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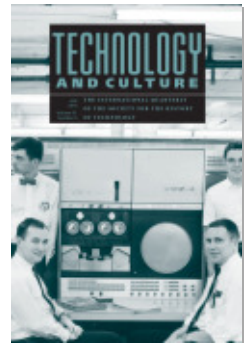
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Innovation, Technology, or History What is the Historiography of Technology About?

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Innovation, Technology, or History

What Is the Historiography of Technology About?

DAVID EDGERTON

Our brief in this symposium is to look at “both the continuing significance of some long-lived patterns in the scholarship of this field, and the importance of newer emergent trends and themes,” particularly in relation to “big questions that scholars—not just historians—might ask about technology, culture, and the world.” Bruce Seely further asked us for “insights about where historians of technology and the Society should be directing their scholarship and activities in the years ahead.” This is a tall and problematic order: what exactly is the field we should be considering, since the study of technology is clearly not confined to self-proclaimed historians of technology? How can we even begin to give a picture of its accomplishments? Indeed, ought we not distrust narratives that purport to tell us where the historiography (and other studies) of technology has been, is, and is going? Furthermore, should we not bear in mind that exhortations that fields are shifting or ought to shift to one particular method, problem, or period often repress rather than stimulate novelty, and reflect a narrowing of conversation and debate, perhaps inevitable in diverse fields, but no less regrettable for that? In this essay I hope to avoid some of these problems by asking an even bigger prior question: what is the history of technology (in

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many different guises, and in many different modes) the history of? What, in practice, is meant by technology in histories, and what is meant by history in histories of technology? Our thinking about technology, and indeed our thinking about the historiography of technology, is, I suggest, uncritically focused on some, but not all, novelties.

In the last generation, public policies in the United States, Europe, and the rest of the rich world have placed enormous rhetorical emphasis on the need for increased “innovation,” which has been reflected in increased institutional support for implicitly instrumentally useful social and historical studies of technological change.¹ In the historiography of technology too there has been a strong focus on novelty, on radical breaks with the past. We in the academy are supposed to have got past unreflexive progress-talk, and are now (in theory, and in Theory) eclectic, playful with time, and open to the marginal. But, in historiographical pronouncements that introduce and summarize new work, a very old-fashioned and narrow progressivism is prevalent.² Authors invoke the specter of a darkly ignorant past, an enlightenment in “recent years” (embellished with a citation to a work *decades* old), and a contemporary revolution. They attack paper tigers like “whig history,” “technological determinism,” and “linear models” as if they were made of scholarly living flesh and bone. For example, in 2003 technological determinism could still be described as a “fast-dying horse,” when it was surely either never alive, long dead, or, to labor the point, the slowest dying horse in the annals of veterinary science.³ From its creation in the 1980s till today, the “linear model” is attacked despite having been an object of attack from its very creation. Such caricaturing of analysts of the past has led to the caricaturing of what happened in the past, for example giving the impression that the linear model was central to belief about and policy for science and technology in recent times.⁴

In the academy, as in technology and in politics, novelty-mongering does not necessarily reflect novelty, much less progress. During the 1980s

NSF ESSAY
SERIES

1. It is, however, a mistake to believe that this has been central to public policy (market liberalization has been much more significant) or that innovation has in fact increased.

2. As an example see Mark Poster, *Cultural History + Postmodernity: Disciplinary Readings and Challenges* (New York, 1997). While this tone is evident in programmatic statements, it is not generally noted that this reflects a profoundly modernist mode of thought. An exception is Richard Evans in his *In Defence of History* (London, 1997), 201–2, where he cites William Reddy noting “postmodernism’s replication of the eternally recurring pretension of absolute originality characteristic of intellectual debate since the Enlightenment” (p. 278, n15).

3. Michael G. Gordin, “A Modernization of ‘Peerless Homogeneity’: The Creation of Russian Smokeless Gunpowder,” *Technology and Culture* 44 (2003): 677.

4. See my “‘The Linear Model’ Did Not Exist—Reflections on the History and Historiography of Science and Research in Industry in the Twentieth Century,” in *The Science-Industry Nexus: History, Policy, Implications*, ed. K. Grandin, N. Wormbs, and S. Widmalm (Sagamore Beach, Mass., 2004), 31–57.

historians of technology were invited to embrace, as a supposed novelty, applied sociology of scientific knowledge—although this meant applying to science what was *already* known about technology/politics/history, as well as embodying the view (explicitly rejected by many historians of technology) that technology is applied science.⁵ While this approach (SCOT, in shorthand) did open up new questions for some historians of technology, others were already alert to alternatives, to paths not taken, to the reality that not all change is progress, and to an understanding that the invocation of theory is not in itself a sign of methodological or historiographical sophistication.⁶ Other approaches taken to be novel have been influential, even when they embodied scholarly tendencies at best indifferent to the economic, the institutional, the social, and the material.⁷ “Material culture” was much more cultural than material, as a browse through the “thing studies” literature will quickly confirm.⁸ Studies of “consumption” have been in fashion, while investigation of “production” is shockingly *démodé*. In this context it does not come as a surprise that the standard text on technological determinism of recent years was mainly about *beliefs* in technological determinism (itself generally defined as a belief, rather than a theory).⁹ Indeed, “cultural history” of technology has been in vogue, as evidenced by Mikael Hård and Andrew Jamison’s book subtitled *A Cultural History of Technology and Science*¹⁰ and by Paul Forman’s recent reflection on the place of technology and science in modernity and post-modernity.¹¹ And, in SHOT’s NSF Workshop, Carroll Pursell particularly insisted on the virtues of cultural history as applied to technology, though in a much broader sense.¹²

5. This was the argument of my “Tilting at Paper Tigers,” *British Journal for the History of Science* 26 (1993): 67–75.

6. “The idea seems to be that if our findings or our arguments fit neatly into some widely accepted theoretical framework, then that will satisfy all the conceivable methodological concerns: theory provides that common language of argument . . . and it also provides as much social science as we might need to ensure that our statements are anchored in a plausible understanding of human nature and social being.” Peter Mandler, “The Problem with Cultural History,” *Cultural and Social History* 1 (2004): 94–117.

7. See the reviews of John Law, *Aircraft Stories: Decentering the Object in Technoscience* (Durham, 2002), by Eric Schatzberg, “On Attempting to Construct Alternative Narratives,” in *Technology and Culture* 45 (2004): 406–12, and by David Edgerton in *Metascience* 12 (2003): 85–87.

8. See for example the “Focus: Thick Things” section of *Isis* 98 (2007), and Bill Brown, ed., *Things* (Chicago, 2004).

9. Merritt Roe Smith and Leo Marx, eds., *Does Technology Drive History? The Dilemma of Technological Determinism* (Cambridge, Mass., 1994). See my review in *British Journal for the History of Science* 28 (1995): 370–72.

10. Mikael Hård and Andrew Jamison, *Hubris and Hybrids: A Cultural History of Technology and Science* (London, 2005).

11. Paul Forman, “The Primacy of Science in Modernity, of Technology in Postmodernity, and of Ideology in the History of Technology,” *History and Technology* 23 (2007): 1–152.

12. Carroll Pursell, “Technologies as Cultural Practice and Production,” *Technology and Culture* 51 (2010): 715–22.

We need to attend to meanings not just in relation to technology but in the work of historians of technology too. To get at what historians of technology are actually doing and how they do it, we need to look beyond the claims to methodological and historiographical novelty, implicit and explicit, and attend to what is said and done. Yet in the history of technology, analysis of what historians have argued, produced, established, assumed, and concluded is extraordinarily rare, whether in celebratory or critical mode. In SHOT meetings and in the journals, it is surprising how few and far between critical references to specific historical arguments are: there is hardly any debate or even serious substantive disagreement.¹³ Even more telling is the fact that SHOT's NSF Workshop, which was designed to produce reflections on what had been done, generally did not.

In what follows I make a particular assessment and critique of what is commonly done and made and how it is commonly done and made (to echo an old and yet, as we shall see, hardly ever observed definition of technology) in the historiography of technology.¹⁴ I suggest that much history of technology has been concerned with illustrations, through historical examples, of the nature of technological change. This is done by studying selected novelties, when they were new, in historically familiar surroundings, with the aim of illuminating the technology-society relation. "Technology" in academic historical practice means a peculiar conflation of novelty and power.¹⁵ It is indeed a hazardous term, to use Leo Marx's term, which often seems to blunt analytical tools; sometimes it seems to make critical thought impossible.¹⁶ As recent work by Eric Schatzberg makes clear, the term "technology" is a much-changing, fluid concept; its widespread use in something like the modern sense dates only from the inter-war years, and though it was closely connected to the idea of progress it was not then conflated with novelty.¹⁷ It became identified with technological

13. There are partial exceptions—for example, the exchange between Ken Alder and Charles Gillispie in *Technology and Culture* 39 (1998): 733–54; Leo Marx's review of Stephen H. Cutcliffe and Robert C. Post, eds., *In Context: History and the History of Technology—Essays in Honor of Melvin Kranzberg* (Bethlehem, Pa., 1989), in *Technology and Culture* 32 (1991): 394–96; and "Comment and Response on the Review of *In Context*," in *Technology and Culture* 33 (1992): 406–7.

14. Charles Singer et al., eds., *A History of Technology* (London, 1955), 1:vii.

15. I have also argued there is an analogous problem in the history of twentieth-century science, which is focused on *research*, not science, and within that on academic research in subfields of physics and biology, while claiming to be engaged with questions of "science and society" rather than merely the history of the academy. See my "The Linear Model? Did Not Exist" (n. 4 above).

16. Leo Marx, "Technology: The Emergence of a Hazardous Concept," *Social Research* 64 (1997): 965–88. A revised version, which I have not seen, is Leo Marx, "Technology: The Emergence of a Hazardous Concept," *Technology and Culture* 51 (2010): 561–77.

17. Eric Schatzberg, "Technik Comes to America: Changing Meanings of Technology before 1930," *Technology and Culture* 47 (2006): 486–512; Ruth Oldenziel, *Making Technology Masculine: Men, Women and Modern Machines in America, 1870–1945* (Amsterdam, 1999).

JULY
2010
VOL. 51

novelty after World War II, and this identification, I argue, has profoundly affected historical work.¹⁸ In other words, the history of technology uses very particular definitions of technology and history, definitions that would need replacing should one want to inquire into the place of technology in history, to answer questions like, “What technologies shaped twentieth-century America?” or better still, “Was Tom Hughes right about technology in American history?”

My assessment is a particular and limited one, concerned mainly (but certainly not only) with outstanding general texts in the history of technology, concentrating on what they say about the twentieth century.¹⁹ The field is fortunate that some of its very best practitioners have self-consciously brought together the scholarly journal and book output of the last few decades in general texts for students and the public.²⁰ By studying these

18. David Edgerton, “De l’innovation aux usages: Dix thèses éclectiques sur l’histoire des techniques,” *Annales HSS* iv–v (1998): 815–37 (the English version is “From Innovation to Use: Ten [Eclectic] Theses on the History of Technology,” *History and Technology* 16 [1999]: 1–26).

19. I would insist that many of my observations do not apply to the study of earlier periods, particularly the early modern (the historiography of which is addressed by Pamela Long in an essay from this same workshop that follows on pages 698–714). For an important and original big-picture work notable for bringing together science, technology, and medicine, and for distinguishing between types of each, see John V. Pickstone, *Ways of Knowing: A New History of Science, Technology, and Medicine* (Chicago, 2001). I do not deal with it here because it is focused on periods before the twentieth century, and because technology is not its main concern.

20. I note here the following, in chronological order, though I do not discuss them all. Some I have discussed in my “De l’innovation aux usages.” Arnold Pacey, *The Maze of Ingenuity: Ideas and Idealism in the Development of Technology* (Cambridge, Mass., 1992; first edition, London, 1974); Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm, 1870–1970* (New York, 1989); Arnold Pacey, *Technology in World Civilisation: A Thousand Year History* (Oxford, 1990); R. A. Buchanan, *The Power of the Machine: The Impact of Technology from 1700 to the Present* (London, 1992); Donald Cardwell, *Fontana History of Technology* (London, 1994), known in the United States as the *Norton History of Technology* and more recently as *Wheels, Clocks, and Rockets: A History of Technology*; Carroll Pursell, *White Heat: People and Technology* (Berkeley, Calif., 1994); Carroll Pursell, *The Machine in America: A Social History of Technology* (Baltimore, 1995); Carroll Pursell, *Technology in Postwar America: A History* (New York, 2007); Ruth Schwartz Cowan, *A Social History of American Technology* (New York, 1997); Thomas P. Hughes, *Human-Built World: How to Think about Technology and Culture* (Chicago, 2004); Thomas J. Misa, *From Leonardo to the Internet: Technology and Culture from the Renaissance to the Present* (Baltimore, 2004); Hård and Jamison (n. 10 above); David Nye, *Technology Matters: Questions to Live With* (Cambridge, Mass., 2006); Robert Friedel, *A Culture of Improvement: Technology and the Western Millennium* (Cambridge, Mass., 2007). For younger readers there is also W. Bernard Carlson, ed., *Technology in World History* (New York, 2005). See also Dick van Lente, “Three Overviews of the History of Technology,” *History and Technology* 24 (2008): 89–96, which deals with *Leonardo to the Internet*, with *Hubris and Hybrids* (n. 10 above), and with Harry Lintens, *Made in Holland: Een techniekgeschiedenis van Nederland (1800–2000)* (Zutphen, Netherlands, 2005), which alas I cannot read.

rich fruits we shall know the field, its implicit and explicit assumptions. I show that key assumptions about technology and history to be found in this literature are also commonplaces in many different historical and social scientific literatures, in the best and most celebrated works.

It might be objected that such general texts in their very generality cut against the grain of recent developments, and that they therefore cannot stand for the field as a whole. Whether there is in fact a great difference between the explicit big pictures and the implicit ones in local studies is something to be established, not assumed. My own view is that, for all the supposed incredulity toward meta-narratives, there is a usually implicit credulity toward *some* meta-narratives in narrower studies, usually the familiar long-established ones though often inverted into anti-progressive forms. But in this essay I make no attempt to assess the journal literature.

I should say something about my own contribution to the big-picture genre. *The Shock of the Old* was written for the general reader, so I did not set out a full critique of the literature or label every novelty. This has led inevitably to both expected and unexpected misunderstandings of its argument and aims. The book was based on the idea (developed here) that accounts of the material constitution of twentieth-century society have been flimsy, yet had very great authority; that theories of material modernity have stood in for empirical studies; and that echoes of past boosterism shaped historiographical agendas. *The Shock of the Old* seeks to present new historical arguments in relation to technology in history, about such matters as production, nations and nationalism, war, and so on. It rests on a very general historiographical critique, rather than on a call to shift attention to under-researched aspects of technology. Although it has been interpreted as arguing for the study of use over invention/innovation, or for the small rather than the big, or for extending studies of users and consumers, or to shift attention from the rich to the poor, it is a call to rethink invention/innovation as well as use—to rethink the big as well as the small, production as well as consumption, and the rich world as well as the poor world.²¹

NSF ESSAY
SERIES

21. *The Shock of the Old: Technology and Global History since 1900* (New York, 2007). Furthermore, I had set out some of my general argument in relation to the existing literature in my “De l’innovation aux usages.” I have added some reflections and elaborations on particular aspects in two papers derived from particular chapters in “Creole Technologies and Global Histories: Rethinking How Things Travel in Space and Time,” *HOST: Journal of the History of Science and Technology* 1, no. 1 (2007): 75–112, available at <http://www.johost.eu/user/data/media/hostn1v1-a2.pdf> (accessed 12 May 2010), and “The Contradictions of Techno-Nationalism and Techno-Globalism: A Historical Perspective,” *New Global Studies* 1, no. 1 (2007): article 1, available at <http://www.bepress.com/ngs/vol1/iss1/art1> (accessed 12 May 2010).

What Is the History of Technology About?

JULY
2010
VOL. 51

Reviewing the T. K. Derry and Trevor Williams *Short History of Technology*, the 1961 condensation of the multivolume *History of Technology* published by Oxford University Press, Thomas P. Hughes lamented that “influenced by prior scholarship they have generally written of the history of technology as if it were identical with the history of invention” despite their very broad and noninnovation-centric definition of technology, alluded to above.²² Hughes’s complaint notwithstanding, the identification of technology not with invention, but with *some successful* invention and the early histories of particular technologies, lives on powerfully, and is especially evident in (though certainly not restricted to) general texts.

Let us move from the past observations from the last of the founders to the newest general text, Robert Friedel’s *Culture of Improvement*. Friedel’s introduction tells us that the subject matter is the “nature of technological change,” why and how technological change has changed, and how the changes have changed. It promises to be a history of invention and innovation, usefully recast as part of a wider history of “improvement,” avoiding the misleading and almost always post-hoc distinctions between radical and incremental inventions, which are still very prominent in the literature. For Friedel, improvements can be small or large and apply to all technologies, whether old or new, an important analytical advance. Yet the book presents a familiar account of selected technologies at early points in their history. Agriculture thus appears in a chapter on the medieval heavy plow, the horse, and three-course rotation and again in the nineteenth century with mechanization and artificial fertilizers. The greatest-ever age of agricultural improvement in the rich world, that of the late twentieth century, is not discussed. The subjects of the four chapters on the twentieth century are the *early* histories of strategic bombing, the nuclear bomb, dams and electrification, computers, the internet, jets and supersonic airliners, eugenics, television, and radio, with bicycles making a welcome appearance to provide some contrast.

Friedel’s choice of technologies, and the focus on their early history, are perfectly representative of the field. For example, in Tom Misa’s *From Leonardo to the Internet*, the period 1870–1930 is discussed in terms of research and invention in electricity and chemicals; 1936–90 in terms of the *wartime* (World War II, that is) history of the atomic bomb, electronics, and computing; and 1970–2001 in terms of the fax, hamburgers, and the internet. The period 1900–50 is also dealt with in terms of modern architecture, but otherwise, apart from the hamburger, the technologies and their periodizations are very familiar. A variant is given in Ruth Schwartz Cowan’s textbook on U.S. technology which claims explicitly that “four technological systems

22. Thomas P. Hughes, review of T. K. Derry and Trevor I. Williams, *A Short History of Technology: From the Earliest Times to A.D. 1900* (London, 1961), in *Isis* 54 (1963): 417–18.

have dominated twentieth-century history: automobiles, and their attendant roads and fuel sources; aircraft, spacecraft and also rockets; electronic communication devices, from wireless telegraphy to personal computers; and finally, biotechnologies, new foodstuffs, medications, and contraceptives,” an argument which has the virtue of insisting on the simultaneous existence of these systems.²³

Even when there is an explicit concern to engage with general history, the familiar technologies in their early years are center-stage. Thomas Hughes’s *American Genesis* is focused on the early history of electricity, research and development, mass production, and the atomic bomb. More recently a general American history textbook written by Pauline Maier, Merritt Roe Smith, Alexander Keyssar, and Daniel J. Kevles includes much material on science, technology, and medicine and deals with the usual suspects in the usual period—for example, the atom bomb in World War II.²⁴

For all that they concentrate on the early history of a small sample of technologies, such studies are not histories of invention or innovation. They are not concerned with the analysis of invention and innovation in particular historical periods. Were they to do so they would be largely histories of failure, and they would be much more broad-ranging in the technologies covered.²⁵ What we have in these texts is a *conflation* of stories of invention/innovation and of use. There is a focus on the early history of selected technologies which later came into widespread use, or which appear self-evidently important. They are neither a history of technologies in use at a particular time, nor yet a history of invention or innovation at that time. It is the conflation, not the focus on invention or innovation, which is a crucial problem with the literature if one is interested in the place of technology in history, or indeed the history of invention or innovation.²⁶

There are, however, many significant general works which are less innovation-centric than the norm: they include the works of Arnold Pacey, especially *Maze of Ingenuity*, and Carroll Pursell, especially *White Heat and Technology in Postwar America*. There are many studies of technologies in use, particularly but not only by historians concerned with gender and the domestic: think of Ruth Schwartz Cowan’s *More Work for Mother*.²⁷ In the

23. Cowan, *A Social History of American Technology*, 221.

24. Pauline Maier, Merritt Roe Smith, Alexander Keyssar, and Daniel J. Kevles, *Inventing America: A History of the United States* (New York, 2003), 2 vols.

25. For clear evidence on this see Ian Inkster, “Patents as Indicators of Technological Change and Innovation—an Historical Analysis of the Patent Data,” *Transactions of the Newcomen Society* 73 (2003): 179–208.

26. It is for this reason that I have argued in *The Shock of the Old* not, as is sometimes suggested, for studies of use *rather* than invention, but rather for properly specified studies of each. I did not explain clearly enough in “Innovation to Use” that innovation-centric studies were not typically studies of innovation or invention as such. In either case, the originality of the point resides not in the point itself—which is obvious—but in noting the systematic way the literature conflates innovation and use.

27. Among the histories to be noted are Ruth Schwartz Cowan, *More Work for Mother*

environmental case note should be taken of Paul Josephson's work on "brute force technologies."²⁸ Important as the exceptions are, exceptions to the rule are not the same as critiques, nor do they necessarily even betoken awareness of the problem of innovation-centric conflation. In this light it is important to recall Svante Lindqvist's unjustly neglected article on mapping technological landscapes, which notes the focus on early history and the lack of studies of both use and, most interestingly, disappearance.²⁹ Pursell has argued that "the history of technology, as currently studied, privileges design over use, production over consumption and periods of 'change' over those which seem static and traditional."³⁰ But neither of these crucial articles addressed the central conflation I am focusing on.

However, the move among some historians of technology to studying users and consumption does not necessarily mean a move to the study of technologies-in-use. Studies of users, central to work in the SCOT tradition, focus on users in innovation. Indeed an innovation-centric definition of technology is central to SCOT.³¹ In Ruth Schwartz Cowan's call for the study of the "consumption junction," and in Ruth Oldenziel's subsequent arguments, a central point made is that studying users shows them active in the *shaping* of technology.³² It is revealing, too, that the key concept of tech-

er: The Ironies of Household Technology from the Open Hearth to the Microwave (New York, 1983); Claude Fischer, *America Calling: A Social History of the Telephone to 1940* (Berkeley, Calif., 1992); K. Jellison, *Entitled to Power: Farm Women and American Technology* (Chapel Hill, N.C., 1993); Ronald Kline, *Consumers in the Country: Technology and Social Change in Rural America* (Baltimore, 2000); and Andrea Tone, *Devices and Desires: A History of Contraceptives in America* (New York, 2001). An excellent recent example is Kenneth Lipartito and Orville R. Butler, *History of the Kennedy Space Center* (Gainesville, Fla., 2007). Note must be taken of works on technology focused on use by those who were not primarily historians: Siegfried Giedion, *Mechanization Takes Command: A Contribution to Anonymous History* (New York, 1948); Cynthia Cockburn and Susan Ormrod, *Gender and Technology in the Making* (London, 1993); Stewart Brand, *How Buildings Learn: What Happens After They're Built* (New York, 1994); Vaclav Smil, *Energy in World History* (Boulder, Colo., 1994); Arnulf Gröbler, *Technology and Global Change* (Cambridge, 1998).

28. Paul Josephson, *Industrialized Nature: Brute Force Technology and the Transformation of the Natural World* (Washington, D.C., 2002); John McNeill, *Something New Under the Sun: An Environmental History of the Twentieth Century* (London, 2000).

29. Svante Lindqvist, "Changes in the Technological Landscape: The Temporal Dimension in the Growth and Decline of Large Technological Systems," in O. Granstrand, ed., *Economics of Technology* (Amsterdam, 1994), 271–88.

30. Carroll Pursell, "Seeing the Invisible: New Perceptions in the History of Technology," *ICON* 1 (1995): 9–15.

31. This is a criticism made by Langdon Winner, who had long been concerned with use, in "Upon Opening the Black Box and Finding It Empty: Social Constructivism and the Philosophy of Technology," *Science, Technology & Human Values* 18 (1993): 362–78.

32. Ruth Schwartz Cowan, "The Consumption Junction: A Proposal for Research Strategies in the Sociology of Technology," in Wiebe E. Bijker et al., eds., *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology* (Cambridge, Mass., 1987), 261–80; Ruth Oldenziel, "Man the Maker, Woman the

nological determinism has been routinely defined as something along the lines of “technical change causing social change” rather than in terms of technology shaping society—the old, standard definition. It is also significant that it is criticized as a theory of technology, rather than what it classically was: a theory of society and history.³³

The innovation-centric conflation of innovation and use in the case of technology is something that the history of technology shares with a very broad scholarly community. It appears as a problem even where one might least expect it. If one looks at the work of general historians at the macro level, the innovation-centric focus is strongly evident.³⁴ It is there in studies of technology in the ancient through to the early-modern periods, where data on invention are scarce to say the least.³⁵ It is present in anthropology too, though of course so are, as one would expect, studies of use.³⁶ Sociology is replete with naive innovation-centrism, evident, for example, in the work of Manuel Castells.³⁷ For economics and economic history, the import of the distinction between invention/innovation, diffusion, and impact is so well-known as to be obvious. Yet in economic history the dominant tradition of thinking about technology has been Schumpeterian in inclination, and thus very innovation-centric, as is evident in the work of David Landes and Joel Mokyr.³⁸

NSF ESSAY
SERIES

Consumer: The Consumption Junction Revisited,” in *Feminism in the Twentieth Century: Science, Technology, and Medicine*, ed. Londa Schiebinger et al. (Chicago, 2001); Trevor Pinch and Nelly Oudshoorn, eds., *How Users Matter: The Co-Construction of Users and Technologies* (Cambridge, Mass., 2003). See also “Presidential Symposium,” *Enterprise & Society* 7, no. 3 (2006): 422–55 (Joanne Yates).

33. See Edgerton, “De l’innovation aux usages” (n. 18 above).

34. John R. McNeill and William H. McNeill, *The Human Web: A Bird’s-Eye View of Global History* (New York, 2003).

35. See Pamela Long’s essay, which follows in this issue of *T&C* on pp. 698–714; see also the comments on this topic by Serafina Cuomo in *Technology and Culture in Greek and Roman Antiquity* (Cambridge, 2007); by Kevin Greene in “Archaeology and Technology,” in *Blackwell Companion to Archaeology*, ed. J. Bintliff (Oxford, 2004), 155–73; and by Kevin Greene in “Technological Innovation and Economic Progress in the Ancient World: M. I. Finley Re-considered,” *Economic History Review* 53 (2000): 29–59.

36. Thus Pierre Lemonnier notes of his own collection of essays that “most papers are concerned [not with invention but] with a subsequent step of the process of innovation, that of ‘choosing’ what to do with a new technical element, whether it has been contrived locally or not” (Lemonnier, ed., *Technological Choices: Transformation in Material Cultures since the Neolithic* [London, 1993], 21). See also Francesca Bray, *Technology and Gender: Fabrics of Power in Late Imperial China* (Berkeley, Calif., 1997), and Robert McC. Adams, *Paths of Fire: An Anthropologist’s Inquiry into Western Technology* (Princeton, N.J., 1997), for different sorts of arguments about different places.

37. Manuel Castells, *The Information Age: Economy, Society, and Culture*, vol 1: *The Rise of the Network Society* (Oxford, 1996). It was this and similar studies I was attacking (while protecting the identity of the guilty), particularly in the “Production” chapter of *The Shock of the Old* (n. 21 above): the idea that we have now moved into a dematerialized, information age.

38. David S. Landes, *The Unbound Prometheus: Technological Change and Industrial*

The focus on use is clear in the tradition of cliometric history—in the work of Paul David, for example—but it is far from general.³⁹ The economics of technology is mostly the economics of innovation; influential and well-known work conflates the two, for example William Nordhaus's work on the impact of technology on productivity in the long run.⁴⁰ The issue is not just one of timing of impacts, but also of which technologies are significant. Even when these issues are explicitly considered (as in studies of the use and impact of "general purpose technologies"), they are the usual suspects (steam, electricity, and information technology) in the usually associated periods.⁴¹ We might note, too, the extreme innovation-centricity and reification of the usual suspects in the so-called "long-wave" theories, in vogue from the late 1970s into the 1980s.⁴²

Development in Western Europe from 1750 to the Present (Cambridge, 1969); Joel Mokyr, *The Lever of Riches: Technological Creativity and Economic Progress* (New York, 1990); Joel Mokyr, *The Gifts of Athena: Historical Origins of the Knowledge Economy* (Princeton, N.J., 2002). As examples of innovation-centric and very limited treatments of technology in economic history, see Barry Eichengreen, *The European Economy since 1945: Coordinated Capitalism and Beyond* (Princeton, N.J., 2006).

39. See G. N. von Tunzelmann, *Steam Power and British Industrialization to 1860* (Oxford, 1978); D. N. McCloskey, *Econometric History* (London, 1987); and Paul David, "Computer and Dynamo: The Modern Productivity Paradox in a Not-Too-Distant Mirror," Center for Economic Policy Research, No. 172, Stanford University, July 1989 (also available in other versions).

40. William D. Nordhaus, "Traditional Productivity Estimates Are Asleep at the (Technological) Switch," *Economic Journal* 107 (1997): 1548–59, gives a new price index for lighting, but one which appears to take the moment of innovation as changing the overall price! For the full treatment see William D. Nordhaus, "Do Real Output and Real Wage Measures Capture Reality? The History of Lighting Suggests Not," in *The Economics of New Goods*, ed. Timothy F. Bresnahan and Robert J. Gordon (Chicago, 1997), 29–70. William D. Nordhaus, "Two Centuries of Productivity Growth in Computing," *Journal of Economic History* 67 (2007): 128–59, repeats the same procedure—it deals with the frontier, assuming instantaneous diffusion.

41. A recent example: Richard G. Lipsey, Kenneth I. Carlaw, and Clifford T. Baker, *Economic Transformations: General Purpose Technologies and Long Term Economic Growth* (Oxford, 2005). See my remarks in chapter 1 of *The Shock of the Old*, and especially Alexander J. Field, "Does Economic History Need GPTs?" (working paper, September 2008), electronic copy available at <http://ssrn.com/> (accessed 14 June 2010). His answer is an emphatic no, noting among many other things that many supposed examples of GPTs do not conform to the usual definitions, and in any case the assumption that something like GPTs are in principle likely to have the greatest impact does not hold. In addition he makes many criticisms of particular studies.

42. Chris Freeman and Francisco Louçã, *As Time Goes By: From the Industrial Revolutions to the Information Revolution* (Oxford, 2002). In *Hubris and Hybrids* (n. 10 above), Hård and Jamison take them up explicitly in their cultural history and relate each wave to cultural reactions to technoscience (p. 56).

The Question of History

In his review of Derry and Williams, Hughes lamented their failure to integrate the history of technology into history, despite their claim to have done this.⁴³ The focus on history, of placing technology within its historical context, has been central to U.S. history of technology for decades—evident, for example, in the work of Hughes and his students, and in the American Historical Association/SHOT booklet series.⁴⁴ Yet it is worth noting that despite this commitment among many of its American founders and long-time supporters, the so-called Society for the History of Technology does not put history first in its constitution: “The purpose of the Society shall be to foster interest in the development of technology and its relations with society and culture, and to promote scholarly study of the documents and artifacts of the history of technology.” In this the constitution was prescient, or perhaps prescriptive, in that most SHOT conference sessions are organized by technology and theme, not historical period, nor historical question (though of course some are).

That historical questions are often secondary is reflected in the fact that the explicit aim of key books by SHOT figures is to say something about what Thomas Misa calls, after Martin Heidegger, “the question of technology.”⁴⁵ Friedel’s book is concerned with “technological change,” and the reader is invited to think of the “moral” questions around technology. Hughes’s *Human-Built World: How to Think about Technology and Culture* and David Nye’s *Technology Matters: Questions to Live With* are concerned explicitly with the nature of technology and its relations to wider culture, not with history, as the titles indicate.⁴⁶ Though more historical, the concern with the question of technology is also unmistakable in Pursell’s recent *Technology in Postwar America* and in Hård and Jamison’s *Hubris and Hybrids*. Indeed, it was striking, at least to me, how much of the discussion in the SHOT plenaries in Washington in 2007 was directly concerned with moral questions and political engagement rather than with history.⁴⁷

43. Hughes, review of T. K. Derry and Trevor I. Williams (n. 22 above).

44. Hughes has, after all, written *American Genesis* (n. 20 above). For Gabrielle Hecht, “The history of the [early] French nuclear program is . . . both a history of technology and a history of France” (*The Radiance of France: Nuclear Power and National Identity after World War II* [Cambridge, Mass., 1998], 4).

45. Misa (n. 20 above), xiv; the term also provides the title for the final chapter. My assessment differs somewhat from that of Eda Kranakis, who hailed the book in that “it puts technology back into mainstream history” (*Technology and Culture* 46 [2005]: 812), a comment which suggests previous attempts had not succeeded!

46. And so too in many ways is *Hubris and Hybrids* a work which usefully decries the “romance and tragedy” styles of discussing technoscience. Note also that the tone of all these works is very different from the standard history book, either for the academy or the general public.

47. In particular the contribution of Rebecca Herzig, but also the roundtable of da Vinci Medalists. To be clear: I am far from arguing against such an engagement, but there

Of course addressing “the question of technology” is laudable and reflects the many and varied publics with which the history of technology engages. In terms of academic audiences, historians of technology address non-historians primarily, above all engineering and science students, and, among researchers, the external audience is most likely to be social scientists interested in technology. The wider public interested in the history of technology is also primarily interested in technology rather than history; the policy concerns of historians of technology tend to be in the area of technology policy. This is as it should be, yet historians of technology and their publics exist in a state of tension, which shapes the work of historians in direct ways.

Historiography from Below

Historians of technology have stressed fundamental differences in the way they understand technology from the way they believe their publics understand technology. In particular, the historians emphasize their freedom from what they consider common public delusions, among them technological determinism, the linear model, and whig history. However, there is much that is common to both once we look seriously at non-academic and non-professional literatures. We should take non-professional historical ideas seriously not merely as objects of study, but also as contributions to our shared understanding of technology in history. What I call doing historiography from below shows vast stores of accumulated knowledge which can be used by academic historians, as well as reminding us that popular understanding of technology in history is much more sophisticated than is often assumed.⁴⁸ It is a powerful way, particularly if this knowledge is studied in time, of uncovering and understanding core assumptions in academic studies, particularly those that endure over long periods. For example, it helps make visible key assumptions which underlie most academic accounts of the relations of science, technology, economics, and twentieth-century war, and indeed many other aspects of thinking about science and technology over the last century.⁴⁹

is a difference between engagement in a political/moral question through an engagement in a historical debate, and a direct engagement with politics. At least that is my experience of doing both.

48. At the NSF Workshop a participant criticized my optimistic view of the public sphere, stressing the lack of civic solidarity across age, gender, etc., and the consequent self-isolation which left people vulnerable to insidiously propagandistic notions. All I can say from my experience of the reception granted *The Shock of the Old* (n. 21 above) is that there is a public, of all ages and genders, for grown-up accounts of technology in history.

49. For examples see my *Warfare State: Britain 1920–1970* (Cambridge, 2005), and *The Shock of the Old*. Raphael Samuel was a pioneer not just of “history from below” but of “historiography from below” in his generous recovery of the contributions of indus-

Looking at non-professional accounts of technology in society and history can help us understand the depth of the commitment to the standard account of twentieth-century technology. In his 1934 text *Technics and Civilization*, Lewis Mumford celebrated the *neotechnic* revolution (the term was coined by Patrick Geddes, but rendered into English, *new technology* makes its meaning and significance clearer) being brought about by electricity and new alloys.⁵⁰ Mumford was not the first or the last to think in this way. For example, Harry Elmer Barnes, a noted U.S. historical sociologist and exponent of the “technological conception of history,” thought in 1948 that the world had gone through three industrial revolutions, the first of iron, steam, and textiles, the second of chemistry and large industries, steel, and new communications, and the third, still occurring in 1948, was “the age of electrification, automatic machinery, electric control over manufacturing processes, air transport, radios and so on.” A fourth was on the way: “with the coming of intra-atomic energy and supersonic stratospheric aviation we face an even more staggering fourth Industrial Revolution.”⁵¹ Barnes was known at this time for his “revisionist” views on the United States and the world wars, and he would become a pioneering Holocaust denier; his views on technology were orthodox commonplaces.

NSF ESSAY
SERIES

The Left too thought in these terms. Marxism had long focused on what bourgeois propagandists took to be the most radical and novel forms of industrial organization.⁵² It was to be an enduring feature of Marxist thought. The Belgian Trotskyite economist Ernest Mandel, writing in the early 1960s, claimed the first industrial revolution had been based on the steam engine, the second on the electric motor and the internal combustion engine, and the third, of which the “warning signs” appeared in the 1940s, was based on nuclear energy and electronically controlled automation.⁵³ A British communist writing in the mid-1960s, and one who believed in only one industrial revolution, treated the period since World War II in terms of atomic power, computers, automation, and space exploration.⁵⁴ In the Soviet Union the idea of a “Scientific-Technical Revolution,” centered on automation, became Communist Party doctrine from the mid-1960s. The idea may well have been lifted from the earlier bourgeois idea of the “Scientific Revolution” (as in C. P. Snow, *The Two Cultures and the Scientific Revo-*

trial archaeologists and others to our historical understanding. The term is mine. See in particular Samuel’s “Unofficial Knowledge,” in *Theatres of Memory: Past and Present in Contemporary Culture* (London, 1994).

50. For a recent very interesting statement of the significance of this work, see Hård and Jamison (n. 10 above), 8.

51. Harry Elmer Barnes, *Historical Sociology: Its Origins and Development: Theories of Social Evolution from Cave Life to Atomic Bombing* (New York, 1948), 145.

52. I owe this point to Gareth Stedman Jones.

53. Ernest Mandel, *Marxist Economic Theory* (London, 1968), 605.

54. Samuel Lilley, *Men, Machines, and History: The Story of Tools and Machines in Relation to Social Progress*, 2nd ed. (London, 1965).

lution) applied not to the seventeenth century but to the twentieth, and associated with airplanes, electronics, and atomic power.

The similarity of the short lists of technologies, along with the closeness of the point of innovation to the period of their supposed world-historical significance, add up to a striking consensus across political, ideological, and national boundaries. Also notable is the lack of empirical justification for the centrality of this or that technology to this or that historical period. We need to understand the content of such claims not merely for historical but also for historiographical reasons: such accounts remain profoundly influential in shaping our historical understanding.⁵⁵

Contextual Histories

The aim of many historical studies of technology in the SHOT tradition has been to think about technology by placing it in its historical and cultural context. What that context is or should be has not provoked much discussion, perhaps necessarily so.⁵⁶ An obvious limitation is that historians do not agree about history. There is a more significant flaw in contextualism in that it assumes that the existing historical work used to establish context does not already have a particular account of technology in it. But it generally does, at least implicitly, resulting in a range of possibilities from contradiction to circularity. Circularity is more likely, in that general historical accounts have implicit accounts focused on the usual technological suspects in the usual periods.

One way out of these problems might be to write the “history of content and context together,” by emphasizing “co-production,” a program strongly influenced by the work of Bruno Latour and his critique of social construction. Andy Pickering puts the case powerfully for science, but the argument applies equally to technology: he calls for work “without regard for traditional distinctions between history of science and history more generally, and especially without centering research upon an archive demarcated by such distinctions.” Pickering continues: “Such an approach would blur the disciplinary identity of historians of science, of course, but no one is better placed than historians of science to speak of the *truly* integral place of science in global history, and the end result might be a clearer view of global history itself.”⁵⁷ But in this kind of post-contextual history,

55. See for example Waqar Zaidi, “‘Aviation Will Either Destroy or Save Our Civilization’: Proposals for the Internationalisation of Aviation, 1920–1945,” *Journal of Contemporary History* (forthcoming, 2010).

56. For an exception see Leo Marx’s review of Cutcliffe and Post, and the responses thereto (n. 13 above).

57. Andy Pickering, “The Rad Lab and the World,” *British Journal for the History of Science* 25 (1992): 251. Latour is of course right to warn against the use of context (given by existing social science or history) to explain other knowledge. We shouldn’t explain

there is always the Latourian temptation of seeing the world as being re-created from scratch in the laboratory, and of depicting it as described by scientists and engineers, without noting that their images are far from being original to them.⁵⁸

A different kind of post-contextual history is possible. Let me give a concrete instance of how this might work. Let us imagine that we had a full account of global twentieth-century invention, innovation, and technologies-in-use, derived independently from contemporary commentary and our histories. Could we usefully contextualize this within existing global histories? I think this answer is no. An account of the material constitution of the human race in the twentieth century would stand as a rebuke to our understanding of the historical context; it would also stand as a rebuke to most theorizing on modernity. For example, it would reveal the rise of a new poor world, which hardly figures in global histories or theories of modernity.⁵⁹ This is not so much as a result of lack of interest in the poor world, rather that of seeing it as a deficient, behind-the-times version of the central model.

Indeed the astonishing power of the standard picture of twentieth-century technology is demonstrated by its centrality to studies of the colonial and post-colonial worlds. Thus Gyan Prakash notes that to “speak of India is to call attention to the structures in which the lives of its people are enmeshed—railroads, steel plants, mining, irrigation, hydro-electric projects . . . and now, the bomb.”⁶⁰ The long list he produces hardly includes anything which did not come from outside India and was not central to Western accounts of modernity. Most studies of India and of colonial and post-colonial settings deal with just such machines and structures.⁶¹ The same

NSF ESSAY
SERIES

(say) technology through sociology; fine, but Latour often confounds sociology with society. In order to understand society, and how it relates to technology, we need to understand sociology and criticize it in connection with empirical materials.

58. Hecht’s *The Radiance of France* (n. 44 above) is a very good example of this post-contextualist approach, as is Timothy Mitchell, *Rule of Experts: Egypt, Techno-Politics, Modernity* (Berkeley, Calif., 2002), chap. 1, “Can the Mosquito Speak?” This chapter deals with DDT, Aswan Dams, and synthetic nitrate fertilizer in a very well-realized Latourian way of writing about the co-production of new material and technical forms, though the latter are high-profile imports into Egypt.

59. An important and honorable exception is Pacey, *Technology in World Civilisation* (n. 20 above), which has a fair amount on poor countries in the twentieth century. Peter Worsley, *The Three Worlds: Culture and World Development* (London, 1984), is a rare case of a comprehensive account.

60. Gyan Prakash, *Another Reason: Science and the Imagination of Modern India* (Princeton, N.J., 1999), 3.

61. See, for example, the papers covering the twentieth century in Morris Low, ed., “Beyond Joseph Needham: Science, Technology, and Medicine in East and South East Asia,” special issue of *Osiris*, 2nd ser., 13 (1998); Roy MacLeod and Deepak Kumar, eds., *Technology and the Raj: Western Technology and Technical Transfers to India, 1700–1947* (New Delhi, 1995); David Arnold, *Science, Technology and Medicine in Colonial India* (Cambridge, 2000); and, to a considerable extent, Mitchell.

applies to the great majority of studies of “post-colonial technoscience.”⁶² There is nothing subaltern about technologies in post-colonial literature. This is all the more striking given that a central concern of studies of post-colonialism is to challenge the view that Western models of modernity apply to the non-Western world, as Francesca Bray has.⁶³ There is a more general challenge to be made than “provincializing Europe”: the problem is not just the so-called Eurocentricity of our account of technology and global history, but that our picture of the Eurocenter is of very dubious merit. Looking at the poor world is a challenge not merely to the universality of standard models but their applicability anywhere.⁶⁴

Toward Material Histories

Rosalind Williams has called for a history of technology “whose ultimate goal is understanding how history works.”⁶⁵ But we are a long way from it. Technological determinism (the potentially interesting notion that society is determined by the technology it uses) is at present untestable because of the weakness of our material explanans by comparison with the social and historical explanandum. We simply don’t have a picture of, say, the complete matériel of an army, let alone of a society as a whole.⁶⁶ Indeed, appreciating the sheer weakness of our account of the material constitution of the past and present seems to me to be a critical point. We don’t even properly understand the large-scale production technologies of the rich

62. See the special issue of *Social Studies of Science* from 2002, and one with the same title in *Science as Culture* in 2005, both of which contain studies dealing with the recent past in Tibet, Australia, Peru, Brazil, Mexico, French Africa, and French Guyana, mostly not post-colonial cases. The examples of “technoscience,” with maybe two exceptions, are the reassuringly familiar “Western” bioscience and medicine, uranium mining, rockets, and computers. This is no aberration: at the SHOT meeting in Lisbon in 2008, I estimate there were fifteen papers on poor countries in the twentieth century (excluding former socialist countries). Three dealt with nuclear issues, three with computers or IT, two with television, and there were single papers on mobile phones, rockets, airplanes, the green revolution, engineers, and two unspecified. This is not wholly typical because in previous years dams have been prominent, but even then the point is made.

63. Francesca Bray, “Technics and Civilisation in Late Imperial China: An Essay in the Cultural History of Technology,” in Low, 11–33.

64. This is the argument of *The Shock of the Old* (n. 21 above). See also my “Creole Technologies and Global Histories” (n. 21 above), and David Arnold, “Europe, Technology and Colonialism,” *History and Technology* 21 (2005): 85–106.

65. Rosalind Williams, “Opening the Big Box,” *Technology and Culture* 48 (2007): 104.

66. See the wonderful critique of the military-historical literature, and the way it deals with technology, by George Raudzens in “War-Winning Weapons: The Measurement of Technological Determinism in Military History,” *Journal of Military History* 54 (1990): 403–34. Raudzens notes that “we have assertions, images and impressions of technological decisiveness in war, but we have no detailed measurement, analysis or consensus” (p. 432).

world. The history of technology-in-use, and the history of invention, too, have barely begun to be written.

Getting to a better account of technology means counteracting what Australians usefully call the “cultural cringe”; the term is used as a criticism of local intellectuals who underrate the cultural production of their locality and overestimate foreign high culture. The very lowness and ubiquity of technology make it significant in history but suspect in the academy. Yet there are other unfashionable areas of history, such as business, economic, and military history, that need to be engaged with rather than going down the now traditional path of seeking respectability by applying novel high theory to low subjects. Indeed, we need to reach down the food chain, to the amateur specialists on plows, tractors, airplanes, rickshaws, aircraft, small arms, and electric toasters.

Worthwhile historical studies of technology are likely to, and might be directed to, *challenge* not what we take to be popular misconceptions, but rather the best academic work, its substantive content as much as its methodology. Taking seriously how a wide range of scholars treat technology opens up a powerful site of critique, not least of self-consciously advanced modes of historical analysis and other analyses, many of which assume very limited models of the material constitution of society and its development. Understanding what the founding members of SHOT got wrong (let alone right) about modernity might well be more significant than finding a new way of bashing technological determinism, and more interesting than a ride on the latest novelty in the academic fairground. We should beware of privileging the novel, in both history and in historiography, not out of conservatism, but because we understand the power and influence of claims to novelty to disguise a lack of novelty, and indeed sometimes to suppress it. Novelty-mongering is itself profoundly unoriginal, but old-fashioned futurism, despite being passé, is still surprisingly effective. As the Uruguayan engineer (stretching both definitions) the Comte de Lautréamont quipped a long time ago, progress implies plagiarism; but, we might add, not all plagiarism is progressive.

NSF ESSAY
SERIES