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Scientific Instruments and/as Oil Spillovers

The Role of the Oil Industry in Developing Nuclear Instruments for the Manhattan Project

Michiel Bron | ORCID: 0000-0001-5835-5048
Tilburg University, Tilburg, The Netherlands
M.Bron@tilburguniversity.edu

Cyrus C.M. Mody | ORCID: 0000-0002-5266-5878
Maastricht University, Maastricht, The Netherlands
c.mody@maastrichtuniversity.nl

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Abstract

More than other history of science subfields, histories of instrumentation have considered the industrial dimensions of scientific knowledge. A few industries figure repeatedly in such histories: telecommunications; agribusiness; defense. We argue that the *oil industry* has been remarkably innovative in scientific instrumentation and indeed helped drive instrumentation R&D in other industries. These contributions are examples of “oil spillovers”—flows of people, money, ideas, technologies between the oil industry and other industries or scientific fields. Viewing scientific instruments as oil spillovers helps resolve some old historiographic questions and raises new ones. In this article, we show that *nuclear instruments* were applied, scaled up, and developed during the Manhattan Project in close collaboration with the oil industry. We also briefly show that various nuclear technologies based on oil industry instrumentation continued to be improved postwar by oil companies such as Exxon, sometimes with the help of well-known scientists such as Hans Bethe.

Keywords

spillovers – nuclear energy – oil history – Manhattan Project

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1 Employed by Shell

In the spectacle of Christopher Nolan's biopic *Oppenheimer* (2023), one fleeting interaction was probably neglected in most post-film conversations: Robert Oppenheimer walks into a meeting of the Federation of Architects, Engineers, Chemists, and Technicians (FAECT), and as he mounts the podium is grabbed by a young attendee who introduces himself as George C. Eltenton, a physicist employed by Shell Oil. Hardly the film's most memorable moment, but one that exposes a link that is underappreciated in many histories of nuclear technology in general, and the Manhattan Project specifically: the role of private industry, and of *oil* firms in particular. Between 1941 and 1945, various American oil companies—including some of the largest, such as Standard Oil of New Jersey (later Exxon), Standard Oil of New York (later Mobil), Standard Oil of California (later Chevron), Standard Oil of Indiana (Amoco), and employees of Royal Dutch Shell's US affiliate, Shell Oil—developed instruments, performed experiments, and aided the project's uranium exploration and enrichment efforts. In this article, we take the Manhattan Project as a starting point for understanding the oil industry's contributions to scientific instrumentation. Among other things, those contributions show how histories of scientific instruments overlap with other literatures, such as business history, environmental history, or studies of "agnotology" (i.e., the creation of scientific ignorance).[1] Innovation in scientific instrumentation was crucial to the oil industry's commercial success, its profound impact on the environment and climate, and to its use of a reputation for scientific excellence to bolster dubious science (i.e., both *bad* and *doubt-inducing* science) in order to hinder regulation and avoid responsibility for the environmental damage it has caused.[2]

In this article, we therefore argue the following: pre-war, oil firms had developed extensive expertise in both laboratory and field instrumentation. *Both* kinds of instruments served as vehicles for oil firms to play a significant role in the Allies' wartime atomic bomb effort and postwar nuclear weapons and energy programs in at least the Netherlands, US, and France. Finally, looking at the triad oil industry-instrumentation-nuclear technology helps resolve some

1 A nice entry point for applying histories of scientific instrumentation to environmental history is Hugh S. Gorman and Erik M. Conway, "Monitoring the Environment: Taking a Historical Perspective," *Environmental Monitoring and Assessment* 106, no. 1–3 (2005): 1–10 and the four articles in that special issue. On agnotology, see Robert N. Proctor and Londa Schiebinger, eds., *Agnotology: The Making and Unmaking of Ignorance* (Stanford, CA: Stanford University Press, 2008).

2 On the oil industry's strategic cultivation of dubious science, see Naomi Oreskes and Erik M. Conway, *Merchants of Doubt: How a Handful of Scientists Obscured the Truth on Issues from Tobacco Smoke to Global Warming* (London: Bloomsbury, 2011).

open historiographic questions. Although we do not have the space to explore the complex interplay among all three legs of that triad in depth in this article, we do survey the landscape and offer examples of two historiographic questions (regarding the German nuclear bomb program and the dominance of the US instrument industry) that our perspective could help address.[3] Instruments offer a useful entry point for discussing the epistemology of the oil industry because they are already one of the main points of contact among history of science, history of technology, and business history (as well as management science, economics, and innovation studies).[4] In writing about instruments you would have to work hard to ignore that there is (both commercial and non-commercial) *trade* in instruments, and also that the materials that instruments are made from and that they are used to study or inspect often have a *commercial* value (and thus scientists in industry develop, buy, sell, and use instruments).[5] Of course, some industries traffic more in instruments than others, and those industries figure prominently in histories of instruments: telecommunications;[6] food and agriculture;[7] biomedicine;[8] pharmaceuticals

3 We plan to, and we invite others to, take this line of research further elsewhere. See for more updates "Managing Scarcity, A Blog about the Oil Industry, Alternative Energy and the Resource Scarcity Debate of the 'Long 1970s'," https://managingscarcity.com/ (accessed November 24, 2025).

4 For intersections of histories of scientific instruments with history of technology and business history, the works and authors awarded the Bunge Prize provide a good introduction; but see also Bernward Joerges and Terry Shinn, eds., *Instrumentation between Science, State, and Industry* (Dordrecht: Kluwer Academic, 2001). For intersections between the scientific instrument historiography and economics and innovation studies, prominent examples include Eric von Hippel, "The Dominant Role of Users in the Scientific Instrument Innovation Process," *Research Policy* 5, no. 3 (1976): 212–239 and Nathan Rosenberg, "The Economic Impact of Scientific Instrumentation Developed in Academic Laboratories," in *Studies on Science and the Innovation Process: Selected Works of Nathan Rosenberg* (Singapore: World Scientific, 2009), 57–69.

5 An excellent recent study of the trade—both commercial and non-commercial—in instruments and related ideas, illustrations, and artifacts is Lea Beiermann, "'A Co-operation of Observers': Crafting Knowledge Infrastructures for Microscopy" (PhD diss., Maastricht University, 2023), especially chapters 2 and 4.

6 James Strick, "Swimming against the Tide: Adrianus Pijper and the Debate over Bacterial Flagella, 1946–1956," *Isis* 87, no. 2 (1996): 274–305; Kendrick Oliver, "'The Lucky Start toward Today's Cosmology'? Serendipity, the 'Big Bang' Theory, and the Science of Radio Noise in Cold War America," *Historical Studies in the Natural Sciences* 49, no. 2 (2019): 151–193; Nicholas Rasmussen, *Picture Control: The Electron Microscope and the Transformation of Biology in America, 1940–1960* (Stanford, CA: Stanford University Press, 1999).

7 Deborah Jean Warner, "How Sweet It Is: Sugar, Science, and the State," *Annals of Science* 64, no. 2 (2007): 147–170; Arnold Thackray and Minor Myers Jr., *Arnold O. Beckman: One Hundred Years of Excellence* (Philadelphia, PA: Chemical Heritage Foundation, 2000), chapter 4.

8 Boelie Elzen, "Two Ultracentrifuges: A Comparative Study of the Social Construction of Arti-

and chemicals;[9] armaments;[10] semiconductor manufacturing;[11] and even the automotive industry.[12] The oil industry, however, has not yet taken its rightful place in synthetic histories of instrument use and development, or in generalist histories of 20th century science and technology. True, some histories of *particular* scientific instruments do gesture to the oil industry, though mostly in passing. For instance, Carsten Reinhardt, as well as Michael Grayson and Tom Lassman, have cited Humble Oil, CEC, Shell, Standard Oil of Indiana, and Phillips Petroleum as early sites of development of mass spectrometry.[13] Similarly, Peter J.T. Morris mentions BP and Shell as early and innovative adopters of gas chromatography and Union Oil as an important early contributor to High-Pressure Liquid Chromatography.[14] Shell physicist Robert Brattain also built an important early IR spectrophotometer, which Beckman Instruments then produced in quantity, thereby making IR spectroscopy affordable to Beckman's other customers.[15] Oil firms were therefore both directly and indirectly responsible for the "instrumentation revolution" that swept across postwar chemistry.[16] Other kinds of organizations associated with the oil industry contributed to that rev-

facts," *Social Studies of Science* 16 (1986): 621–662; Anja Hiddinga and Stuart S. Blume, "Technology, Science, and Obstetric Practice: The Origins and Transformation of Cephalopelvimetry," *Science, Technology & Human Values* 17, no. 2 (1992): 154–179; Amit Prasad, *Imperial Technoscience: Transnational Histories of MRI in the United States, Britain, and India* (Cambridge, MA: The MIT Press, 2014).

9 Anthony S. Travis and Peter J.T. Morris, "The Instrumental Transformation," in *The Oxford Handbook on the History of the Modern Chemical Industry*, ed. Carsten Reinhardt (in preparation).

10 Axel Volmar, "Listening to the Cold War: The Nuclear Test Ban Negotiations, Seismology, and Psychoacoustics, 1958–1963," *Osiris* 28 (2013): 80–102; Timothy Lenoir and Christophe Lécuyer, "Instrument Makers and Discipline Builders: The Case of Nuclear Magnetic Resonance," *Perspectives on Science* 3, no. 3 (1995): 276–345.

11 David C. Brock, "From Automation to Silicon Valley: The Automation Movement of the 1950s, Arnold Beckman, and William Shockley," *History and Technology* 28, no. 4 (2012): 375–401; Cyrus C.M. Mody, *Instrumental Community: Probe Microscopy and the Path to Nanotechnology* (Cambridge, MA: The MIT Press, 2011).

12 Ann Johnson, "How Ford Invented the SQUID," *IEEE Spectrum* 51, no. 11 (2014): 40–61.

13 Carsten Reinhardt, *Shifting and Rearranging: Physical Methods and the Transformation of Modern Chemistry* (Boston: Science History Publications, 2006); Michael A. Grayson (ed. with significant but unattributed contributions by Thomas Lassman), *Measuring Mass: From Positive Rays to Proteins* (Philadelphia, PA: Chemical Heritage Foundation, 2002).

14 Peter J.T. Morris, "Laboratories and Technology: An Era of Transformations," in *A Cultural History of Chemistry in the Modern Age* (London: Bloomsbury, 2022), 73–98.

15 Arnold Thackray and Minor Myers Jr., *Arnold O. Beckman: One Hundred Years of Excellence* (Philadelphia, PA: Chemical Heritage Foundation, 2000).

16 Peter J.T. Morris, ed., *From Classical to Modern Chemistry: The Instrumental Revolution* (London: Royal Society of Chemistry, 2002).

olution as well. For example, a trade association, the American Petroleum Institute, advanced both IR spectroscopy and mass spec.[17] The oil industry was also a major sponsor and organizer of the conferences that acted as knowledge infrastructures for instrument-builders.[18]

Mass spectrometry, chromatography, IR spectroscopy—these are all laboratory techniques that have attained general use outside the oil industry and in academic research far removed from the concerns of that industry. It's perhaps less surprising that oil firms have also contributed to the development of geophysical instruments meant to measure depths, identify sedimentary layers, and explore for minerals. Whereas the historiography on laboratory instruments generally minimizes the oil industry's role to emphasize academic contributions, in contrast, the historiography on geophysical field instruments has sometimes overemphasized developments within the oil industry at the expense of following those instruments' careers beyond petroleum exploration. Indeed, several notable studies of geophysical instrumentation have focused on a single firm, such as Geoffrey Bowker or Louis A. Allaud and Maurice H. Martin's histories of innovation at the oil field service company Schlumberger, or Robert J. Forbes and D.R. O'Beirne's work on Shell.[19] Yet these instruments also often found applications *outside* the oil business which earlier works have downplayed. Our contribution is not in identifying oil-instrumentation linkages, but in observing the wide variety of such linkages *and* their importance beyond the oil industry, for both laboratory and field instruments.

In earlier work, we have described similar flows of people, money, materials, technologies, methods, concepts, and knowledge between the oil industry

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17 José Ramón Bertomeu-Sánchez and Antonio García-Belmar, "Practice and Experiment: From Laboratory Research to Teaching and Policy-Making," in Morris, *A Cultural History of Chemistry in the Modern Age*, 51–72; Keith A. Nier, Alfred L. Yergey, and P. Jane Gale, eds., *The Encyclopedia of Mass Spectrometry, Volume 9—Historical Perspectives Part A: The Development of Mass Spectrometry* (Amsterdam: Elsevier, 2016).

18 Apostolos Gerontas, "Chromatographs as Epistemic Things: Communities around the Extraction of Material Knowledge," in *From Bench to Brand and Back: The Co-Shaping of Materials and Chemists in the Twentieth Century*, ed. Pierre Teissier, Cyrus C.M. Mody, and Brigitte Van Tiggelen (Nantes: Centre François Viète, 2017), 93–116, 105; Georgiana Kotsou, "Periodic Table Manners: Rituals and Routines in International Chemistry Conferences of the 20th Century" (PhD diss., Maastricht University, 2024).

19 Geoffrey C. Bowker, *Science on the Run: Information Management and Industrial Geophysics at Schlumberger, 1920–1940* (Cambridge, MA: The MIT Press, 1994); Louis A. Allaud and Maurice H. Martin, *Schlumberger: The History of a Technique* (New York: John Wiley & Sons, Inc., 1977); Robert J. Forbes and Denis R. O'Beirne, *The Technical Development of Royal Dutch Shell, 1890–1940* (Leiden: Brill, 1957).

and various scientific and technological fields as "oil spillovers."[20] The instances in the previous paragraphs are merely a handful of the many important oil spillovers related to scientific instrumentation. However, a synthetic overview of oil-instrumentation connections is still lacking. In this article, we do not offer such an overview. Instead, we aim to flesh out the oil spillover concept for a limited domain, namely *nuclear* instrumentation and technology. Instruments—both laboratory instruments such as mass spectrometers and field instruments such as radioactive well logging devices—spilled over from the oil industry first to the Manhattan Project and eventually to the postwar nuclear energy industry and nuclear weapons complex. Thus, while an oil spillover *may* be a two-way flow, or a flow *into* the oil industry, the examples we offer are of instruments that flowed outward from oil firms to state, industrial, and academic users involved in the development of the atomic bomb and nuclear energy.[21]

The word "spillover" here is polyvalent—it gestures of course to the concept (originating in economics) of spillovers from firm to firm, especially in regional industrial clusters, and to similar concepts in other social sciences such as the "social movement spillover" where affiliation with one social movement is predictive of affiliation with related or allied movements.[22] But "oil spillover" is also one "over" from "oil spill," and hence the concept reminds us that not all flows from the oil industry are positive. "Spill" also indicates the level of agency involved in most flows. After all, most oil spills are "accidents," but the conditions that give rise to them were deliberately created by the oil industry. Similarly, most oil spillovers to various fields of science and technology didn't happen with too much foresight or encouragement from the boardroom; and yet firms' strategic decisions created the conditions that encouraged or sometimes hindered those flows.

20 Cyrus C.M. Mody, "The Oil Spillover: Prospecting for Oil in Innovation Studies and the History of Technology," *History and Technology* 40, no. 3 (2024): https://doi.org/10.1080/07341512.2024.2403755; Michiel Bron, "The Uranium Club: Big Oil's Involvement in Uranium Mining and the Formation of an Infamous Uranium Cartel," *Historical Social Research* 49, no. 1 (2024): 55–76.

21 For examples of two-way and reverse flows, see Owen Marshall, "The Oleaginous Voice: Auto-Tune, Linear Predictive Coding, and the Security-Petroleum Complex;" and Odinn Melsted, "Geoscience Spillover: Gunnar Böðvarsson, Petroleum Technologies, and the Exploration and Exploitation of Iceland's Geothermal Resources," both *History and Technology* 40, no. 3 (2024): 276–296 and 218–249 respectively.

22 Maryann P. Feldman, "The New Economics of Innovation, Spillovers, and Agglomeration: A Review of Empirical Studies," *Economics of Innovation and New Technology* 8, no. 1–2 (1999): 5–24; David S. Meyer and Nancy Whittier, "Social Movement Spillover," *Social Problems* 41, no. 2 (1994): 277–298.

2 The Manhattan Project as a Commercial Business Endeavor

Between 1945 and 1957 some of the secrecy bans regarding the role of US industry in the Manhattan Project were lifted, resulting in a small surge of publications by the various companies that had participated in the project. All claimed their part of the "success story" of the creation of the atomic bomb and the dawn of the Atomic Age.[23] Earlier authorized profiles of the Manhattan Project, such as the Smyth report of 1945, had portrayed the atomic bomb as mainly the work of a small band of theoretical physicists—largely to maintain a shroud of secrecy around the actual bulk of the project, namely the efforts of industrial contractors and their employees.[24] That early and deliberate obscuring of industrial contributions to the bomb is reflected in the vast historical literature on the topic from almost every perspective imaginable (environment, labor, politics, science, espionage, etc.)—*except* business history.[25] Although studies of the Manhattan Project are littered with references to contractors such as Westinghouse and General Electric, and a handful of business histories have focused on one of the most important contractors (Dupont), a comprehensive history of the commercial dimensions of the project as a whole is thus far lacking.[26]

23 E.g. Briscoe Center for American History, Austin, TX, ExxonMobil Historical Collection, DBCAH, Box 2.207/LD12_D, Standard Oil of New Jersey, *Oil and the Atom* (1955), 1–2; and DBCAH, Box 2.207/G75, Letter A.R. Purdy to R.H. Crist (August 29, 1945). See also "Now It Can Be Told: How Our Scientists at Whiting Research Contributed to Development of A-bomb," *Standard Torch*, May 1957, 16–21; see also the blog post of the Whiting-Robertsdale Historical Society: Frank Vargo, "How Whiting's Standard Oil Company Helped End World War II," June 2020, https://www.wrhistoricalsociety.com/how-whitings-standard-oil-company-helped-end-world-war-ii (accessed March 29, 2022).

24 On the Smyth Report's obscuring of the bomb program's industrial dimension, see Rebecca Press Schwartz, "The Making of the History of the Atomic Bomb: Henry Dewolf Smyth and the Historiography of the Manhattan Project" (PhD diss., Harvard University, 2008).

25 Partial overviews of various Manhattan Project literatures can be found in Rosemary B. Mariner and G. Kurt Piehler, eds., *The Atomic Bomb and American Society* (Knoxville: University of Tennessee Press, 2009) and Michael Kimmage, "Atomic Historiography," *Reviews in American History* 38, no. 1 (2010): 145–152. See also Alex Wellerstein, "Manhattan Project," *Encyclopedia of the History of Science* (October 2019), https://doi.org/10.34758/9aaa-ne35.

26 Examples of studies where different industrial contractors are mentioned are Richard Rhodes, *The Making of the Atomic Bomb* (New York: Simon & Schuster, Inc., 1986) and Martin Melosi, *Atomic Age America* (New York: Routledge, 2013). On Dupont, see Marcia Rorke, "The Manhattan Project, the Du Pont Company, and the Management of New Product Development" (PhD diss., George Washington University, 2003); Pap Ndiaye, *Nylon and*

A partial exception can be found in studies of the patenting of nuclear technology during and following the Manhattan Project. This literature often focuses on the national-security state's efforts to limit circulation of nuclear knowledge, showing how the US government's preoccupation with secrecy frustrated participating firms'—including oil firms'—hopes for turning involvement in the Manhattan Project into a stake in the postwar nuclear energy industry.[27] Yet to the extent that they wade into business history, due to their focus on the economics and epistemology of secrecy they do not yet provide a comprehensive picture of oil firms' and other businesses' practices in relation to the Manhattan Project.

Because of that gap, the existing historiography contains some misleading interpretations. For instance, in the literature and in many of the participants' memoirs and recollections on which that literature is partly based, the reason so many oil companies were involved in the Manhattan Project was because of their generic expertise in managing large construction projects and operating facilities (rigs, refineries, chemical plants) for continuous production of specialty materials (expertise that many firms outside the oil industry also possessed).[28] However, closer inspection reveals the crucial importance of specifically petroleum-related technologies and instruments in the development of the atomic bomb. In particular, oil firms possessed (1) the geophysical and extractive-industry expertise required to find and exploit uranium deposits; and (2) the research, instrumentation, and chemical engineering expertise needed to enrich natural uranium. Those areas of expertise, more than their

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Bombs: DuPont and the March of Modern America, trans. Elborg Foster (Baltimore: Johns Hopkins University Press, 2007); and David A. Hounshell and John Kenly Smith Jr., *Science and Corporate Strategy: Du Pont R&D, 1902–1980* (Cambridge, UK: Cambridge University Press, 1989).

27 Alex Wellerstein, *Restricted Data: The History of Nuclear Secrecy in the United States* (Chicago: University of Chicago Press, 2021); Simone Turchetti, "Patenting the Atom: The Controversial Management of State Secrecy and Intellectual Property Rights in Atomic Research," in *Knowledge Management and Intellectual Property: Concepts, Actors and Practices from the Past to the Present*, ed. Stathis Arapostathis and Graham Dutfield (Cheltenham: Edward Elgar Publishing, 2013), 216–232.

28 Leslie Groves himself stated in his memoirs that he hired the former Shell Oil geologist Paul Guarin because of the oil industry's experience with large-scale projects: Leslie R. Groves, *Now It Can Be Told: The Story of the Manhattan Project* (New York: Da Capo Press, 1962), 185–186. A similar point is made by Hewlett and Anderson when discussing the participation of Eger V. Murphree from Standard Oil of New Jersey: Richard G. Hewlett and Oscar E. Anderson Jr., *The New World, 1939/1946: A History of the United States Atomic Energy Commission, Volume 1* (University Park: The Pennsylvania State University Press, 1962), 64.

experience in managing large-scale engineering projects and chemical production, allowed US oil and chemical firms to offer competitive bids for Manhattan Project contracts. Many of the responsible military and political leadership were in fact reluctant to include industrial parties in the atomic bomb program due to potential security risks. Yet the benefits of access to *oil* industry expertise, particularly *instrumentation* expertise in mass spectrometry and well-logging, were deemed to outweigh the risks—even when the oil companies themselves were often already weighed down with other mission-critical war-time contracts and expressed doubts about the feasibility of the atomic bomb project.[29]

Indeed, a few big oil companies were already involved in the atomic bomb program prior to the official launch of the Manhattan Project. Just before the Japanese raid on Pearl Harbor in 1941, several committees were tasked with studying possibilities for the deployment of nuclear fission, including a planning board that considered the practical, engineering feasibility of building an atomic bomb.[30] Eger Vaughan Murphree from the Standard Oil of New Jersey Development Company headed the planning board, becoming responsible for the planning of a vast amount of technical and engineering work, including the procurement of materials and the building of pilot plants and eventually full-scale production plants. No consideration could be given to making an atomic bomb without the work of Murphree's board.[31] The board's members, all chosen by Murphree, were: L. Warrington Chubb (Westinghouse Research Laboratories), Percival C. Keith (M.W. Kellogg, an oil refinery construction company), George O. Curme (Union Carbide and Carbon, a chemical company), and Warren K. Lewis (MIT).[32] Although then employed in academia, not industry, Lewis had previously worked on modeling flow through oil sands, prediction of oil-field lifespan, methods of increasing oil recovery, and petroleum "cracking." Pre-war, Murphree regularly hired Lewis as a consultant for subsidiaries of Standard Oil of New Jersey such as Humble Oil & Refinery.[33]

After the Manhattan District Project was formed in mid-1942, it absorbed the pre-existing committees investigating nuclear fission, including Murphree's

29 "Under the best of circumstances, plutonium could be produced by 1945; however, the chances of this happening are low," official Appraisal from Dupont, fall 1942, quoted on Atomic Heritage Foundation, "Corporate Partners," June 4, 2014, https://ahf.nuclearmuseum.org/ahf/history/corporate-partners/ (accessed December 19, 2023).

30 Hewlett and Anderson, *The New World*, 49–50.

31 Standard Oil of New Jersey, *Oil and the Atom*, 1–2.

32 Hewlett and Anderson, *The New World*, 62.

33 Hoyt C. Hottel, "Warren Kendall Lewis, 1882–1975," *Biographical Memoirs* (Washington, DC: National Academies Press, 1969), 6–7.

planning board. The project then let contracts with a variety of firms spanning several industries, particularly chemical manufacturing (especially Dupont, Union Carbide, and Mallinckrodt Chemical Works), engineering/specialty construction (especially M.W. Kellogg and Stone & Webster), and oil. The main chemical and construction firms involved in the project had some tie to the oil industry as well—chemical manufacturers through their growing use of petroleum and natural gas feedstocks and construction firms through their prewar contracts to build pipelines and refineries.

The oil companies involved in the Manhattan Project were contracted for a variety of tasks: to design and manufacture equipment and materials, conduct research, construct various facilities, supply personnel, oversee operations, and so on.[34] For instance, Standard Oil of New York produced lubricants for the devices used in research on uranium enrichment.[35] Standard Oil of New Jersey was involved in solving the production problem for moderators, materials needed in most types of chain reactions to slow down neutrons and help direct them into the fissionable material. Jersey Standard also built a pilot plant for the fabrication of heavy water, and eventually a full-scale D_2O production plant at Trail, British Columbia.[36] Although most of these tasks accounted for only a tiny fraction of the Manhattan Project budget (heavy water plants, for instance, cost about 1% of the total), the bomb effort would not have succeeded without them. Moreover, some of the subprojects represented hedges in case other aspects of the planned bomb design did not work; for instance, the heavy water plants' "product was not used on a large scale during the war; it was produced as a back-up in case graphite proved to be a bad moderator."[37]

Likewise, the Standard Oil Company of Indiana produced the boron-10 isotopes to stabilize fissionable materials within the bomb.[38] That task relied heavily on mass spectrometry as a means of sorting different isotopes of the

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34 Briscoe Center for American History, Austin, TX, ExxonMobil Historical Collection, DBCAH, Box 2.207/G75, Letter A.R. Purdy to R.H. Crist (August 29, 1945).

35 Ibid.

36 Standard Oil of New Jersey, *Oil and the Atom*, 2–3. See also Rhodes, *The Making of the Atomic Bomb*, 388.

37 The percentages and dollar amounts here and below are ultimately from Stephen Schwartz, *Atomic Audit: The Costs and Consequences of U.S. Nuclear Weapons since 1940* (Washington, DC: Brookings Institution, 1998), although we have relied on the interpretation of Schwartz's figures offered in Alex Wellerstein, "The Price of the Manhattan Project," *Restricted Data: A Nuclear History Blog*, May 17, 2013, https://blog.nuclearsecrecy.com/2013/05/17/the-price-of-the-manhattan-project/ (accessed June 9, 2025). The quote is from Wellerstein.

38 "Now It Can Be Told," 16–21.

same chemical element. As we noted earlier, several scholars have already pointed out that the interwar US oil industry incubated development of the mass spectrometer as an instrument for analyzing the mass-to-charge ratio of ions, mainly for analysis of fluids and mineral rocks. In the Manhattan Project, mass spectrometers were also sometimes used for analysis, which explains why tasks involving mass spectrometry were mostly entrusted to firms affiliated with the oil and chemical industries. In addition, however, the Manhattan Project also used mass spectrometry for industrial manufacturing (or, put differently, extraction), both for enrichment of boron-10 and, at a much larger scale, uranium-235. We will return to that story in a moment.

3 Deriving Uranium from Oil Geophysics

Before enrichment, though, came the search for uranium deposits. That search was greatly advanced by oil firms' extensive prewar experience in incorporating the new quantum mechanics into their operations, largely in the form of instruments for taking readings down boreholes or via aerial surveys to locate oil deposits.[39] Coincidentally, use of those instruments had also provided oil firms with much more information about the location and properties of uranium than firms in any other industry. That is because uranium tends to aggregate in sedimentary layers where it groups around fossils and biomass in so-called uranium deposits.[40] Thus, the sedimentary layers where both uranium and gold form deposits are frequently found in petroleum source rock. Beginning in the early twentieth century, this correlation between petroleum and uranium led early geophysicists to design techniques, such as radioactive well-logging, to search for radioactive minerals in oil boreholes—not to find the minerals themselves, but to find oil.[41] Such techniques were quickly adopted and further developed by companies such as Schlumberger, Shell, and the Well Survey Company, to assist in oil exploration during the 1930s and early 1940s.[42]

It was therefore no surprise that people and organizations with experience in oil exploration became widely involved in the Manhattan Project's efforts

39 H.G. Reinhardt and H. Gast, "The Importance of Radioactivity in Geoscience and Mining," *Experientia* 51 (1995): 704.

40 Amherst College, Amherst, MA, College Archives and Manuscript Collections, Box 10. IV. George W. Bain Papers, George Bain, "Geology of Fissionable Materials" (n.d.).

41 Bron, "The Uranium Club," 55–76.

42 Allaud and Martin, *Schlumberger*, 268; Simone Turchetti, *The Pontecorvo Affair: A Cold War Defection and Nuclear Physics* (Chicago: University of Chicago Press, 2012), 39–68.

to obtain uranium. For instance, when the Manhattan Project started, refining of natural uranium from the already known deposits at the Shinkolobwe mine in Belgian Congo and Great Bear Lake, Canada was carried out by the Eldorado company under the supervision of geologist Philip Merrit, who had been involved in uranium, gold, and oil exploration projects before the war.[43] The Manhattan Project's military leader, General Leslie Groves, also asked the former Shell Oil geologist Paul Guarin to head a subdivision responsible for mapping the world's fissile material reserves, which Guarin staffed with geophysicists and geologists who had experience in oil exploration and were familiar with the technologies used in finding radioactive minerals.[44] Under Guarin's oversight, and managed by Union Carbide and Carbon, those geoscientists reviewed 67,000 volumes of geology reports from over fifty countries, conducted field exploration in 37 countries, and collected soil samples from twenty friendly or neutral countries.[45] Two of the main contributions of Guarin's team were the finding that uranium had a tendency to be found together with hydrocarbon-bearing minerals such as coal and oil, and the development of the easily-portable Geiger-Muller Counter.[46] Thus, uranium prospecting within the Manhattan Project became even more connected to the petroleum industry both on a theoretical level and via the development of instruments, thereby facilitating the oil industry's continued presence in the uranium value chain *after* the war (as we will see in section 5).

4 The Structure of the Pre-war US Oil Industry: Open Historiographic Questions That Oil Spillovers Can Help Answer

That the instruments needed to find uranium were largely developed within the framework of the US oil industry before World War Two is no coincidence.

43 Thomas E. Gillingham, "Memorial to Philip Leonidas Merrit, 1906–1981," *The Geological Society of America* (1981): 1–3; Groves, *Now It Can Be Told*, 185–186.

44 Two companies affiliated with Jersey Standard, Humble Oil and Refining Company and Carter Oil Company, provided geologists such as Wallace E. Pratt to advise the Manhattan Project on how to detect radioactive minerals. Standard Oil of New Jersey, *Oil and the Atom*, 4. Roger F. Robison, *Mining and Selling Radium and Uranium* (New York: Springer, 2015), 231–232; Groves, *Now It Can Be Told*, 187; Tom Zoellner, *Uranium: War, Energy, and the Rock that Shaped the World* (New York: Viking, 2009), 48–49; Jonathan E. Helmreich, *Gathering Rare Ores: The Diplomacy of Uranium Acquisition, 1943–1954* (Princeton: Princeton University Press, 1986), 43–46.

45 Robison, *Mining and Selling Radium and Uranium*, 231–232; Helmreich, *Gathering Rare Ores*, 43–46.

46 Helmreich, *Gathering Rare Ores*, 44.

After all, the United States has an immense and fragmented oil industry not seen anywhere else. At the big company end, the so-called "Seven Sisters" that dominated the postwar "free world" oil supply (their terms, not ours) were made up of five US companies, plus one—Shell—with a giant and quite independent US subsidiary, and one—BP—with longstanding partnerships with a number of US firms, particularly Standard Oil of Ohio.[47] The US oil industry also features a thick stratum of "mid-size" firms, such as Richfield Oil or Kerr-McGee, which were capable of innovative scientific research.[48] In addition, the US oil industry is populated by an astonishing array of smaller "independent" producers, construction and oilfield services firms like M.W. Kellogg or Brown & Root, companies such as Monsanto that own and operate refineries, gasoline marketers like Diamond Shamrock, and firms providing services or equipment for oil exploration such as Texas Instruments or United Geophysical Corporation.[49] Other countries have oil companies, of course, but not the nearly the same *number* of petroleum-related companies capable of contributing to instrumentation development. We should, naturally, be wary of arguments that rely on American exceptionalism; but we fool ourselves if we don't notice that the US oil industry is different, and in ways that had important implications for the history of scientific instruments.

With such a large and diverse domestic industry also came increasing competition for the best oil concessions, access to consumers, and the most advanced products. As a result, there was a constant incentive to design new technologies and improve existing ones. Some companies were, of course, reluctant to dive into such a competitive marketplace. In his study of the French oilfield services company Schlumberger's development of electric well-logging devices, for instance, Geoffrey Bowker showed how the competitiveness of the US oil industry during the interwar period encouraged European

47 The label "Seven Sisters" was first coined by the Italian oil entrepreneur Enrico Mattei referring to Exxon, Mobil, Chevron, Texaco, Gulf, BP and Shell. With this gendered frame, Mattei advanced the image of these "big oil" companies as a monolithic entity, working together as a family and unwilling to fully engage in competition. The term was further popularized by journalist Anthony Sampson in *The Seven Sisters: The Great Oil Companies and the World They Made* (New York: Viking Press, 1975).

48 John Samuel Ezell, *Innovations in Energy: The Story of Kerr McGee* (Norman: University of Oklahoma Press, 1979).

49 For an overview of the oil industry's structure (and how it came to be), see Daniel Yergin, *The Prize: The Epic Quest for Oil, Money and Power* (New York: Simon & Schuster, 1991). On the independents more specifically, see Robert Lifset, "The Independents Strike Back: The Energy Crisis of the 1970s and the Forging of a New Chapter in the Environmental History of the Oil Industry," *Journal of Energy History/Revue d'Historie Énergie*, no. 12 (2024): 1i–16i.

firms to focus first on Eastern Europe and the Soviet Union in order to obtain a training ground for personnel and new technologies *before* entering the US market.[50] The same was true of radioactive measurement devices developed by Schlumberger. These were first developed on European and Soviet oil wells before they were introduced in the US by the Well Survey Company in 1938. Once those techniques did land on US shores, however, US companies competed fiercely to develop their own, distinctive means of finding oil based on the measurement of radioactive decay that would not infringe earlier patents. Studies by Shell Oil, by the later alleged nuclear spy Bruno Pontecorvo at Well Survey (funded by Standard Oil of New York), and by Standard Oil of New Jersey and the Lane Wells Company rapidly increased the knowledge of natural radiation within the oil industry and provided an arsenal of different technologies for measuring natural radioactivity, from neutron well-logging and radioactive traces to aerial mapping of the radioactivity emitted by radon gases released from underground deposits.[51]

We believe that the peculiar structure of the US oil industry and its hegemonic role in the global oil industry cast some light on two historiographic questions related to our essay. First, for more than eight decades now, there has been much puzzlement as to why Germany did not build an atomic bomb during World War Two while the US-led alliance did. Explanations such as Nazi persecution of many of Germany's leading scientists, the Wehrmacht's preference for nuclear power rather than a bomb, or Werner Heisenberg's ambivalence or ineptitude have been advanced;[52] however, we agree with scholars who argue that the main reason is that the Allies could, as Niels Bohr put it, turn the US into one huge factory.[53] Yet Germany (in combination with its allied and

50 Bowker, *Science on the Run*, 55–65.

51 Turchetti, *The Pontecorvo Affair*, 39–68; Archives Marcel Schlumberger, Crèvecoeur-en-Auge, Fondation Musée Schlumberger, Folder AM-835. Radioactivité dans les sondages, expérience d'application de la Texas Company: rapport; Forbes and O'Beirne, *The Technical Development of Royal Dutch Shell*, 206–207; C.L. Rabe, "A Relation Between Gamma Radiation and Permeability, Denver-Julesburg Basin," *Journal of Petroleum Technology* 9, no. 2. (1957): 65–67; Luisa Bonolis, "Bruno Pontecorvo: From Slow Neutrons to Oscillating Neutrinos," *American Journal of Physics* 73 (2005): 487–499; Frank E. Close, *Half Life: The Divided Life of Bruno Pontecorvo* (New York: Basic Books, 2015).

52 For a critical overview of works advancing these explanations, see Jonothan Logan, "The Critical Mass," *American Scientist* 84, no. 3 (1996): 263–277.

53 E.g., Jeff Hughes, *The Manhattan Project: Big Science and the Atom Bomb* (London: Icon Books, 2003); Thomas P. Hughes, *American Genesis: A Century of Invention and Technological Enthusiasm* (New York: Penguin Books, 1989); Charles Thorpe, "The Political Economy of the Manhattan Project," in *The Routledge Handbook of the Political Economy of Science*,

occupied powers) was also an industrial giant—just not an *oil* industry giant, largely due to its lack of oil resources. The US oil industry may not have given the Allies a decisive atomic advantage, but its contributions did accelerate the Manhattan Project relative to the atomic contributions of the much smaller oil industries of the Axis powers. More generally, the order in which the first four nations joined the nuclear club (US, USSR, UK, France) corresponded to the relative sizes of their respective oil industries—not a direct causal relationship but probably not a coincidence either.

Historians of scientific instrumentation, meanwhile, have been similarly puzzled by US dominance in the postwar instrument industry.[54] During the (long) nineteenth century, that industry had been centered largely on Germany, the UK, and to some extent France.[55] In the interwar period, however, US companies such as Beckman Instruments, Perkin Elmer, and Baird Associates became leading instrument manufacturers and innovators.[56] That was, of course, not solely due to US leadership in oil production. Yet, as we've seen, oil firms sometimes transferred their own technology to US instrument manufacturers and/or offered an early, sizeable, and engaged market that helped those manufacturers make their products better and cheaper. The lack of such a large and fragmented domestic oil industry—and the customer base it provided—must surely have posed a competitive disadvantage for instrument manufacturers elsewhere.

5 Enriching Uranium (and Eventually Their Shareholders?)

We return now to the Manhattan Project. As we've shown, oil firms and their instruments were crucial to the project's acquisition of a uranium stockpile. Merely possessing uranium was only a beginning, however. Because non-fissile uranium-238 comprises some 99% of naturally occurring uranium, and fissile U-235 less than 1%, much of the Manhattan Project's effort (in terms of

ed. David Tyfield, Rebecca Lave, Samuel Randalls, and Charles Thorpe (London: Routledge, 2017), chapter 3.

54 The question crops up most explicitly in Morris, "Laboratories and Technology," and more implicitly in Morris, *From Classical to Modern Chemistry*.

55 On British instrument-making, see Alison D. Morrison-Low, *Making Scientific Instruments in the Industrial Revolution* (London: Routledge, 2007). On the shift from German to US predominance in chemistry in the early 20th century, including in instrumentation, see most of the chapters in Morris, *A Cultural History of Chemistry in the Modern Age*.

56 E.g., Thackray and Myer, *Arnold Beckman* and Davis Baird, "Analytical Chemistry and the 'Big' Scientific Instrumentation Revolution," *Annals of Science* 50, no. 3 (1993): 267–290.

time, personnel, electricity, and physical plant) went into separating out or synthesizing enough fissile material to construct a working bomb. This was done partly by bombarding U-238 with neutrons to create fissile plutonium-239—a task primarily entrusted to the chemical manufacturer Dupont.[57] At the time, Dupont was gradually adopting petroleum as one of its primary feedstocks; much later (in the 1980s) it would become an oil producer in its own right through its takeover of Conoco. The Hanford operation cost close to $400,000 in 1945 dollars; roughly a fifth of the Manhattan Project's total cost of nearly $2 billion.[58]

Oil firms' instrumentation expertise was more important to the Manhattan Project's enrichment of U-235 from the naturally occurring proportion of ~0.7% upward to the proportion needed for an explosive chain reaction (somewhere between 80% and 90% depending on the type of bomb). As the most efficient means of enrichment was unknown at the outset, the Manhattan Project's leadership investigated multiple routes. For instance, mechanical separation using centrifuges seemed promising early on, and after vigorous lobbying from Jersey Standard, Eger Murphree was given permission to initiate research into that approach, with his employer as principal contractor. Jersey Standard, like many oil firms, boasted long experience in laboratory use of centrifuges to separate liquids and gases, which facilitated the company's construction of a full-scale experimental mechanical separation plant. Yet initial results were disappointing enough that Manhattan Project leaders decided to abandon centrifugal enrichment for the duration of the war.[59] After the war, however, contributions by Shell and other oil companies have made it the standard approach to isotope separation and enrichment today.[60]

During the war, meanwhile, the bomb program's leaders eventually opted to produce weapons grade uranium through a sequence of iterative steps. That

57 "Walter S. Carpenter Interview," *Voices of the Manhattan Project*; interview by Stephane Groueffe, Wilmington, January 25, 1965.

58 Again, we draw the figures in this section from Wellerstein, "The Price of the Manhattan Project."

59 Hewlett and Anderson Jr., *The New World*, 64; Edwin R. Gilliland, "Eger Vaughan Murphree: November 3, 1898–October 29, 1962," *Biographical Memoirs* (Washington, DC: National Academy of Sciences, 1969), 230; Standard Oil of New Jersey, *Oil and the Atom*, 1–2; B. Cameron Reed, "Centrifugation during the Manhattan Project," *Physics Perspectives* 11 (2009): 427.

60 Susanna Schrafstetter, and Stephen Twigge, "Spinning into Europe: Britain, West Germany and the Netherlands: Uranium Enrichment and the Development of the Gas Centrifuge 1964–1970," *Contemporary European History* 11, no. 2 (2002): 253–272; Abel Streefland, *Jaap Kistemaker en uraniumverrijking in Nederland, 1945–1962* (Amsterdam: Prometheus, 2017), 256.

is, at each step, a different separation technology was employed, with large numbers of machines of a given type each working in parallel with low-grade uranium as input and giving slightly higher-grade uranium as output, which would then be fed back into the same set of machines (i.e., iteration). Once the machines used in a given step were producing U-235 of a certain grade, that uranium would then be passed on to the next step for further enrichment.

Most of the uranium produced for the Manhattan Project went through three such steps: thermal diffusion, then gaseous diffusion, then electromagnetic separation. Oil firms made little or no contribution to the thermal diffusion step (which only absorbed about 1% of the Manhattan Project's total outlay). The project's gaseous diffusion plant, however, was built by Kellex (a subsidiary of M.W. Kellogg), and operated by Union Carbide and Carbon; the gaseous diffusion plant absorbed a little over a quarter of the project's total budget. Oil industry expertise in chemical engineering, more than instrumentation, was crucial in getting gaseous diffusion to work. Instrumentation was, however, central to the final step, electromagnetic separation. This step consisted of a set of particle accelerators which fed uranium ions into several mass spectrometers, where U-235 ions were preferentially diverted into an enriched yield. The electromagnetic separation plant again cost about a quarter of the project's total.

One problematic aspect of electromagnetic separation was its heavy electricity usage; the main uranium enrichment site at Oak Ridge, Tennessee was thus chosen partly for its proximity to the Tennessee Valley Authority's hydroelectric dams. Electromagnetic separation also required significant scale-up of a finicky laboratory technology—mass spectrometry—that few organizations outside of the oil industry had much experience with. Thus, the company chosen to build the electromagnetic separation plant was Stone & Webster, an engineering firm with deep expertise in electrical utilities (both hydroelectric and coal-fired) *and* in oil and gas (e.g., in building gas pipelines, oil storage tanks, and refineries). Tennessee Eastman (a chemical company) was chosen to operate the plant.[61]

6 Building on the Infrastructure of the Manhattan Project

When the Manhattan Project came to its devastating end with the dropping of the bombs on Hiroshima and Nagasaki, the spillover between nuclear techn-

61 Charles O. Jackson, *City Behind a Fence: Oak Ridge, Tennessee, 1942–1946* (Knoxville: University of Tennessee Press, 1981), 79–80.

ology and the oil industry did not stop, despite the US Atomic Energy Commission's (AEC) restrictions on commercial uses of the instruments that were developed for the nuclear industry by oil actors.[62] Many of those oil actors continued their wartime atomic work within the postwar AEC—often while remaining connected to the oil industry. Eger V. Murphree, for one, was a member of the AEC's General Advisory Committee from 1950 to 1962, while also being employed as vice-president of Jersey Standard and President of the Permanent Council of the World Petroleum Congress. Similarly, Marion W. Boyer, a former executive vice president of Jersey Standard, was the general manager of the AEC from 1950 to 1953.[63] In addition, oil geologists and geophysicists including Philip Merrit, Everette DeGolyer (co-founder of DeGolyer and MacNaughton and an innovator in oilfield instrumentation such as torsion balances and seismometers), and Wallace Pratt and Morgan Davis (both with Humble Oil and Refinery Company), held seats in the AEC's Raw Materials Advisory Committee.[64]

Also, various oil firms (especially smaller "independents") and individual oil actors joined the early uranium mining industry. Based on the technologies developed for oil exploration and applied to uranium mining during the Manhattan Project, wildcatters like Charlie Steen and companies like Kerr-McGee, Philips Petroleum, and DeGolyer and MacNaughton started investing in uranium mining projects, sometimes even spending more than fifty percent of their annual capital investments to enter the new uranium market.[65] To do so, oil actors used the same radioactive well-logging techniques that had connected the oil industry to the search for uranium in the first place. For instance, geologist Louis B. Lothman made use of old well-logging data when he made one of the largest uranium discoveries in the United States on land owned by the oil speculator Stella Dysart at Ambrosia Lake in New Mexico.[66] Likewise Kerr-McGee, which during the 1950s would transform itself into a

62 Wellerstein, *Restricted Data*; Turchetti, "Patenting the Atom," 216–232.

63 Thomas W. Ennis, "Marion W. Boyer, Oil Executive," *New York Times*, November 23, 1982.

64 Everett DeGolyer Collection, Southern Methodist University—DeGolyer Library, Dallas, TX, Box 54, Folder 3490, Report of luncheon meeting (March 27, 1952); Lon Tinkle, *Mr. De: A Biography of Everette Lee DeGolyer* (Boston: Little, Brown and Co., 1970); Amherst College, Amherst, MA, College Archives and Manuscript Collections, George W. Bain Papers, Box 15, "US Atomic Energy Commission" (n.d.).

65 Ezell, *Innovations in Energy*, 298–299.

66 Virginia T. McLemore, "Uranium Industry in New Mexico—History, Production, and Present Status," *New Mexico Geology* (August 1983): 46; Michael A. Amundson, *Yellowcake Towns: Uranium Mining Communities in the American West* (Boulder, CO: University Press of Colorado, 2002), 24–25.

combined oil and uranium company, developed a wheeled well-logging device which allowed geophysicists to quickly search for uranium in New Mexico and Wyoming.[67]

In the early 1950s many executives of smaller oil companies declared that uranium would be the energy source of the future, and some oil geophysicists in the major oil companies—such as Marion King Hubbert—also stated that nuclear energy would soon overtake oil as the United States' (if not the world's) primary energy source. Yet even so, for the moment, the *big* oil firms could afford to sit on the nuclear sideline. Their connections with the Manhattan Project and the AEC provided them with access to documents, such as the 1948 Oppenheimer report for the AEC, which suggested that only if billions of dollars were invested in research and development *and* industry entered the nuclear business in a large way, *and* provided that "there were quite a bit of luck along the way," then by 1968 (two decades in the future) *half* of the new electric power plants being ordered *might* be nuclear.[68] Access to vast new oil concessions in the Middle East during the 1950s provided the big companies with steady revenue for years to come; thus, the big companies did not need to commit significant resources to a novel energy source (nuclear power) that they knew to be financially risky. Instead, the big oil firms pursued—and explicitly communicated—a strategy of getting their ducks in a row in preparation for *eventual* entry to the nuclear market while avoiding the turmoil and risk of participating in the nuclear industry's early years.[69]

Thus, in the 1950s and early 1960s the big oil companies quietly kept in touch with nuclear scientific and industrial developments in preparation for a possible move later. Among other low-level activities in the nuclear arena, the big oil firms continued providing members of various AEC committees, funded new research institutions, projects, exhibitions and meetings, and hired (geo)scientists formerly employed by the Manhattan Project.[70] For instance,

67 University of Kansas—Kenneth Spencer Research Library, Lawrence, KS, Dean McGee Papers, Box 48, Folder 6, John A. Hermann and P.C. Ellsworth, *Selection and Construction of Gamma Ray Probe Curve for Estimation of Pacific Uranium Orebody* (N.p.: Kerr-McGee Oil Industries Inc., 1957), 3; Ezell, *Innovations in Energy*, 212–214.

68 Carroll L. Wilson, "Nuclear Energy: What Went Wrong?," *Bulletin of Atomic Scientists* (June 1979): 13–16.

69 Wallace E. Pratt, "The Impact of the Peaceful Uses of Atomic Energy on the Petroleum Industry," *Report of the Panel on the Impact of the Peaceful Uses of Atomic Energy* 2, no. 89 (1956): 273–275.

70 Standard Oil of Indiana hired Seymour Meyerson after his work at their boron-10 production plant for the Manhattan Project: Seymour Meyerson, interview by Michael A. Grayson at Gary, Indiana, March 7, 1991, Philadelphia, Chemical Heritage Foundation, Oral History

Samuel King Allison, a Manhattan Project veteran and X-ray diffraction specialist, obtained funding for his Institute of Nuclear Physics at the University of Chicago from Standard Oil of Indiana, Standard Oil of New Jersey, the Shell Development Company, and Sun Oil.[71] Similarly, MIT administrators saw oil firms as their main fundraising targets when their institute waded into postwar nuclear research.[72] Oil companies in other countries soon followed suit. Royal Dutch Shell Group in the Netherlands, in particular, made substantial if somewhat covert contributions to centrifugal enrichment technology for early Dutch nuclear research.[73] As early as 1957, Shell even sponsored an exhibition in Amsterdam, "Het Atoom" (The Atom), where the newest nuclear developments and applications were presented, with the explicit goal to expand the exhibition into an ongoing site for discussion of nuclear developments in order to keep Shell personnel informed of commercial possibilities.[74]

Oil companies' research and development divisions also sometimes applied knowledge gained from the Manhattan Project to improve their petroleum products *and* their reputations for science-based innovation. Shell's "The Atom" exhibition, for instance, presented several improvements for their lubricants based on radioactive isotope research.[75] Similarly, Mobil regularly promoted their research on measuring radiation, radioisotopes for lubricants, and

Transcript # 0398. Other oil majors also hired physicists and chemists who had previously been employed by the Manhattan Project, such as the later infamous nuclear spy Russel McNutt and the engineer and mathematician Philip Cooperman. See Lou Blazquez, "Dr. Phil Cooperman, 1918–1983," *Life of Jamie Times* (1983): 4–6; Library of Congress, Washington, DC, Manuscript Division, Alexander Vassiliev Papers, "Black notebook of Alexander Vassiliev, translated by Philip Redko" (2009), via Wilson Center Digital Archive: https://digitalarchive.wilsoncenter.org/document/vassiliev-black-notebook (accessed December 19, 2023).

71 Samuel King Allison, "Institute for Nuclear Studies, The University of Chicago," *The Scientific Monthly* 65, no. 6 (1947): 483; Joseph D. Martin, "The Simple and Courageous Course: Industrial Patronage of Basic Research at the University of Chicago, 1945–1953," *Isis* 111, no. 4 (2023): 713.

72 Massachusetts Institute of Technology, Cambridge, MA, MIT Distinctive Collections, MIT Office of the President, Box 161, Folder 8, Karl T. Compton, "Nuclear Science and Its Practical Applications" (1948).

73 A.H. Streefland, "Jaap Kistemaker en uraniumverrijking in Nederland 1945–1962" (PhD diss., Leiden University, 2017), 188–189.

74 City Archives Amsterdam, Collection 259 Tentoonstelling "Het Atoom," Box 3, "Notulen gesprek Slotboom 22 April 1955" (April 22, 1955); and "Notulen Het Atoom, 10 mei 1955" (May 10, 1955).

75 City Archives Amsterdam, Collection 259 Tentoonstelling "Het Atoom," Box 18, "Inventaris van de tentoonstelling" (1957).

well-logging technologies.[76] Again, scientific instruments were often at the center of these efforts. A good example is Socony Mobil's Nuclear Research Center at Stony Brook, near Princeton, which opened in 1959. That lab, operating as a subdivision of Socony Mobil's Central Research Division, employed a staff of 15 scientists conducting research in nuclear physics and chemistry to discover new ways to convert petroleum into more high-quality products, mainly with the help of a 2 billion electron-volt Van de Graaff accelerator providing high-energy electrons, protons, X-rays, and neutrons for basic research. One important area of research was the study of catalysts used in refinery processes and petroleum chemical manufacturing.[77]

7 Oil Spillovers in Nuclear Energy

Studying these spillovers between the US oil sector and early developments within the nuclear industry contributes to a better understanding of major oil companies' diversification strategies during the 1970s. When many of the major oil companies eventually returned to full-scale nuclear energy development at the end of the 1960s, they made use of the connections and knowledge they had built up during and since the Manhattan Project. Between 1967 and 1986 the Western oil industry became omnipresent across the entire nuclear value chain. For instance, various major oil companies, such as Mobil and Gulf Oil, entered the uranium mining industry based on their technological expertise in measuring radioactivity to find both petroleum and radioactive minerals.[78] Shell had already entered the Dutch uranium enrichment program in 1967, based on its innovations in gas centrifuge technology, before it agreed to a joint venture with Gulf Oil in 1973 to develop new High Temperature Gas Cooled Reactors and research nuclear fusion.[79] Standard Oil of New Jersey (Exxon from

76 Briscoe Center for American History, Austin, TX, ExxonMobil Historical Collection, DBCAH, Box 2.207/F160, W.J. Shanahan, ed., "Power from the Atom," *Oil Power* 60, no. 2 (1960): 14–15.

77 Briscoe Center for American History, Austin, TX, ExxonMobil Historical Collection, DBCAH, Box 2.207/F160, "Discovery about Composition of Petroleum: New Scientific Knowledge Sheds Light on Its Origin" (1964).

78 Briscoe Center for American History, Austin, TX, ExxonMobil Historical Collection, DBCAH, Box 2.207/F120, "Double-Duty Prospectors" (1968), 19; Heinz History Center—Detre Library and Archives, Pittsburgh, PA, Gulf Oil Corporation Records, Box B, Folder 14, "The Rabbit Lake Operation" (1979).

79 Royal Dutch Shell, *Annual Report 1973* (The Hague: Royal Dutch Shell, 1973), 14; Keetie

1972 onward), meanwhile, covered almost all the bases in the 1970s: uranium mining, radioactive waste reprocessing, and most notably uranium enrichment.[80]

Exxon's renewed investments in uranium enrichment sprang from the Industrial Access Program initiated by the US AEC in 1971 and the concurrent lifting of AEC restrictions on the enrichment industry. Between 1971 and July 1975, Jersey Nuclear Company (later Exxon Nuclear) investigated whether they could establish their own enrichment projects based on the already existing AEC technologies of gaseous diffusion and gas centrifuges.[81] To determine which technologies would become the most profitable, the company's managers relied on experts at Exxon's research laboratories and on an external network of atomic physicists who had contributed to the Manhattan Project, including the Nobel laureate (and former director of the Theoretical Division at Los Alamos) Hans Bethe.[82] Based on Bethe's advice, Exxon chose in 1977 to focus solely on the uranium metal process—vaporizing uranium and exposing it to selectively chosen laser radiation to form ions of uranium-235, and then separating the ions.[83] The project was rebranded Jersey Nuclear-Avco Isotopes (JNAI) and became a jointly owned subsidiary with Exxon Nuclear keeping 87 % of the shares.[84]

With these investments, the oil industry—with Exxon as a prime example—came full circle from its first involvement with nuclear energy during the Manhattan Project. Like their initial involvement, familiarity with nuclear instrumentation proved crucial for the oil companies (re)entering the nuclear industry in the 1960s and '70s. Both regarding investments in uranium exploration—where oil companies continued to use radioactive well logging devices to

Sluyterman, *Concurreren in turbulente markten, 1973–2007: Geschiedenis van Koninklijke Shell*, vol. 3 (Amsterdam: Boom, 2007), 103–104.

80 H. Eugene McBrayer, interview by James J. Bohning at Mercer Island, Washington, May 11, 1995, Philadelphia, Chemical Heritage Foundation, Oral History Transcript # 0144.

81 Cornell University Library, Ithaca, NY, Rare and Manuscript Collection, Hans Bethe Papers, Box 31, Folder 10, Discussion draft, "Exxon Nuclear Company Summary Conclusions from its Centrifuge Enrichment Study Program" (1977).

82 Briscoe Center for American History, Austin, TX, ExxonMobil Historical Collection, DBCAH, Box 2.207/H19B, "Exxon Nuclear and AVCO Announce Formation of Laser Enrichment Review Panel" (Exxon Nuclear Press Release, 1978), 21.

83 Cornell University Library, Ithaca, NY, Rare and Manuscript Collections, Hans Bethe Papers, Box 31, Folder 10, F.A. Long, "Visit to Exxon Nuclear Company Facilities at Richland, Washington, July 29–30, 1976" (Memorandum for Record: August 20, 1976).

84 Briscoe Center for American History, Austin, TX, ExxonMobil Historical Collection, DBCAH, Box 2.207/H19B, "Exxon Nuclear and AVCO Announce Formation of Laser Enrichment Review Panel" (Exxon Nuclear Press Release, 1978), 21.

explore for oil—and nuclear enrichment projects, oil firms used their familiarity and access to nuclear know-how and technology as an explanation for their nuclear diversification strategies.[85] The Royal Dutch Shell oil company, for example, explicitly claimed that their experience with chemical processing and instrumentation made possible their stake in the Dutch enrichment project that would later become Urenco.[86] In the context of the 1970s oil shocks, diversification into nuclear energy allowed the major oil companies to claim that they were working to keep the price of oil low by exploring alternative energy.[87] Though those nuclear programs were abandoned when the price of oil fell in the 1980s, today some oil firms use their earlier experience in nuclear energy either to associate themselves with low-carbon alternatives (perhaps as a form of greenwashing) or to argue that such alternatives are doomed to fail.[88] Either way, the oil industry's very real contributions to nuclear energy have assisted oil firms' obstruction of a transition to a less carbon-intensive economy.

8 Concluding Observations

These later spillovers into the nuclear industry were not part of a strategy already determined in the boardrooms of Big Oil companies before or during the Manhattan project, however. Still, those firms' nuclear investments in the 1960s and '70s built on infrastructures that they had purposefully constructed dating back at least to the 1930s. Those infrastructures were sometimes born out of accidental connections or access to the right people but were almost always reinforced by technological expertise and instruments developed within the oil industry. That expertise ranged from geophysical methods for locating radioactive minerals underground to (geo)chemical instru-

85 Michiel Bron, "The Petro-Atom: A Century of Ubiquitous Oil Involvement in Nuclear Energy, 1986–1993" (PhD diss., Maastricht University, 2025), 97.

86 "Stroom gegevens over geheim uraniumprojekt," *Algemeen Handelsblad*, February 23, 1968.

87 See, for example, "Global Energy Trends and Prospects," a speech given by John G. Francis, president and CEO of Scallop Corporation, Shell's nuclear subsidiary, on September 10, 1979. In Kenneth Spencer Research Library, University of Kansas, Lawrence, KS, Charles Heller Papers (RH MS 314), Box 14, Folder 62.

88 For the former, see ExxonMobil press release, "ExxonMobil Renews Support for MIT Energy Initiative's Low-Carbon Research," *ExxonMobil*, October 21, 2019, https://corporate.exxonmobil.com/news/news-releases/2019/1021_exxonmobil-renews-support-for-mit-energy-initiatives-low-carbon-research, accessed June 6, 2025. For the latter, see Avi Salzman, "Exxon Enters the Electricity Business, Takes a Swipe at Nuclear," *Barron's*, February 3, 2025, https://www.barrons.com/articles/exxon-gas-power-nuclear-52ebd242?reflink=desktopwebshare_permalink (accessed June 9, 2025).

ments for measuring molecular mass that could be applied to both petroleum research and uranium enrichment.

Thus, the oil industry has played an outsized *and* varied role in the development of nuclear instruments and in industrial applications of atomic physics. Spillovers from the oil industry into the nuclear sector proved crucial in establishing Western nuclear industries during the decades following the Second World War. Similar oil spillovers were just as crucial to the development of many of the industries we listed toward the beginning of this essay as innovators in scientific instrumentation. That's perhaps self-evident for the automotive, chemical, and (increasingly mechanized) agricultural industries, which became almost existentially entangled with the oil industry from the early 20th century onward. Yet oil spillovers were also omnipresent in less-obvious industries that made significant contributions to scientific instruments, such as the aerospace and defense industries (Hughes Aircraft and Texas Instruments were both founded with oil money and maintained a foot in the oil industry) and the microelectronics and semiconductor industries. Although we don't want to claim that oil provides the key to a grand unified theory of the history of scientific instrumentation, this article has aimed to highlight the omnipresence of oil in many, sometimes surprising, industries, and to steer historians of instrumentation to the many oil flows—often invisible or unremarked—running through the 20th century history of instruments.

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