

DARTMOUTH COLLEGE  
Physics 7, First-Year Seminar, Fall 2008  
**Reading Artifacts: The Material Culture of Science**  
www.dartmouth.edu/~writing/ (Institute for Writing and Rhetoric)  
projectsx.dartmouth.edu/DARTsico/ (Scientific Instruments Collection)

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Office Hours: Wed 1-3  
and by appointment

**Schedule**

Sept	25	Introduction: Reading artifacts
	30	How do we study material culture?
Oct	1	X-Hour: Sources, plagiarism and scholarly manners
	2	Snapshots of science in America; WriteWorkshop 1
	7	Science at Dartmouth College
	9	Field trip to Harvard's Collection of Historical Scientific Instruments (7:30 a.m. – 2:00 p.m.)
	14	What are “scientific instruments” and how are they classified? WriteWorkshop 2 (breakfast meeting, 9 – 10:45 a.m.)
	16	The challenge of primary sources, with Peter Carini
	21	“Performative” vs. “forensic” historiography, or how can we study earlier experimental practices? Introducing the King Collection
	22	X-Hour: Research strategies, with Jane Quigley and Noah Lowenstein
	23	Introduction to exhibition planning and design, with Bart Thurber and Patrick Dunfey (meet at the offices of the Hood Museum of Art)
	28	Material culture and scientific research; WriteWorkshop 3
	30	Exhibit planning 1
Nov	4	Material culture, science teaching and moral discipline; WriteWorkshop 4
	6	Handling instruments and connoisseurship; Exhibit planning 2
	11	Collections, collectors and museums: Who saves what and why? WriteWorkshop 5
	13	Exhibit planning 3
	18	Three centuries of instrument makers: Ramsden in London, Brashear in Pittsburgh, and Rich Johnson at Dartmouth
	20	Exhibit planning 4; WriteWorkshop 6
	25	How do we study the recent material culture of science? WriteWorkshop 7
	27	No class meeting
Dec	2	Install the exhibit
	4	Exhibit opening
	8	Revised fourth essay due by 5 p.m., no final examination

## Goals

First and foremost, this is a seminar about writing. In the WriteWorkshops we will talk about and practice writing. We will examine examples of good and bad prose, including pieces written by yourselves, and will criticize these with the aid of a guide to writing. We will focus not only on the mechanics of grammar but also on how to write precisely, concisely and logically. Special sessions will be devoted to the issues of plagiarism, research strategies, points of view in primary sources, and to oral presentation.

Second, we will study the material culture of science by exploring Dartmouth's Allen King Collection of Scientific Instruments. With more than 3000 items, Dartmouth's collection is one of the largest at any North American university or college. We shall investigate who made the instruments, how they were used at Dartmouth, and how they relate to earlier scientific theories, laboratory practices, and classroom teaching. We shall visit one of the world's largest university instrument collections at Harvard and shall explore the significance of collections and collectors. We shall also read and discuss literature on how to "read artifacts" and on how to study historic scientific apparatus and their related sciences.

Finally, we will create an exhibit in Rauner Special Collections, drawing on materials in the King Collection and College Archives. The class will formulate a concept for the exhibit, select items to display, study those items, prepare labels and catalog, and install the exhibit. At the end of the term, we will present the exhibit for review and critique by one or more experts on scientific instruments.

## Requirements

Class participation and oral presentation (1/4): For most seminar sessions, we will discuss assigned readings. You should read these materials critically before class, and come prepared to raise questions and participate actively in the discussion. You will also offer several formal oral presentations to the seminar that will be evaluated as part of your class participation. And you should contribute actively to the planning and implementation of the exhibit.

Short essays (1/2): During the first half of the term, you will write three short essays (3-5 pages or about 1000 words each), each of which will require a specific type of writing. You will rewrite each essay after considering criticisms of your first draft. Only the final version of each essay will be graded. Late papers, without an official College excuse (health or family emergency), will be penalized.

Exhibit project (1/4): By 30 October we will have selected the theme and apparatus for the exhibit and defined your role in the project. You will write a research paper of about 10-12 pages (about 3000 words) relevant to this role. The initial draft of this paper is due on 25 November; the revised draft is due on 8 December, by 5 p.m.

## Policies

Full participation in class is required to successfully complete this course. According to the *ORC*, pp. 79-80, there are no excused absences for participation in College-sponsored extracurricular events. If you anticipate such conflicts, please see me before the end of the second week of the term so that we can discuss appropriate accommodations.

Some students may wish to take part in religious observances that occur during this academic term. If you have a religious observance that conflicts with your participation in the course, please meet with me before the end of the second week of the term to discuss appropriate accommodations.

Students with disabilities enrolled in this course who may need disability-related classroom accommodations are encouraged to make an appointment to see me, ideally, before the end of the second week of the term. All discussions will remain confidential, although the Student Accessibility Services office may be consulted to discuss appropriate implementation of any accommodation requested.

For this course, following Dartmouth's Academic Honor Principle means that all written work that you submit will be your own, and that you will follow standard citation practices as outlined in *Sources and Citation at Dartmouth College* (<http://www.dartmouth.edu/~writing/sources/>).

## Required Textbooks (available at Wheelock Books)

White, Joseph M. *Style: The basics of clarity and grace*. 2d ed. New York: Pearson, 2006.

Ulrich, Laurel Thatcher. *The age of homespun*. New York: Random House, 2002.

**Syllabus & Bibliography**

(\*'d items available on e-reserve or at the Kresge Library)

**Sept 25 Introduction: Reading Artifacts**

Handout on the "Winterthur Protocol."

Background Reading

Fleming, E. McClung. "Artifact study: A proposed model." In *Material culture studies in America*, ed. Thomas J. Schlereth, pp. 162-73. Nashville, 1982.

Maquet, Jacques. "Objects as instruments, objects as signs." In *History from things: Essays on material culture*, ed. Steven Lubar and W. David Kingery, pp. 30-40. Washington, D.C., 1993.

Eversmann, Pauline K., *et al.* "Material culture as text: Review and reform of the literacy model for interpretation." In *American material culture*, ed. Ann S. Martin and J. Ritchie Garrison, pp. 135-67. Winterthur, Delaware, 1997.

**Sept 30 How do we study material culture?**

Prown, Jules David. "The truth of material culture: History or fiction?" In *History from things: Essays on material culture*, ed. Steven Lubar and W. David Kingery, pp. 1-19. Washington, D.C., 1993. Available on blackboard site.

Ulrich, Laurel Thatcher. *The age of homespun*. New York, 2001. Read the introduction and at least two of the subsequent chapters. Come to class prepared to critically discuss Ulrich's analysis of the two artifacts in your chapters (no longer than five minutes). How does Ulrich's approach differ from the Winterthur protocol?

**First essay due:** Prompted by the Winterthur protocol and Ulrich's book, write a 3-page analysis of one of the selected objects from Dartmouth's King Collection of Scientific Instruments. Be sure to include both description and analysis.

Background Reading

Mahoney, Michael S. "Reading a machine." Unpublished ms, 2003. Available at <http://www.princeton.edu/~hos/h398/readmach/modelt.html>.

Hindle, Brooke. "Technology through the 3-D time warp." *Technology and Culture* 24 (1983), 450-64. E-journal.

**Oct 1 X-Hour: Sources, plagiarism and scholarly manners**

*Sources and Citation at Dartmouth College*, 2008. Available at <http://www.dartmouth.edu/~writing/sources/>.

**Oct 2 Science in America: Snapshots; WriteWorkshop 1**

\*Greene, John. *American science in the Age of Jefferson*. Ch. 1-3 = pp. 1-90. Ames, 1984.

Plus one of the following:

- Goldstein, Daniel. "'Yours for science': The Smithsonian Institution's correspondents and the shape of the scientific community in 19<sup>th</sup>-century America." *Isis* 85 (1994), 573-99. E-journal.
- \*Seidel, Robert. "The origins of the Lawrence Berkeley Laboratory." In *Big science*, ed. Peter Galison and Bruce Hevly, pp. 21-45. Stanford, 1992.
- Kevles, Daniel J. "The National Science Foundation and the debate over postwar research policy, 1942-1945." *Isis* 68 (1977), 5-26. E-journal.

#### Background Reading

- Bedini, Silvio A. *Thinkers and tinkers: Early American men of science*. New York, 1975.
- White, Craig Howard. "Natural law and national science: The 'Star of Empire' in Manifest Destiny and the American Observatory Movement." *Prospects* 20 (1995), 119-60.
- Bruce, Robert V. *The launching of modern American science*. Ithaca, 1987.
- Goldberg, Stanley and Stuewer, Roger H., eds. *The Michelson era in American science, 1870-1930*. New York, 1988.
- Kevles, Daniel J. *The physicists: The history of a scientific community in modern America*. New York, 1978.
- Numbers, Ronald L. and Rosenberg, Charles E., eds. *The scientific enterprise in America: Readings from "Isis"*. Chicago, 1996.
- Thackray, Arnold, ed. *Science after '40*. *Osiris* 7, 1992.

### Oct 7 Science at Dartmouth College

- \*Pantalony, David; Kremer, Richard L.; and Manasek, Francis. *Study, measure experiment: Stories of scientific instruments at Dartmouth College*. Norwich, 2005. Page through entire book, read pp. 207-35.
- Klaas, James. "From Bavaria to Hanover: The early history of x-rays." *Dartmouth Undergraduate Journal of Science* 5 (2002), 42-44. E-journal.
- Investigate a topic using resources from Rauner Special Collections as identified by a bibliography to be distributed. Be prepared to present your findings orally to the seminar.

#### Revised first essay due.

#### Background reading

- Guralnick, Stanley M. *Science and the ante-bellum American college*. Philadelphia, 1975.
- Brown, Sanford C. and Rieser, Leonard M. *Natural philosophy at Dartmouth*. Hanover, 1974.
- Mitman, Gregg. "Evolution as Gospel: William Patten, the language of democracy, and the Great War." *Isis* 81 (1990), 446-63.
- King, Allen L. *Dartmouth College: From natural philosophy to contemporary science, 1769-1969*. Hanover, 1969. [Rauner DC History LD1438 .I94]

- Tully, William. *The journal of William Tully, medical student at Dartmouth, 1808-1809*. Ed. Oliver S. Hayward and Elizabeth H. Thomson. New York, 1977.
- Hayward, Oliver S. and Putnam, Constance E. *Improve, perfect & perpetuate: Dr. Nathn Smith and early American medical education*. Hanover, 1998.
- Putnam, Constance E. *The science we have loved and taught: Dartmouth Medical School's first two centuries*. Hanover, 2004.
- Kimball, William Phelps. *The first hundred years of the Thayer School of Engineering at Dartmouth College*. Hanover, 1971.
- Nartonis, David K. "Locke-Stewart-Mill: Philosophy of science at Dartmouth College, 1771-1854." *International Studies in the Philosophy of Science* 15, no. 2 (2001), 167-175.

**Oct 9 Field trip to Harvard's Collection of Historical Scientific Instruments (7:30 a.m. to 2:00 p.m.)**

<http://www.fas.harvard.edu/~hsdept/chsi.html>

**Oct 14 What are "scientific instruments" and how are they classified? Write Workshop 2**

- Warner, D. J. "What is a scientific instrument, when did it become one, and why?" *British Journal for the History of Science* 23 (1990), 83-93. E-journal.
- \*Hackman, W. D. "Scientific instruments: Models of brass and aids to discovery." In *The uses of experiment*, ed. David Gooding, *et al.*, pp. 31-66. Cambridge, 1990.
- Carroll-Burke, Patrick. "Tools, instruments and engines. Getting a handle on the specificity of engine science." *Social Studies of Science* 31 (2001), 593-625. E-journal.

**Second essay due:** Write a 3-page review of Harvard's permanent exhibit "Time, Life, & Matter: Science in Cambridge" for the *New York Times*. What are the goals of the exhibit. How well does the installation achieve those goals? Be sure to discuss specific objects or entire cases in the exhibit.

Background Reading

- Van Helden, Al. "The birth of the modern scientific instrument, 1550-1700." In *The uses of science in the age of Newton*, ed. J. G. Burke, pp. 49-84. Berkeley, 1983.
- Brenni, Paolo. "Art and science: The design of scientific instruments." In *Creativity in the arts and sciences*, ed. William R. Shea and Antonio Spadafora, pp. 121-41. Canton, MA, 1990.
- Field, J. V. "What is scientific about a scientific instrument?" *Nuncius* 3 (1988), 3-26.
- Mendelsohn, Everett. "The social locus of scientific instruments." In *Invisible connections: Instruments, institutions and science*, ed. Robert Bud and Susan E. Cozzens, pp. 5-22. Bellingham, 1992.

- Turner, A. J. "Intrepreting the history of scientific instruments." In *Making instruments count*, ed. R. G. W. Anderson, *et al.*, pp. 17-26. Aldershot, 1993.
- Van Helden, Al and Hankins, T. L. "Introduction: Instruments in the history of science." *Osiris* 9 (1994), 1-6.
- Corn, Joseph J. "Object lessons/object myths? What historians of technology learn from things." In *Learning from things: Method and theory of material culture studies*, ed. W. David Kingery, pp. 35-54. Washington, D.C., 1996.
- Bud, Robert and Warner, Deborah, eds. *Instruments of science: An historical encyclopedia*. New York, 1998.
- \*Baird, Davis. *Thing knowledge: A philosophy of scientific instruments*. Berkeley, 2004.

**Oct 16      The challenge of primary sources (a murder at Dartmouth), with College Archivist Peter Carini**

**Oct 21      "Performative" vs. "forensic" historiography, or how can we study earlier experimental practices? Visit to the King Collection**

- \*Polanyi, Michael. "Tacit knowing." In idem, *The tacit dimension*, pp. 3-25. Garden City, NJ, 1966.
- Heering, Peter. "On Coulomb's inverse square law." *American Journal of Physics* 60 (1992), 988-994. E-journal.
- Martinez, Alberto A. "Replication of Coulomb's torsion balance experiment," *Archive for History of Exact Sciences* 60 (2006), 517-63. E-journal.
- \*Brooks, Randall C. "Forty years of analytical studies." *Bulletin of the Scientific Instrument Society* (2004), 82: 4-9.

#### Background Reading

- Blondel, Christine and Dörries, Matthias, eds. *Restaging Coulomb*. Florence: Olschki, 1994. Essays by Peter Heering and John L. Heilbron.
- Voskuhl, Adelheid. "Recreating Herschel's actinometry: An essay in the historiography of experimental practice." *British Journal for the History of Science* 30 (1997), 337-55.
- Sibum, Heinz Otto. "Experimental history of science." In Svante Lindqvist, ed., *Museums of modern science*, pp. 77-86. Canton, MA, 2000.
- Idem. "Reworking the mechanical value of heat: Instruments of precision and gestures of accuracy in early Victorian England." *Studies in History and Philosophy of Science* 26 (1995), 73-106. E-journal.
- Höttecke, Dietmar. "How and what can we learn from replicating historical experiments: A case study." *Science and Education* 9 (2000), 343-62.

**Revised second essay due.**

**Oct 22 X-Hour: Research strategies for studying historical scientific instruments, with Jane Quigley and Noah Lowenstein of Kresge Physical Sciences Library**

<http://www.dartmouth.edu/~library/kresge/help/>

**Oct 23 Introduction to exhibition planning and design, with Bart Thurber and Patrick Dunfey (meet at the offices of the Hood Museum)**

\*Greenblatt, Stephen. "Resonance and wonder." In *Exhibiting cultures*, ed. Ivan Karp and Steven D. Lavine, pp. 42-56. Washington, D.C., 1991.

**Oct 28 Material culture and the practice of scientific research; WriteWorkshop 3**

Dörries, Matthias. "Balances, spectrosopes, and the reflexive nature of experiment." *Studies in History and Philosophy of Science* 25 (1994), 1-36. E-journal.

Read the above essay and one of the following. Be prepared to report back to the seminar on how your author analyzes the role of instruments in scientific research.

\*Heilbron, John L. "Churches as scientific instruments." *Bulletin of the Scientific Instrument Society* (1996), issue 48, 4-9.

Hoskin, Michael. "Herschel's 40 ft. reflector: Funding and functions." *Journal for the History of Astronomy* 34 (2003), 1-32.

\*Holmes, Frederic L. and Levere, Trevor H., eds. *Instruments and experimentation in the history of chemistry*. Cambridge, 2000. Select one essay from among Chs. 4-14.

Hopwood, Nick. "'Giving body' to embryos: Modeling, mechanism, and the microtome in late nineteenth-century anatomy." *Isis* 90 (1999), 42-96. E-journal.

### **Background Reading**

Cahan, David. "The institutional revolution in German physics, 1865-1914." *Historical Studies in the Physical Sciences* 15 (1985), 1-65.

Shapin, Steven and Schaffer, Simon. *Leviathan and the air-pump: Hobbes, Boyle and the experimental life*. Princeton, 1985.

Galison, Peter. *Image and logic: A material culture of microphysics*. Chicago, 1997.

Hankins, Thomas L. and Silverman, Robert J. *Instruments and the imagination*. Princeton, 1995.

Dick, Steven J. *Sky and ocean joined: The U.S. Naval Observatory, 1830-2000*. New York, 2002.

Max Planck Institute for the History of Science. "The virtual laboratory: Essays and resources on the experimentalization of life, 1830-1930." <http://vlp.mpiwg-berlin.mpg.de/essays/data/index.html>

**Third essay due:** Write a 4-page essay comparing and contrasting the "performative" and "forensic" approaches to the study of scientific instruments. Discuss general issues and at least one case study for

each approach (see the “relevant papers” listed in Brooks, 2004, pp. 7-9). Evaluate the strengths and weaknesses of each approach.

**Oct 30 Exhibit planning 1**

Define a concept for the exhibit, assign tasks to working teams.

**Nov 4 Material culture, science teaching and moral discipline; WriteWorkshop 4**

\*Warner, Deborah. “Physics as a moral discipline: Undergraduate laboratories in the late nineteenth century.” *Rittenhouse* 6 (1992), 116-28.

\*Wells, H. G. “A slip under the microscope.” In idem, *Short stories*, pp. 591-612. London, 1927.

Gooday, Graeme. “Nature in the laboratory: Domestication and discipline with the microscope in Victorian life science.” *British Journal for the History of Science* 24 (1991), 307-341. E-journal.

Background reading

\*Brenni, Paolo. “Silbermann’s didactic paintings in the University of Mississippi Museum.” *Bulletin of the Scientific Instrument Society* (2007), 95: 2-6.

Borrell, Merriley. “Training the senses, training the mind.” In *Medicine and the five senses*, ed. William Bynum and Roy Porter, pp. 244-61. Cambridge, 1993.

Gooday, Graeme J.N. *The morals of measurement: Accuracy, irony, and trust in late Victorian electrical practice*. Cambridge, 2004.

Olesko, Kathryn M. *Physics as a calling: Discipline and practice in the Königsberg seminar for physics*. Ithaca, 1991.

Pyenson, Lewis and Gauvin, Jean-François, eds. *The art of teaching physics: The eighteenth-century demonstration apparatus of Jean Antoine Nollet*. Québec: Septentrion, 2002.

Wise, M. Norton, ed. *The values of precision*. Princeton, 1995.

**Revised third essay due.**

**Nov 6 Handling instruments and connoisseurship; Exhibit planning 2**

Progress reports from each team; review draft list of objects to include; refine research topics for the catalog.

**Nov 11 Collections, collectors and museums: Who saves what and why? WriteWorkshop 5**

\*Impey, O. and MacGregor, A., eds. *The origins of museums: The cabinet of curiosities in sixteenth and seventeenth-century Europe*. Oxford, 1985. Read one article and be prepared to discuss the collecting impulses it reveals.

\*Lubar, Steven. “What do we keep?” *American Heritage of Invention & Technology* 14 (Spring 1999), 28-38.

Kremer, Richard L. "A time to keep, and a time to cast away': Thoughts on acquisitions for university instrument collections." Forthcoming in *Rittenhouse* (available on blackboard site).

#### Background reading

- Anderson, R.G.W. "Connoisseurship, pedagogy or antiquarianism? What were instruments doing in the nineteenth-century national collections in Great Britain?" *Journal of the History of Collections* 7 (1995), 211-25.
- Andrewes, William J.H. "The life and work of David Pingree Wheatland (1898-1993)." *Journal of the History of Collections* 7 (1995), 261-268.
- Clifford, James. "On collecting art and culture." In *The cultural studies reader*, ed. Simon During, 2d ed., pp. 57-76. London, 1999.
- Fara, Patricia. "Fit for a king? The George III Gallery at the Science Museum." *History of Science* 33 (1995), 359-367.
- Findlen, Paula. *Possessing nature: Museums, collecting, and scientific culture in early modern Italy*. Berkeley, 1994.
- Henson, Pamela M. "Objects of curious research': The history of science and technology at the Smithsonian." In *Catching up with the vision: Essays on the occasion of the 75th anniversary of the founding of the History of Science Society*, ed. Margaret W. Rossiter, pp. S249-S269. Chicago, 1999. [In stacks with *Isis*]
- Heesen, Anke te and Spary, E.C., eds. *Sammeln als Wissen: Das Sammeln und seine wissenschaftsgeschichtliche Bedeutung*. Göttingen, 2001.
- Kenseth, Joy. "Introduction." In *The age of the marvelous*, ed. idem, pp. 25-59. Hanover, 1991. Page through the exhibition catalogue.
- MacGregor, Arthur. "The life, character and career of Sir Hans Sloane." In idem, ed., *Sir Hans Sloane: Collector, scientist, antiquary, founding father of the British Museum*, pp. 11-44. London, 1994.
- Museum collecting policies in modern science and technology: Proceedings of a seminar held at the Science Museum, London, 3 November 1988*. London, 1991.
- Orosz, Joel J. *Curators and culture: The museum movement in America, 1740-1870*. Tuscaloosa, 1990.
- Osietzki, Maria. "Die Gründungsgeschichte des Deutschen Museums von Meisterwerken der Naturwissenschaften und Technik in München, 1903-1906." *Technikgeschichte* 52 (1985), 49-75.
- Schaffer, Simon. "Object lessons." In *Museums of modern science*, ed. Svante Lindqvist, pp. 62-76. Canton, MA, 2000.
- Schubert, Karsten. *The curator's egg: The evolution of the museum concept from the French Revolution to the present day*. London, 2000.
- Stephenson, Bruce. "American instruments at the Adler." *Rittenhouse* 10 (1996), 81-89.

#### Nov 13 Exhibit planning 3

Prepare instruments and other materials for exhibit. Critique layout and text for labels.

**Nov 18      Three centuries of instrument makers: Ramsden in London, Brashear in Pittsburgh, and Rich Johnson at Dartmouth**

\*McConnell, Anita. *Jesse Ramsden (1735-1800): London's leading scientific instrument maker*, Ch. 1-4. Aldershot: Ashgate, 2007.

Brashear, John A. *John A. Brashear: The autobiography of a man who loved the stars*, ed. W. Lucien Scaife, Ch. 1-9. New York, 1924. Available at <http://apps.libraries.psu.edu/digitalbookshelf/bookindex.cfm?oclc=26832881>

Examine a catalogue from one instrument-making company, and be prepared to report briefly on the history of the firm, the types of apparatus it offered, potential audiences for its products, and how the catalogue attempts to “sell” the products. Some 18<sup>th</sup> and 19<sup>th</sup>-century trade catalogues are at [www.sic.iuhps.org/refertxt/catalogs.htm](http://www.sic.iuhps.org/refertxt/catalogs.htm).

Background reading

“Autobiography of Alvan Clark.” *New England Historical and Genealogical Register* 43 (1889): 3-8.

Schechner, Sara J. “Tools for teaching and research: John Prince, the Deerfield Academy, and educational reform in the early republic.” *Rittenhouse* 10 (1996), 97-120.

Bedini, Silvio A. “At the sign of the compass and quadrant: The life and times of Anthony Lamb.” *Transactions of the American Philosophical Society*, 74/1 (1984), 1-84.

Gee, Brian. “Joseph Henry’s trade with instrument makers in London and Paris.” *Bulletin of the Scientific Instrument Society* (1990), 25: 19-24.

Turner, Gerard L'Estrange. *Elizabethan instrument makers: The origins of the London trade in precision instrument making*. Oxford, 2000.

Bryden, D. J. *Scottish scientific instrument makers, 1600-1900*. Edinburgh, 1972.

Millburn, John R. *Adams of Fleet Street: Instrument makers to King George III*. Aldershot, 2000.

Jackson, Myles W. *Spectrum of belief: Joseph von Fraunhofer and the craft of precision optics*. Cambridge, 2000.

Bennett, J.A. *Le citoyen Lenoir: Instrument making in revolutionary France*. Cambridge, 1989.

De Clercq, P.R., ed. *Nineteenth-century scientific instruments and their makers*. Leiden, 1985.

Brenni, Paolo. “Nineteenth-century French scientific instrument makers.” *Bulletin of the Scientific Instrument Society*, many issues, 1993-96.

Williams, Mari E.W. *The precision makers: A history of the instruments industry in Britain and France, 1870-1939*. London: Routledge 1994.

Cattermole, M. J. G. and A. F. Wolfe. *Horace Darwin's shop: A history of the Cambridge Scientific Instrument Company, 1878 to 1968*. Bristol, 1987.

Thackray, Arnold and Myers, Minor, Jr. *Arnold O. Beckman: One hundred years of excellence*. Philadelphia, 2000.

Thiessen, Arthur R. *A History of the General Radio Company*. West Concord, Massachusetts: General Radio Company, 1965. Available at [www.ietlabs.com/Genrad/index.html](http://www.ietlabs.com/Genrad/index.html).

Van Veen, Frederick. *The General Radio story*. Lulu.com, 2007.

**Nov 20 Exhibit planning 4; WriteWorkshop 6**

**Fourth essay due:** Your contribution to the exhibition catalogue.

**Nov 25 How do we study the recent material culture? WriteWorkshop 7**

\*Hoddeson, Lillian. "The first large-scale application of superconductivity: The Fermilab energy doubler, 1972-1983." *Historical Studies in the Physical and Biological Sciences* 18 (1987), 25-54.

\*Wilson, Robert. "Architecture at Fermilab." In *The architecture of science*, ed. Peter Galison and Emily Thompson, pp. 459-73. Cambridge, 1999.

Smith, Robert W. and Tatarewicz, Joseph N. "Counting on invention: Devices and black boxes in very big science." *Osiris* 9 (1994), 101-23. E-journal.

Background reading

Heilbron, J. L. and Seidel, Robert W. *Lawrence and his laboratory*. Berkeley, 1989.

Traweek, Sharon. *Beamtimes and lifetimes: The world of high energy physicists*. Cambridge, MA, 1988.

Galison, Peter Louis. *Image and logic: A material culture of microphysics*. Chicago, 1997.

Smith, Robert W. *The space telescope: A study of NASA, science, technology, and politics*. 2d ed. Cambridge, 1993.

Latour, Bruno. *Laboratory life: The social construction of scientific facts*. Beverly Hills, 1979.

Clarke, Adele E. and Fujimura, Joan H., eds. *The right tools for the job: At work in twentieth-century life sciences*. Princeton, 1992.

Rasmussen, Nicolas. *Picture control: The electron microscope and the transformation of biology in America, 1940-1960*. Stanford, 1997.

Joerges, Bernward and Shinn, Terry, eds. *Instrumentation between science, state and industry*. Dordrecht, 2001.

Dartmouth Space Physics, at <http://www.dartmouth.edu/~spacephy/>

**Dec 2 Install the exhibit**

**Dec 4 Opening and critique of the exhibit**

**Dec 8 Revised fourth essay due, by 5 p.m.**