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Beyond the Glass Cabinet: The History of Scientific Instruments

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Resumen

La historia de la ciencia desde siempre e interesó por los instrumentos científicos, sin embargo, en los últimos años, hubo un cambio en lo que concierne al carácter y alcance de ese interés. Para ilustrar las posibilidades de un análisis centrado en los artefactos, este trabajo presenta dos ejemplos: un espectroscopio de 1870 y una balanza geofísica de torsión. Ellos nos permiten mostrar cómo los temas de la historia de la ciencia contemporánea se cruzan con los debates alrededor de los instrumentos y la cultura material, incluyendo aquellos problemas ligados a su exhibición.

Palabras clave: instrumentos científicos - cultural material - colecciones

Abstract

The study of scientific instruments has always been a branch of the history of science, but in recent years, its character and scope have been changing. Two examples (a 1870s spectroscope and a 1920s geo-physical torsion balance) are discussed in order to sketch possibilities in artefact-centred study and to show how recent methodological debates about instruments and material culture, including their display in contemporary settings, intersect with current themes in history of science.

Key words: scientific instruments - material culture - museums - methods

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Introduction

The study of scientific instruments has always been a branch of the history of science, but in recent years, its character and scope have been changing. The field grew well beyond a world of connoisseurs and glass cabinets in the 1990s. At the same time, a wealth of literature on the history of collecting, on laboratory practice, on the circulation of knowledge among practitioners, technicians, and audiences made it increasingly effective to place things at the centre of our inquiries. Studies expanded from the specialized meaning of instrument as experimental device to consider a broader spectrum of material culture. Accordingly, other categories of scientific artefacts have come into focus, from soap bubbles to botanical specimens, and their relationship to concepts of nature, order and scientific authority explored. Within the last decade, lively streams of debate in philosophy, science and technology studies, design studies, theoretical archaeology and literary criticism have given renewed attention to questions of materiality in many different intellectual contexts. These debates both feed and absorb the work of historians. Finally, the many challenges facing museums −our traditional repositories of instruments– may have brought historians a silver lining. As budgets shrink, as curatorial expertise is stretched more and more thinly, as both museums and science centres wonder how to preserve and display the recent heritage of science and technology, the atmosphere seems less hushed, the discussions more open. There are new opportunities for collaboration and exchange between different communities interested in science, history and culture.

In what follows I will use two examples from my own work to outline research practices and indicate their debt to a range of methodological discussions. The aim here is not a comprehensive analysis of methodologies. Nor is it the view of a museum-trained specialist. Instead it represents a sketch for historians of science who wish to expand their approaches in both research and teaching to include artefact-centred study. I want to suggest how methodological debates about instruments and other aspects of material culture in science intersect with key historiographical themes: biographies and micro-biographies, circulation and global history, science and practice, embodied knowledge. Anchored by strong traditions of the history of instruments and of museums, historians of science can engage critically and fruitfully with contemporary material culture studies. The obvious energy of the scholarly work across the disciplines will continue to widen the range of possibilities of work with artefacts in history of

science. Indeed, in some sense, the challenges are typical of modern historical scholarship more generally: the demands of an increasingly multi-disciplinary conversation that can be bewildering to survey, let alone enter.

Instrument research: cheap thrills and beyond words

In the 1870s, the Astronomer-Royal of Scotland, Charles Piazzi Smyth, became fascinated with the pocket spectroscope as a means of predicting the weather. Piazzi Smyth found that a small spectroscope directed at the horizon showed water vapour in the atmosphere in a distinctive band of varying intensity that he called the rainband. To observe, one looked through the instrument ten to twenty degrees above the horizon (to maximize the thickness of the atmosphere in the view) with the sun at a distant angle or behind a cloud. The so-called rainband would appear to the red side of the solar D line; the observer must then judge it greater or lesser, darker or lighter, than its usual appearance. Piazzi Smyth promoted the instrument energetically as a means of private weather forecasting that was scientific, immediate and accessible to all. The instrument sparked considerable discussion in both Britain and the United States not only about exploiting knowledge of the atmosphere's spectrum for meteorology, but also about visual sensibilities and trained observation in scientific work more generally.[1]

I came across this instrument by way of conventional archives, following a paper trail. Piazzi Smyth's personal diaries were strikingly illustrated with sketches of countryside, weather reports, and his drawings and notes of the spectroscopic observations of the atmosphere.[2] His publications advocating the instrument could be found in scientific journals of the period, while the trade catalogues of instrument makers provided drawings, descriptions and prices. Traces of complaints and questions about the instrument could be found in manuscript collections of scientists' correspondence, in periodicals, and in reports of scientific meetings. It was only at the end of this research that I actually handled a rainband spectroscope, at the Science Museum in London. About ten centimeters long, two centimeters in diameter, it was

[1] Katharine ANDERSON, "Looking at the sky: the visual context of Victorian meteorology", *British Journal for the History of Science*, vol. 36, núm. 3, 2003, pp. 301-332; Klaus HENTSCHEL, *Mapping the Spectrum: Techniques of Visual Representation in Research and Teaching*, Oxford, Oxford University Press, 2002.

[2] Charles Piazzi SMYTH, *Journals*, 1876. PS/ROE. Royal Society of Edinburgh Piazzi Smyth archive, held on deposit at the Royal Observatory Edinburgh.

made of brass, and heavier than it looked. It had a fine slit opening at one end and eyepiece at the other, with the compound prism inside the cylinder invisible from the outside. It was smooth, glossy, self-contained and discreet. Its shape made me think of a large cigar. Piazzi Smyth's descriptions of keeping it in his vest pocket, ready to whip out at any promising moment of observation, made much more sense. It was also magical to look through, a transformation of the everyday experience of looking at the sky into vivid, organized colour. The textual records of observation for the period (before inexpensive colour printing) represented the image from the spectroscope as a small rectangular chart of Fraunhofer lines, with colour efficiently abstracted from the image. Yet colour, of course, is the overwhelming aesthetic aspect of the spectroscopic view. Holding this instrument gave new dimensions to its history. It made it possible to connect the instrument to the experience of nineteenth-century railway journeys, to Piazzi-Smyth's other interests in photography, painting and precise rankings of colour, and to other sciences of travel and data exchange, like hydrography.

Albert Van Helden and Thomas Hankins have catalogued the roles of instruments in science in their introduction to an influential volume of *Osisris*. Instruments may be reified theory, rhetorical devices, natural wonders, models or analogies, extensions of the senses, measurement devices, the means for creating artificial conditions, or visual displays. They confer authority, and sometimes build bridges between different practitioners and audiences, sometimes divide them.[3] Many of these roles can be traced in the history of the rainband spectroscope. But above all, this instrument stands in my mind for the value of a direct encounter and immediate response to an object. This sort of experience has been described memorably as the value of a cheap thrill.[4]

The idea of a cheap thrill is a distinctive thread in the methodological literature on objects in the history of science. There is a consistent preoccupation in this literature with the relationship between things and words. In part, of course, it is a classic epistemological concern. In part, it may reflect debts to the history of books, in which

[3] Albert VAN HELDON and Thomas L. HANKINS, "Introduction: Instruments in the History of Science", *OSIRIS*, vol. 9, 1994, pp. 1-6. Other surveys of definitions and the classic historiography are Deborah WARNER, "What is a scientific instrument, when did it become one, and why?", *British Journal for the History of Science*, vol. 23, 1990, pp. 83-93, and the essays in R.G.W. ANDERSON (et al.), *Making instruments count: essays on historical scientific instruments*, London, Variorum, 1993. More recently, see Liba TAUB, "Reengaging with Instruments", *Isis*, vol. 102, núm. 4, 2011, pp. 689-696 and the following essays of this "Focus on Museums and the History of Science".

[4] Thomas SÖDERQVIST and Adam BENCARD, "Do Things Talk?", Susanne LEHMANS-BRAUN, Christian SICHAU, Helmuth TRISCHLER (eds.), *The Exhibition as product and generator of scholarship*, Berlin, Max Planck Preprints, 2010, pp. 93-102.

attention to materiality, circuits of communication, provenance and experience of reading, have served as inspiration for our interest in other categories of scientific objects.[5] But the preoccupation runs deeper, for it is at heart a deeply practical question. As Otto Sibum has noted, "we have to distinguish between texts and physical things of the past, if only because engaging with them requires different sense economies and modes of working that require and prompt cognitive effects."[6] How does the text-trained historian behave when confronted with an artefact? Is the historical interpretation of things like 'reading'? Or, does the metaphor of reading, of the language and speech of an object, mask our reluctance to take seriously its qualities? In her introduction to *Things That Talk*, Lorraine Daston has proposed that historical analysis must be the production of speech and stories from the mute material before the investigator, a form of forced cooperation rather than ventriloquism.[7] In contrast, Söderqvist and Adam Bencard have argued that we should resist notions of speech and reading in the study of artefacts.[8] Instead, Söderqvist and Arnold, writing in the context of museum display of medical instruments have called for closer attention to "immediate impressions" as part of our historical investigation: "more consideration of the aesthetic, sensuous, subjective and emotional approaches to instruments" and their conditions of display.[9] Our immediate reaction to an amputation saw or leather-covered forceps (or a small brass cylinder) is a valuable aspect of the objects' historical meaning.

[5] See Owen GINGERICH, *The book nobody read: chasing the revolutions of Nicolas Copernicus*, New York, Walker and Company, 2004, as well as Adrian JOHNS, *The Nature of the book: print and knowledge in the making*, Chicago, University of Chicago Press, 1998. A recent short introduction to book history methods is David PEARSON, *Books as history: the importance of books beyond their texts*, London, British Library, 2011. For a striking example of the overlap between books and other objects, see Anne SECORD, "Pressed into service: specimens, space, and seeing in botanical practice", David N.LIVINGSTONE and Charles W. J. WITHERS (eds.), *Geographies of nineteenth-century science*, Chicago, Chicago University Press, 2011, pp. 283–310.

[6] Leora AUSLANDER (et al.), "A Conversation: historians and the study of material culture", *American Historical Review*, vol. 114, núm. 5, 2009, pp. 1355-1404 and p. 1358.

[7] Lorraine DASTON, "Speechless," *Things That Talk*, New York, Zone, 2007, pp. 9-26.

[8] See note 4 above. There is a fuller discussion in Thomas SÖDERQVIST, Adam BENCARD and Camilla MORDHORST, "Between meaning culture and presence effects: Contemporary Biomedical Objects as a challenge to museums", *Studies in History and Philosophy of Science*, vol. 40, 2009, pp. 431-38. Related work on affect and objects, like Sherry TURKLE (ed.), *Evocative objects: things we think with*, Cambridge, MA, MIT Press, 2007.The literary theory approach critiqued by Soderqvist can be represented by Bill BROWN (ed.), *Things*, Chicago, University of Chicago Press, 2004. An earlier useful critique of language-based knowledge of instruments is Martin KEMP, "Intellectual ornaments: style, function and society in some instruments of art", Joan H. PITTOCK and Andrew WEAR (eds.), *Interpretation and cultural history*, New York, St. Martin's, 1991, pp. 135-52.

[9] Ken ARNOLD and Thomas SÖDERQVIST, "Medical Instruments in Museums: Immediate Impressions and Historical Meanings", *Isis*, vol. 102, núm. 4, 2011, pp. 718-29 and 719.

This insistence on an 'unspeakable' dimension to the artifact is related to a concern familiar to historians of science: the importance of tacit knowledge in scientific practice. This is one of the most significant connections of instrument-based studies to the wider historiography in our field. The muteness of objects is a counterpart to the skills, customs and experience of the practitioner. Essential discussions here emerge from a particular sub-field associated equally with history of instruments and with science pedagogy: the reconstruction of scientific experiments.[10] Otto Sibum's work is an influential example. Sibum reconstructed the measurement of heat by the nineteenth-century experimenter, James Joule. He discovered that Joule's descriptions in both published work and in rough laboratory notebooks, often failed to impart key information about the measurement in practice –information not only about the position and actions of the paddle-wheel, weights, thermometers and ropes, but the position and behavior of the bodies that manipulated and recorded them−. His reconstruction of the workings of the thermodynamic measurement led directly to insights about tacit skills and embodied knowledge. Sibum had to recognize the effect of objects, motion and bodies in this experiment; moreover, he had to confront and account for the possible difference between his own laboring self and the nineteenth-century bodies who carried out the original experimental work.[11] In making this last point, Sibum's replication study parallels the call for immediate impressions. Noting an aesthetic, sensory or emotional response is the opposite of solipsism; it leads to new awareness of other, historical bodies in interaction with things and spaces.

The methodological debates about language and things hold significant practical benefits for the historian, then, in two different senses. First, these debates support the importance of physical presence of an artefact, and the value of touching, holding, swinging, or looking thought it as part of our effort to understand –whether or not we know (or think we know) how it 'works' and what it means−. This is an immensely reassuring methodological position to adopt as a starting point –one that does not depend on expertise with a repertoire of forms, techniques and materials, although of course such knowledge and familiarity enriches the encounter−. Secondly, these word-

[10] Examples of reconstruction of experiments work are Hasook CHANG, *Inventing temperature: Measurement and scientific progress*, New York, Oxford University Press, 2007; Peter HEERING and Roland WITTJE (eds.), *Learning by doing: Experiments and instruments in the history of science teaching*, Stuttgart, Franz Sterner Verlag, 2011 as well as Sibum, below.

[11] H. Otto 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* vol. 26, núm. 1, 1995, pp. 73-106.

thing discussions build historical sophistication. However we work out for ourselves the difference (or not) between words and thing, the questions of muteness, eloquence and agency demand attention. The artefacts, the forms that survive, paradoxically provide a closer awareness of what has not travelled through time so easily, underlining the limits of our access to the bodies, spaces and sensibilities of the past.

Shop-talk

For historians of science, though, the distinctive challenge of adapting material culture analysis to their research may well be not mutism, but layers of words and things in combination. Scientific objects have functions that are closely connected to ideas and communication, so language seems barely a step away. For both the practitioners we study and ourselves as historians, then, there is a flow back and forth between what Sibum called "different sense economies and modes of working." Scientific instruments make compelling research subjects precisely because they generate texts and talk. Description of an instrument's performance dominate laboratory or field notes, for example, and justifications of an instrument's purchase to patrons or directors of institutions are common. These and other forms of shop-talk, of course, tend to be especially visible when the instruments are new, expensive or controversial.

Talk is also often conspicuous because, and when, objects move around. Many (though not all) scientific instruments do move a great deal in the course of field-work, transfers between laboratories, and/or commercial transactions. An object-centered approach thus provides historians of science with a compelling means of combining texts and material cultural analysis to connect local and global narratives and study the circulation and exchange of knowledge. In addition to the models offered in recent studies of scientific travelling, our concerns intersect here with work from anthropology on a globalized account of commodities. The anthropologist George Marcus, for example, discusses the shift in modern anthropology from a localized study of artefacts *in situ* to a "world systems approach." He advocates 'following things': people, artefacts, metaphors, severally and in combination.[12]

[12] George E. MARCUS, "Ethnography In/Of the World System: The Emergence of Multi-Sited Ethnography", *Annual Review of Anthropology*, vol. 24, 1995, pp. 95-117; Marie-Noëlle BOURGUET, Christian LICOPPE, and Heinz Otto SIBUM (eds.), *Instruments, travel, and science: itineraries of*

These two features of shop-talk and mobility emerged prominently in my second example, the torsion balance. The torsion balance, an instrument that measures local gravitational variation, was developed in the late-nineteenth-century physics laboratory by the Hungarian physicist Loránd Eotvos. It subsequently acquired a short-lived prestige in geo-physics as a field instrument for isotasy research and oil prospecting after World War One. In this case, unlike the research project on the rainband spectroscope, my encounter with the instrument came before texts. A torsion balance made by the Hungarian firm Ferdinand Süss was on the floor of a storage facility in Ottawa, part of a random set of objects pulled from storage for a workshop called "Reading Artefacts" held by the Canada Science and Technology Museum (CSTM).[13] A group of colleagues studied it first without texts, then with museum accession records, then finally incorporated conventional textual sources[14] In subsequent work, I examined the field photographs of its Canadian user, other instrument by Oertling and Askania, and published and manuscript texts from the British Geological Survey, a geophysical survey in Australia, and geo-physicists' reminiscences.

In this research experience, objects and texts were inter-dependent. Our immediate impressions of the field instrument –human-sized, hard-working– remained crucial. There was (literally and figuratively) much to read on the instrument and its cases –inscription of the Hungarian maker's name, a coat of arms, scratches, instructions for assembling, packing labels and even tourist photographs from Budapest taped inside its cases–. The story of this instrument emerged from its material features –what it is made of, how it works, how heavy it is, how fragile its interior wire, how it can be dis-assembled and carried in cases–. Yet the relationship between material and textual evidence is intriguing. The physical features of the torsion balance contrasted with the fluctuations of the textual sources. The museum torsion balances seemed distinctively solid, whereas textual evidence is remarkably thick in some times and places (geo-physical field tests in 1927-32, evaluations and reminiscences of geo-physicists in the petroleum industry), thin in others (its early laboratory origins, its connection to military sensing techniques during World War I, its field use by private oil companies). This

precision from the seventeenth to the twentieth centuries, New York, Routledge, 2002 and Simon SCHAFFER (et al.) (eds.) *The Brokered world: go-betweens and global intelligence, 1770-1820*, Sagamore Beach, Science History, 2009.

[13] This workshop continues annually; see the CSTM website, http://www.sciencetech.technomuses.ca/english/whatson/2013-reading-artifacts-summer-institute.cfm. Accessed 24 Jul 2013.

[14] Katharine ANDERSON, Melanie FRAPPIER, Elizabeth NESWALD, Henry TRIM "Reading instruments: objects, texts and museums", *Science and Education*, vol. 22, issue 5, 2013, pp. 1167-1189.

disparity is critical to the instrument's story. Combining different kinds of evidence, we can trace through this instrument the history of geo-physical science, the movement of precision measurement from laboratory to field, and the significant impact of the oil boom of the 1920s. We can gain a sense of its symbolic value to its maker in Budapest, its users in Canada, and in Texas. As this instrument and its fellows circulate from Hungary to Ontario, Potsdam to Houston, London to Melbourne, they trace science on a global scale spanning many different interests.

Types, individuals and collections: biography and provenance studies

The original analysis of this instrument took a life-history approach. Similar micro-biographies or provenance studies represent a longstanding and valuable approach in the history of scientific instruments.[15] The Eötvös torsion balance now in the CSTM was purchased for the national Dominion Observatory in Ottawa in early 1930, and its particular history came to life through of a report written by the Canadian geophysicist A. H. Miller in 1929, describing his European tour to assess geophysical instruments, and Miller's photographic archives.[16] With our torsion balance tied to a particular user and institution, we could trace many stages of its existence, from its origins in Budapest, its use in different terrains in Ontario and Nova Scotia, and its eventual transfer to the storage rooms of a national museum.

Yet there is an interesting way in which the individualized biographical style, at least in this case of the torsion balance, would tell an incomplete story. The Eötvös torsion balance, in each context, was part of an intricate world of other instruments and scientific objects. It was of interest to national and international centres of geo-physical research because it offered new levels of precision for isotasy research, but it was in vogue because of the post-war petroleum boom and several emerging geophysical prospecting techniques, including gravitational, seismic, and magnetic methods. It users always evaluated it within clusters of other things. Here Miller's report of 1929 is especially revealing, as he outlined in chronological sequence visits to conference

[15] Many of the methodological works explicitly treat life-history approaches. A recent example on an unusual mid-twentieth century example is David PANTALONY, "Biography of an Artefact: The Theatron Junior and Canada's Atomic Age", *Scientia Canadensis,* vol. 34, 2011, pp. 51-63.
[16] Andrew H. MILLER, *Trip to Britain and Europe correspondence and report* [1929] Archives Canada. Miller fonds, MG30 B167.

exhibits and museums, sessions at observatories in Greenwich, Potsdam, Budapest, and even a personal walking tour along the trench lines he had known a decade earlier. In this report, the scientific instrument is almost inextricable from other new technologies, scientific displays, and geophysical instruments of the era. It is also inextricable from Miller's own personal history as an artillery engineer in World War I.

This obvious point, that things are intricately connected to worlds of things, is worth emphasizing as a methodological issue. In a museum setting especially, instruments often seem to evoke a particularity that is distracting, even deceptive. Moreover, in pursuing relationship to other objects, we most readily think of genealogies, or relationships of type (spectroscope as part of the class of optical instruments, the torsion wire in electro-magnetic measurement instruments). Here we have many impressive models of historical work to follow, perhaps most notably Peter Galison's remarkable account of styles of instruments − image or logic machines− as a counter-weight to the traditional narrative of the history of modern physics.[17] But other approaches may be just as revealing in 'scaling up' our history. Recent work has valuably analyzed the object as incomplete, broken or fantastic, as part of clusters or constellations, or as diasporic survivors of former collections.[18]

Archives and museums

It is clear that the category of the scientific artefact is wide, and can easily extend beyond the specialized sense of instrument. Yet if museums are not the only place to encounter scientific artefacts, they are the conventional one, and so may well epitomize the task of finding a different mode of working. For practical and for intellectual

[17] Peter GALISON, *Image and logic: A material culture of microphysics*, Chicago, University of Chicago Press, 1997.

[18] Here I am thinking of Thomas L. HANKINS and Robert SILVERMAN, *Instruments and the Imagination*, Princeton, Princeton University Press, 1995; Vermier KOEN, "Athanasius Kircher's magical instruments: an essay on 'science,' 'religion' and applied metaphysics", *Studies in History and Philosophy of Science*, vol. 38, 2007, pp. 363-400 on fantastical instruments; on diasporas, Marta LOURENCO and Samuel GESSNER, "Documenting collections: cornerstones for more history of Science in museums", *Science and Education*, DOI 10.1007/s11191-012-9568-z 28 Dec 2012; on broken ones, Simon SCHAFFER, "Easily Cracked: Scientific Instruments in States of Disrepair", *Isis*, vol. 102, 2011, pp. 706-17. Intriguing work on collections and juxtapositions in cultural history are Martha LANGFORD, *Suspended conversations: the afterlife of memory in photographic albums*, Montreal, McGill-Queen's University Press, 2001 and Isobel ARMSTRONG, *Victorian glassworlds: glass culture and the imagination , 1830-1880*, New York, Oxford University Press, 2008. Another approach to collective things is Jane BENNETT, *Vibrant matter: a political ecology of things*, Durham, Duke University Press, 2010.

reasons, this increasingly involves us in consideration of the nature of museums, past, present and future. Most obviously, museums come in all shapes and sizes, from local to corporate to national holdings. They also hold many different mandates that may have significance; for example, the distinction between science centres and science museums. The diversity of mandates means that conditions of access, supporting records, and local expertise vary widely as well. Larger national museums increasingly have online records of holdings, often with photographs. But those records can be frustratingly limited for the purposes of historians – they are designed for curatorial work, not historical study−. A more interesting feature of the modern museum environment is the growing experimentation with virtual display, which will perhaps become more important both as resources and as sites through which to think about materiality and narrative practices.[19] From the study of cabinets of curiosities and museums in the history of natural history, we already know how traditions of display and collection practices can be unpacked to address major themes in the history of science.[20] So in the present day, the issue of virtual spaces in museums serves us as a reminder that museum context of artefacts is itself a rich starting point for thinking about change over time. Readers who examine the growing body of work on the politics of display, on replicas, or on modern collection practices will find many threads to the historical literature on curiosities and collections; the connections between modern museums and their predecessors are mutually illuminating.[21]

In summary, historians of science need to think further about museums and access to artefacts. Access involves sheer proximity, as well as familiarity with methods of research, but it also involves re-thinking our conventional ideas of where to find them. Few departments have museums with established collections on their doorsteps. Yet many more might have access to the jumble of storage closets, whether within the

[19] Two very different examples are the demonstration videos produced by Paolo Brenni and the Fondazione Scienza e Tecnica for utube, and the object biographies of the Pitt-Rivers Museum, University of Oxford. See Paulo Brenni's demonstrations at http://www.youtube.com/user/florencefst#p/ accessed 23 Jul 2013; and "Object Biographies", *Re-Thinking Pitt Rivers: Analyzing the Activities of a Nineteenth Century Collector*, http://web.prm.ox.ac.uk/rpr/index.php/objectbiographies/ accessed 23 Jul 2013.

[20] Paula FINDLEN, *Possessing nature: Museums, collecting, and scientific culture in early modern Italy*, Berkeley, University of California Press. 1994; Helmer SCHRAMM, Ludger SCHWARTE (eds,), *Instruments in Art and Science*, Berlin: Walter de Gruyter, 2008.

[21] Svante LINDQVIST (ed.), *Museums of modern science*, Canton, MA, Science History Publications, 2000; Sharon MACDONALD (ed.), *Politics of display: museums, science, culture*, New York, Routledge, 1998; Susan PEARCE (ed.), *Exploring science in museums*, London, Athlone Press, 2005; Giorgio STRANO (et al.) (eds.), *European collections of scientific instruments 1550-1750*, Brill, 2009. See also the heterogeneous essays on publics and materiality in Bruno LATOUR and Peter WEIBEL (eds.) *Making Things Public: Atmospheres of Democracy,* Cambridge, MA, MIT Press, 2005.

university or in institutions outside it. Should we steer students (and ourselves) in those directions? These questions of access and modes of working need to be addressed on the ground.

Other Resources

A recent essay by Marta Lourenco and Samuel Gessner suggested that, despite growing interest in artefact-centered research, there are few clear guides or reference books for the historian of science. There is much to this point, and yet it is also true, as I have tried to indicate above, that there are many inspiring discussions (including that of Lourence and Gessner's). Much work on methods has already been discussed above, but some categories deserve further mention. The general literature on material culture studies is large and growing fast.[22] The Winterthur method, developed for the study of design and material culture, catalogues four types of questions that can be applied to artefacts. It asks research to focus in turn on physical properties, comparisons to related objects, the cultural context of the artefact, and the present-day significance of the artefact.[23] The recent article by Marta Lourenco and Samuel Gessner mentioned earlier builds on this method to set out a systematic approach for scientific artefacts in particular; it is especially valuable for charting the path of analysis from the singular object to wider questions about types of devices, and the cultural and intellectual context of their use that interest historians of science.[24] One example of interesting intersections in material culture theory and historical work is the work of behavioral archaeologists who combine theory, archaeology and technology studies.[25] Big science

[22] Chris CAPLE, *Objects: reluctant witnesses to the past*, New York, Routledge, 2006; Marie-Pierre JULIEN, Céline ROSSELIN, *La culture matérielle*, Paris, Découverte, 2005. A useful anthology of short texts providing a historiography of material culture studies is Susan PEARCE (ed.), *Interpreting objects and collections*, New York, Routledge, 1994.

[23] For the Winterthur method, see E. McClung FLEMING, "Artifact Study: A Proposed Model", Thomas SCHLERETH (ed.), *Material Culture Studies in America*, Nashville, University of Kentucky Press, 1982, pp. 162-73. Its relation to history of scientific instruments is taken up in Katharine ANDERSON, Melanie FRAPPIER, Elizabeth NESWALD and Henry TRIM, "Reading instruments: objects, texts and museums", *Science and Education*, vol. 22, issue 5, 2013, pp. 1167-1189.

[24] Marta LOURENCO and Samuel GESSNER, "Documenting collections: cornerstones for more history of Science in museums", *Science and Education*, DOI 10.1007/s11191-012-9568-z 28 Dec 2012.

[25] Michael SCHIFFER and James SKIBO, *People and Things: A Behaviourial approach to material culture*, New York, Springer, 2008.

and big instruments have prompted new questions about scale and space.[26] Other writings that provide rich ground for thinking about artifact-based research include Davis Baird in the philosophy of science, Karen Barad on agency and feminist epistemology, and Hans-Jorg Rheinberger on epistemic things in the modern life sciences.[27]

In terms of bibliographies and databases, the most important starting point is online, through the Scientific Instruments Commission,[28] which maintains a large online database of publications on the history of scientific instruments. The site also holds a list of the journals their database draws. This list usefully indicates the journals that have been prominent in the study of scientific instruments, such as *Nuncius*, or *Rittenhouse*, but perhaps more importantly it shows that studies of instruments are difficult to compartmentalize and can be found across a wide range of journals. The SIC site also has links to valuable collections of trade literature held in different national museums, and works by and about instrument makers. The *Osiris* volume and other recent collections of essays mentioned in this review provide orientation to the classic general texts in the history of scientific instruments.[29] Although of varying quality, the short essays on a wide range of instruments in *Dictionary of Scientific Instruments: An Historical Encyclopedia* can provide a good starting point for research.[30]

[26] Examples of work that investigates 'big" and/or contemporary science includes Thomas GIERYN "What buildings do", *Theory and Society*, vol.31, 2002, pp.35-74; Gabrielle HECHT, "A Cosmogram for Nuclear Things", *Isis*, vol. 98, 2007, pp. 100-108; Patrick CARROLL-BURKE, "Tools, Instruments and Engines: Getting a Handle on the Specificity of Engine Science", *Social Studies of Science*, vol. 31, núm. 4, 2001, pp. 593-625**;** Roland WITTJE, "A Proton Accelerator in Trondheim in the 1930s", *Historical Studies in the Physical and Biological Sciences*, vol. 35, 2004, pp. 115-152; and Thomas SÖDERQVIST (ed.), *Historiography of Contemporary Science and Technology*, Amsterdam: Harwood Academic, 1997.

[27] Hans-Jorg RHEINBERGER, *An Epistemology of the concrete: twentieth century histories of life*, Durham, Duke University Press, 2010; Karen BARAD, *Meeting the universe halfway: quantum physics and the entanglement of matter and meaning*, Durham, Duke University Press, 2007; Davis BAIRD, *Thing knowledge: a philosophy of scientific instruments*, Berkeley, University of California Press, 2004.

[28] SCIENTIFIC INSTRUMENT COMMISSION, Cumulative Bibliography, http://iuhps.org/bibliography/index.shtml Accessed 23 Jul 2013.
For links to trade catalogues, see "Online Scientific Instruments Trade Catalogues". http://iuhps.org/references/index.shtml Accessed 23 Jul 2013.

[29] See note 3.

[30] Robert BUD and Deborah WARNER, *Instruments of science: An historical encyclopedia*, New York, Science Museum, London, and National Museum of American History, Smithsonian Institution, in association with Garland Publishers, 1998.