

BOOKS

... Where Engine Grease Meets Up With Experimental Results ...

Image and Logic: A Material Culture of Microphysics

▶ Peter Galison
U. Chicago P., Chicago, 1997.
984 pp. \$90.00 hc (\$34.95 pb)
ISBN 0-226-27916-2 hc
(0-226-27917-0 pb)

Reviewed by W. K. H. Panofsky

Peter L. Galison's *Image and Logic* is an important but highly selective compilation of items within the history of elementary particle physics. It attempts to chart the evolution of particle physics in both its social and its substantive contexts. In the latter respect, it chooses to focus on the particle detectors used in conjunction with high-energy accelerators and colliders. As Galison defines his purpose in his preface: "I want to know . . . how pictures and counts get to be the bottom-line data in physics. . . . Historically, historiographically, philosophically, this book is a back-and-forth walk through physics to explore the site where engine grease meets up with experimental results and theoretical constructions." In the process, the technical evolution of accelerators and colliders on the one hand and the evolution of ideas on the other become adjuncts to case histories of specific detectors and detector systems whose technical principles and administrative arrangements he covers in detail.

In the category of "image" detectors, Galison deals with cloud chambers and bubble chambers and, to a more limited extent, nuclear emulsions. He traces the history of the bubble chamber from Donald Glaser's tabletop devices to Luis Alvarez's giant chamber built at Berkeley and then transferred to the Stanford Linear Accelerator Center. He also describes in detail the disastrous July 1965 explosion and fire at the Cambridge Electron Accelerator.

Galison designates as "logic" detectors the counter arrays, wire and spark chambers that result in electronic readouts. He then focuses on "hybrid"

detectors in which logic and image merge. In that latter category, he selects as primary examples SLAC's MARK I detector at the SPEAR storage ring and the Time Projection Chamber (TPC) at SLAC's PEP storage ring. The administrative shortcomings of the TPC projects are described in depth; however, the other side of the story—the generally successful construction of multimillion dollar detectors by many agencies, and, frequently, different countries—is not described.

Each case history is presented in elaborate and scholarly detail, and the author then draws social generalizations based on these examples. The reader may find it difficult to discern the extent to which such social conclusions depend on the particular example chosen. The case histories are imbedded in a recital of the evolution of physics and physicists during and after World War II and the consequent drastic transformation and expansion of the physics enterprise at the universities and the creation of the postwar national laboratories.

In citing the context of both the chosen case histories and the evolution of the conduct of high-energy physics, Galison deals in considerable detail with many topics that have been the subjects of major historical studies by other authors: There is a brief recital of the history of nuclear weapons and the postwar struggles over the policy dealing with the hydrogen bomb. There is a discussion of the basic concepts underlying quantum chromodynamics (QCD) but specifically related to the case history of the TPC. The author justifies this approach by dwelling on what he calls "trading zones" through which accelerator designers, technicians, engineers, experimentalists and theoretical physicists communicate in a relatively narrow context. Thus, the universality that permeates the work of the different participants in the physics enterprise tends to be underestimated.

Drawing broad conclusions from narrow case histories can lead to misinterpretation of the physical facts that lead to the choice of particular detectors for a particular application. One example: Since the expansion of a bubble chamber cannot be triggered once a particular class of events is

identified, it is difficult to identify rare events against a large background of competing processes. In the extensive discussion of the struggles by Alvarez to make the bubble chamber the preeminent tool in postwar particle physics, this fact is not recognized; Galison does not mention the hybrid bubble chamber in which an electronic adjunct decides when a picture shall be taken or not following expansion. He does provide a critical discussion of competing data-analysis systems for bubble-chamber photographs, focusing on the degree of human intervention, but his description of these methodologies implies much more discontinuity than really exists. The broad conclusions drawn from the Cambridge Electron Accelerator fire disregard the special circumstances at that laboratory, which impose limits on the ability of the laboratory's management to control its users.

There is considerable discussion of the evolution of the size of the detection instruments and of the collaborations that go with them, interpreted as a continuing quest for ever-growing expansion. However, Galison does not mention the accompanying contraction in the number of facilities operating at the frontier of the science. While the observations on the social dynamics of high-energy physics are meticulously documented and generally well interpreted, the author does not attempt to suggest a better way of advancing the field.

Let me summarize. This book indeed contains a scholarly and extremely valuable selective description of important episodes in the recent history of elementary particle physics. However, the broad conclusions drawn from these examples are of more limited significance than is perhaps the author's intent.

The Neutron and the Bomb: A Biography of Sir James Chadwick

▶ Andrew Brown
Oxford U. P., New York, 1997.
384 pp. \$35.00 hc
ISBN 0-19-853992-4

James Chadwick is known to every physicist as the discoverer of the neutron. That discovery, in 1932, is often

W. K. H. PANOFSKY is a past president of the American Physical Society and the director emeritus of the Stanford Linear Accelerator Center in Stanford, California.



JAMES CHADWICK (left) with General Leslie R. Groves and Richard Chace Tolman in 1945. (Courtesy National Archives and AIP Emilio Segrè Visual Archives.)

seen as initiating the field of nuclear physics as an independent discipline. Remarkably, no biography of Chadwick has appeared during the succeeding 65 years. Andrew Brown, an English radiation oncologist practicing in New Hampshire, has now filled this gap. His biography, based upon extensive historical and archival research, was conceived and written on a grand scale, setting Chadwick's life within the context of his times and setting his work within the context of the places and institutions in which it was carried out.

Chadwick was born in Bollington, a small town southeast of Manchester, England, in 1891. He was the eldest son of a poor cotton-spinner and his wife, who left him in the care of his grandparents when they moved to Manchester a few years later. That separation turned into alienation, especially from his father, and may have been the source of Chadwick's lifelong extreme shyness, seeming aloofness and taciturnity. Later in life, as Brown points out, Chadwick became terrified at the prospect of giving public lectures and avoided doing so whenever possible. He suffered from stomach disorder, back pain and insomnia, relying on a sleeping pill every night of his life after 1941.

The course of Chadwick's career was set by default in 1908, when he won a scholarship to enter the University of Manchester and, in a preliminary interview, made the mistake—which he was too shy to admit—of joining a group of entering physics instead of mathematics students. Thus began his long association with Ernest Rutherford, first at Manchester (1908–13) and later at Cambridge (1919–35). Chadwick graduated from Manchester with first class honors in 1912, received his MSc degree there the following year and then was awarded an 1851 Exhibition Scholarship to pursue further research in Hans Geiger's laboratory

at the Physikalisch-Technische Reichsanstalt in Berlin. There, in early 1914, Chadwick made his first important discovery: the continuous beta-ray spectrum.

When war broke out that August, Chadwick was trapped in Berlin and interned, along with many others, in abandoned racehorse stables in Ruhleben, on the western outskirts of the city. He soon began lecturing and carrying out rudimentary experiments, with equipment supplied by German colleagues, on radioactivity, and he took another internee, Charles D. Ellis, under his wing. After the Armistice in November 1918, suffering severely from malnutrition, Chadwick returned to Manchester and then accompanied Rutherford to the University of Cambridge. In 1921 he was awarded one of the first of the new Cambridge PhD degrees and two years later became assistant director of research in the Cavendish Laboratory. In August 1925, with Peter Kapitza as best man, Chadwick married Aileen Stewart-Brown, daughter of a prominent and wealthy Liverpool stockbroker. Twin daughters, Joanna and Judy, were born in February 1927.

Brown sets these events in Chadwick's life on a broad canvas, insightfully portraying the very different institutional atmospheres and conditions under which Chadwick worked in Manchester, Berlin and Cambridge, for the most part under the powerful influence of Rutherford and only gradually emerging as his own man. Brown discusses in detail Chadwick's collaboration with Rutherford during the 1920s, while he was following up Rutherford's discovery of artificial disintegration. The biography details the intense controversy that that work precipitated with researchers in the Institute for Radium Research in Vienna, the background and nature of Chadwick's discovery of the neutron in 1932,

the experiments he carried out with Maurice Goldhaber on the photodisintegration of the deuteron in 1934 and the great difference between Chadwick's and Rutherford's views on the necessity of constructing a cyclotron to pursue future experimental research in nuclear physics. That disagreement ultimately led Chadwick to leave Cambridge for the University of Liverpool in 1935. The Liverpool cyclotron went into operation in the middle of 1939, a few months before Europe was again embroiled in war.

Chadwick's scientific and diplomatic services during the second world war have often been undervalued, and one of the great strengths of Brown's biography is its correction of that assessment. Chadwick played a leading role in formulating the Maud Committee report, so important in initiating the American atomic bomb project; he arranged to bring Niels Bohr and his son Aage to Los Alamos after their escape from Denmark in September 1943; and time and again he provided the essential glue to keep the Anglo-American relationship from disintegrating. Apart from General Leslie R. Groves and his scientific adviser, Richard C. Tolman, Chadwick was the only person to have access to all of the US research and production facilities of the Manhattan Project. He and his wife and daughters lived for about a year in Los Alamos in 1944–45.

After returning to Liverpool after the war, a changed man in a radically changed scientific milieu, Chadwick left in 1948 to accept his last academic appointment, master of Gonville and Caius (pronounced "keys"), his old Cambridge college. A decade later, frustrated by intramural conflicts and unwilling to relinquish many of his deeply held academic and personal principles, he resigned the mastership and went into retirement, moving with his wife to a country house in North Wales. There he tended his garden and, despite his frail health, performed the last of his devoted services to his esteemed mentor, editing Rutherford's *Collected Papers* for publication. In 1968 he and his wife moved back to Cambridge, to be near their daughters. He died in his sleep on 24 July 1974, at the age of 82. By the time of his death, Chadwick had received numerous high awards and honorary degrees, including the Nobel Prize in physics and the US Medal for Merit. Andrew Brown's biography beautifully reveals the scientific, diplomatic and personal achievements that formed the basis for those high honors.

ROGER R. STUEWER

University of Minnesota, Minneapolis