Science and Technology in the Twentieth Century: Cultures of Innovation in Germany and the United States

Conference at the GHI, October 15–16, 2004. Co-sponsored by the GHI and the DFG-Research Group 393. Conveners: Christoph Strupp (GHI), Helmuth Trischler (Deutsches Museum, Munich).

Participants: John A. Alic (Avon, NC), W. Bernard Carlson (University of Virginia), John Cloud (National Oceanic and Atmospheric Administration, Central Library, Silver Spring, MD), Arthur Daemmrich (Chemical Heritage Foundation), Michael Eckert (Deutsches Museum, Munich), Lars Heide (Copenhagen Business School), Martina Heßler (RWTH Aachen), Ulrike Kissmann (Berlin), Wolfgang König (Technische Universität Berlin), John Krige (Georgia Institute of Technology), André Müller (University of Bielefeld), Michael J. Neufeld (National Air and Space Museum, Washington, DC), Dominique Pestre (Centre Alexandre Koyré, Muséum National d'Histoire Naturelle, Paris), Michael B. Petersen (University of Maryland, College Park), Carsten Reinhardt (University of Regensburg), Philip Scranton (Rutgers University), Thomas Steinhauser (University of Regensburg), Ulrich Wengenroth (Technische Universität, Munich), Stephan Wolff (Deutsches Museum, Munich), Thomas Zeller (University of Maryland, College Park).

The so-called linear model of the relationship between science and technology states that basic science drives technological change. As a 1963 article in *The Economist,* quoted by John Krige in his presentation, put it, "Prosperity depends on investment, investment on technology, and technology on science. Ergo prosperity depends on science." The linear model, the roots of which are usually traced back to Vannevar Bush's landmark report of 1945 entitled "Science: The Endless Frontier," has entered a state of crisis, requiring new models of interpretation and a better understanding of the role of science and technology within innovation processes and innovation cultures.

The first session of the conference, chaired by Helmuth Trischler, aimed at a broader understanding of science-technology relations "beyond the linear model." John Alic mainly dealt with agricultural research, more heavily funded by the U.S. government before World War II than any other technology, in order to emphasize the role of diffusion-oriented policies. Federal spending through the U.S. Department of Agriculture for research rose roughly parallel to that for extension from the 1920s to the 1970s. Alic criticized policymakers in other areas. While public support of research is generally accepted, there is a widespread lack of understanding concerning the importance of diffusion. The second speaker, Bernard Carlson, focused on innovation processes in the private sector rather than on government policies. From a number of diverse innovations such as heat-tolerant and shock-resistant glass (Pyrex, Chemcor) developed at Corning, or the invention of the transistor at Bell Labs, he concluded that the linear model fails to apply in these cases. Firms generally invest in research and development in order to maintain the status quo or to improve their position on the market. The emergence of innovations in the private sector should be considered primarily a demand-side story. André Müller's presentation analyzed the discourse on academic-industrial relationships in Germany and in the United States based on policy documents in the late twentieth century. The discourse displayed different national attitudes about knowledge transfer across the academy-industry divide. For the American case, university-industry relations were found to be subject to established rules and regulations, for example, while such a reference was missing in the German case. But there were also common features. Both the American and the German national systems displayed a tendency to blur the boundaries between academia and industry. The last speaker of the first session, Philip Scranton, used the history of the development of jet propulsion in the United States after 1945 to probe the validity of the linear model, and found little to no support for it. In critical areas of technology, basic science could not offer help because it was in too rudimentary a state. Jet engine innovation was "Edisonian," Scranton concluded, as "it was a contingent, negotiated struggle with the material world's capabilities and limits, a fierce effort to defeat failure along with the Soviets, a political conflict between and within powerful organizations, and a collective, secret, industry-state project whose interior messiness merits our attention." Ulrich Wengenroth in his comment broadened the view and displayed a modification of the linear model as used by the Organization for Economic Cooperation and Development (OECD) in 1970 (the "Frascati Manual"). In this model, science still was viewed as playing a crucial role, but it was not viewed as simplistically as it was during the immediate postwar era.

The second session, chaired by Christoph Strupp, focused on transatlantic discourses. John Cloud presented the parallel developments of cartographic innovations before and after World War II as an example. The complex computer mapping and geo-referenced database management systems that became known as Geographic Information Systems (GIS) had a precursor in Military Geographic Intelligence Systems (MGIS). The MGIS were based on advanced military and intelligence technologies utilizing top-secret reconnaissance imagery and data coupled to advanced American and European data processing, geopositioning, and computer mapping systems. These Cold War geographic technologies were rooted in pre-war analog map overlay systems. A transatlantic discourse took place when, at the end of the Second World War, Allied Intelligence captured German overlay sets developed and used by planning units of the SS for the infamous *Generalplan Ost*. The second speaker of the session, Arthur Daemmrich, reported about health and safety regulations of pharmaceutical drug development in the United States and Germany. He observed that the legal frameworks and national styles for regulating new medicines differed significantly between both countries, reflecting differences concerning the authority of public interest groups, the medical profession, and the pharmaceutical industry. John Krige considered the influence of two German émigrés (Richard Courant and Natalie Artin) on the Marshall Plan. At the request of the Office of Naval Research, Courant and Artin were sent to Germany in order to assess the quality of the work done there during the war and to establish whose knowledge "deserves more exploitation." The rehabilitation of science in Germany, as well as its support by Marshall funds, was to a considerable extent influenced by their reports. Commentator Carsten Reinhardt pointed to the cultures of innovation and regulation in Germany and the United States as the unifying topic behind these transatlantic discourses. He noted that judging from Daemmrich's presentation, quite different systems of innovation and regulation can prove remarkably successful as a consequence of long-term adaptation and coevolution. Reinhardt also noted how the old historian's rule to "follow the money" applied in Krige's presentation.

The third session, chaired by Michael Eckert, dealt with transatlantic comparisons. Lars Heide presented the case of IBM and the Deutsche Hollerith-Maschinen AG (Dehomag), IBM's German affiliate. While IBM's office machine technology, in particular its punch-card technology, flourished in the United States as a consequence of considerable support by the federal government, Dehomag did not attract much interest in Germany. German government institutions between 1911 and 1945 used punch cards extensively, but the institutions never had significant influence on the shaping of this technology. Wolfgang König shed light on the fundamental difference of a German culture of design and an American culture of production. In American industry, design work was interpreted as a means and not as an end. The goal was design for production and economy. In Germany, design was more formalized as a result of the engineers' education in *Ingenieurschulen* and *Technische Hochschulen*, which taught more theory than did engineering schools in other countries. Thomas Steinhauser compared two instrument suppliers that provided nuclear magnetic resonance (NMR) technology for chemical analysis: Varian, a Silicon Valley firm, and Bruker, a Swiss-German enterprise. While Varian remained a local product of Silicon Valley, Bruker "de-localized" into a network. Stefan Wolff contrasted the German and the American academic environments of the physicists who emigrated to the United States after 1933, when American universities were in a phase of transition. The role of physicists educated at European universities, particularly in the new field of theoretical physics, was crucial for the coming-of-age of physics in the United States. With the emigrants, two different scientific cultures met and often clashed. In his commentary on these four presentations, Michael Neufeld called for a broader analysis rather than a focus on special cases. He noted that Lars Heide's case of punch-card development contradicts the dominant interpretation of a weak U.S. federal government and a strong German state, and issued a plea for cautious historical differentiation. Finally, he criticized the fact that the papers on the German case had not examined the innovation culture of the German Democratic Republic.

The final session was dedicated to "Cultures of Producing and Consuming Knowledge," and was chaired by Thomas Zeller. The first speaker, Michael Petersen, reported on the mentality of scientists and engineers in Peenemünde before and during World War II. He described them as a community totally dedicated to their mission, forged in secrecy, held together by deep personal and professional bonds, and reinforced by the tasks carried out there. They pursued this mission as "a distinct social and professional unit in which individuals found a high level of acceptance, solidarity, and happiness." This proved to be an important reason for the rapid and successful development of the A-4 rocket. The regime of secrecy shaped a specific culture of innovation, and the move of the Peenemünde team to the United States after 1945 eventually transferred this regime across the Atlantic. Dominique Pestre's talk was broadly oriented toward the production and regulation of the sciences in late twentieth-century society. Pestre pointed to "a process of profound recomposition affecting science as well as society" beginning in the 1970s and characterized by a growing privatization of knowledge on a global scale. He asserted that science has moved from a system of science in society "dominated by an equilibrium between science as public good and science as industrial good to a system in which a financial and market-oriented appropriation of scientific knowledge is now in the ascendant." This radical regime change of knowledge production, which he followed on five different levels, is most visible in new definitions of intellectual property rights and rules for patenting. Ulrike Kissmann, the final speaker of the session, presented results from a psychosocial study on the biographical reconstructions of researchers working on nuclear energy in Germany. Her key concept was Bourdieu's notion of "habitus."

She concluded that the nuclear scientists were disassociating themselves from society. They constructed the affiliation with their own professional community by projecting the military potential and its risks onto "the others." Thus, they expressed the historically grown habitus of scientists as working in a societal vacuum. Martina Heßler, who commented on this session, took up the question of a considerable change around the 1970s, and asked how helpful three additional categories might be to describe and understand this change: first, the topic of a new culture of scientific communities, as Petersen described for the case of Peenemünde for the 1930s and 1940s; second, the question of whether the change since the 1970s coincided with a generational turn; and finally, if this change could be described as a "pragmatization of science."

The discussions after each session addressed more problems and raised further questions. Wolfgang König, for example, missed a broader historical approach concerning the emergence of the linear model. He argued that in Germany, the emancipation of the *Technische Hochschulen* around 1900 offered a first case where the notion of the linear model became publicly disputed, and he suggested that discourse analysis would provide a suitable starting point for further research. Michael Eckert pointed to the problems faced by those interested in analyzing science-based innovations due to the lack of cooperation between historians of science and historians of technology. John Krige issued a plea for closer historical analyses, and Phil Scranton asked for thick descriptions of specific cases of innovation processes. A number of participants, especially Dominique Pestre, stressed the importance of secret knowledge and regimes of secrecy, which historians usually tend to neglect in their research based on public sources. The general discussion, led by Helmuth Trischler at the end of the two-day conference, focused on three main questions. First, it asked for appropriate, or simply interesting, historiographical frameworks, if not explanatory models, to better understand the dynamics of innovation systems and innovation cultures beyond the linear model. Second, it stressed the differences of regimes of knowledge production and consumption discussed during the conference (open science or knowledge as a public good, private science or proprietary knowledge, and secret knowledge). Finally, it addressed the question of the specific place and space of science within innovation processes.

Michael Eckert and Helmuth Trischler