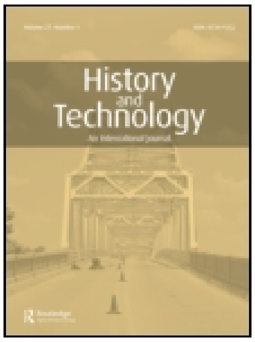

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Book reviews

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of plants reshaped the ecological and agricultural map of the tropical regions, and played indeed a crucial role in the material and mental construction of the tropics as a unified entity. Plant transfer practices and know-how were crucial to European Edenic projections on tropical islands Grove is interested in, and ought to be part of the story. For instance, actively circulated plants like the coconut tree (present in Bernardin de Saint-Pierre's *Paul and Virginie*), the hibiscus or the flamboyant tree contributed in all colonial cities of the world, to the crafting of a cosmopolitan standardized urban tropicality which still colonizes our minds (who can today imagine the tropics without coconut trees?). Finally, some historians of biology might be frustrated by the loose treatment of Hale's dessiccationist theory, or unsatisfied with the rather unsubstantiated claim that Humboldt promulgated "a new ecological concept of relations between man and natural world which was drawn almost entirely from the characteristically holist and unitary thinking of Hindu philosophers" (p. 11).

But such limitations were inescapable in such a grand narrative exploring so many places over three centuries. A big picture at the junction of environmental history, of the history of European expansion, and of the history of science was a risky but highly fruitful undertaking, and Grove has cleared the way for and stimulated many young historians in the North and in the South, who will sharpen, revise and extend his pioneering work.

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Peter Galison, *Image and Logic. A Material Culture of Microphysics.* (Chicago and London: The University of Chicago Press, 1997) pp. xxv+955.

The first impression of "Image and Logic" is intimidating: almost one thousand pages, and, to make things worse, typeset in Times New Roman at an unreadable eighty characters per line. This will no doubt deter many possible readers, which is a pity, since they will miss one of the most important books in the history of physics that has appeared in the last years.

The book spans a period of roughly one hundred years, from Wilson's early cloud chamber experiments to the planned large detectors for the ill-fated Superconducting Supercollider. Each chapter, except the first and the last, studies one particular episode in the history of instrumentation. At every time, with every change in instrumentation, new answers to the questions of what an experiment is, who counts as an experimenter and who is in control of the experiment and the laboratory have to be found.

One can identify at least three lines of argumentation in the book. On the epistemological level, Galison argues against positivism and (post-) Kuhnian ideas he dubs "block relativism" to establish his image of science as a complex structure held together by networks of trading zones and interlanguages. This interest in epistemology also motivated his choice to study the material culture of instruments and detectors over other material cultures of microphysics like those of the accelerator builders. On the historiographic level, he argues for a *mesohistory*. He wants to study individual episodes, but not as case studies that reveal something about some abstract thing like experimentation, but as parables on the changing nature and meaning of experiment itself. Finally, on the historical level, despite his confession to mesohistory, he wants to tell the grand story of two competing traditions, the "image" and the "logic" tradition, that finally merge in the large, image producing electronic detectors of the last quarter of the twentieth century, which he calls postmodern devices.

Galison's epistemological goal is to find out what keeps a scientific discipline like physics together through all the changes in methods, instruments and theories To do so he develops a new concept that might prove a valuable tool for the whole field of science and technology studies and merits a closer look. He contests the traditional positivist and antipositivist positions on these questions, both of which he finds untenable. For the positivist, the basis of science is a continuous stream of accumulating empirical data while theories replace one another whenever new data become available. For the traditional antipositivist or "block relativist" in Galison's terms, the basis is a sequence of mutually incommensurable theories, where each change in theory cuts the whole discipline into disparate blocks, so that even empirical data are uncomparable across theoretical divides. While the first explains the perceived stability of science by an unfounded assumption, the second one makes this stability unexplainable.

The solution Galison proposes to this dilemma rests on the concept of *intercalation* that he developed several years ago. He argues that there are several distinct subcultures within any given field of science, like theorists, experimenters and instrument makers. Each of these has a history of its own, with its own continuities, changes and ruptures. These changes usually do not occur at the same time, so whenever there is radical change in one sector, there usually is stability in others. But intercalation alone does not suffice to explain the stability of a scientific discipline like particle physics. If one looks closely at each of these subcultures with the usual tools used to study the formation of disciplines, they turn out to be disjointed: they have different aims and methods, their members read different journals and attend different conferences. Something more is needed to tie these intercalated subcultures together so they can stabilize each other. To describe this 'something', Galison borrows two closely related concepts from anthropological linguistics: that of a *trading zone* and that of an *interlanguage*. A trading zone is a space where members of different cultures may meet to exchange goods they both rely on. To organize this exchange, they may develop an interlanguage, a *pidgin*, that allows them to establish a restricted and strictly local common meaning and value for the exchanged goods, although the goods may have totally different meanings in the respective cultures. In the course of time, as more people start using a given interlanguage and it becomes richer in expression, the pidgin may stabilize into an independent language, a *creole*, or it may disappear altogether if the exchange stops. The application of these concepts to the study of scientific practice offers both a descriptive language for relations between different subfields and a dynamical model for the formation and dissolution of new disciplines.

This framework is also used to analyse the relations between physics, industry and the military. In doing so, Galison (seemingly unknowingly) comes close to a suggestion made by one of his favourite block relativists in the late 1980s. While discussing the relations between high energy physics and the military, Andrew Pickering proposed to describe these "in terms of the *circulation* of cultural resources between bounded domains of practice" (A. Pickering: Big Science as a Form of Life. In M. De Maria *et al.*: *The Restructuring of the Physical Sciences in Europe and the United States, 1945–1960.* (Singapore: World Scientific 1989), pp. 42–54). But the two approaches take different directions. For Pickering, this form of description replaces an epistemological critique of the cognitive content of science, which is impossible in a block relativist framework, while Galison uses it primarily as an epistemologic tool that allows one to study the differences as well as the continuities between different forms of experimental life.

The experiments and experimenters Galison describes have very little in common, supporting his thesis that the meaning of experimentation was in constant flux. The first scientist he studies is C.T.R. Wilson, who worked with the "peculiar genius of British physics" on cloud chamber physics in the Cavendish Laboratory, almost on his own. Wilson's work tied together romantic meteorology and a Cavendish tradition of analytical matter theory to form *the intermediate field or trading zone of condensation physics*, that stabilized for some years and then disintegrated into physical meteorology, climatology, condensation physics for steam engines and matter theory of particles. This chapter serves two purposes: It provides a first example of the use of the analytical categories proposed by Galison, especially the trading zone, and it introduces the language of images of particle tracks that entered into microphysics through the cloud chamber. These two notions dominate the rest of the book.

After the cloud chamber came the cosmic ray physicists, who travelled to lonely mountaintops to expose their emulsions to cosmic rays, but then distributed the developed emulsions in a highly coordinated effort among several laboratories to get the analysis done. They were replaced by the large bubble chamber groups that used the experience in collaborative work gained during World War II to generate and analyse experimental data in an industrial style. While in the first years still considered as an extension of a single physicist, they turned into more anonymous, collective entities at the end of the sixties: When Luis Alvarez left his group, the "Alvarez Group" at the Lawrence Berkeley Laboratory, no one took his place and the group was known as "Group A" afterwards. All these experiments generated images similar to those of the cloud chamber, and a central epistemological ideal was that of a clear image of a physical reaction, the *golden event*.

After the demise of the emulsion method physicists who resented these large, factory like "image" experiments worked with smaller "logic" experiments that used electronic counters. While these experiments used the same large accelerators, the same *outer laboratory* as the bubble chamber groups, the experimental space itself, the *inner laboratory* did not grow to the same size and remained under control of the experimenter: The apparatus gave immediate feedback and the conditions of the experiment could be changed on the fly, without having to wait for the images to be developed and analysed. These experiments relied heavily on statistical methods and on the use of computers both for the analysis of the data and for Monte Carlo simulations that were the basis for statistical comparisions. Golden events were impossible in this tradition since single events were meaningless for experiments of *this* type.

With the advent of storage rings these two traditions started to merge. The interaction regions were surrounded with electronic counters, while computers were used to reconstruct images of the events from the output of the electronic devices. Galison sees the first electronically generated golden event, the discovery of the W particle at CERN in 1983, as an indicator for this unification. The decisive epistemoloical innovation that made this possible was the use of computers as an experimental tool. Monte Carlo simulations, in itself a totally new form of experimentation, provided a way to translate between theoretical models and experimental data while track reconstruction algorithms translated between the languages of statistical counter signals and of images of individual events.

Looking at the book as a whole, Galison scores two and a half marks out of a possible three. His studies of the individual episodes are convincing; several of them would make important monographs if published separately. They rest on extensive research using a wide spectrum of published and archival materials. Of course there are some small glitches, especially when dealing with handwritten German sources, like taking an *u* for an *ü*, but these are minor details. Nobody working on the history of high energy physics and related topics like Monte Carlo simulations or the effect of World War II on physical research can afford to ignore this book.

Galison has also convincingly shown the usefulness of the concepts of trading zones and interlanguages for the study of science and technology.

Where his account is wanting is the overall picture, the story of the two traditions that gave the title to the book. While his treatment of the the image tradition is as comprehensive as one could wish for, a treatment of the history of the logic tradition is almost entirely missing. The logic tradition proper is confined to about 25 pages in the first part of chapter six, tellingly titled "The Electronic Image." The rest of the chapter is devoted to the efforts to construct electronic devices that would produce images and to the first "hybrid" experiment, the magnetic detector at the Stanford storage ring SPEAR.

One might even wonder whether the epistemologically inspired image/logic divide is the best one for an analysis of the material culture of elementary particle physics. Control over the workspace, another prominent topic in "Image and Logic", might have provided a better conceptual framework for the organization of the book. For example at one time the organisation of CERN followed the structure of the inner laboratory with a large/small divide: There was one division for emulsion and counter physics, and one for bubble chamber physics. Seen from this perspective, the change that undeniably took place with the rise of storage rings might rather be seen as a hybridisation of work organizations than one of epistemological traditions: while at least comparable in size to the largest bubble chamber groups, storage ring experiments are usually done by collaborations of smaller groups, where each group has a considerable autonomy in designing and operating its part of the detector. This leads to a far less industrialized working environment for the individual scientist than one might expect if one only looks at the size of the experiment alone. Most probably, these experiments should be seen as spaces of constant exchange where benefits of work organisation are traded in for epistemological positions and vice versa.

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