Exposing Electronics

Artefacts: Studies in the History of Science and Technology

In growing numbers, historians are using technological artefacts in the study and interpretation of the recent past. Their work is still largely pioneering, as they investigate approaches and modes of presentation. But the consequences are already richly rewarding. To encourage this enterprise, three of the world's great repositories of the material heritage of science and technology: the Deutsches Museum, the Science Museum and the Smithsonian Institution, are collaborating on this new book series. Each volume will treat a particular subject area, using objects to explore a wide range of issues related to science, technology and medicine and their place in society.

Volume 1 Manifesting Medicine: Bodies and Machines

Principal Editor Robert Bud

Volume 2 Exposing Electronics

Principal Editor Bernard Finn

Further volumes in preparation, on the themes of:

Transport
Communication
Environment

Exposing Electronics

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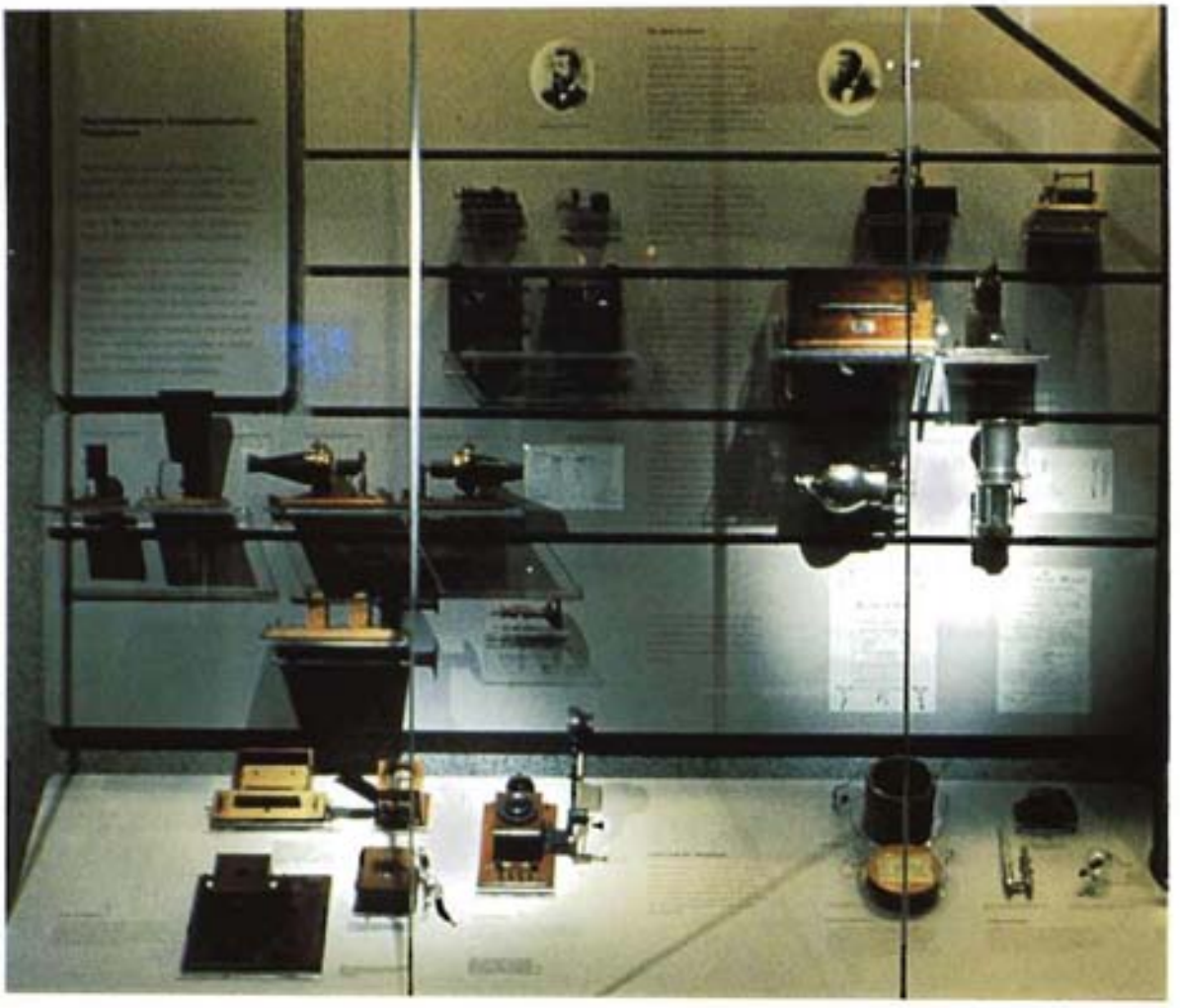
Contents



Bell-Gray comparison. Photo by Laurie Minor

Illustrations

Series Preface

In the long history of the efforts made by science museums to promote the importance of their collections, the past decade has been among the most exciting. Whereas the competition from non-object based science centres has become ever stronger, interest in using objects to communicate insight into the history of our technological and scientific heritage has gained new strength. For millions of visitors, artefacts provide a uniquely attractive and direct link to the past.

Museums also have a research mission. They are a vital force in the community of scholars, especially in the history of technology, and here, too, they have come to be better appreciated. Many outside their walls have come to share the belief that artefacts have played a role which is both inadequately understood and indispensable for a better understanding of historical and cultural change.

Initially, perhaps, it was the insight into technical detail provided by close inspection of the real thing that was generally of greatest scholarly importance. More recently, however, studies of experiments and technology have widened the view to the complex role of artefacts within their larger geographical, economic, social and political setting. Rather than being treated in isolation, technological objects and instruments are coming to be used as material expressions of human culture that shape, mediate and reflect the interactions amongst science, technology and society. Latter-day onlookers are therefore helped to see not just machines, but also imaginative worlds of the past.

Building on rapidly maturing scholarly interest, three of the world's great repositories of material heritage (the Deutsches Museum in Munich, the National Museum of American History in Washington and the Science Museum in London) are cooperating to support this new series of publications. Volumes will explore innovative approaches to the object-oriented historiography of science and technology. The series will seek to go beyond a strict technical description of artefacts on the one hand, and an overly broad social history on the other.

Collections reflect local, regional and national traditions and express their cultures and history. This character confers certain constraints, but also advantages. Museums are sensitive to, and reflect, the specific local meanings of objects, but they have the asset, too, of curators whose detailed knowledge of the collections is couched within a wider historical perspective.

Building on these dual strengths, the series is intended to initiate an international discussion which both emphasizes local material cultures, and also draws upon recent research in the overall history of science and

technology. The authors will therefore include curators, but the series will attract into the discussion other scholars from a much wider orbit. Many people have, of course, been concerned with the problems examined in this series; but all too often this has been in individual or institutional isolation. These volumes will engage an international community that is large enough to develop research programmes and debates that will have enduring momentum and excitement.

Situated at the interface between museum, university and independent research institution, the series will address professional historians of science and technology, curators, those in charge of the day-to-day administration of museums and those who, so often passionately, simply enjoy visiting. As museums do in general, the series aims to build a bridge between historical research and the use and application of historical knowledge in education and the public understanding of science and technology.

Each volume will focus on a specific field of technology and science in its wider historical context. The first, and larger, part of each volume will present the honed products of presentation and debate at joint conferences. The second part will consist of exhibit reviews, critical expeditions into the respective museum's landscape, bibliographical overviews on recent literature, and the like.

The collaboration between three national institutions has been made possible by their directors. We thank Neil Cossons, Director of the Science Museum, Spencer Crew, Director of the National Museum of American History of the Smithsonian Institution, and Wolf Peter Fehlhammer, Director of the Deutsches Museum. Their personal enthusiasm for this project has made it possible.

This series has also depended on the staff of Harwood Academic Publishers for their engaged and passionate interest.

Notes on Contributors

Ross Bassett is an assistant professor of history at North Carolina State University. His dissertation on the history of the MOS transistor won the 1998 Krooss Prize from the Business History Conference.

Roger Bridgman is Curator of Communications at the Science Museum, London, but currently working full time on exhibition content for the digital technology gallery of the museum's new Wellcome Wing. Research interests include the use of instruction leaflets as a source for the history of technology.

Paul Ceruzzi is Curator of Aerospace Electronics and Computing at the Smithsonian's National Air and Space Museum. His most recent book is *A History of Modern Computing*, and his latest exhibition deals with the Global Positioning System; both appeared in 1998.

Jon Eklund is Curator Emeritus at the Smithsonian's National Museum of American History. His former responsibilities were for chemistry and computers and was a co-curator of the Information Age exhibit. He is presently completing documentation of the chemistry collections.

Bernard Finn is Curator of the electrical collections at the Smithsonian's National Museum of American History, USA. Current research interests include electric lighting, submarine telegraphy, and the history of technical museums. He was a co-curator of the Information Age exhibit.

Paul Forman has been curator for modern physics at the Smithsonian Institution's National Museum of American History, since 1973. His research has dealt largely with the cultural and institutional context of the pursuit of physics, and with the influence of such context upon the constructs of that science.

Sungook Hong teaches the history of physics and engineering at the Institute for the History and Philosophy of Science and Technology, University of Toronto. He is interested in the history of wireless telegraphy, power engineering, and the relationship between science and technology in their developments.

Kirk Jeffrey is a Professor of History at Carleton College, Minnesota. His book on the invention of the cardiac pacemaker and the implantable

defibrillator, and the subsequent growth of the rhythm management industry will be published in 2001.

Alan Q. Morton is Acting Head, Physical Sciences and Engineering Group, at the Science Museum, London. Currently he is leading a project to develop a new exhibition on energy. His research interests are in the area of energy policy.

Harmut Petzold is curator for computer science and also for time measurement at the Deutsches Museum. His research interests involve the history of information technology.

David Rhees is Executive Director of the Bakken Library and Museum in Minneapolis. His current research concerns the development of therapeutic medical technologies, for which he is conducting oral histories with some of the pioneers of the medical device industry in Minnesota.

Bernard Finn

Introduction

In the first volume of *Artefacts: Manifesting Medicine,* we demonstrated some of the ways that object-driven research can provide fresh insights into the history of medicine and health. Here, in the second volume, we turn to electronics, with a rich diversity of approaches—about which more shortly.

But first I shall make some more general comments about the task that we have undertaken. Our goal is to persuade other historians that artefacts are fruitful sources of inspiration and of evidence, which might help persuade them to pay more attention to the collections we have so carefully accumulated in our museums. We also want to provide examples of how to write about those artefacts in a historically fruitful manner.

It isn't easy. Archeologists provide a model of sorts. For them, objects are the main—sometimes the only—evidence to be considered, and a whole system of interpretive procedures has emerged which, in effect, defines the discipline. But as we move forward in time, into periods where artefacts compete with written records, there is an increasing tendency to rely on the word instead of the object. And that is the way historians are trained. They use books and business documents and letters, and in the process learn how to use libraries and archives and microfilm readers and even computers. They employ prescribed forms of footnotes to provide readers with explicit references, and thus the opportunity to confirm statements. There is no room here for the object.

Each of our museums has, in the past, sponsored publications related to its collections. At the Smithsonian Robert Multhauf pressured, cajoled and otherwise stimulated members of the staff to produce a number of articles and short monographs which appeared as *Contributions from the Museum of History and Technology*; and in 1966 Walter Cannon was the founding editor of the *Smithsonian Journal of History*, which for three years accepted manuscripts from a broad range of authors.

In *Artefacts* we build on these earlier traditions, but we are also more explicit in wanting to encourage the development of a historiography that includes objects. We have a format that allows for the use of illustrations (a partial equivalent to the footnotes employed for text references), and as editors we do whatever we can to stimulate potential authors to think in this direction. With that in mind, our museums sponsor an annual meeting where ideas and sometimes whole papers emerge. Three

major articles in this volume were the product of such meetings (the one by Jeffrey and Rhees from a session at the Science Museum in 1996, those by Petzold and Morton from a meeting at the Smithsonian in 1997). I hasten to add that they, like the other contributions, were all subjected to normal peer review.

Let me now take the opportunity to share with you some suggestions for how artefacts can be significant to historians. Most obvious, perhaps, is the use of the object as inspiration. We look at a Hershel telescope or a Watt engine or a de Forest audion and think 'isn't this interesting, I wonder how it came to be?' and promptly turn to traditional documents for the answers. The use of the object in this instance is not trivial. It provides a visual (and perhaps tactile) stimulus that is absent in a written or pictorial description. It also provides an emotional link that even for the jaded historian is not insignificant. There are many examples of this approach, including Kim Pelis' article on blood transfusion in *Manifesting Medicine*—the author clearly having been fascinated by early 19th century blood-collecting apparatus in the Science Museum collections.

But the object may also have been inspiring to someone else, at some earlier point in time, thus making it and the reaction to it the stuff of history. Here again there are many examples. My thoughts are drawn to a conference inspired by the centennial of the Brooklyn Bridge (an artefact of majestic proportions) in 1984, which resulted in several articles, including, for example, Alan Trachtenberg, 'Brooklyn Bridge as a Cultural Trust,' in M. Latimer, B. Hindle and M. Kranzberg (eds.), *Bridge to the Future: A Centennial Celebration of the Brooklyn Bridge* (New York, 1984).

The historian may want to consider the materials from which the object is made—information often lacking in or at odds with the literary sources. Robert Gordon has used his metallurgical skills to produce several revealing works, among them 'Material Evidence of the Development of Metal-Working Technology at the Collins Axe Factory,' *Journal of the Society for Industrial Archaeology* 9 (1983), 19–28.

Operation of the artefact can sometimes lead to surprising results. When John White revived the Smithsonian's locomotive 'John Bull' for its 150th birthday he found the ride smoother and the mechanism much more forgiving than anticipated—as can be seen in his *The John Bull: 150 Years a Locomotive* (Washington, 1981). And when I worked with some of Bell's early telephones I discovered that electrochemical decomposition had probably been the reason—left unexplained in his notebooks—that he so quickly abandoned the variable-resistance transmitter. For this see 'Alexander Graham Bell's Experiments with the Variable Resistance Transmitter,' *Smithsonian Journal of History* 1 (Winter 1966–67), 1–16. Another form of operation can tell us about the capabilities of an instrument, and therefore about the limitations on its users. A classic study in this area is Gerard Turner's 'An Electron

Microscopical Examination of Nobert's Ten-Band Test-Plate,' *Journal of the Royal Microscopical Society* 84 (April 1965), 65–75.

The object may yield clues through evidence of the way it was constructed. Thus some of the myths surrounding the history of 'interchangeable parts' were exploded by Edwin Battison in 'Eli Whitney and the Milling Machine,' *SJH* 1 (Winter 1966), 9–34 and by David Hounshell in Appendix 2 ('Singer Sewing Machine Artifactual Analysis') to his *From the American System to Mass Production, 1800–1932* (Baltimore, 1984), pp. 337–344. More recently, Rolf Willach has caused us to revise our notions of how John Dollond developed his achromatic lens in 'New Light on the Invention of the Achromatic Telescope Objective,' *Notes and Records of the Royal Society of London*, 50 (1996), 195–210.

Sometimes evidence of use—wear and tear—can provide significant historical clues. Again, Robert Gordon, in his 'Laboratory Evidence of the Use of Metal Tools in Machu Picchu and Environs,' *Journal of Archaeological Science* 12 (1985), 311–327.

Where we find things, how many we find, the serial numbers—this is the kind of evidence that can tell us about the popularity of a product, how many were sold and who was buying them. Deborah Warner used this technique in her pursuit of a particularly elusive instrument in 'Davis Quadrants in America,' *Rittenhouse* 3 (1988), 23–40.

Design elements have been used to draw conclusions about the 'style' of invention. Reese Jenkins applied this line of reasoning in his 'Elements of Style: Continuities in Edison's Thinking, in *Bridge to the Future*, pp. 149–162, though, unfortunately for us, he was working from drawings instead of objects. Steven Lubar uses artefacts for this purpose in considering John Howe in his 'Cultural and Technological Design in the Nineteenth Century Pin Industry,' *Technology & Culture* 28 (1987), 253–82.

Finally there is the matter of physical appearance—especially size and weight—which can make a strong impression on the historian (as on anyone else). The influence may be too subtle to register in a citation, but it is nevertheless something we should be aware of.

Now to more urgent matters: volume II of *Artefacts*. The choice of subject was determined at the London meeting of 1996 and was explored in several presentations and discussions in Washington the following year. Electronics, like Medicine in our first volume, obviously embraces a very broad territory. We were anxious to provide a feeling for that breadth and, through a combination of design and happenstance, I believe have managed to do so. And objects are at the focus of each contribution, although not covering the breadth of possibilities discussed above.

Sungook Hong appropriately starts us with a perceptive essay on how, or we might better say why, the electronic age began. The objects to which he draws our attention are the early Fleming valves which are

preserved at the Science Museum; their function here is largely one of inspiration. Hong's message is yes, Fleming was directly influenced by Edison; and yes, his 'valve' emerged as a practical electron-manipulating device that triggered all that followed. But his motivation for and understanding of what he was doing are seen as quite different from the traditional account. Call it social determinism if you like; I see it as a wonderful example of the human nature of inventors as they pursue a technological course.

Alan Morton looks at the scientific side of electronic origins, examining the inspiration that J. J. Thomson's cathode ray tube provided for an earlier generation of would-be historians. Here there is no questioning of what J. J. Thomson did, or why he did it, but rather an intriguing exposure of how the physics community (with help from others, including Thomson himself) manipulated the memory of his experiments to establish a positive image for its discipline. Providentially, museums figure prominently in the story.

Skipping the major early-twentieth century applications of these events, Hartmut Petzold demonstrates how strongly the need was felt in the 1930s for a machine that electronics would eventually make possible. He examines several computational devices in order to assure himself that he knows how they work. The frustration is almost palpable as we consider how Wilhelm Cauer and numerous contemporaries were struggling to solve complex mathematical problems with ingenious arrangements of wires and resistors and gears and punched paper. Some of them, of course, worked, and were put to practical use; but unfortunately this was not true for Cauer's. From all this activity one might think that in the immediate post-ENIAC era there would have been a much greater realization that the electronic solution would have far-reaching consequences.

Kirk Jeffrey and David Rhees take us back to the realm of symbolism, describing in detail how a small white device became a cultural icon for a corporation and for public and professional communities. In the course of this they also describe one of the earliest and most significant applications of the solid-state form of electronics, embodied in the transistor. The cardiac pacemaker was a remarkable achievement, all the more interesting because of the fortuitous encounter at a fortuitous moment between an electrical engineer and a heart surgeon, producing the kind of interaction that we find much more common—and even actively encourage—today.

Finally, we approach the end of a hundred years of electronics, and Ross Bassett examines that ultimate black box—the integrated circuit, and more specifically the microprocessor. It turns out that with a proper microscope the IC can be very revealing of its character. With the assistance of a view at that level, he delves into an exploration of motivations—both personal and corporate. He finds that what is virtu-

ally the same device my have different meanings—and hence different historical fates—to their inventors.

But there is more. We proceed now to a museum's-eye view of electrical technology. First, I and a colleague, Jon Eklund, describe what we thought we were doing when we used certain artefacts in a major Smithsonian exhibition on the Information Age, concluding that they at least had the potential of being quite effective in conveying portions of our story. Our Science Museum counterpart, Roger Bridgman, believes that it is difficult—indeed virtually impossible—for objects to convey any real meaning in a thematic exhibit except to other experts; and he concludes that we have done no better than anyone else in this regard. There seems to be a difference of opinion here, which the reader can ponder. Then please come to the museum (where the exhibit is likely to be available for a few more years) and make the determination for yourself.

Next, two other Smithsonian colleagues take a curator's view of specific artefacts. Paul Ceruzzi considers some computers designed by Seymour Cray and asks questions about style. Can there be a style to circuit design? Was this true of Cray? If so, is it observable in his machines? And what meaning does it have?

Paul Forman takes a longer look at a couple of seemingly insignificant items that came to us from the estate of I. I. Rabi. He establishes that they must have had symbolic meaning to Rabi himself and goes on to consider what that meaning was and how it is relevant to us as historians.

To close the volume I expound on an issue that has long fascinated me, the relationship between private and public collecting. This takes me into a specific consideration of electrical collections at the Smithsonian. I then move out again to a broad survey of electrical collections in the world's museums, which I hope will be of some value to people both inside and outside the museum community.

The exercise of editing this volume has helped me to achieve personally much of what we hoped to achieve collectively through *Artefacts*: a closer relationship with colleagues in other museums, and a better understanding of the value of the objects that we collect. I hope that you, the readers, may achieve something of the same feeling.

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