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FOCUS: THE HISTORY OF SCIENTIFIC INSTRUMENTS

Introduction

Reengaging with Instruments

By Liba Taub*

ABSTRACT

Over the past twenty years or so, historians of science have become increasingly sensitized to issues involved in studying and interpreting scientific and medical instruments. The contributors to this Focus section are historians of science who have worked closely with museum objects and collections, specifically instruments used in scientific and medical contexts. Such close engagement by historians of science is somewhat rare, provoking distinctive questions as to how we define and understand instruments, opening up issues regarding the value of broken or incomplete objects, and raising concerns about which scientific and medical artifacts are displayed and interpreted in museums and in what manner. It is hoped that these essays point historians of science in new directions for reengaging with scientific objects and collections.

IN 1994 THE NINTH VOLUME of *Osiris*, focusing on instruments and edited by Albert Van Helden and Thomas L. Hankins, was published by the History of Science Society.[1] This volume can be read as part of a larger trend during the 1990s, characterized by some

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[1] Albert Van Helden and Thomas L. Hankins, eds., *Instruments*, *Osiris*, N.S., 1994, *9*.

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as a "pragmatic turn," in which historians of science were increasingly concerned with issues relating to scientific practice, including experimentation and instruments.[2] At the same time, there was a growing fascination on the part of many scholars, in a range of disciplines, with "materiality"; this "material turn" also invited attention to artifacts relating to various aspects of science.[3] Certainly, the publication of the *Osiris* volume *Instruments* was indicative of an increase of interest in this area within the academic community of historians of science. By 2003, in his presidential address to the British Society for the History of Science, Jim Bennett, one of the authors contributing to this Focus section, was able to refer to the "current vogue" for instruments.[4]

The publication of the *Osiris* volume by Van Helden and Hankins contributed to and fueled this "vogue," evident in a growing number of articles, monographs, and edited volumes by historians of science dealing with various aspects of instruments and their design, manufacture, and use. However, scientific instruments also attract the intellectual attention of others, including museum curators and collectors, many of whom are not historians of science but have other intellectual priorities, including the history of the decorative arts or economic history. Indeed, in some collections scientific instruments were acquired primarily for their aesthetic appeal and symbolic value; it is possible to wander through museums whose reputations are founded on their artistic and cultural holdings and view exquisitely fashioned objects without noticing their scientific character. How the artifacts of science are studied and interpreted within such museums varies, depending on institutional ambitions and staff expertise. These different perspectives have made the study of scientific instruments a rich and varied field, as the literature reveals.[5] However, much of the specialist literature—for example, the articles in the *Bulletin of the Scientific Instrument Society*—probably lies outside the normal purview of most historians of science. The questions posed, approaches adopted, and interpretations offered reflect the very varied backgrounds and concerns of those who choose to focus on instruments.

The backgrounds and experience of the contributors to this Focus section on instruments are particularly relevant in this context. Each is a historian of science who has experience in working closely with museum objects and collections, specifically scientific and medical instruments. Jim Bennett is director of the Museum of the History of Science at Oxford University; previously he was curator of the Whipple Museum of the History

[2] As examples see H. O. Sibum, "Reworking the Mechanical Value of Heat: Instruments of Precision and Gestures of Accuracy in Early Victorian England," *Studies in History and Philosophy of Science*, 1995, *26*:73–106, as well as articles by two of the contributors here: Simon Schaffer, "Glass Works: Newton's Prisms and the Uses of Experiment," in *The Uses of Experiment: Studies in the Natural Sciences*, ed. David Gooding, Trevor Pinch, and Schaffer (Cambridge: Cambridge Univ. Press, 1989), pp. 67–104; and J. A. Bennett, "A Viol of Water or a Wedge of Glass," *ibid*., pp. 105–114.

[3] See, e.g., the seminal article by Jules Prown, "Mind in Matter: An Introduction to Material Culture Theory and Method," *Winterthur Portfolio*, 1982, *17*:1–19.

[4] Jim Bennett, "Presidential Address: Knowing and Doing in the Sixteenth Century: What Were Instruments For?" *British Journal for the History of Science*, 2003, *36*:129–150, on p. 129; this address was delivered at the BSHS meeting "Do Collections Matter to Instrument Studies?" held at the Museum of the History of Science, Oxford, June 2002.

[5] For examples of the range of work carried out from various perspectives over the last couple of decades, in addition to contributions in the *Osiris Instruments* volume (cit. n. 1), see the essays in Thomas L. Hankins and Robert J. Silverman, *Instruments and the Imagination* (Princeton, N.J.: Princeton Univ. Press, 1995); R. G. W. Anderson, J. A. Bennett, and W. F. Ryan, eds., *Making Instruments Count: Essays on Historical Scientific Instruments Presented to Gerard L'Estrange Turner* (Aldershot: Variorum, 1993); and Liba Taub and Frances Willmoth, eds., *The Whipple Museum of the History of Science: Instruments and Interpretations, to Celebrate the Sixtieth Anniversary of R. S. Whipple's Gift to the University of Cambridge* (Cambridge: Cambridge Univ. Press and the Whipple Museum, 2006).

of Science. Simon Schaffer has long been associated with the collections of the Whipple Museum, part of the Department of History and Philosophy of Science at the University of Cambridge; he has also served as a trustee of the Science Museum, London. Ken Arnold is head of the Public Programmes team at the Wellcome Trust, London, a popular public venue that explores connections between medicine, art, and life; he is responsible for the Wellcome Collection there as well. Arnold has also been a visiting professor in medical science communication and museology at the Medical Museion of the University of Copenhagen, where Thomas Söderqvist serves as director, aiming to integrate the contemporary history of medicine with studies of material culture and medical aesthetics. The contexts of museums and of collections—not only individual objects—have had significant influences on the working life and practice of these contributors, who regularly confront questions of how we understand and encounter "instruments" and how we—as historians—study them and interpret and explain them to ourselves and to others.

This close engagement by historians of science with instruments and objects in museums is relatively rare and provokes distinctive questions, rather different from those posed by historians less familiar with actual objects in actual collections. The contributors here offer fresh perspectives informed by their professional encounters, on a daily basis, with real instruments and the challenges they present not only for curators but for other historians and researchers. Few of the historians of science writing on instruments in the *Osiris* volume, as well as other publications, have had such close professional familiarity with objects as the contributors here.[6] Intensive interaction with and thinking about instruments has informed the work of each of them; their work shows that different questions emerge when one's historical perspective is informed, over a long period of time, by curatorial interests and objectives.[7]

Indeed, as Van Helden and Hankins pointed out in their own introduction, there is ambiguity in the meaning of the word "instrument" in English. They note, for example, that Francis Bacon, in the *Novum Organum* (1676), used the word to describe both a physical tool and an intellectual method. Bacon argued that

> Man, Natures Minister and Interpreter, acts and understands only so much of the ordering of Nature, as he hath observed by the assistance of Experience and Reason: more he neither doth, nor can apprehend. Neither the Hand alone, nor an Understanding left to it self, can do much. Things are performed by instruments and helps, which the Understanding needs as much as the Hand. Now as Mechanick Instruments assist and govern the Hands motion, likewise the instruments of the Understanding prompt and advise it.[8]

[6] Simon Schaffer contributed to the *Osiris* volume as well as to this Focus section.

[7] Another specific category of historical studies, the in-house official history, often requires the historian to have intimate engagement with instrumentation. See, e.g., Robert W. Smith, *The Space Telescope: A Study of NASA, Science, Technology, and Politics*, with contributions by Paul A. Hanle, Robert H. Kargon, and Joseph N. Tatarewicz (Cambridge: Cambridge Univ. Press, 1989); J. L. Heilbron, Robert W. Seidel, and Bruce R. Wheaton, *Lawrence and His Laboratory: Nuclear Science at Berkeley* (Berkeley: Lawrence Berkeley Laboratory and Office for History of Science and Technology, Univ. California, 1981); Armin Hermann *et al.*, *History of CERN*, Vol. 1: *Launching the European Organization for Nuclear Research* (Amsterdam: North-Holland, 1987), Vol. 2: *Building and Running the Laboratory* (Amsterdam: North-Holland, 1990); and Soraya de Chadarevian, *Designs for Life: Molecular Biology after World War II* (Cambridge: Cambridge Univ. Press, 2002).

[8] Albert Van Helden and Thomas L. Hankins, "Introduction: Instruments in the History of Science," in *Instruments*, ed. Van Helden and Hankins (cit. n. 1), pp. 1–6, on p. 4; quotation from [Francis Bacon], *The Novum Organum of Sir Francis Bacon, Baron of Verulam, Viscount St. Albans, Epitomiz'd, for a Clearer Understanding of His Natural History, Translated and Taken Out of the Latine by M.D.* (London: Thomas Lee, 1676), p. 1.

Questions about relationships between physical tools, the hand, intellect, and nature recur throughout the historical literature devoted to scientific instruments, as do ambiguities regarding the use of the term "instrument" itself.

The important function of measurement, so much a hallmark of modern conceptions of scientific instrumentation, is captured by the *Oxford English Dictionary*, which notes that the term "instrument" is "also applied to devices whose primary function is to respond to a physical quantity or phenomenon, esp. by registering or measuring it, rather than to accomplish an effect, and which may function with little direct human intervention and be of complicated design and construction." Yet even though the *OED* acknowledges that instruments may not much need humans for their workings, the appellation "instrument" may itself confer on its users a particular professional or disciplinary status. Thus an "instrument" is "now usually distinguished from a *tool*, as being used for more delicate work or for artistic or scientific purposes." This scientific purpose is highlighted in the examples of usage given: "a workman or artizan has his *tools*, a draughtsman, surgeon, dentist, astronomical observer, his *instruments*."[9]

The first usage cited by the *OED* makes clear that the word "instrument" was used in what we would regard as a scientific context even from an early date in English; this example is from Geoffrey Chaucer's *Treatise on the Astrolabe* (1391), where he refers in the prologue to "Conclusions apertenyng to the same instrument [*sc.* the Astrolabe]." The next example cited by the *OED* dates from some three hundred years later (1691), when William Petty, in his *Political Anatomy of Ireland*, offered a list of various "instruments" (including the thermometer and "barrimeter") to be used for making observations and measurements of wind, rain, and air, to give an account of meteorological conditions. Petty outlined "which Instruments many men must make use of in the several parts of *Ireland*, and the rest of the World, and corresponding with each other, communicate and correct their Observation by Reason"; here, as in the *Novum Organum*, instruments play an important role in intellectual work.[10] That instruments could work to shape and define an intellectual discipline is the view of Bennett, who argues compellingly in his essay here that early modern "mathematical" instruments should be understood as a category of objects defined not simply by manufacturing techniques and retailing arrangements, but by a discipline of knowledge and practice that characterized itself as "mathematical."

The number and variety of citations in the *OED* to material things understood as "scientific" and designated by the term "instrument" is striking: examples are cited right through the twentieth century.[11] However, the modern term "scientific instrument," as Deborah Warner has pointed out, does not reflect historical usage. Warner (a curator at the Smithsonian Institution) and others have studied the emergence and use of the term "scientific instrument," dating its coinage in English—motivated in part by commercial

[9] *Oxford English Dictionary* online, http://oed.com/viewdictionaryentry/Entry/97158 (accessed 13 Apr. 2011). In their contribution to this Focus section, Ken Arnold and Thomas Söderqvist specifically consider definitions of "medical instruments"; this gloss from the *OED* also informs their reading of the term. I have previously discussed issues relating to defining instruments in Liba Taub, "On Scientific Instruments," *Stud. Hist. Phil. Sci.*, 2009, *40*:337–343.

[10] William Petty, *Political Anatomy of Ireland* (London: D. Brown and W. Rogers, 1691), p. 50.

[11] As Petty's listing of a number of different meteorological instruments suggests, users may have required an ensemble of, rather than merely individual, instruments: *ibid.*, pp. 49–50. Such an expectation is indicated by the penultimate example cited, in the abbreviated list from F. W. Goddard and M. Brown's *Practical Chemistry* (London: Longmans, 1963), which notes that, "in modern analytical techniques, heavy reliance is placed upon the use of instruments, such as pH-meters, potentiometric titrators, . . . spectrographs, polarimeters, refractometers, etc."

Figure 1. *Trade card of Heath and Wing, near Exeter Exchange in the Strand (1751–1767). (Whipple Museum of the History of Science, University of Cambridge, Wh. 3546.)*

interests—to the mid-nineteenth century.[12] Many of the objects that today are described as "scientific instruments" were manufactured, in the seventeenth and eighteenth centuries, as "mathematical," "optical," or "philosophical" instruments. To some extent these distinctions were determined by business and trade considerations, sometimes reflecting specialized manufacturing practices. The designation "optical instrument," used by spectacle makers, could describe a lens, mirror, or prism, while "philosophical instrument" referred to objects used in experimental philosophy and physics. However, these designations were not always applied without variation in the period, nor are they always interpreted in the same manner by historians.[13] Some makers and retailers marketed their wares broadly. So, for example, the firm Heath and Wing advertised that they "Make and Sell all sorts of Mathematical and Philosophical Instruments accurately finished according to the best improvements of the most eminent Professors" from their premises near Exeter Exchange in the Strand, London; they also hawked "the best Black lead Pencils and Books of the use of Instruments." (See Figure 1.) With their trade card advertising texts as well

[12] Deborah Jean Warner, "What Is a Scientific Instrument, When Did It Become One, and Why?" *Brit. J. Hist. Sci.*, 1990, *23*:83–93, esp. pp. 86–88. Warner, who has extensive curatorial experience, was one of the contributors to Van Helden and Hankins's *Osiris* volume. She has somewhat altered her usage of the term "science" (and associated "instruments") since 1990 (personal communication); see Robert Bud, Warner, and Stephen Johnston, eds., *Instruments of Science: An Historical Encyclopedia* (London: Science Museum; Washington, D.C.: National Museum of American History, Smithsonian Institution, 1998).

[13] See, e.g., G. L'E. Turner, "Foreword," in Joyce Brown, *Mathematical Instrument Makers in the Grocers' Company, 1688–1800* (London: Science Museum, 1979), pp. iii–iv, on p. iv; A. J. Turner, *Mathematical Instruments in Antiquity and the Middle Ages* (London: Vade-Mecum, 1994); and Bennett, "Presidential Address" (cit. n. 4), on usage of the term "mathematical instrument." On mathematical instruments see also Stephen Johnston, "Mathematical Practitioners and Instruments in Elizabethan England," *Annals of Science*, 1991, *48*:319–344.

as instruments, Heath and Wing signaled the importance of printed literature related to instruments in the period; indeed, a number of prominent makers and sellers were engaged in producing and purveying books as well as instruments.[14]

During the nineteenth and twentieth centuries, terms such as "science" and "scientific instruments" were gradually and increasingly used in contexts in which expressions such as "natural philosophy," "experimental philosophy," and "philosophical instruments" would have prevailed in earlier periods. As Warner emphasizes, this newer terminology did not simply replace previous appellations in a one-to-one fashion; rather, the development and adoption of new expressions was more subtle. Furthermore, the choice of kinds of objects to be described as "scientific instruments" has not been static.[15]

Each of the contributors to this Focus section confronts issues related to understanding the term "instrument." Historians of instruments have tended to define mathematical instruments—such as sundials, quadrants, theodolites, and rules—by their engraving and division and by their function of measurement. Jim Bennett argues in his essay that such instruments were also, in the early modern period, defined by a discipline of knowledge and practice and by the application of a number of geometrical techniques to mathematical arts. An important feature of mathematical instruments is their primary focus on disciplinary practices rather than on the natural world. Furthermore, the mathematical arts were, to some degree, characterized by the use of these instruments.

The study of mathematical instruments offers a special window on a significant area of intellectual culture of the early modern period, reflecting part of a larger European movement that combined learning, technical innovation, practical application, publication, manufacture, and commerce. In some cases the manufacture and retailing of such instruments has been studied by scholars focusing on engraving techniques, master–apprentice relationships, and commercial culture. Bennett suggests that a deeper understanding of the making and use of "mathematical" instruments can be achieved through a greater engagement with the intellectual culture in which they were produced and sold.

Simon Schaffer is concerned in his essay with what happens to instruments after they have been manufactured, purchased, and used, at the points at which they are failing or faulty, repaired and reused. Citing the philosopher Davis Baird's observation that "the materiality of instruments only surfaces in their making and breaking," he cogently reminds us that the definition and character of an instrument is not permanent and fixed but can be altered in many ways, including through repairs, refinements, and reworkings. The mutable character of instruments is revealed by studying individual cases focusing on particular scientific objects and their histories, including "normal" planned maintenance and repair. When instruments are employed in work, they may not always function optimally but may require adjustment or reconfiguration. Defining and judging what "works" is a requirement of using scientific instruments, as Schaffer highlights, even as he notes that adequate performance may be difficult to define. And there is the question of

[14] For further examples of trade cards see H. R. Calvert, *Scientific Trade Cards in the Science Museum Collection* (London: HMSO, 1971); for trade literature see also R. G. W. Anderson, J. Burnett, and B. Gee, eds., *Handlist of Scientific Instrument-Makers' Trade Catalogues, 1600–1914* (Edinburgh: National Museums of Scotland, 1990).

[15] For examples of historical work on modern instruments, and what happens to the categorization of instruments in the twentieth century, see Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: Univ. Chicago Press, 1997); Bernward Joerges and Terry Shinn, eds., *Instrumentation between Science, State, and Industry* (Dordrecht: Kluwer, 2001); and Peter Morris, ed., *From Classical to Modern Chemistry: The Instrumental Revolution* (Cambridge: Royal Society of Chemistry with the Science Museum, 2002).

the identity of specific objects, of whether an instrument remains the same object throughout repeated maintenance and adjustment; for example, as Bennett has pointed out, historically the question arose repeatedly with regard to telescope mirrors, which require polishing.[16] Does the same object persist, through instances of polishing, adjustment, refitting? Such issues may be addressed by philosophers, as well as by astronomers, technicians, and historians.

The problem of definition also intrigues Ken Arnold and Thomas Söderqvist, who, while focusing on medical instruments displayed in museums, argue that much can be gained from grappling with intellectual, philosophical, historical, and anthropological questions regarding the concept "instrument." They are also concerned with probing issues relating to the "evolution" of instruments from tools—and from hands and fingers themselves. The design and adoption of instruments is influenced by many factors; some are theoretical, others technological, while commercial, economic, political, and social factors play their roles, and taste and fashion have an influence as well. Arnold and Söderqvist review a series of theorized approaches to understanding instruments, but in the end they urge the adoption of a more pragmatic and empirical attitude, informed primarily through the experience of seeing, even handling, instruments as material objects. Advocating an "aesthetic turn," as suggested by the literary theorist Hans Ulrich Gumbrecht, they urge resisting the academic temptation to unravel the "meaning" of instruments, relying instead on sensory experience, imagination, and even emotion. They emphasize the fundamental importance of engaging with the material objects—the "instruments"—themselves, while recognizing that the opportunities for most historians of science to get close to instruments are very restricted, probably limited to visits to museums. Indeed, it could be argued that the museum context has led to a redefinition of what counts as an "instrument."

For many wishing to study instruments, museum collections provide the starting point for work. In an earlier Focus section on "Museums and the History of Science," partly influenced by anthropological work on the cultural biography of things, Samuel J. M. M. Alberti considered the "lives" or "careers" of scientific objects; he usefully explored ways in which historians of science might study the material culture of science held in museum collections by tracing relationships between specific items, other objects, and people.[17] Each of the contributors here offers valuable insights from his own museum experience. Bennett notes that most historians' encounters with mathematical instruments will be in museums. The mathematical instruments to which he refers feature heavily in museums; particular examples can be very beautiful, wonderfully engraved, even extravagant objects, suitable for display even in museums whose primary focus is not mathematical or scientific. In such settings, the tendency to focus on materials (precious metals and ivory, for example) and on exquisite engraving technique may deflect our attention from the mathematical character—and all that might have signified in the period of manufacture and use—of these objects. Schaffer highlights that in many cases when we look at instruments in museums we can be led astray by information proffered, for example, regarding their makers and date and place of manufacture. In many cases we know very little of the history of use, disuse, and reuse of the object and any adjustments and repairs it may have undergone. The information we have is often very incomplete, and the stories

[16] Davis Baird, *Thing Knowledge: A Philosophy of Scientific Instruments* (Berkeley: Univ. California Press, 2004); and Bennett, "Viol of Water or a Wedge of Glass" (cit. n. 2), pp. 112–113.

[17] Samuel J. M. M. Alberti, "Objects and the Museum," *Isis*, 2005, *96*:559–571.

we tell may be partial (in both senses). Furthermore, as he reminds us, the category of scientific instrument is itself defined by curatorial interests—and not only those identified by Warner. Questions and decisions dependent on aesthetic judgment and conservation practice crucially influence collection, retention, and display in museums. Broken instruments and those that are missing bits are not usually regarded as worthy of display, even though the breakage and loss may show important evidence of use. Schaffer urges us to exhibit instruments even when they are not beautiful and whole. Arnold and Söderqvist also have advice for museum curators, encouraging the closer involvement of visitors with objects and exhibits and, especially for historians of science more generally, urging that they should become more involved in selecting, preserving, displaying, and interpreting instruments.[18]

In 1994 Van Helden and Hankins noted that many, if not most, historians of science regarded instruments as relatively unproblematic. Through their work, and that of others over the past twenty years or so, more historians have become sensitized to issues involved in studying and interpreting instruments, even confronting the ways we thought we understood the term "instrument" itself. It is hoped that the essays in this Focus section point historians of science in new directions for engaging with instruments of all sorts—mathematical, scientific, medical, broken, whole, beautiful, and otherwise. The study of instruments is a rich and diverse field, populated by scholars from a number of different backgrounds. Our contention here is that by reengaging with instruments in museums historians of science can offer fresh perspectives, informed by our discipline.

[18] Ken Arnold and Thomas Söderqvist published a Dogme-style manifesto regarding science, technology, and medicine exhibitions in "Back to Basics," *Museums Journal*, 2011, *111*(2) (www.museumsassociation.org/museums-journal/features/01022011-back-to-basics).