: the Freudian Dimensions Of Lewis Mumford's Theories of Technology," *History of the Human Sciences* 17(2004): 45-68.

[24] John Staudenmaier, *Technology's Storytellers: Reweaving the Human Fabric* (Cambridge, Mass., 1985).

[25] For insight into those early years, see Robert C. Post, "Missionary: An Interview with Melvin Kranzberg," *American Heritage of Invention and Technology* (winter 1989), now available at http://shotnews.net/fiftieth/?p=294

formed a supportive matrix for one of the most important developments in the 1960s and 1970s in the scholarship of premodern technologies, namely the difficult and often unheralded work of the creation of facsimiles, critical editions, and translations of some of the large number of manuscripts on crafts, engineering, and machines from the medieval and late medieval periods.[26] Such projects, which are continuing, have made these fundamental sources far more available for further study.[27]

The history of technology in medieval and late medieval Europe remains a flourishing field of study, or more accurately, a thriving aggregate of fields. In the space remaining I characterize some of the best current scholarship and then suggest that several related fields—archaeology, material culture studies, and the history of science—have undergone developments or are sustaining practices that make it a particularly propitious time for interdisciplinary interaction between those disciplines and the European history of technology.

A striking characteristic of the newer scholarship is that it concerns either particular locales or particular technologies or both. All are based on primary source research including archival investigation of contemporary records. Many scholars have traded the traditional

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(last accessed 9/5/07). For Ferguson, see David A. Hounshell, "Memorials: Eugene S. Ferguson, 1916-2004," *Technology and Culture* 45 (2004): 911-921.

[26] A selection includes Martha Teach Gnudi and Eugene S. Ferguson, ed. and trans., *The Various and Ingenious Machines of Agostino Ramelli (1588)* (Baltimore, 1976); Bert S. Hall, *The Technological Illustrations of the so-called "Anonymous of the Hussite Wars": Codex Latinus Monacensis 197, Pt. 1* (Wiesbaden, 1979); Ladislao Reti, ed. and trans., *The Madrid Codices*, 5 vols. (New York, 1974); Anneliese Grünhaldt Sisco and Cyril Stanley Smith, ed. and trans., *Bergwerk- und Probierbüchlein* (New York, 1949); Smith and John G. Hawthorne, ed. and trans., *Mappae clavicula: A Little Key to the World of Medieval Techniques* Philadelphia, 1974; Smith and Gnudi, ed. and trans., *The Pirotechnia of Vannoccio Biringuccio: The Classic Sixteenth-Century Treatise on Metals and Metallurgy* (Mineola, N.Y., 2005); Theophilus, *On Diverse Arts*, trans. and ed. Hawthorne and Smith (New York, 1979); Mariano Taccola, *De machinis. The Engineering Treatise of 1449*, ed. Gustina Scaglia, 2 vols. (Wiesbaden, 1971); and Taccola, *De ingeneis*, ed. Scaglia, Frank D. Prager, and Ulrich Montag, 2 vols. (Wiesbaden, 1984). This selection is not inclusive, and in particular omits numerous editions in German, French, and Italian.

[27] A remarkable recent addition is Konrad Gruter von Werden, *De machinis et rebus mechanicis: ein Maschinenbuch aus Italien für den König von Danemark: 1393-1324*, [Ms. Vat. Lat. 5961] (Vatican City, 2006). Another is a manuscript containing the first extant treatise on shipbuilding, a mathematical treatise and much else, written in the 1430s by a mariner, Michael of Rhodes—Pamela O. Long, David McGee, and Alan M. Stahl, eds., *The Book of Michael of Rhodes: A Fifteenth-Century Maritime Manuscript*, 3 vols. (MIT Press, forthcoming).

emphasis on inventions as isolated phenomena for broader concerns about how particular technologies developed and were used, including both tradition and innovative aspects. Examples include a rich and on-going tradition of scholarship on medieval and early modern hydrology focused on many parts of Europe, including Italy, Holland, England, France, and the Iberian Peninsula;[28] extensive work on textiles including silk;[29] wide-ranging scholarship, mostly French and German, on mining and metallurgy, including numerous local studies;[30] studies of specific industries in particular regions;[31] and studies of engineering and construction in particular locales.[32]

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[28] A small selection includes Eric H. Ash, *Power, Knowledge, and Expertise in Elizabethan England* (Baltimore, 2004), esp. 55-86 on Dover Harbor; Armelle Bonis and Monique Wabont, eds. *L'hydraulique monastique: milieux, réseaux, ,usages*, directed by Léon Pressouyre and Paul Benoit (Grâne, 1996); Ricardo Córdoba de la Llave, "Some Reflections on the Use of Water Power in Al-Andalus," in *Economia e Energia secc. XIII-XVIII,* Atti della "Trentaquattresima Settimana di Studi," 15-19 aprile 2002, ed. Simonetta Cavaciocchi (Florence, 2003), 931-949; Alessandra Fiocca, Daniela Lamberini, Cesare Maffioli, eds., *Arte e scienza della acque nel Rinascimento* (Venice, 2003); Thomas F. Glick et al., *Els molins hydraulics valencians: tecnologia, històriai i context social* (València, 2000); Roberta J. Magnusson, *Water Technology in the Middle Ages: Cities, Monasteries and Waterworks after the Roman Empire* (Baltimore, 2001); Paolo Squatriti, ed., *Working with Water in Medieval Europe: Technology and Resourse*-Use (Leiden, 2000); Petra Van Dam, "Ecological Challenges, Technological Innovations: The Modernization of Sluice Building in Holland, 1300-1600," *Technology and Culture* 43 (2002): 500-520; and Chandra Mukerji, "Tacit Knowledge and Classical Technique in Seventeenth-Century France: Hydraulic Cement as a Living Practice among Masons and Military Engineers," *Technology and Culture* 47 (2006): 713-733. It also includes a published edition of an important manuscript, Giovanni Battista Aleotti, detto L'Argenta, *Della scienza et dell'arte del ben regolare le acque*, ed. Massimo Rossi (Modena, 2000).

[29] David Jenkins, ed., *The Cambridge History of Western Textiles*, vol. 1 (Cambridge, 2003), provides a comprehensive introduction to the field with articles on a wide range of textiles and eras that include from early medieval to early modern times. See also Luca Molà, *The Silk Industry of Renaissance Venice* (Baltimore, 2000); and Luca Molà, Reinhold C. Mueller, and Claudio Zanier, eds., *La seta in Italia dal Medioevo al Seicento: Dal baco al drappo* (Venice, 2000).

[30] For an introduction to some of the older scholarship, see Paul Benoit and Philippe Braunstein, *Mines, carriers et métallurgie dans la France médiévale*, Actes du Colloque de Paris, 19, 20, 21 June 1980 (Paris, 1983); and Pamela O. Long, "The Openness of Knowledge: An Ideal and its Context in 16th-Century Writings on Mining and Metallurgy," *Technology and Culture* 32 (1991): 318-355. A small sampling of more recent work includes Thomas Beddies, *Becken und Geschütze: der Harz und sein nördliches Vorland als Metallgewerbelandschaft in Mittelalter und früher Neuzeit* (New York, 1996); Philippe Braunstein, ed., *La sidérugie alpine en Italie:X II^{e}-XVII^{e} siècle* (Rome, 2001); Paul Benoit and Catherine Verna, ed., *Le charbon de terre en Europe cccidentale avant l'usage industriel du coke* (Turnhout, Belgium, 1999); Marco Tizzoni and Costanza Cucini Tizzoni, *Il comprensorio minerario e metallurgico delle valli Brembana, Torta e Averara dal XV al XVII secolo*, and Costanza Cucini Tizzoni, *Le fucine da ferro e I magli da rame delle Alpi lombarde. Il caso bergamasco e lecchese* (Bergamo, 1997); and Angelika Westermann, *Entwicklungsprobleme der Vorderösterreichischen Montanwirtschaft im 16.Jahrhundert* (Idstein, 1993)

[31] Examples include John Blair and Nigel Ramsay, eds., *English Medieval Industries: Craftsmen, Techniques, Products* (London, 1991); Ricardo Córdoba de la Llave, *La industria medieval de Córdoba* (Córdoba, 1990); Uta

Scholars continue to study attitudes toward craft knowledge and its transmission. For example, S.R. Epstein, challenging the traditional view of the guilds as a force working against innovation, investigated journeymen mobility or "tramping" as an important modality for the transmission of technologies. Other research investigates proprietary attitudes (whether evidenced by patents or secrecy), as well as openness.[33] Current research also approaches the many machine books of the period, not so much as lenses into contemporary technologies as objects of study in their own right, deserving of scrutiny both in terms of the individual machines depicted, and as important, in terms of the various contexts of authorship and readership.[34]

While there is no doubt that invention and innovation were important components of medieval and Renaissance cultures, they arose very much in the context of on-going, every day technologies and technological processes which heretofore often have been neglected as objects

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Lindgren, ed., *Europäische Technik im Mittelalter: 800 bis 1200, Tradition und Innovation: Ein Handbuch* (Berlin, 1996); and Daniela Stiaffini, *Il vetro nel medioevo: techniche, strutture, manufatti* (Rome, 1999).

[32] For example, Alessandra Fiocca, *Giambattista Aleotti e gli ingegneri del Rinascimento* (Florence, 1998); and Nicoletta Marconi, *Edificando Roma Barocca: Macchine, apparati, maestranze e cantieri tra XVI e XVIII secolo* (Rome, 2004).

[33] S.R. Epstein, "Craft Guilds, Apprenticeship, and Technological Change in Preindustrial Europe," *Journal of Economic history* 58 (1998): 684-713. For recent work on development of patents, see Carlo Marco Belfanti, "Guilds, Patents, and the Circulation of Technical Knowledge: Northern Italy during the Early Modern Age, *Technology and* Culture 45 (2004): 569-589; Roberto Berveglieri, *Inventori stranieri a Venezia (1474-1788): Importazione di tecnologia e circolazione di tecici, artigiani, inventori* (Venice, 1995); Karel Davids, "Patents and Patentees in the Dutch Republic between c. 1580 and 1720," *History and Technology* 16 (2000): 263-283; Pamela O. Long, "Invention, Authorship, 'Intellectual Property, and the Origin of Patents: Notes toward a Conceptual History," *Technology and Culture* 32 (1991): 318-355; and Luca Molà, "Energia e brevetti per invenzioni nell'Italia del rinascimento," in *Economia e Energia*, ed. Cavaciocchi, 981-991 (See note 26). Issues of credit and patenting have also become a focus of scholarship in the historiography of science. See especially, Biagioli, *Galileo's Instruments* (note 15 above); and Biagioli, "From Print to Patents: Living on Instruments in Early Modern Europe," *History of Science* 44 (2006): 139-186. For traditions of technical openness, see Pamela O. Long, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance* (Baltimore, 2001).

[34] William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton, N.J., 1994); Marco Formisano, *Tecnica e scrittura: Le letterature tecnico-scientifiche nello spazio letterario tardolatino* (Rome, 2001); Wolfgang Lefèvre, ed., *Picturing Machines, 1400-1700* (Cambridge, Mass, 2004); Rainer Leng, *Ars belli: Deutsche taktische und kriegstechnische Bilderhandscriften und Traktate im 15. und 16. Jahrhundert*, 2 vols. (Wiesbaden, 2002); Long, *Openness, Secrecy*; and Marcus Popplow, *Neu, nützlich und erfinungsreich: Die Idealisierung von Technik in der frühen Neuzeit* (Münster, 1998). See also Wolfgang Lefèvre & Marcus Popplow, "Database Machine Drawings: http://dmd.mpiwg-berlin.mpg.de/home (last accessed 7 September 2007).

of study. Indeed, most discussions of invention involve a process of scanning the traditional secondary literature in the history of technology, and pulling out particular inventions for discussion. Archivally based primary research focused on particular groups of documents, typically does not yield large amounts of information about invention, but rather, reveals information about on-going, usual technologies. To use the example I know best, my own current research on engineering in Rome in a thirty year period (1560-1590) has produced much information on payments to workers, mundane municipal decisions concerning construction, discussions (and arguments) about how to pay for needed projects, and tracts involving proposals for say moving obelisks, repairing aqueducts and sewers, paving streets, and preventing floods of the Tiber River. More often than not, traditional remedies are suggested, including a return to ancient ones.[35] Of course, Rome was a highly unusual, not to say unique city in the sixteenth century, but I do not think the fruits of my archival work are unusual. And I would claim that they inform an interesting, a legitimate field for study—how a burgeoning city governed by two entities, the papal curia and the communal council, carried out ordinary and extraordinary technological tasks on a day to day basis.

This recent historical work is quite different methodologically from the work of economic historians such as Joel Mokyr and Anver Greif. They, in contrast, have written influential studies using historical data framed by economic theory and models to tell a progressive story about western civilization.[36] Their approach is profoundly different from that

[35] For early results of this research, see Pamela O. Long, "Engineering, Patronage, and the Authorship of Practice in Early Counter-Reformation Rome," in *Conflicting Duties: Science, Medicine, and Religion in Rome, 1550-1750*, ed. Maria Pia Donato and Jill Kraye (forthcoming, Warburg Institute); and Brian Curran, Anthony Grafton, Pamela O. Long, and Benjamin Weiss, *Obelisk: A History* (Cambridge, Mass.: MIT Press and the Burndy Library, in press).

[36] Anver Greif, *Institutions and the Path to the Modern Economy: Lessons from Medieval Trade* (New York, 2006); Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (Oxford, 1990); and Mokyr, *The Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton, N.J., 2002). For Langdon, see notes 16 and 18.

of historians (including some economic historians such as John Langdon) who focus on contextual histories based on archival research. The latter investigate primary sources which inform further questions about the peoples and cultures of the past. The contextual work of historians also includes an exploration of the conceptual categories and meanings used in the past. It deliberately refrains from imposing modern categories and meanings upon them, because such imposition tends to obscure or obliterate actors' categories. In contrast, the economic historians analyze historical data (taken as "facts" in an argument about progressive developments, rather than as material to be further explored) by using terminology carefully defined in modern economic terms. In my view it should be admitted that historians pursuing contextual studies and those economic historians who are engaged in explaining present phenomena by using past examples are simply tilling different fields. Just because the two different kinds of project have the word "history" attached to them should not obscure the fact that they are asking profoundly different kinds of questions which shape their respective researches in highly significant ways. In my view, a fence should be built between the two fields, so that it is clearly recognized that these are very diverse kinds of projects; it should not be imagined that one is doing a poorer or deficient version of the other. It is also important that the fence should be low enough to allow conversation across it.[37]

In addition to economic history, several other disciplines have much to offer to the early history of technology, in some cases because of developments within the disciplines themselves. Archaeology has always focused on material objects and specific sites, while it also possesses an extensive scientific toolkit for dating and studying those objects. It is a field that has much to offer to historians of technology. Medieval archaeology is a flourishing field in which it has

[37] A good example of which is Rosalind Williams, "Does Progress have a Future? Joel Mokyr's *Gifts of Athena*," *Technology and Culture* 44 (2003): 371-375.

become routine to examine not just small, specific sites and objects, but the larger surroundings contingent to those sites. This development along with the emergence of landscape archaeology has in a sense broadened out the field and made it more accessible and relevant to historians of technology. Kevin Greene has underscored the relevance of the fields of archaeology and the history of technology to each other, pointing out that archaeology has the ability to discover new things about everyday life by discovering small objects and analyzing how they were made and what implications they have. The archeological site and its analysis provides much information about a highly local and focused context that historians of technology might well fit into a larger picture through textual sources as well as other material artifacts.[38]

The rise of material culture studies and growing interest in material culture in other disciplines is also significant for historians of premodern technology. One aspect of this interest involves burgeoning scholarship on the history of collecting.[39] Other scholarship emphasizes the growing appreciation of objects in the European Renaissance, including luxury objects, the changing status of craftwork, and, in the sixteenth century, the growing confluence and conceptual overlap between artifactual and natural objects.[40] In a very different field, literary

[38] See esp. Kevin Greene, "Archaeology and Technology," and T. J. Wilkinson, "The Archaeology of Landscape," in *A Companion to Archaeology*, ed. John Bintliff (Oxford, 2004), 155-173 and 334-356. An excellent example of the use of archaeology by a technologically oriented historian is Thomas Glick's adoption of the concept of *incastellamento* from the countryside around Rome to Al-Andalus. As Glick notes, *incastellamento* is "the term given by Pierre Toubert to a process of the general reorganization of the countryside of Lazio in the high Middle Ages around AD 1000 which resulted in the disappearance of dispersed habitats and a regrouping of settlements around castles." Thomas F. Glick, *From Muslim Fortress to Christian Castle: Social and Cultural Change in Medieval Spain* (Manchester, 1995), 105-113, citation on 105, referring to Pierre Toubert, *Les structures du Latium medieval* (Rome, 1973). The archaeologist Matthew Harpster organized an interesting session on archaeology and the history of technology at the annual SHOT meeting October 1-15, 2006 in Las Vegas—"Roundtable: Archaeology, Technology, History."

[39] See esp. Paula Findlen, *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy* (Berkeley, 1994).

[40] See esp. Paula Findlen, "Possessing the Past: The Material World of the Italian Renaissance," in "AHR Forum: The Persistence of the Renaissance," *American Historical* Review 103 (1998): 83-114; Lisa Jardine, *Worldly Goods: A New History of the Renaissance* (New York, 1996); Martin Kemp, "'Wrought by No Artist's Hand': The Natural, the Artificial, the Exotic, and the Scientific in Some Artifacts from the Renaissance," in *Reframing the*

scholars have investigated the influence of the culture of machines and mechanics on medieval and Renaissance literature.[41] Investigations of material culture always can and sometimes do involve a history of technology component. Such a component, for example, is an instrinsic part of the only graduate program in the U.S. devoted to the decorative arts and material culture.[42]

Finally, historians of science concentrating on medieval and early modern topics are increasingly focusing on practices, technologies, instrumentation, and modalities of investigating nature. They are, in other words, pursing research that could as easily fit under the rubric of the history of technology. The relationship of the two disciplines is thus far different than it was at the famous meeting at Cornell between Henry Guerlac, Mel Kranzburg, and others, whatever happened there. At that time, before the writings of Thomas Kuhn, Bruno Latour, Steven Shapin and Simon Schaffer, before social constructionism, science was more often than not conceived as primarily theoretical, following Alexandre Koyré. Edgar Zilsel's ideas concerning artisanal contributions to the development of the "scientific revolution," although published in the early 1940s, were taken up and developed only much later and within intellectual frameworks very different from that of Zilsel.[43] The role of the artisan and of craftwork and instrumentation in the

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Renaissance: Visual Culture in Europe and Latin America, 1450-1650, ed. Claire Farago (New Haven, 1995), 177-196; Pamela O. Long, "Objects of Art/Objects of Nature: Visual Representation and the Investigation of Nature, " in *Merchants and Marvels*, ed. Pamela H. Smith and Paula Findlen (New York, 2002), 63-82; and Pamela H. Smith, *The Body of the Artisan: Art and Experience in the Scientific Revolution* (Chicago, 2004).

[41] Scott Lightsey, *Manmade Marvels in Medieval Culture and Literature* (New York, 2007); and Henry S. Turner, *The English Renaissance Stage: Geometry, Poetics, and the Practical Spatial Arts, 1580-1630* (Oxford, 2006).

[42] The Bard Graduate Center for Studies in the Decorative Arts, Design, and Culture. For a statement concerning the Center and its philosophical background, see Peter N. Miller, "What We Are," at http://www.bgc.bard.edu/ (last accessed 7 September 2007)/

[43] For Zilsel and his writings, see Edgar Zilsel, *The Social Origins of Modern Science*, ed. Diederick Raven, Wolfgang Krohn, and Robert S. Cohen (Dordrecht, 2000). For social constructivism and the figures mentioned here, see Golinski, *Making Natural Knowledge*. For Koyré's thought, see esp. Alexandre Koyré, *From the Closed World to the Infinite Universe* (New York, 1957), and a collection of his essays, Koyré, *Metaphysics and Measurement* (Cambridge, Mass., 1968).

development of empirical an experimental methodologies is very much an on-going issue.[44] Many historians, myself included, identify themselves as both historians of science and historians of technology and travel seamlessly between the two professional societies.

In conclusion, the history of medieval and late medieval/Renaissance technology is being investigated actively on numerous fronts by historians from a variety of disciplinary backgrounds, most often that of history per se. These areas of research, as I have shown, originated long before the origin of SHOT, but were actively promoted in the early history of the organization, both by the great historian of medieval Europe, Lynn White, jr. and by other early members and officers of SHOT. Indeed, although there were issues in the early years of the organization concerning how much culture should be involved in the new endeavor, and how much technology (an "internalist" / "externalist" debate), there does not seem to have been any debate concerning the "history" part of the mission of the new society. Although SHOT's formation had much to do with developments in American engineering education and culture, as Bruce Seely has shown, there seems never to have been any question that the "history" of technology should refer to any and all history, through all time periods and in every part of the world. While SHOT's activities have never quite reached the "world" as a whole, there have been and continue to be efforts to extend the geographical range included in the organization's effective (as opposed to theoretical) purview.[45]

At the same time, however, SHOT in the past decade has made a radically presentist turn. This is evident primarily, and it must be said, strikingly, at the annual meetings—one of the most

[44] See for example, J. A. Bennett, "The Mechanics' Philosophy and the Mechanical Philosophy," *History of Science* 24 (1986): 1-28; Long, *Openness, Secrecy*; Paolo Rossi, *Philosophy, Technology, and the Arts in the Early Modern Era*, trans. Salvatore Attanasio, ed. Benjamin Nelson (New York, 1970); Smith, *Body of the Artisan*.
[45] Bruce E. Seely, "SHOT, The History of Technology, and Engineering Education," *Technology and Culture* 36 (1995): 739-772.

important public faces of any professional organization. Most recent annual meetings containing sixty or so panels, will if we are lucky, include perhaps one or two that concern18th century topics. Typically, all the remaining focus on 19th and (mostly) 20th century topics. In recent years it is not unusual for not a single paper to appear on the program on any topic before the 18th century. If the annual meetings are taken as a measure, SHOT has become the Society for the History of Modern Technology. This represents a radical if mostly silent change, one which represents a marginalization of the organization from the point of view of the mainstream of historical studies. This shrinkage of purview is a great loss to the highly active if scattered group of scholars working in the premodern history of technology. Such scholars could certainly benefit from an umbrella organization that represented some of their respective fields at the annual meeting. It is a loss as well, in my view, to the scholars working in the modern history of technology, who miss the chance to interact with fascinating and active research fields related closely to their own.