Institution:
University of Cambridge

Unit of Assessment:
UoA32B

Title of case study:
Scientific Machines and the Enlightenment World

1. Summary of the impact (indicative maximum 100 words)

Research on the making and use of precision instruments and automatic machinery on a global scale in the period of the European Enlightenment has been used to develop museum displays and the interpretation of material culture from the seventeenth and eighteenth centuries in public collections. The research has contributed directly to a range of broadcast materials in rendering accessible lessons from the history of science and technology. In a series of interviews and broadcasts, the research has been used to deliver new approaches to the public understanding of the past of the sciences at a period of key transformation in their history and policy.

2. Underpinning research (indicative maximum 500 words)

Schaffer has been employed by the University of Cambridge since 1984 and became Professor in 2003. This research project started in 1997-98. Public support for the research was gained from the British Academy, Leverhulme Trust, and Arts and Humanities Research Council (including a major Research Grant in 2010-14 with Schaffer as principal investigator to study the development of instruments and archives of the Board of Longitude). The research included the detailed analysis of the pathways of production, distribution and use of a range of accurate mechanisms in astronomical and experimental sciences between the late seventeenth and early nineteenth centuries. Three sets of devices provided the focus of this geographical and commercial study: (a) automatic machinery both as simulacra of human activity (Schaffer 1999) and as recording devices that are used to capture and display variables that require permanent and vigilant observation (Schaffer 2012); (b) optical devices deployed in land based surveys for cadastral and economic purposes and in astronomical and marine surveys of position (Schaffer 2009; Schaffer 2012); (c) analytical instruments to assay the quality and properties of a range of commodities, including precious metals and chemical products, whose distribution and consumption was decisive for the development of global mercantile and colonial systems (Schaffer 2002; Schaffer 2005). The project has drawn on many the major museum collections of scientific instruments, notably those at the National Maritime Museum, the Science Museum London, and the Whipple Museum Cambridge. Evidence from trade cards, from manuscript logs, correspondence and reports to the metropolis, was combined with statements based on machine and instrument use in the range of printed formats that travellers, savants and entrepreneurs then published. Important in this approach has been an attention to the fundamental aspects of the lives of instruments and machines, since it has been shown that none of these devices was so weak that its meaning was entirely dictated by the particular setting of its use, nor so robust that its use stayed constant across all these settings. Thus, an approach drawn from historical geography has been followed, in which the model of enlightened sciences, based on precision design and accurate observation, were complemented by a cartography of the many sites at which these machines were put to use (Schaffer 2009; Schaffer 2009a). A complementary aspect of the research has been the study of the manifold interactions between the design of new self-acting machines in the epoch of industrialisation, developments in clockwork, and the long career of automata and androids in the eighteenth century (Schaffer 1999). The research has therefore generated important results connecting the practice of enlightened sciences worldwide, including significant sites such as southern and eastern Asia and the south Pacific with the use of the material culture of these sciences as objects of trade, of status and of control.

3. References to the research (indicative maximum of six references)

Schaffer, S. (1999), *The sciences in enlightened Europe*, co-editor (Chicago University Press), including Schaffer, S., 'Enlightened automata', 126-65

Schaffer, S. (2002), 'Golden means: assay instruments and the geography of precision in the Guinea trade', in Marie-Noelle Bourguet, Christian Licoppe and H. Otto Sibum (eds.), *Instruments, travel and science* (Routledge), 20-50

Schaffer, S. (2005), L'inventaire de l'astronome: le commerce d'instruments scientifiques au

XVIIIe siècle', *Annales: histoire, sciences sociales* 60: 791–815
Spanish version: 'El inventario del astrónomo: el comercio de instrumentos científicos en China y el Pacífico en el siglo XVIII', in Simon Schaffer, *Trabajos de cristal: ensayos de historia de la ciencia 1650–1900* (Ambos mundos, 2011), 285–320

Schaffer, S. (2009), 'Newton on the Beach: the information order of the *Principia mathematica*', *History of science* 47: 243–76
Swedish version: *Hans Rausing Lecture 2008: The information order of Isaac Newton's* Principia Mathematica (Salvia Såmskrifter, 2008) (invited public lecture at Uppsala University)

Schaffer, S. (2009a), *The brokered world: go-betweens and global intelligence 1770–1820*, co-editor (Science History Publications), including Schaffer, S., 'The Asiatic enlightenments of British astronomy', 49–104

Schaffer, S. (2012), 'In transit: European cosmologies in the Pacific', in Kate Fullagar (ed.), *The Atlantic world in the Antipodes* (Cambridge Scholars), 70–93

4. Details of the impact (indicative maximum 750 words)

The research has had impact on the development of museum displays and interpretation of the material culture and instrumentation of the period of the Scientific Revolution and the Enlightenment. Schaffer was a Trustee of the National Museum of Science and Industry 2007-2011 and is a member of the Science Museum Advisory Board. His studies of the best ways of interpreting and displaying scientific instruments from the enlightenment led to his appointment to lead the committee that drafted the National Museum's policies on research into the material culture of scientific instrumentation. He was lead consultant on a Science Museum gallery on making of modern sciences since the period of the enlightenment, which depends directly on expertise in the roles such devices played in research sciences of the seventeenth and eighteenth centuries. The Science Museum's head of research and public history confirms that Schaffer 'led on the production of research policy', and adds that Schaffer's 'guidance in shaping plans for galleries on science, mathematics and their history have enabled the development of plans for the next generation of displays' [5.1].

Schaffer's research on the Board of Longitude and its material culture (as PI in the AHRC project) delivered immediate impact on outreach and exhibition programming at the National Maritime Museum [5.2]. The research on instrumentation in British navigation has been used to deliver public lectures on the development of observatories and on the Board of Longitude, as well as designing a major international exhibition on Longitude and instruments for measurement and navigation. The senior curator and head of science and technology at the Museum states that Schaffer's research on early modern instruments in the physical sciences 'has had an important influence' on these projects [5.3]. A direct output of the research was a JISC programme to release the entire manuscript archive of the Board in a digitized edition of more than 65000 images available online through free public access, together with links through to images and documentation of each instrument and measurement device mentioned in the archive, released worldwide in July 2013. This material is officially described as 'a wonderful resource for research and education in many spheres' and of very wide 'public interest' [5.4]. Schaffer's research project has provided selection, thematic commentaries, and much of the metadata of the JISC digital edition to aid the preservation of extremely fragile and sensitive papers. Schaffer's research has attracted significant press coverage of the digitized longitude archive [5.5] and the production of a BBC audio slideshow [5.6].

This research has also underpinned programming in BBC radio interviews with Schaffer about the interpretation of the material culture of early modern and eighteenth century sciences. Broadcast series on the Royal Society in the period between the presidencies of Isaac Newton and Joseph Banks used this research on the global significance of the early modern sciences. Audiences for these broadcasts were estimated at 1.5 million [5.7, 5.8]. Schaffer researched, wrote and presented a new programme for broadcast on BBC4 television on early modern automata and clockwork machinery with a first-night live audience of 550,000. Schaffer's 'expertise drawn from his research on the history of science, especially instruments, makes his contribution an invaluable

and crucial part of all these programmes' [5.9]. The broadcast on automata has been praised as 'a beautifully made and consistently fascinating account' and as 'a precisely calibrated treat' [5.10]. These broadcasts followed a series of interviews on the public understanding of sciences, especially a radio interview for the Canadian Broadcasting Corporation in 2008-9 on the popular image of the past of the sciences and its material culture [5.11].

5. Sources to corroborate the impact (indicative maximum of 10 references)

[5.1] Letter form Person 1 (Head of Research and Public History, Science Museum), 15 May 2013.

[5.2] Connor, S. (2010), 'How Britannia came to rule the waves', *The Independent*, 14 May 2010 (interview with S. Schaffer): http://www.independent.co.uk/news/science/how-britannia-came-to-rule-the-waves-1973025.html

[5.3] Letter from Person 2 (Senior Curator and Head of Science and Technology, Royal Museums Greenwich), 19 April 2013.

[5.4] JISC (2013), 'Navigating eighteenth century science and technology: the Board of Longitude', www.jisc.ac.uk/whatwedo/programmes/digitisation/content2011_2013/Board%20of%20Longitude.aspx

[5.5] Johnson, D. (2013), 'Voyage of discovery', *Daily Telegraph*, 18 July 2013: http://www.telegraph.co.uk/science/10187760/Voyage-of-discovery-bizarre-inventions-from-the-1700s.html

[5.6] BBC News (2013), 'The crazy ideas that failed to solve the longitude problem', 1 August 2013, http://www.bbc.co.uk/news/science-environment-23514521

[5.7] Bragg, M. (2010), *The Royal Society and British Science: episodes 1 and 2*, BBC Radio 4, 4–5 January 2010: http://www.bbc.co.uk/programmes/b00pk7j0

[5.8] Bragg, M. (2012), *The written world: episode 5*, BBC Radio 4, 6 January 2012 (interviews with S. Schaffer): http://www.bbc.co.uk/programmes/b018xy22

[5.9] Letter from Person 3 (Managing Director, Furnace), 19 April 2013.

[5.10] Radford, C. (2013), 'Mechanical marvels, clockwork dreams', *Daily Telegraph*, 4 June 2013: http://www.telegraph.co.uk/culture/tvandradio/tv-and-radio-reviews/10096897/Mechanical-Marvels-Clockwork-Dreams-BBC-Four-review.html

[5.11] Cayley, D. (2009), 'Knowledge is an institution', *Ideas on the nature of science* (Goose Lane Editions), 17–33 (interview with S. Schaffer): http://www.gooselane.com/media/657.pdf