"For Slow Neutrons, Slow Pay"

Enrico Fermi's Patent and the U.S. Atomic Energy Program, 1938–1953

By Simone Turchetti*

ABSTRACT

This essay focuses on the history of one of the "atomic patents." The patent, which described a process to slow down neutrons in nuclear reactions, was the result of experimental research conducted in the 1930s by Enrico Fermi and his group at the Institute of Physics, University of Rome. The value of the patented process became clear during World War II, as it was involved in most of the military and industrial applications of atomic energy. This ignited a controversy between Fermi and U.S. government representatives over royalties to be paid for use of the process during and after the war. The controversy sheds new light on the role that the management of patents played in the context of the Manhattan Project and in the postwar U.S. nuclear program, encompassing issues of power and economic influence in the relationship between scientists, the military, and public administrators.

> The invention covered by Patent No. 2,206,634 covers the basic process used in the research and development leading up the production of atomic energy and the production of the atomic bomb. Such invention is of continuing importance in the production of fissionable materials and atomic weapons.
>
> The Chairman: So Jones might make the greatest invention in the field and be deprived of any award for it?
> Captain Lavender: If he did not want to accept the award that was offered to him.

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ON 8 DECEMBER 1953 President Dwight D. Eisenhower launched the "Atoms for Peace" campaign, announcing that the U.S. government was ready to set up an international "bank of fissionable materials" to be used for peaceful applications of atomic energy. His speech marked the beginning of new international relations in the nuclear age. But the venture's economic implications were also far reaching. It paved the way to the creation of a new market, dependent on U.S. nuclear products made available through the Atomic Energy Commission (AEC), for which foreign governments would spend no less than $20 billion in the following decade. The president suggested that "the miraculous inventiveness of man" would now be consecrated to life rather than death.[1] Yet a far more mundane type of ingenuity, embodied in one patent, had played a key role in forming the edifice of the emergent U.S. nuclear industry. The patent (see Figure 1) claimed intellectual rights over a process to slow down neutrons in nuclear reactions that was instrumental in the functioning of nuclear piles, the main devices for the production of fissile materials. Hence, any economic venture based on making nuclear products relied on the acquisition of the right to use the patented process.

Eisenhower's speech was timely: just four months earlier, the AEC had finally awarded the Italian-born nuclear physicist Enrico Fermi and his associates $300,000 for the purchase of U.S. patent no. 2,206,634. If the parties involved were satisfied with this outcome, it was nonetheless the subject of ironic remarks in the media. *Time* magazine ran the story under the title "For Slow Neutrons, Slow Pay," noting that it was not until eighteen years after originally filing the patent that Fermi and his colleagues would reap any financial benefit from it. Moreover, the patent was finally sold for a sum that was far less than had initially been agreed upon. Whatever this "slow" acquisition had contributed to the success of the fast-growing U.S. nuclear industry, it seemed that the celebrated "Italian navigator" had gained little more than celebrity from it.[2]

This essay examines the history of Fermi's patent from 1938 to 1953, with particular attention to the political and historical contexts of its slow and bargained acquisition. Such an investigation may initially look like a digression into administrative matters that are of little or no relevance to the historian of science. Yet I suggest that there is more to the history of this patent than meets the eye. Recent controversies about patent provisions and their impact on scientific communities have shown that the management of inventions

[1] The epigraphs come from G. M. Giannini & Co., "Application for Just Compensation and the Determination of a Reasonable Royalty Fee under Section 11 of the Atomic Energy Act of 1946," p. 3, in "Neutron Patent," Scatola [Box] 2, Fascicolo [Folder] 2, Amaldi Collection; and "Senate Hearing on Atomic Energy, Atomic Bomb Patents," *Bulletin of the Atomic Scientists,* 1946, *1*(7):10–11. Eisenhower launched the "Atoms for Peace" campaign in a speech to the United Nations General Assembly, 8 Dec. 1953; see http://www.eisenhower.utexas.edu/atoms.htm (accessed 3 Aug. 2004). On the new "nuclear" international relations see Spencer Weart, *Nuclear Fear* (Cambridge, Mass.: Harvard Univ. Press, 1988), pp. 155–158; see also A. M. Winkler, *Life under a Cloud: American Anxiety about the Bomb* (Oxford: Oxford Univ. Press, 1993). According to Leonard Weiss, "many in the U.S. government and private industry saw Atoms for Peace as the umbrella under which a U.S.-dominated world nuclear market would be realized": Leonard Weiss, "Atoms for Peace," *Bull. Atom. Sci.,* 2003, *59*(6):34–41.

[2] "For Slow Neutrons, Slow Pay," *Time,* 10 Aug. 1953. See also "U.S. Settles with Seven over Suit," *New York Times,* 1 Aug. 1953; Giuseppe Prezzolini, "Il brevetto delle scoperte atomiche italiane comprato dagli SU per trecentomila dollari," *Corriere della Sera,* 1 Aug. 1953; and "Atomic Patent Payoff: Italian Scientists Who Derived Isotopes Are Compensated," *New York Times,* 9 Aug. 1953. "Italian navigator" was a code name referring to Fermi that Arthur Holly Compton used in a phone conversation with James B. Conant to inform him about Fermi's successful experiment with the first nuclear pile in December 1942. Compton said: "Jim, you'll be interested to know that the Italian navigator has landed in the new world." Richard Rhodes, *The Making of the Atomic Bomb* (New York: Penguin, 1986), p. 442.

Patented July 2, 1940 **2,206,634**

UNITED STATES PATENT OFFICE

2,206,634

PROCESS FOR THE PRODUCTION OF RADIOACTIVE SUBSTANCES

Enrico Fermi, Edoardo Amaldi, Bruno Pontecorvo, Franco Rasetti, and Emilio Segre, Rome, Italy, assignors to G. M. Giannini & Co., Inc., New York, N. Y., a corporation of New York

Application October 3, 1935, Serial No. 43,462
In Italy October 26, 1934

7 Claims. (Cl. 204—31)

This invention relates to the production of isotopes of elements from other isotopes of the same or different elements by reaction with neutrons, and especially to the production of artificial radio activity by formation of unstable isotopes.

It has been known for many years that, although each chemical element has always the same atomic number or charge, it may exist in different forms having different atomic weights. These forms of the elements are referred to as isotopes.

It has also been known that the radio-active elements, by disintegration or break down occurring in their nuclei are spontaneously converted into various isotopes of other elements. Thus, for example, the radio-active element uranium may be converted into lead of atomic weight 206, while the element thorium may be converted into a different isotope of atomic weight 208.

It has long been known that such spontaneous disintegration of radio-active elements is accompanied by emission of alpha, beta, and gamma rays, that is to say, of the helium nucleus, electrons, and electromagnetic radiation of extremely short wave length.

In more recent years it has been demonstrated that isotopes of various elements could be converted into other isotopes of the same or different elements by bombardment with alpha particles, diplons, protons or gamma rays of very high energy and that the isotopes thus produced used which require tremendous energy to break through the potential barrier surrounding the nucleus; and that if, instead of charged particles, neutrons are used for the nuclear reactions, the greatest efficiencies are in some cases attained with low energy or "slow" neutrons, e. g., of the order of a few hundred electron volts, or even much less down to a small fraction of an electron volt.

Neutrons when produced in any ordinary manner, e. g., by the action of radon on beryllium or of polonium on beryllium or by bombardment of atomic nuclei with artificially accelerated particles, might have a very wide range of energies but high average energy. These energies range up to several million volts. It is necessary, therefore, if the greatest efficiency of reaction is to be attained, to reduce by artificial means the energy of these neutrons. We describe below a method for slowing down fast neutrons.

We have demonstrated that the absorption of slow neutrons is anomalously large as compared with that of the faster or higher energy neutrons. The simplest explanation for most cases is to admit that the neutron is captured by the nucleus with formation of an isotope heavier by one mass unit. If this heavier isotope is unstable a strong induced radio-activity may be expected. This occurs, for example, with silver and iridium which go over into radio-active isotopes. In other cases it is found that no activation, or at least

July 2, 1940. E. FERMI ET AL 2,206,634

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Filed Oct. 3, 1935

Fig. 1.

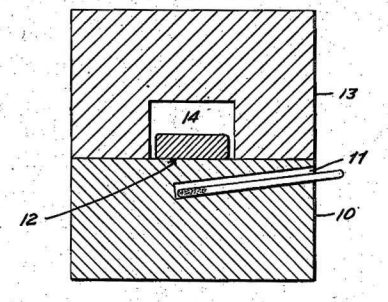
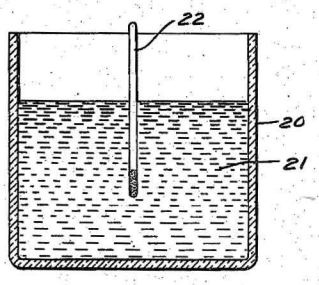


Fig. 2.



INVENTORS
ENRICO FERMI, EDOARDO AMALDI,
BRUNO PONTECORVO, FRANCO RASETTI, EMILIO SEGRE
BY
ATTORNEYS

Figure 1. *The U.S. patent on the slow neutron process.*

informs the research activities of contemporary scientists.[3] Coverage of these controversies has also indicated that we still know comparatively little about how patent cases influenced the development of the physical sciences in the twentieth century.[4] The story of Fermi's patent deepens our understanding of how such matters were interwoven with the career of one of the most distinguished U.S. scientists, helping to set his research directions and goals.

More significantly, this history sheds new light on the relationship between scientists, the government, and the military involved in the U.S. nuclear program: in looking at one important patent case, we can focus on how this relationship was molded by the parties' respective economic interests and clout. In the war and postwar years the control of intellectual property rights made both the military and the government important mediators in the financial relationships with scientists and firms. Their involvement weakened the contractual power of scientists and limited their ability freely to dispose of their "atomic patents." Some of these developments aroused Fermi's and other scientists' resistance, which led to financial and legal arguments with U.S. military and civilian administrators. It is my contention that these disputes were symptomatic of changing power relationships in the context of the U.S. nuclear program. And because these controversies unfolded in three important moments in U.S. history—the Manhattan Project, the establishment of the Atomic Energy Commission, and the rise of domestic anti-Communism—their examination offers a new historical narrative that fills important gaps in the historiographies of those moments as well.

Some historians have claimed that the Manhattan Project was pivotal to the establishment of what we now call "big science" and that it defined a new power relationship between scientists and the military.[5] However, little has surfaced on the specific conditions in patent provisions and management that influenced this change.[6] Peter Bacon Hales's

[3] See, e.g., the recent debate on the consequences of the Bayh-Dole Act (1980), which established a uniform federal patent policy in the United States under which universities would be free to patent and license their discoveries in exchange for royalties and fees. Recent changes in research direction and individual scientists' pursuits have been informed by the new patent legislation. See Jennifer Washburn, *University, Inc.: The Corporate Corruption of Higher Education* (New York: Basic, 2004), pp. 60–69.

[4] For patents in general see Geof Bowker, "What's in a Patent," in *Shaping Technology/Building Society: Studies in Sociotechnical Change,* ed. Wiebe E. Bijker and John Law (Cambridge, Mass.: MIT Press, 1992), pp. 53–74. See also Henry Etzkowitz and Andrew Webster, "Science as Intellectual Property," in *Handbook of Science and Technology Studies,* ed. Sheila Jasanoff *et al.* (Beverly Hills, Calif.: Sage, 1994), pp. 480–505. For patent management and controversies in twentieth-century physical sciences see John L. Heilbron and Robert W. Seidel, *Lawrence and His Laboratory: A History of the Lawrence Berkeley Laboratory,* Vol. 1 (Berkeley: Univ. California Press, 1989); Peter Galison, Bruce Hevly, and Rebecca Lowen, "Controlling the Monster: Stanford and the Growth of Physics Research, 1935–1942," in *Big Science: The Growth of Large-Scale Research,* ed. Galison and Hevly (Stanford, Calif.: Stanford Univ. Press, 1992), pp. 46–77, on pp. 54–55; and Galison, *Einstein's Clocks, Poincaré's Maps* (London: Sceptre, 2003).

[5] On the Manhattan Project see Rhodes, *Making of the Atomic Bomb* (cit. n. 2); Stephane Groueff, *Manhattan Project: The Untold Story of the Making of the Atomic Bomb* (Boston: Little, Brown, 1967); Lawrence Badash, J. O. Hirshfielder, and H. P. Broida, eds., *Reminiscences of Los Alamos, 1943–1945* (Dordrecht: Reidel, 1980); and Lillian Hoddeson *et al., Critical Assembly: A Technical History of Los Alamos during the Oppenheimer Years, 1943–1945* (Cambridge: Cambridge Univ. Press, 1993). On big science see Galison and Hevly, eds., *Big Science;* and Jeff Hughes, *The Manhattan Project: Big Science and the Atom Bomb* (London: Icon, 2002). On the role played by patents in shaping big science in biomedicine see Nicolas Rasmussen, "Of 'Small Men,' Big Science, and Bigger Business: The Second World War and Biomedical Research in the United States," *Minerva,* 2002, *40:*115–146. Rasmussen claims that "the perception of a sharp shift rests upon a conflation of wartime contracts—which multiplied collaborative projects of an existing type—with qualitative changes introduced by a different post-war funding regime" (p. 116).

[6] This is not to say that there is a lack of historical details but, rather, that a "big picture" has not yet emerged. Richard Rhodes has shown that in 1942 scientists associated with Fermi and the Manhattan Project had already

imaginative study on the Manhattan Project has recently analyzed the "appropriation of land and people" by the U.S. military-industrial complex.[7] My study of Fermi's patents parallels his analysis by showing how this complex seized intellectual property rights as well. When the exploitation of atomic energy became feasible, scientists and military administrators clashed over the use of patented knowledge and the processes necessary to capitalize on it. Compensation for this use was promised but never effected.

At the end of the war, the Atomic Energy Act ratified the establishment of the AEC, which sought to restore legality in the use of atomic patents by allowing their purchase. The new patent provisions embodied in this act have been the subject of a number of historical studies.[8] Yet these studies have failed to show comprehensively how the provisions informed existing controversies between inventors and administrators. The case of Fermi's patent demonstrates that the AEC managers were resistant to settling existing claims and that they used the new legislation to argue that no compensation should be paid. It augmented their power to dispose of atomic patents, while further hampering the scientists' intellectual rights.

The tightening of national security in the Cold War, coupled with the rise of domestic anti-Communism, added a new element to these quarrels. We already know a great deal about the tension between scientists and the security apparatus. Alleged espionage activities and (real or constructed) anxieties about the presence of an "enemy within" are also well understood.[9] However, even as the public image of some atomic scientists fell into the dichotomy of patriot/traitor, they were still engaged in clashes with administrators for their due rewards. As the persecutory campaign gained momentum, it eroded the position of Fermi and his colleagues as they sought to negotiate favorable conditions for the sale of their atomic patent.

Overall, then, examining the management of atomic patents allows us to gain a new perspective on the shifts in the economy of power within the U.S. nuclear program. In

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demanded compensation for inventions relating to nuclear methods: Rhodes, *Making of the Atomic Bomb,* pp. 504–508. Ferenc Morton Szasz has argued that the U.S. and British governments had similar regulations allowing them to use inventions stemming from military research projects: Ferenc Morton Szasz, *British Scientists and the Manhattan Project: The Los Alamos Years* (London: Macmillan, 1992), p. 25. See also Henry DeWolf Smyth, *Atomic Energy for Military Purposes: The Official Report on the Development of the Atomic Bomb under the Auspices of the U.S. Government* (1945; Stanford, Calif.: Stanford Univ. Press, 1989), p. 284; and David Hawkins, ed., *Project Y: The Los Alamos Story* (San Francisco: Tomash, 1983). Some details have also emerged on the history of patents on nuclear fission designed by the French physicist Frédéric Joliot and his coworkers Lev Kowarski and Hans Von Halban. These patents fueled litigation during and after World War II. See Margaret Gowing, *Britain and Atomic Energy, 1939–1945* (London: Macmillan, 1954), pp. 201–215; and C. Gilguy, "A Good Example of Protection in the Nuclear Field: The Story of the Fundamental Patents of Joliot's Team," trans. O. S. Whitston, UKAEA Research Group, Oct. 1963.

[7] Peter Bacon Hales, *Atomic Spaces: Living on the Manhattan Project* (Urbana: Univ. Illinois Press, 1997), p. 5.

[8] Richard G. Hewlett and Oscar E. Anderson, Jr., *The New World: A History of the U.S. Atomic Energy Commission, 1939–1946* (Berkeley: Univ. California Press, 1962); Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America* (Cambridge, Mass.: Harvard Univ. Press, 1971), pp. 324–348; Jessica Wang, "Liberals, the Progressive Left, and the Political Economy of Postwar American Science: The National Science Foundation Debate Revisited," *Historical Studies in the Physical Sciences,* 1995, *26:*139–166; Rasmussen, "Of 'Small Men,' Big Science, and Bigger Business" (cit. n. 5); and Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford* (New York: Columbia Univ. Press, 1993).

[9] Marjorie Garber and Rebecca L. Walkowitz, eds., *Secret Agents: The Rosenberg Case, McCarthyism, and Fifties America* (New York/London: Routledge, 1995); Jessica Wang, *American Science in the Age of Anxiety: Scientists, Anticommunism, and the Cold War* (Chapel Hill: Univ. North Carolina Press, 1999); and David Kaiser, "The Atomic Secret in Red Hands? American Suspicions of Theoretical Physicists during the Early Cold War," *Representations,* 2005, *90:*28–60 (I thank Kaiser for providing me with an earlier version of this paper).

particular, the circumstances leading to the purchase of Fermi's patent in 1953 show that the new arrangements provided little economic benefit to the scientists whose inventiveness had contributed so much to the establishment of that program.[10]

FERMI AND THE ATOMIC PATENT(S), 1938–1941

In 1938 Enrico Fermi migrated to the United States. Following a ceremony in Sweden that culminated in the award of the Nobel Prize for his research, he continued on to the New World instead of returning to Italy. His wife and two of his closest coworkers, Bruno Pontecorvo and Emilio Segrè, were Jewish, and the anti-Semitic campaign recently launched by the Fascist regime made it clear that their future in Italy was clouded. Pontecorvo and Segrè had already left Italy when the legislation barring Jews from holding university positions was implemented, migrating to Paris and Berkeley, respectively. When Fermi arrived in New York he took up a post at Columbia University. But Fermi was not new to the American scientific and industrial community. Since 1935 he had traveled to the United States almost every summer, participating in research activities and attending to business centered on the "slow neutron patents."[11] These activities continued to be an important aspect of his (and his former colleagues') career throughout the period that anticipated his active involvement in U.S. military research.

In 1934 Fermi and his associates had developed a new method for the production of artificial radioactive substances that used slow neutrons as projectiles. The group, based at the University of Rome, included Fermi's friend and colleague Franco Rasetti; three young physicists—Edoardo Amaldi, Segrè, and Pontecorvo; and the young chemist Oscar D'Agostino. They began their research on neutrons when, in January 1934, the French physicists Frédéric Joliot and Irène Curie announced that they had obtained important radioactivation effects by bombarding nuclei of a light element with α-particles at their institute in Paris. Fermi soon realized that neutrons might prove to be better projectiles than α-particles because they have no electric charge. The group's early experiments with the neutron sources polonium and beryllium produced encouraging results, showing important radioactivation effects in some elements and confirming Fermi's initial intuition. This research became known internationally through publications in prominent journals.[12]

[10] Fermi's friends and colleagues Emilio Segrè and Edoardo Amaldi have analyzed these issues, but without discussing the content of previously unseen documentary evidence pertaining to Fermi's controversy with the AEC or relating this controversy to changes in the U.S. nuclear program. See Emilio Segrè, *Enrico Fermi: Physicist* (Chicago: Univ. Chicago Press, 1970), pp. 83–85; and Edoardo Amaldi, "From the Discovery of the Neutron to the Discovery of Nuclear Fission," *Physics Reports,* 1984, *111:*5–331, on pp. 154–160.

[11] On Fermi's move to the United States see Giulio Maltese, *Enrico Fermi in America: Una biografia scientifica, 1938–1954* (Bologna: Zanichelli, 2003), p. 35; and Segrè, *Enrico Fermi,* p. 101. See also James W. Cronin, *Fermi Remembered* (Chicago: Univ. Chicago Press, 2004). For his business activities see Simone Turchetti, "The Invisible Businessman: Nuclear Physics, Patenting Practices, and Trading Activities in the 1930s," *Hist. Stud. Phys. Sci.,* Fall 2006, in press. On the Fascists' anti-Semitic policy and how it affected Italian physicists see Lucia Orlando, "Physics in the 1930s: Jewish Physicists' Contribution to the 'New Tasks' of Physics in Italy," *ibid.,* 1998, *29:*141–181; and Giorgio Israel and Pietro Nastasi, *Scienza e razza nell'Italia Fascista* (Bologna: Il Mulino, 1998).

[12] F. Joliot and I. Curie, "Artificial Production of a New Kind of Radio-Element," *Nature,* 1934, *133:*201–202; E. Fermi, "Radioactivity Induced by Neutron Bombardment," *ibid.,* p. 757; and Fermi, E. Amaldi, O. D'Agostino, F. Rasetti, and E. Segrè, "Artificial Radioactivity Produced by Neutron Bombardment," *Proceedings of the Royal Society of London,* 1934, *146:*483–500. For an account of this work see Segrè, *Enrico Fermi,* pp. 68–78, esp. p. 77. See also Laura Fermi, *Atoms in the Family: My Life with Enrico Fermi* (Chicago: Univ. Chicago Press, 1954); Gerald Holton, "Fermi's Group and the Recapture of Italy's Place in Physics," in *The Scientific Imagination: Case Studies* (Cambridge, Mass.: Harvard Univ. Press, 1978), pp. 155–198; and Giovanni Battimelli and Michelangelo De Maria, "La fisica," in *Per una storia del Consiglio Nazionale delle Ricerche,* ed. R. Simili and G. Paoloni (Bari: Laterza, 2001), pp. 281–311.

But the group's members continued to design new experiments, and in the summer of 1934 Amaldi and Pontecorvo observed that the same neutron-induced nuclear reactions yielded differently if performed on tables made of different materials. This suggested that different media affect them. In October 1934 Fermi placed a block of the hydrocarbon paraffin between his neutron source and several target elements, registering an exceptional increase in the yield of radioactivity in fourteen different elements: substances containing atoms of hydrogen could slow neutrons down, thereby increasing the probability of collisions between the neutrons and the target elements' nuclei.[13]

Fermi's well-known "Eureka!" moment also involved an awareness of the technique's industrial implications. These included the possibility of producing artificial radioactive substances for use in medical treatment and the possibility of exploiting the neutrons in energy-liberating processes.[14] Given the state of knowledge in the prewar years, harnessing this energy for power generation did not look like an immediately viable prospect; nonetheless, Fermi's work engendered expectations that this would become possible in a not-too-distant future.[15] Aware of the potential industrial significance of their research, Fermi and his coworkers covered the method with two patents over the next two years, one describing the process of slowing down neutrons through the action of "hydrogenated" substances and the other depicting the production of sixty new artificial isotopes through this method and following β-decay.[16] The patents were filed in the U.S., Canadian, and fourteen European patent offices, and Gabriello M. Giannini (a businessman and Fermi's consultant, whose office was located in New York) was made responsible for trading the patents and discussing their purchase with major industrial companies such as General Electric and Westinghouse. Giannini was to receive an equal share of any royalties that were forthcoming from the U.S. and Canadian patents, in return for working on the inventors' behalf, and his newly established company—G. M. Giannini and Company—became the assignor of these patents. In 1935 Giannini established a financial partnership with the Dutch firm Philips, which was interested in exploiting Fermi's process for the production of new neutron tubes. Later he also partnered with L. V. Graner, a Philips consulting engineer who lived and worked in New York.[17]

[13] E. Fermi, E. Amaldi, B. Pontecorvo, F. Rasetti, and E. Segrè, "Azione di sostanze idrogenate sulla radioattività provocata da neutroni," *Ricerca Scientifica,* 1934, *5:*282–283. See also Gerald Holton, "The Miracle of the Two Tables: Enrico Fermi, a Piece of Paraffin, and the Way towards Nuclear Fission," in *Victory and Vexation in Science: Einstein, Bohr, Heisenberg, and Others* (Cambridge, Mass.: Harvard Univ. Press, 2005), pp. 48–64.

[14] Just four days after the publication of the paper announcing the group's results, Fermi filed an application for a patent on the process (Privativa no. 324,458). A copy was also sent to Britain's patent office: E. Amaldi, O. D'Agostino, E. Fermi, B. Pontecorvo, F. Rasetti, and E. Segrè, "Method for Increasing the Efficiency of Nuclear Reactions and Products Thereof," GB 465,045, convention date (Italy): 26 Oct. 1934; application date: 25 Oct. 1935; issued: 26 Apr. 1937. At the time, the major field of application for radioisotopes was in medicine, where they were used as sources of radiation for diagnosis (as X-rays emitters) and treatment (of leukemia and other cancers). See Heilbron and Seidel, *Lawrence and His Laboratory* (cit. n. 4), pp. 187–188.

[15] The promise of this work was stressed in June 1934 by Fermi's patron, Orso M. Corbino: O. M. Corbino, "Prospettive e risultati della fisica moderna," *Ric. Sci.,* 1934, *5:*615–620, on p. 618.

[16] E. Fermi, E. Amaldi, B. Pontecorvo, F. Rasetti, and E. Segrè, "Process for the Production of Radioactive Substances," U.S. patent application no. 43,462, filed on 3 Oct. 1935 (the Italian patent differed from its U.S. equivalent because it also contained the names of D'Agostino and Giulio C. Trabacchi, who was the director of the Institute for Higher Health in Rome and provided the radioactive material that Fermi used); and E. Fermi, "Composition of Matter and Method of Producing the Same," U.S. patent application no. 57,325, filed on 2 Jan. 1936.

[17] Giannini was one of Fermi's former students. He considered himself a scientist of lesser quality than the other members of the group and believed that his future lay in trading scientific inventions rather than in research. Thus he left Italy for the United States and opened an office in New York. See Amaldi, "From the Discovery of the Neutron to the Discovery of Nuclear Fission" (cit. n. 10), p. 318 n 526. On the partnership with Philips see

While Fermi was employed at Columbia, the understanding of physical processes associated with his transmutation method greatly improved. In the period between 1939 and 1941, further studies revealed that—under certain conditions—the nuclear fission of an isotope of uranium, U-235, could yield an enormous amount of energy and radioactivity. These developments emerged thanks to studies and experiments conducted independently by Joliot, Hans Von Halban, and Lev Kowarski in France, Otto Hahn and Lise Meitner in Germany, and Rudolf Peierls and Otto Frisch in Britain. The theoretical process behind nuclear fission was also explored by the physicists Niels Bohr and John Wheeler and discussed by Fermi and Bohr in January 1939. This accumulating evidence convinced Fermi to continue his work, assisted by the American researchers Herbert Anderson and Walter Zinn. As the war was beginning in Europe, Fermi and his émigré colleague Leo Szilard (who was also conducting research on nuclear fission at Columbia) became aware that the process of nuclear fission had military implications and thus asked for government support to explore it further.[18]

However, these findings not only opened a path toward military applications of fission but also confirmed the importance of the work Fermi sought to protect through his patent applications. Precisely because of these new developments, Fermi continued to follow the proceedings at the U.S. patent office.[19] Since 1936, the two patent applications had been scrutinized by patent officers, who had moved a number of objections. The first—and only—slow neutron patent was issued on 2 July 1940. Patent officers rejected the second application several times on the grounds that Fermi had published his findings in papers before filing it.[20] These rulings forced Fermi and his attorney, Truman Safford, to file a claim before the U.S. Patent Office Board of Appeals, which rejected it on 12 May 1941, thus terminating the case.[21]

Patenting and business activities had been important for Fermi's former associates too. Emilio Segrè, who from 1938 was employed at the Berkeley Radiation Laboratory, began a study on a new artificial element, plutonium (Pu), that was produced through neutron capture in uranium (U-238) and following decay by β-emission. Between 1939 and 1942,

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Philips to Emilio Segrè, 20 Sept. 1935, and H. Hijman, Chef des Services des brèvets d'invention des usines, Philips, to Enrico Fermi, 20 Sept. 1935, Scatola 1, Fascicolo 2, "Brevetto Neutroni," carte 34–35, Amaldi Collection. More details about the industrial research activities of Philips can be found in Kees Boersma, "Tensions within an Industrial Research Laboratory: The Philips Laboratory's X-ray Department between the Wars," *Enterprise and Society,* 2003, *4:*65–98, on p. 77. On Giannini's partnership with Graner see Philips claim for just compensation, copy in Box 19, Folder 7, Fermi Papers.

[18] Details on Peierls and Frisch's work can be found in Gowing, *Britain and Atomic Energy, 1939–1945* (cit. n. 6), pp. 40–44; see also Rhodes, *Making of the Atomic Bomb* (cit. n. 2), Chs. 9–12. On explorations of the theoretical process behind nuclear fission see Segrè, *Enrico Fermi* (cit. n. 10), p. 106; and Smyth, *Atomic Energy for Military Purposes* (cit. n. 6), p. 24. Bohr and Wheeler contributed to this research by showing that natural uranium (U-238) would not produce a chain reaction, in contrast with one of its isotopes, U-235. On Szilard see William Lanouette, *Genius in the Shadows: A Biography of Leo Szilard, the Man Behind the Bomb* (Chicago: Univ. Chicago Press, 1992).

[19] According to U.S. legislation, patent officers are to take an active role in investigating the novelty and effectiveness of the device or process to be protected by a patent, which forces the inventors to document and defend their claims actively before any patent is finally issued.

[20] According to the U.S. law, "the inventor is required to move fairly promptly with respect to the filing of a patent application or his invention may be rendered un-patentable by the publication of an article": Casper Ooms, "Atomic Energy and U.S. Patent Policy, Pt. 1: History of the Patent System," *Bull. Atom. Sci.,* 1946, *2*(9):28–29.

[21] U.S. Patent Office, Board of Appeals, Appeal No. 32,841, copy in Box 19, Folder 2, Fermi Papers. The appeal was rejected on the grounds that Fermi's invention was anticipated in at least four publications published in scientific journals between 1933 and 1934. A patent with the same content—but a different title—was issued by the Canadian patent office on 22 Sept. 1942: E. Fermi, "Radio-active Isotope Production," Canadian patent no. 407,559.

working in a team that included Glenn T. Seaborg, Herbert F. York, Joseph W. Kennedy, and Arthur C. Wahl, Segrè investigated the chemical and physical properties of a plutonium isotope (Pu-239) that was believed to have fissile characteristics similar to those of U-235. Their research ultimately led to the filing of five new patent applications on plutonium and the methods to produce it.[22] Following the invasion of France by German troops, in 1940, Bruno Pontecorvo moved from Paris to the United States. Thanks to Segrè, he was employed by Wells Surveys, Inc., in Oklahoma, where between 1941 and 1943 he developed new industrial methods for geophysical prospecting using neutron-emitting radioactive sources. This work led to the design of four patent applications on detectors. From 1940, Giannini became more involved in the rearmament business. During the war his company became a contractor for the U.S. Army; it also designed, patented, and produced jet engines for the Lockheed Corporation.[23]

On 7 December 1941 the Japanese attacked Pearl Harbor, forcing the United States into the world conflict. The position of Italians in the United States now became far more complicated, as they were considered "enemy aliens" living on American soil. The primary consequence was that the movements of Italian émigrés within the United States were restricted, but it was also feared that alien citizens would soon be forced to leave the country. In September 1942 Safford alerted Fermi and Rasetti (who had also recently moved to the United States) that, as an enemy alien, Fermi should report his patent to the Alien Property Custodian to avoid seizure.[24]

Between 1941 and 1942, the military implications of atomic energy took center stage and the project to build an atom bomb began to take shape. On 19 August 1941 Fermi was named chief of an advisory subcommittee discussing research in the context of the so-called uranium project.[25] Because of the secrecy rules established within the project, contacts regarding financial matters between corporations, Giannini, and Fermi became more sporadic. But even during the conflict the atomic patents continued to be an important issue for Fermi and his colleagues.

[22] The Berkeley researchers filed five patents: one on the substance, two on the chemical methods of producing it, and two on their uses. Fermi was asked to provide advice on one of these patents. Segrè to Fermi, 24 Nov. 1942, "Emilio Segrè," Box 11, Folder 13, Fermi Papers. See also Segrè, *Enrico Fermi* (cit. n. 10), pp. 117–119.

[23] On Pontecorvo see Simone Turchetti, "Atomic Secrets and Governmental Lies: Nuclear Science, Policy, and Security in the Pontecorvo Case," *British Journal for the History of Science,* 2003, *36:*389–415. Giannini's activities interfered with his efforts on behalf of the slow neutron patents. As Giannini wrote to Segrè: "my activities keep me considerably occupied, and I do not feel that I may continue this prosecution in any more advantageous position, as you may, for example do yourself." Gabriello Giannini to Segrè, 11 Nov. 1941, Box 19, Folder 2, Fermi Papers.

[24] "Any individual person to whom an unexpired US Letter Patent has been granted upon an application filed when such a person was a citizen or resident of a foreign country and who has since moved . . . shall on or before 15 August 1942 file with the APC a statement under oath containing the patent number, present residence and citizenship": Capt. Ives Waldo, Division of Investigation and Research, Alien Property Custodian, Chicago, to Fermi, 28 Sept. 1942, Box 19, Folder 2, Fermi Papers. Rasetti could have reported the patent himself, but—given Fermi's reputation and the fact that he had been in the United States longer—he concluded that Fermi was in a better position to deal with the Alien Property Custodian. Giannini had foreseen potential problems as early as 1939, when he wrote that "under these conditions . . . should a state of hostilities become existing between Italy and the US . . . it would be possible to prevent government expropriation by demonstrating to the satisfaction of the US authorities that the patents are actual American property": Giannini to Segrè (copy to Fermi), 18 Apr. 1939, "Emilio Segrè," Box 11, Folder 13, Fermi Papers. On 12 Oct. 1942, to mark the 450th anniversary of the discovery of America, President Franklin D. Roosevelt revoked the status of enemy aliens for Italians. See Maltese, *Enrico Fermi in America* (cit. n. 11), p. 105.

[25] Maltese, *Enrico Fermi in America,* p. 88.

INVENTIONS AT LOS ALAMOS, 1942–1945

The delineation of a patent policy that would accommodate the financial interests of scientists and companies was seen as a priority for military leaders involved in the uranium project. The new circumstances dictated by the war led the military to seek control over patents describing atomic processes, methods, and instruments. Military officers decided that previously issued patents would be used during the project with the promise of future compensation, while new patents coming out of the uranium project would be appropriated by the U.S. government. With the establishment of the project code-named Manhattan Engineer District (MED) and the Los Alamos laboratory, the government sought to defend its security interests by making most new patents a military secret. All scientists employed by the government were pressured to hand over the rights to new patents resulting from their research and led to expect compensation for the use of previously issued patents.

In 1942 the U.S. Office of Scientific Research and Development (OSRD), directed by Vannevar Bush, outlined a patent policy that effectively made any inventor, assignor, or company dealing with the uranium project dependent on its control in the design of new patents. The new provisions gave the government "the power to determine the disposition of all rights in discoveries and inventions made under the contracts" for national defense purposes. This stipulation was accepted by the major companies employed in the project, including Standard Oil, General Electric, Westinghouse, Kellogg, and Du Pont. Inventors involved in the project considered that military control offered them a better prospect than appropriation of their old or newly patented inventions by private companies; therefore they too accepted the new requirements.[26]

At this stage, Fermi was leading the project for the construction of a nuclear pile. After several experiments conducted in New York proved unsuccessful in producing a sustainable chain reaction, Fermi, Szilard, and their teams moved to the University of Chicago, where on 2 December 1942 the Chicago Pile (CP-1) produced the first self-sustaining nuclear fission (see Frontispiece).[27] The scientific principle of slowing neutrons down was integral to the functioning of CP-1, which was moderated with the hydrocarbon graphite. The successful CP-1 experiment contributed to the design of new nuclear reactors that used Fermi's method for slowing neutrons to perform nuclear reactions on a large scale. In years to come, this would enable scientists to produce fissionable materials for atomic weapons and radioisotopes for research, industrial, and medical purposes. Fermi's patented method had now become a prominent feature of applied nuclear physics.

Even in the aftermath of the crucial discovery that allowed the "Italian navigator" to "land in the new world," scientists, science administrators, and military men were considering the problem of existing patents covering the processes and instruments used. This issue was pertinent to Leo Szilard because he had conducted prewar studies—and filed patents—on the chain reaction. On 4 December 1942 (only two days after Fermi's CP-1 experiment), Szilard was requested by a military administrator to file a patent relating to

[26] "The Manhattan District took the responsibility of ferreting out the inventors. They were working for the University of Chicago, and they didn't want to let anybody think that Du Pont was going to grab any of the patents": "Senate Hearing on Atomic Energy, Atomic Bomb Patents" (cit. n. 1), pp. 10–11. The conflict between scientists and corporations is also described in Groueff, *Manhattan Project* (cit. n. 5), pp. 29–30, 133.

[27] In 1942 Fermi's experiments had focused on creating convergent chain reactions of increasing extent; on measurements of the fission cross-section of uranium and the neutron-absorption cross-section of graphite; on determination of the optimum arrangement of materials; and on calculation of the reactivity factor k, indicating the relation between neutrons produced and captured in the system. See Hoddeson *et al., Critical Assembly* (cit. n. 5), Ch. 3; and Maltese, *Enrico Fermi in America* (cit. n. 11), Ch. 6.

the chain reaction. But before doing so, Szilard wanted to know the policy adopted on patents protecting "inventions made and disclosed before we had the benefit of the financial support of the government."[28] The chief administrator of the project, Arthur Holly Compton, referred Szilard's case to Robert A. Lavender, a Navy captain and attorney who headed the OSRD Washington Headquarters patent office.

With the establishment of Los Alamos, the bureaucratic machinery concerned with defending and acquiring patentable nuclear knowledge began to take shape.[29] After the distasteful episode with Szilard, which no one wanted to see repeated, Lavender outlined four different contractual procedures for handling patents issued to (or filed by) companies. As Nicolas Rasmussen has noted, these procedures were similar to those that had been in place in the U.S. industry during the interwar years.[30]

When the Los Alamos laboratory was formed, it included a patent office as part of its administration. This office, which was responsible for dealing with individual inventors, began operating in July 1943. Captain Ralph Carlisle Smith—one of Lavender's assistants at the OSRD—was appointed as advisor on patent matters. The office immediately assumed responsibility for unfinished patents. It collected records of the researchers' completed work, including their existing inventions, with a view to covering them by patents. Smith commanded that the personnel keep workbooks with records of recent discoveries; these records would "be given the greatest evidential effect in legal proceedings" if patents were to be filed.[31] The patent applications on "sensitive" inventions were placed under a "secrecy order"; the patents could not be issued until the applications were declassified.[32] Finally, personnel leaving Los Alamos were to appear before the patent officers and assert that they had made no unrecorded inventions. Smith's office worked on five hundred patent cases altogether; completed cases were transferred to Lavender and filed with the U.S. patent office.[33]

[28] Rhodes, *Making of the Atomic Bomb* (cit. n. 2), pp. 442, 503.

[29] Initially it was believed that atomic patents could fall under a bilateral agreement between the United States and the United Kingdom. In the first half of 1942 Bush discussed these matters with Wallace Akers and Michael Perrin, the representatives of the British wartime atomic program. No agreement was reached, however. See Gowing, *Britain and Atomic Energy, 1939–1945* (cit. n. 6), p. 206.

[30] The first procedure allowed the government to dispose of all rights in discoveries and inventions; it was extended to most research contracts. The second allowed the contractors to retain a nonexclusive license in "outfield" commercial activities (i.e., those outside the atomic energy program). The third, which allowed contractors to retain the sole license and to grant sublicenses, came into play if the patent was largely outside atomic developments. The fourth dealt with patents for which purchases were "off the shelf"; the government would assume liability for their infringement. See "Senate Hearing on Atomic Energy, Atomic Bomb Patents" (cit. n. 1). These contractual procedures were also applied in other fields, such as biomedical research, where "the OSRD adopted customary contractual arrangements between firms and life scientists . . . [and] in these standard contracts, all rights were assigned in advance to the government, just as exclusive licensing if not outright patent assignment was stipulated in interwar industrial sponsorship": Rasmussen, "Of 'Small Men,' Big Science, and Bigger Business" (cit. n. 5), p. 121.

[31] Capt. Ralph Carlisle Smith, Restricted Memorandum to Technical Personnel, 15 Nov. 1943, copy in Leo Lavatelli Papers, Bag 6, American Institute of Physics Collection, Niels Bohr Library. See also David Hawkins, "Toward Trinity," Pt. 1 in *Project Y,* ed. Hawkins (cit. n. 6), pp. 1–259, on p. 34.

[32] The first law allowing "secrecy orders" covering patents that could be used for defense purposes was ratified by the U.S. Congress in 1917. It would be reintroduced during World War II and permanently adopted as Public Law 256 in 1952, thereby allowing the U.S. Navy, Air Force, and Army to make letters patent secret and forbid the issuing of a patent until further decision by the U.S. military agencies involved. Moreover, U.S. Code 37 allowed the government to extend from six months to three years the time allowed for the U.S. patent office to respond to the applicant for an invention used by the government. This period could be extended for another three years if the government officer responsible for keeping the patent secret decided that it was necessary. "Secret" patents would be kept in a safe in the patent office, and only the Chief Examiner and his assistant would be allowed to see them. See "Senate Hearing on Atomic Energy, Atomic Bomb Patents" (cit. n. 1).

[33] Hawkins, "Toward Trinity," pp. 60–63. In August 1946 Smith endorsed the directorship of a newly created

Eighteen of the five hundred patents produced at Los Alamos were based on Fermi's inventions, including patents on nuclear reactor designs, processes, methods, and instrumentation that were assigned to the U.S. government for the symbolic price of one dollar. Handled by Smith and Lavender, most of these patents were issued after ten years.[34]

Both scientists and patent officers recognized that patents filed *before* the beginning of the project should be dealt with through some kind of licensing or compensation agreement. Fermi and Segrè were fully aware that they were entitled to compensation for the slow neutron patent, given the vital role of the process in recent research on nuclear reactors. So while at the end of 1943 Captain Smith was busy instructing the Los Alamos personnel about the importance of record keeping and proper security precautions, Fermi and Segrè were considering how to activate negotiations with the OSRD officers. In the early months of 1944 Segrè asked Fermi to put pressure on Lavender and Smith to make an offer (see Figure 2). But no offer was forthcoming from Lavender, who probably believed that the question of settlement could be set aside until the war was over. The Italian physicists were very unhappy about these delaying tactics and considered informing General Leslie Groves, the project's military head, as to the state of affairs. On 14 July

Figure 2. *Fermi and Segrè at Los Alamos in 1945. Courtesy of AIP Emilio Segrè Visual Archives.*

D-Division, which was responsible not only for patents but for documentary matters more generally, including classification and declassification, drafting, illustration, and even artwork. Connecting declassification and patent matters in this fashion ensured that scientific reports produced at Los Alamos were routed in such a way that government's interest was also protected from a patent standpoint. See Edith C. Truslow and Ralph C. Smith, "Beyond Trinity," Pt. 2 in *Project Y,* ed. Hawkins (cit. n. 6), pp. 263–353.

[34] These were assigned to the AEC, signed by Robert A. Lavender as attorney and Herbert E. Metcalf as witness. They were all issued with a "Secrecy Order." Copies of the patents are in Box 19, Folders 9 and 10, Fermi Papers.

1944 Fermi, Segrè, Smith, and Lavender had a meeting at Los Alamos, but it proved inconclusive.[35]

The Italian scientists also wanted to inform the other inventors and Giannini that the slow neutron patent had proved—indeed, dramatically increased—its commercial value. But any disclosure of the reasons for this increased value (i.e., in connection with MED) would have led them to contravene Los Alamos security regulations, if not openly challenge the Espionage Act.[36] In order to avoid complications, Segrè and Fermi prepared a draft letter for Giannini, which was eventually shown to the OSRD patent officers, in which they claimed that the inventors were now in "a better position" to negotiate with possible "parties that might be interested" in the patent. But Giannini made it clear that he did not want his company to relinquish ownership of the patent.[37]

After the war, Fermi and Segrè left Los Alamos for positions at the University of Chicago and Berkeley, respectively. Giannini, who became aware of the potential value of the slow neutron patent after the atomic bombing of Hiroshima and Nagasaki (and the publication of the Smyth Report), now decided to be more involved in discussing patent matters with parties interested in its purchase. In October 1945 Giannini wrote directly to Bush, who promised him that compensation would be effected and agreed on a sum of about $900,000. Yet further negotiations involving Bush, Lavender, Giannini, and his attorney, Lawrence Bernard of Washington, D.C., proved ineffective.[38]

The war changed the significance and commercial value of the neutron patent, which was now implicated in the military uses of atomic energy. Fermi and Segrè assumed the responsibility of defending the other inventors' interests. This was known to Lavender and the other military advisors, who tried to take advantage of the situation the war had created. Although Lavender established rules that legally authorized compensation, they were not implemented.[39] Since the slow neutron process was already being used in military and

[35] Segrè stressed that allowing use of the patent without registering a complaint would have led to the loss of all the related intellectual rights. Although he did not intend to behave in a fashion that was hostile to the project, he believed it necessary to lodge a formal protest about the lack of consideration of these issues. See Segrè to Fermi, 7 Dec. 1943, "Emilio Segrè," Box 11, Folder 13, Fermi Papers. At this stage, Fermi would have been happy to consider a sum of about $450,000 for the outright sale of the patent. See Fermi's memorandum, 23 May 1944, Folder 7, Fermi Papers. On the fruitless meeting see Segrè to Robert Lavender, 29 July 1944, Box 9, Folder 2, Fermi Papers.

[36] The Espionage Act forbade Los Alamos workers and any other persons involved in the war effort from communicating any details relating to the project. As Fermi wrote in a memorandum: "Segrè and I were concerned as to the fact that by not disclosing to Giannini our knowledge of new applications and uses of the patent we were acting contrary to the agreement with Giannini. We were aware on the other hand that disclosure of the facts to Giannini would violate the Espionage act. Consequently we were asking the Government Attorneys for written instructions." Fermi's memorandum, 23 May 1944, Folder 7, Fermi Papers.

[37] Fermi to Colonel Herbert Metcalf, 9 Dec. 1943, Box 9, Folder 9; Fermi to Segrè, 9 Dec. 1943, Box 9, Folder 10; Segrè to Giannini, 9 Dec. 1943, Box 19, Folder 2; and Segrè to Fermi, 11 Mar. 1944, Box 19, Folder 2, Fermi Papers.

[38] Giannini to Vannevar Bush, 19 Oct. 1945, Box 19, Folder 2, Fermi Papers. Similarly ineffective were negotiations between Szilard and Lavender on the chain-reaction patent. According to Lanouette, Szilard "limited the government's payment to his actual expenses . . . plus a customary $1.00 patent fee. A settlement for the value of the chain-reaction patent itself, Szilard insisted, would be worth much more": Lanouette, *Genius in the Shadows* (cit. n. 18), p. 254. In comparison, the terms agreed to by some scientists within the context of the British nuclear program, Tube Alloys, were far more favorable. Von Halban and Kowarski assigned their patents to the Directorate of Tube Alloys in exchange for salaries more than twice what they were already receiving and a promise of 14 percent of the profits from the exploitation of their patents on nuclear fission. See Gowing, *Britain and Atomic Energy, 1939–1945* (cit. n. 6), p. 212.

[39] In 1946, Segrè wrote to Fermi that Lavender "cerca di spremere tutti all'ultimo sangue [tries to get from each of us as much as he can until the last drop of blood]," because he wanted to have rights on every patent, even those produced at universities: Segrè to Fermi, 27 May 1946, Box 2, Folder 13, Fermi Papers.

industrial applications, the OSRD officers could resort to all sorts of delaying tactics rather than compensating Giannini and the inventors immediately, causing them much frustration.

SOMETHING TO GO NOWHERE: THE MCMAHON ACT, 1946–1948

From 1946 the attorney Bernard assumed control of all the legal procedures relating to Fermi's patent, thereby becoming a chief actor in negotiations with the U.S. government representatives. An expert Washington lawyer, as well as a former chief counsel of one of the divisions of the Treasury Department and a partner in the law firm Sullivan, Bernard, and Shea (John L. Sullivan was an Assistant Secretary of the U.S. Navy for Air), Bernard was fully aware of how recent political and legislative developments could affect the patent case.[40] His attempts to finalize a settlement, however, were thwarted by the provisions in the McMahon Act pertaining to the establishment of the Atomic Energy Commission. Although in theory this new law should have restored legality in the handling of atomic patents, it in fact muddied the waters by combining the question of patent compensation with other issues, such as control over atomic energy at the national and international levels. The controversies surrounding the patent provisions of the bill not only took center stage in the political arena but also delayed the compensation process.

In the postwar years the definition of new legislative means to control atomic energy became one of the prominent aspects of U.S. policy-making. In July 1945 President Harry Truman established a Joint Committee on Atomic Energy (JCAE), led by Senator Brien McMahon, to make recommendations about the country's future atomic policy. The transfer of atomic energy from military to civilian control was seen as a priority for the new legislation. But the process leading to the passage of the McMahon Act was tortuous; the bill was approved only after legislative maneuvering that drained support from the competing bill put forward by Senator Edwin J. Johnson of Colorado, whose proposal had been more favorable toward military control of atomic energy. Although the legislation was primarily aimed at ensuring that control over information and processes leading to the production of atomic weapons would be safely kept by the American government, it also had to ensure that a governmental monopoly would not pose obstacles to the industrial development of atomic energy. Financial considerations were indeed very important in the final approval of the McMahon Act.[41] The final bill, S.1717, was produced in the fall of 1945, amended by Congress, and approved by the Senate in April 1946. On 1 August 1946 the Atomic Energy Commission was created.[42] It included a General Advisory Committee (GAC), with Fermi as one of its members.

Patents had been one of the most controversial aspects of the new bill, which recognized the imperative to safeguard the secrets of the atom bomb by prohibiting individuals or companies from filing new patents and allowing the AEC to purchase all existing patents relating to the production of fissionable materials. Thus, the compulsory purchase of patents was just what the bill enacted. On 11 February 1946 the JCAE had interviewed Captain Lavender, who stressed that the principle of compulsory purchase was already in force in existing legislation. He argued that all the information contained in atomic patents was

[40] Giannini to Segrè (copy to Fermi), 2 Feb. 1946, Box 19, Folder 2, Fermi Papers.

[41] E.g., U.S. Secretary of Commerce Henry A. Wallace supported the bill because it would "foster and develop economic, medical and other peaceful uses of atomic fission and its by-products": H. A. Wallace, "Supports the McMahon Bill," *Bull. Atom. Sci.,* 1946, *1*(5):6–7. On the establishment of the JCAE see Hewlett and Anderson, *New World* (cit. n. 8), p. 411.

[42] Hewlett and Anderson, *New World,* p. 513.

already in the hands of the military and thus could not be disseminated. Thus, inventors who had designed patents in the field of atomic energy could profit only by assigning them to the government; they would then be rewarded with a compulsorily agreed "just compensation."[43] Lavender's position was consistent with that of others, such as Bush, who saw existing patent claims as matters to be settled by the military in a context completely separate from that outlined by the new AEC legislation. They held that the new legislation should not have had any specific patent provision—this was also the reason why they had supported the rival bill proposed by Johnson.

But Lavender's argument anticipated Section 11 of the McMahon Act, which stipulated that "no patent will be issued for any discovery or invention useful solely for the production of fissionable material or atomic energy for military weapons; but the commission will compensate for such invention or discovery" and that "the commission is authorized to purchase, take or condemn and make compensation for any invention or device useful solely in the production of fissionable materials for military weapons." The patent provisions of the bill were attacked in the U.S. Congress as the "Soviet" part of the new legislation.[44] Some analysts pointed out that governmental control could in some measure vitiate the primary functions of the patent system. Others reasoned that these provisions represented a good compromise, as they could prevent private monopolies.[45] The position of the inventors who had developed the methods deployed in the military and industrial uses of atomic energy did not concern many commentators. It was probably believed that the lag between legislating on these matters and putting the provisions into effect would be very short. However, this was not the case—precisely because the military administrators lost control of patent issues, which were now the responsibility of the new AEC administrators.

In 1946 Fermi and his former coworkers considered the outright sale of their patent for about $900,000 a reasonable outcome.[46] The inventors would even have been happy to

[43] Lavender pointed out that the compulsory purchase of patents would come "under police power" rather than "eminent domain." He also argued that an inventor refusing compensation had no chances of further legal protection. He could appeal to the Court of Claims, but he would have no way to prove his case as he could not "obtain from the Government the facts concerning the equipment that corresponds to his patent": "Senate Hearing on Atomic Energy, Atomic Bomb Patents" (cit. n. 1), pp. 10–11.

[44] "The Revised McMahon Bill," *Bull. Atom. Sci.,* 1946, *1*(9):2–5. The patent provisions were attacked by the American Bar Association, the Association of Manufacturers, and the National Patent Council. The chairman of the House Patents Committee denounced the proposal as "the end of the patent system," while a former commissioner on patents criticized it as a provision modeled on the Russian system, calling it dangerous and socialistic. See Byron S. Miller, "A Law Is Passed: The Atomic Energy Act of 1946," *University of Chicago Law Review,* 1948, *15*(4):799–821; and Hewlett and Anderson, *New World* (cit. n. 8), pp. 495–498.

[45] Gordon K. Lister, "Government Patent Rights," *Bull. Atom. Sci.,* 1946, *1*(11):15–16; and Edward H. Levi, "The Atomic Energy Act: An Analysis," *ibid.,* 1946, *2*(5):18–19. One defender of the bill was Casper W. Ooms, a future AEC Commissioner on Patents, who argued that "the act provides an elaborate but flexible procedure designed to prevent the acquisition of patents in the field in which the AEC is given absolute governmental monopoly": C. Ooms, "Atomic Energy and U.S. Patent Policy, Pt. 2: Patent Provisions of the Atomic Energy Act," *ibid.,* 1946, *2*(11):30–31. In 1948 the "socialist vision" in the bill was defended. Science advisors Byron S. Miller and James R. Newman, who had helped to draft the bill, claimed that it had done "nothing less than establish in the midst of our privately controlled economy a socialist island with undefined and possibly expanding frontiers": Wang, "Liberals, the Progressive Left, and the Political Economy of Postwar American Science" (cit. n. 8), p. 144.

[46] A meeting between Giannini, Bernard, Lavender, and Bush was held on 2 Feb. 1946. Bush argued in a "carrot and stick" fashion that if the inventors "are shooting for very high stakes—such as to collect, say, 5%, of the production value of the Hanford Plant—or several million dollars—he would not recommend our offer," but he also noted that he was "sincerely interested in proceeding with this matter and in settling it before he leaves his office": Giannini to Segrè (copy to Fermi), 2 Feb. 1946, Box 19, Folder 2, Fermi Papers. This was certainly consistent with Bush's political stance at the time: he wanted to wrap up all matters pertaining to

consider compensation of $50,000 each (for a total $500,000), but Giannini was more resistant to this compromise figure as he had sold shares in his company during the war and, in the case of an outright sale, he would not profit enough.[47] On 14 June 1946 Bernard made a final proposal to Lavender, offering to sell the neutron patent for a sum not less than $450,000; Lavender replied, "Well, now we have something definite to go on." But this overture led nowhere, and by July Giannini was once again writing to Bush soliciting the final formulation of an offer. Segrè described Lavender as "extremely uncooperative."[48]

Yet whether Lavender was cooperative or not, the creation of the AEC had in fact rendered the negotiations between Bernard and his opposite number at the OSRD pointless, as it was now the AEC's responsibility to purchase the neutron patent and arrange to compensate the inventors. Section 11 of the McMahon Act recommended the establishment of a Patent Compensation Board (PCB) that would negotiate and settle awards for patents dealing with the production of fissionable materials. In January 1947 a Patent Policy Panel was established to provide recommendations for effecting the patent provisions of the McMahon Act. Bernard discovered that all the documentation relating to the neutron patent had been transferred from Bush's administration to the AEC.[49] Six months later, however, the panel had yet to prepare regulations establishing procedures for processing claims, a prerequisite for looking at individual cases in detail. These regulations were finally produced only in June 1948.[50]

The panel took so long to hammer out the new regulations chiefly because repeated attacks on the patent provisions of the McMahon Act, which intensified during 1948, obstructed its work. Because the act was supposed to facilitate the international control of atomic energy, it established a governmental monopoly on patents as a temporary measure.[51] Both within and outside Congress, many lobbied for new legislation that would

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wartime research—with all its implications—and open a new institution devoted to basic research, the National Science Foundation, that would operate under scientists' control. See Kevles, *Physicists* (cit. n. 8), p. 345; and Wang, "Liberals, the Progressive Left, and the Political Economy of Postwar American Science," p. 146.

[47] Giannini also asked the inventors to agree to donate part of the future royalties to him, a request that further eroded their relationship. See Segrè to Fermi, 7 Feb. 1946, "Emilio Segrè," Box 11, Folder 13, Fermi Papers.

[48] L. J. Bernard to Giannini (copy to Fermi), 14 June 1946, "Patents," Box 19, Folder 2, Fermi Papers (reporting the $450,000 offer and Lavender's response). "Fermi and to a lesser degree myself have been extremely generous in patent matters with the Govt. as Mr. Lavender knows, and I think he is trying to pull the rope too much": Segrè to Giannini, 28 May 1946, "Emilio Segrè," Box 11, Folder 13, Fermi Papers.

[49] Ooms was a member of the Patent Policy Panel; see "USAEC Report to Congress," *Bull. Atom. Sci.,* 1947, *3*(9):275–280. Regarding the transfer of the neutron patent documentation see Bennett Boskey, "Inventions and the Atom," *Columbia Law Review,* 1950, *50:*433–447; and Bernard to Giannini (copy to Fermi), 3 Jan. 1947, Box 19, Folder 2, Fermi Papers. Years later, Rasetti claimed that "the American government at first was favorable to giving compensation. It was favorable when atomic energy was managed by the Department of Defense. Because of General Groves. And then Bush, who was a big shot and he knew Fermi. They appreciated what Fermi and Segrè had done for the Manhattan Project, so they were well disposed to it. When the AEC was created and Atomic Energy went into the hands of civilians, then they were extremely unpleasant": Franco Rasetti, interview with John Kennedy, 1966, Fermi Documentary Film Collection, Harvard Project Physics, Box 1, background research materials and interviews, Niels Bohr Library.

[50] The PCB was given power to negotiate the purchase of patents. According to the new regulations, the PCB was supposed to proceed if the owner of the patent and the commission were unable to agree on royalties, taking into consideration four main factors: the extent to which the invention was developed through federally financed research; the degree of its utility, novelty, and importance; the cost to the owner of developing the invention; and the actual use of the invention in the atomic program. See Boskey, "Inventions and the Atom."

[51] Since 1945, Dean Acheson and David Lilenthal had been leading a commission working on the international control of atomic energy under the auspices of Truman's administration. In 1946 Truman nominated Bernard Baruch as representative to the United Nations Atomic Energy Commission. On 14 July 1946 Baruch addressed the commission with a new plan that differed substantially from that put forward by the Acheson/Lilienthal commission but still advocated the international control of atomic energy. See Hewlett and Anderson, *New World* (cit. n. 8), Chs. 15 and 16. The Soviet Union's refusal to cooperate in the establishment of an international control agency derailed this plan.

eliminate the patent provisions of the McMahon Act in order to "restore incentive to private research."[52]

THE UNPREDICTABLE CONSEQUENCES OF A COMPENSATION CLAIM, 1948–1950

It was not until 13 October 1948 that Bernard could finally apply for compensation on behalf of Fermi and his colleagues, claiming that U.S. patent no. 2,206,634 covered "the basic process used in research and development leading up to the production of atomic energy and the production of the atomic bomb." The invention of slow neutron absorption was said to be of "continuing importance in the production of fissionable materials and atomic weapons"; moreover, the technique was used "in the original experimentation for the development of atomic energy for military purposes." In light of the importance of the slow neutron process, the claim prepared by Giannini asked for $1 million as just compensation for the rights conferred by the patent and $100,000 a year "for the remaining life of the patent" (which would expire in 1957) as a license on future applications, including "the production of radioactive isotopes."[53] The claim filed by Giannini was for $1,900,000. Unofficially, however, Bernard stressed that the inventors were willing to settle the matter for a lump sum of $900,000, as agreed by Bush in October 1945.

The patent legislation and its provisions had already delayed the claimants' case, and Giannini's request was now promising to cause more trouble. Giannini decided to stick with the initial offer discussed with Bush rather than the final offer made by Bernard to Lavender ($450,000) because of his dissatisfaction over these delays. Moreover, he was unhappy with the contract binding him and the inventors. Giannini & Company would receive one eighth of the final sum awarded for the patent, with Giannini himself getting one thirty-second of that total (he now owned only 25 percent of the company). He thus decided to "raise the price" with the PCB. Giannini's move did not impress Segrè and Fermi. They objected that they were not responsible for his decision to sell shares of his company to third parties. The decision to stick with the higher figure was thus controversial; Segrè opined that "by challenging the government, [Giannini] could end up breaking his neck [col governo (Giannini) potrebbe anche rompersi il collo]."[54]

The PCB began to function five years after the start of negotiations regarding the Fermi patent. Effectively established in April 1949, it docketed only seven cases up to March 1950. This was "an inexplicably low figure," according to Bennett Boskey of the AEC Office of General Counsel, but in fact not a surprising one given the pessimistic views most claimants now held as to the chances of settlement.[55]

[52] The act "effectively shuts out all private initiative and . . . means inviting selected industrial laboratories to work out pieces of a master development plan established by the Commission": Karl Cohen, "A Re-Examination of the McMahon Act," *Bull. Atom. Sci.,* 1948, *4*(1):7–10. See also Walter DeCew, "New Legislation to Replace the McMahon Act," *ibid.,* 1948, *4*(9):277–279. It is worth noting that the debate over the patent provisions of the act ran in parallel with a similar debate about the establishment of the National Science Foundation, where two parties (one led by Senator Harry Kilgore and the other led by Bush) argued, respectively, for and against public ownership of patents derived from publicly funded research. See Wang, "Liberals, the Progressive Left, and the Political Economy of Postwar American Science" (cit. n. 8), p. 141.

[53] G. M. Giannini and Co., "Application for Just Compensation and the Determination of a Reasonable Royalty Fee under Section 11 of the Atomic Energy Act of 1946" (cit. n. 1).

[54] Segrè also feared that Giannini would make a fool of himself in the eyes of government officials; see Segrè to Fermi, 15 Nov. 1948, "Emilio Segrè," Box 11, Folder 13, Fermi Papers.

[55] Boskey, "Inventions and the Atom" (cit. n. 49), p. 435. Among the cases considered by the PCB were the Seaborg and Segrè patents on the production of plutonium. A detailed list of the docketed cases is in *ibid.,* p. 444.

In June 1949 Boskey analyzed the circumstances pertaining to Fermi's patent and presented his legal comments on Giannini's claim before the PCB. It was not good news. Boskey denied all the allegations forming the core of Giannini's application, claiming that the slow neutron method was not essential to the production of fissionable material; that the invention did not cover the basic process used in research and development leading up to the atom bomb; and, more generally, that the invention was not used as the basic process for the development of atomic energy for military purposes. The neutron patent disclosed a process for the utilization of the slowed-down neutron principle, but Boskey denied the use of such a principle in the production of radioactive isotopes. Finally, he insisted, the claims relating to a licensing fee of $100,000 per year for the use of the patent in the future production of radioactive isotopes were unfounded.[56]

Most significantly, objections were raised in regard to the legal status of the claimants. Boskey drew attention to the fact that some of those interested in the applications were of foreign nationality. Although this did not by itself "disqualify" them from receiving compensation, there were "certain circumstances arising by virtue of the particular nationality" that gave rise to "special questions." Quoting from the Treaty of Peace ratified by the Italian government on 10 February 1947, Boskey stressed that "the United States was not obliged to return industrial properties to Italian nationals" and that "Italy or its nationals were not entitled to any patent with respect to inventions of war materials (whereas this included bombs and all means for exploiting or operating them)." A following Memorandum of Understanding, executed on 14 August 1947, also discharged the United States from claims against the U.S. government relating to "the use of patents or inventions" by Italian nationals.[57] Boskey thus disputed the positions of Amaldi, D'Agostino, and Trabacchi because they were still Italian citizens.

Boskey also pointed to Fermi's GAC membership as a complicating factor. He argued that Fermi was not entitled to apply for compensation because the pertinent legislation stipulated that no right of action in respect to patents was given to U.S. government employees. More generally, Boskey observed that Section 109 of the Criminal Code entitled the U.S. government to take legal action against anyone prosecuting a claim against it while being one of its officers or employees.[58]

Boskey's report seemed to set the stage for refusing the claim—or at least his robust evidence would seem sufficient to force Giannini and Fermi to accept whatever the PCB might have offered. This was the result of a new system of patent provisions that had consolidated governmental control over atomic energy and therefore greatly limited the contractual power of scientists. The new "socialist" vision with regard to atomic patents had led to a new attitude on the part of the AEC administrators, who were now less convinced that compensation should be awarded. And now more problems—including anti-Communist hysteria and the intensification of secrecy regulations—would arise to delay the compensation process even further.

"WITCH HUNTS" AND "BARGAINING POINTS," 1950–1953

The discovery of a spy ring centered at the Soviet Embassy in Ottawa, Canada, in 1946 led to questions about the role of espionage in the dissemination of information on the

[56] B. Boskey, Office of the General Counsel, "Response to the Application of G. M. Giannini and Company, Inc.," USAEC-PCB, Docket No. 2, 6 June 1946, pp. 3–9, copy in "Neutron Patent," Scatola 2, Fascicolo 2, Amaldi Collection.

[57] *Ibid.*

[58] *Ibid.,* pp. 10–14.

U.S. atomic program. Further investigations raised fears that the Soviet effort to harness nuclear weapons had been fostered thanks to information provided by scientists in the United States and Britain. As this debate intensified, it also involved discussions about the McMahon Act, civilian versus military control over atomic secrets, and patent provisions. Boskey's legal advice regarding the slow neutron patent must be seen in the context of intensified pressure to avoid the dissemination of classified information during legal proceedings and to allow the FBI to conduct full background investigations on all people with access to restricted data.[59] On 23 September 1949 Truman announced that there was clear evidence that the Soviets had tested their first atomic bomb. This announcement not only increased fears about the role of spying activities but also coincided with a reevaluation of secrecy policy in the field of atomic energy. Inevitably, the slow neutron patent settlement fell afoul of these issues, all of which affected the claimants' chance to "bargain" for reasonable compensation.

The reaction of the inventors to Boskey's response was one of disappointment. Fermi now claimed that he had embarked on the compensation negotiations mostly in an attempt to defend the interests of his former colleagues, as by this point he had far less interest in the patent as such.[60] But he was very concerned about some of the matters raised in Boskey's report. Because he wanted clarity as to whether the accusation of a conflict of interest was grounded, he wrote directly to the AEC General Counsel, attorney Joseph Volpe, who judged the matter very important and sought clarification from the U.S. Department of Justice.[61] In November 1949 Fermi was informed that claiming compensation from the AEC did not constitute a criminal act but that the accusation of a conflict of interest was founded. In its final decision the Department of Justice also stressed that Fermi's GAC membership not only should have prevented him from presenting a compensation claim but also invalidated the claims presented by others associated with him. The depiction of a conflict of interest so exasperated Fermi that he considered leaving the GAC.[62] And when his term of membership expired in July 1950 he did not renew it; these legal concerns were a factor in his decision, along with the political controversies about whether the United States should build a hydrogen bomb that divided the advisory committee.[63]

[59] Boskey noted that it was difficult for claimants to present a convincing case owing to the secrecy requirement, which "really works its hardship more on the applicant"; that the General Counsel had access to all the pertinent information, while the applicant "is to a considerable extent working in the dark"; and that applicants could not cross-examine witnesses on different methods in use, as they would trespass into the area of secret information: Boskey, "Inventions and the Atom" (cit. n. 49), p. 442. See also Miller, "Law Is Passed" (cit. n. 44).

[60] Writing to Segrè in December 1949, Fermi stressed that he participated in the compensation negotiations reluctantly and that he probably would never have started them had he been the only inventor: Fermi to Segrè, 14 Dec. 1949, Box 11, Folder 13, Fermi Papers.

[61] Fermi stressed that the matter "came to me as a complete surprise": Fermi to Joseph Volpe, 29 June 1949, Fermi Papers. On 3 Aug. 1949 Volpe informed Fermi that he intended to explore these issues with the Department of Justice: Volpe to Fermi, 3 Aug. 1949, Box 19, Folder 4, Fermi Papers.

[62] Fermi wrote to Segrè that "under these circumstances I am seriously considering whether I should not resign from the GAC": Fermi to Segrè, 9 Jan. 1950, Box 19, Folder 4, Fermi Papers. He did not do so because in the following months Congress passed a bill allowing GAC members to file suits on patents.

[63] In a letter to Bernard written on 15 Apr. 1950, Fermi stressed that he was ready to resign from the GAC if such action was absolutely necessary but that he preferred to let his appointment expire naturally "in order to avoid misinterpretations of the reasons for my resignation." He stressed that a sudden resignation would be "damaging" rather than "helpful" to the claim and that, as the commission had taken steps to promote a revision of the law, he was more inclined to wait rather than to resign immediately. See Fermi to Bernard, 15 Apr. 1950, copy in "Neutron Patent," Scatola 2, Fascicolo 2, Amaldi Collection. In any case, Fermi's decision to leave the GAC has been the subject of much speculation, and it is still unclear why he decided not to renew his membership in July 1950. Maltese suggests that the accusation of a conflict of interest particularly annoyed the Italian

Giannini and Bernard's propositions for compensation were far more aggressive than anything Fermi had in mind. In February 1950, when new hearings were scheduled, they were willing to show their support for an amicable solution of the patent controversy. However, as Boskey's report on the matter had in effect taken all earlier offers off the table, they began to feel that it was time to apply additional pressure. They decided to file a petition with the U.S. Court of Claims and publicize its content in the press. This was intended as a measure to force the PCB to conclude the case and accept the claimants' offer of settlement without further unfriendly acts.[64]

Writing to Fermi on 15 August 1950, Giannini stressed his intention to use the petition as a means to pressure the AEC. But the petition he filed asked for $10 million. He argued to Fermi that though "admittedly this figure has no bearing on the settlement," it was likely to "arouse some interest in the press." But Giannini's approach certainly did not please the Italian inventors, who had been unhappy with the price mentioned in the original claim, filed two years earlier. Fermi replied that he had no idea that Giannini had such an amount in mind and insisted that asking for such a high figure, "even only as a bargaining point," would put them all in a "very unfavorable light before the public opinion and ultimately decrease greatly the chances of a just settlement." Above all, Fermi feared the reaction of the press, which at a time of rampaging McCarthyism was already investigating atomic scientists employed by the government. Replying nine days later, Giannini emphasized that Bernard, not he, had decided to ask for so much money, basing the move "on his experience with other similar . . . cases."[65]

But was this strategy really advantageous? It is worth considering that only a few months before the claim was filed, the first allegations about the role played by the German scientist Klaus Fuchs (an émigré, like Fermi and some of the other inventors) in providing secret details on atomic weapons to the Russians appeared in the press. Thus Giannini and Bernard may well have chosen the wrong moment to "go public." Soon major newspapers around the world reported that the Italian physicists associated with Fermi were asking $10 million for the patent. It was easy for the media to perceive—and present—the decision as yet another unpatriotic challenge to the U.S. government, rather than as a principled attempt to force a long-postponed settlement. Bernard recommended that the inventors be extremely factual with the press, answering questions and seeking a "minimum of publicity."[66] But his strategy did not succeed, and matters soon escalated beyond his control.

Bruno Pontecorvo was one of the inventors named in the slow neutron patent. His name

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physicist, even though the vexing debate as to whether the U.S. government should build a hydrogen bomb certainly contributed to his decision: Maltese, *Enrico Fermi in America* (cit. n. 11), p. 348. In late 1949—just when the conflict of interest accusation was unfolding—Fermi and I. I. Rabi composed a minority GAC report in which they stressed that thermonuclear weapons were "necessarily an evil thing in any light." It is thus equally plausible that, as the political pressure to build the "Super" increased and Fermi's views became less influential in the GAC, he decided to leave. See Peter Galison and Jeremy Bernstein, "In Any Light: Scientists and the Decision to Build the Superbomb, 1952–1954," *Hist. Stud. Phys. Sci.,* 1989, *19:*267–347, on pp. 317, 336; and Richard Rhodes, *Dark Sun: The Making of the Hydrogen Bomb* (New York: Touchstone, 1995), pp. 401–402.

[64] A conciliatory attitude is expressed in Giannini to Segrè, 20 Feb. 1950, "Giannini," Scatola 2, Fascicolo 2, Amaldi Collection. But—frustrated with the government's delaying tactics—they had been considering filing a petition in the Court of Claims since late in 1949. This approach aroused the opposition of the inventors: Segrè and Fermi were against going to a court trial. See Segrè to Fermi, 10 Dec. 1949, Box 11, Folder 13, Fermi Papers.

[65] Giannini to Fermi, 15 Aug. 1950; Fermi to Giannini, 18 Aug. 1950; and Giannini to Fermi, 24 Aug. 1950: "Neutron Patent," Scatola 2, Fascicolo 2, Amaldi Collection.

[66] Giannini to Fermi, 24 Aug. 1950, "Neutron Patent," Scatola 2, Fascicolo 2, Amaldi Collection.

was widely mentioned in the press reports that had created the recent frenzy regarding the court case. But in the summer of 1950 Pontecorvo was very concerned for his professional position. He was also worried by the witch hunts prompted by allegations of nuclear spying, and he would thus have preferred to maintain a low profile. In 1948 Pontecorvo had been appointed Senior Principal Scientific Officer at the Harwell nuclear establishment in Britain, the same place were Fuchs had been working. In March 1950, following Fuchs's arrest, Pontecorvo confessed that he had Communist relatives in Italy, although he described himself as uninterested in politics. While in Italy on holiday, Pontecorvo learned from newspaper reports about the recent claim put forward by Giannini and his attorney. Already scared by the witch hunts and aware that his employer knew about his Communist acquaintances, he certainly did not welcome the publicity deriving from his involvement in a $10 million suit against the U.S. government. Less than a month after the claim was filed, Pontecorvo fled to the USSR. The Italian physicists in the United States feared that they might be held accountable for the disappearance of their colleague, while new allegations about Pontecorvo being an atomic spy appeared in newspapers. Giannini withdrew from the court case, claiming that he wanted nothing to do with people involved in "international mysteries"; he suspected that in fact the inventors bore some responsibility for Pontecorvo's defection.[67]

Fermi and Segrè certainly feared the consequences of the Pontecorvo case, and they had to face hearings with AEC officers to discuss it in detail. In these complicated circumstances, it was Franco Rasetti who now stepped forward to represent the other inventors in the neutron patent case (see Figure 3). On 3 November 1950 Rasetti visited Bernard to discuss the consequences of the Pontecorvo affair. Segrè had been "advised" by AEC managers to proceed with settling the case, but—in light of Pontecorvo's defection—for an award much less than that initially considered.[68]

During the period in which the Pontecorvo affair erupted, Fermi, Segrè, and Rasetti proved to be extraordinarily firm in resisting pressure from the press and their colleagues in the scientific community, as well as in facing Giannini's decision to withdraw from the case.[69] Giannini eventually reversed his decision and continued to represent the inventors,

[67] "I am today instructing my attorney to eliminate and disinvest my company of any interest in the $10,000,000 damage suit now pending in the US Court of Claims. . . . This action is a result of the surprise and shock resulting from the amazing disclosure that Bruno Pontecorvo . . . has reportedly disappeared into Russia under circumstances that are highly questionable. . . . I am an American citizen first, and my interests and interests of my company are concerned primarily with the principles of freedom and democracy. Regardless of what sum of money is involved, we do not care to be associated with anyone whose principles or beliefs in our form of Government is in any way in question": Giannini press release, copy in Box 19, Folder 7, Fermi Papers. As Segrè wrote to Rasetti: "The Pontecorvo affair is producing all kinds of disagreeable complications, as you can easily imagine. Giannini seems to feel that we have some responsibility for Pontecorvo, especially I, as representative of the inventors." Segrè to Franco Rasetti, 25 Oct. 1950, "Giannini," Scatola 2, Fascicolo 2, Amaldi Papers. For more on Pontecorvo see Turchetti, "Atomic Secrets and Governmental Lies" (cit. n. 23), pp. 404–405.

[68] Fermi's official statement, made at the request of Senator McMahon, stressed that he did not know the reasons behind Pontecorvo's "alleged escape" to the Soviet Union. See E. Fermi, "Statement about Bruno Pontecorvo," 13 Mar. 1951, Box 15, Folder 12, Fermi Papers. After World War II Rasetti had openly criticized those involved in the Manhattan Project, and he abandoned nuclear physics studies for research in paleontology. However, as he had been responsible for some of the research leading to the neutron patent, in 1950 he actively worked for a quick and satisfactory settlement. See Rasetti to Segrè, 3 Oct. 1950, "Giannini," Scatola 2, Fascicolo 2, Amaldi Papers.

[69] Segrè wrote to Fermi, "Yesterday Louis Alvarez came unrequested [*sic*] to my office and explained to me that he thought it extremely improper that we should ask compensation for the patent because we would have paid more than a million dollars apiece to avoid being in Italy during the war, and since the United States has taken us as guests in this country we should give recognition to the United States by conferring to them whatever

Figure 3. *Amaldi, Rasetti, and Segrè in their old age. Courtesy of AIP Emilio Segrè Visual Archives.*

but by then it was clear that Pontecorvo's defection had enormously deflated their bargaining position. Withdrawing the compensation claim entirely at this point would have looked rather suspicious. But clearly the PCB was ready to use recent developments to turn negotiations in its favor. The inventors were well aware that it was time to accept whatever conditions were offered; they were eager to settle the matter quickly and at any price.

In 1951, then, the Italian inventors agreed to request a lump-sum settlement about one third of what had initially been agreed with Bush. Bernard made an official proposal to the PCB in January 1951 and again in August 1951. Anderson informed Bernard that the PCB now appeared to be interested in settling the claim amicably. However, he also stressed that, in view of the objections raised by Boskey (and in light of the Pontecorvo case), the PCB could only consider a "figure much lower" that the one originally proposed by Bernard. On 4 December 1951 Rasetti wrote to Segrè that the AEC was silent once again. Rasetti now feared that, because the inventors had renounced the U.S. Court of Claims proceedings, the whole matter could be delayed indefinitely. "It is a pig-headed system," he wrote, "but now they can do whatever they want."[70]

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we could. . . . We can not have illusions about the fact that whispering campaigns or defamatory statements will be made against us." Segrè to Fermi, 25 Oct. 1950, "Giannini," Scatola 2, Fascicolo 2, Amaldi Collection.

[70] "È un sistema da porci ma si possono permettere tutto quello che vogliono": Rasetti to Segrè, 4 Dec. 1951, "Giannini," Scatola 2, Fascicolo 2, Amaldi Collection. For Anderson's response to Bernard's official proposal see R. A. Anderson to Bernard, 14 Aug. 1951, "Giannini," Scatola 2, Fascicolo 2, Amaldi Collection.

The final breakthrough came on 19 November 1952. Bernard informed Rasetti that the AEC appeared willing to agree to a settlement of $300,000. As the days turned into months, Segrè became even more exasperated. But the AEC had made a final decision to pay the inventors, and it was now discussing the payment technicalities with the Treasury. In the summer of 1953 the settlement was finally effected.

Eight years after the end of World War II, each of the inventors pocketed around $28,000 after taxes. Giannini's company received the same amount of money. The only interested party who did not receive a penny in royalties was Bruno Pontecorvo, whose share was returned to the AEC and put in a bank account since he was still officially "missing." In 1955 Pontecorvo surfaced exactly where he was thought to be: in the Soviet Union, at the Dubna Institute of Physics, a circumstance that—not surprisingly—did not entitle him to collect any money.

CONCLUSIONS: THE GOVERNMENT MONOPOLY ON ATOMIC PATENTS

This essay shows that the slow neutron patent had been an important matter for Fermi during most of his career. When he first considered applying for a patent relating to the slow neutron method, its industrial possibilities were only dimly understood. Yet during the late 1930s and 1940s Fermi became increasingly aware of its importance and implications and of how it had opened a path toward the applications of nuclear energy. Thus, the patent became a further incentive to expand and focus his research as well as an opportunity to benefit from the innovations associated with applied nuclear physics. It was only in 1949—following the accusations of a conflict of interest—that the problems associated with the purchase of the patent made it a burden.[71] Even so, Fermi's patent had been an important motive for his research from its onset to the design of nuclear reactors and afterward. As the history of this patent sheds new light on Fermi's research motives, it also suggests that the study of patents can provide an innovative historical perspective by showing how private business concerns and expectations have driven important developments in the physical sciences in the twentieth century.[72]

The history of Fermi's patent also illuminates, in a very distinctive way, how the relationship between scientists, the military, and the U.S. government was shaped by disputes about intellectual ownership. Because the slow neutron patent was one of only two that received compensation, it in fact provides an almost unique opportunity for exploring how legal controversies intersected with the development of atomic research in wartime and postwar American science. This study suggests that the establishment of U.S. nuclear

[71] The atomic patent was at the center of more legal controversies. Part of the compensation deriving from the PCB was put aside to pay for proceedings against the Canadian Atomic Energy Control Board (AECB) for a similar infringement of Fermi's patents in Canada. However, in the early 1960s the Exchequer Court of Canada rejected the claim. Most harmed by the unfolding events were the managers at Philips, as the company had an exclusive right to exploit Fermi's process in Europe. When Philips heard about the AEC compensation to the inventors, it started negotiations related to these infringements first with the AEC and then with the United Kingdom Atomic Energy Authority (UKAEA). Philips representatives claimed that they should receive compensation for about $20 million from the AEC. The claim was rejected and Philips never received any money. By contrast, negotiations with the UKAEA terminated in 1958, and Philips was able to undertake a financial partnership with the UKAEA to market radioisotopes.

[72] For more details on Fermi's patent as a motivator, especially with regard to his career in the 1930s, see Turchetti, "Invisible Businessman" (cit. n. 11). This case contrasts with that of the Stanford physicists vs. Sperry described by Galison, Hevly, and Lowen. There, the management of patent issues led the scientists to experience a "loss of control" over the direction of their research; it also raised worries as to whether "selling their inventions" amounted to "selling their souls": Galison *et al.,* "Controlling the Monster" (cit. n. 4), p. 75.

programs coincided with the concentration of patents under a regime of centralized control. This centralization weakened the contractual power of individual scientists and inventors, put governmental and military research agencies in the position of patent owners, and strengthened the position of contracting corporations, which could use innovative instruments and processes under a regime of public licensing. In this respect, by looking at one specific and hitherto unexplored aspect, this work complements existing studies that have analyzed shifts in the economy of power that characterizes big science.[73]

This transition of power in connection with the management of intellectual rights unfolded in three different historical contexts and gained momentum during the war and postwar years. The wartime patent policy adopted within the Manhattan Project was molded by the belief that, during the prewar years, American corporations had been achieving a monopoly on significant inventions by building patent pools. The war emergency did little to reverse this trend, and the OSRD continued to manage innovation in a system that rewarded a very limited number of big corporations. Its patent provisions sought to accommodate the financial interests of scientists and corporations alike, but in reality they gave commercial contractors intellectual property terms more favorable than those offered to most academic scientists. In this respect the case of nuclear physics does not differ from that of other fields, such as biomedical research, where the OSRD "mediated" between corporations and scientists by adopting the existing prewar patent system. In contrast with biomedical research, however, the establishment of new secret laboratories such as that at Los Alamos was disruptive of existing relationships between nuclear physicists and their business partners, as the correspondence between Fermi, Segrè, and Giannini shows.[74] This disruption served further to strengthen the position of the military and its industrial contractors while diminishing the contractual power of scientists. Patents' assignors (or scientists) could claim compensation for the use of patents filed before the war. But although compensation was promised, it usually failed to materialize.

In theory, the establishment of a governmental agency devoted to administering all matters pertaining to nuclear energy, the Atomic Energy Commission, should have restored legality in the management of atomic patents. But in practice it eroded the contractual power of Fermi and other scientists. Many of those (including Bush, Fermi, and Compton) who had actively contributed to the war effort and had tried to "navigate" in the "agitated waters" of wartime contractual procedures were convinced that the end of the war would restore a free trading system in which big corporations, small businesses, and scientists would operate without government intervention in patent matters.[75] Bush's grand vision included the possibility of separating military/applied and basic/pure research, making it possible that those patent cases implicated in military research could all be settled and the

[73] For similar conclusions see Leslie, *Cold War and American Science* (cit. n. 8); and Rasmussen, "Of 'Small Men,' Big Science, and Bigger Business" (cit. n. 5).

[74] Wartime patent policy was a major concern for Vannevar Bush because his company, the Raytheon Corporation, had been forced out of business when General Electric and other companies formed a patent pool on vacuum tubes; see Kevles, *Physicists* (cit. n. 8), p. 345. Nonetheless, OSRD granted 40 percent of its contracts to just ten corporations, 66 percent to sixty-eight corporations: *ibid.,* p. 342. On the situation in biomedical research see Rasmussen, "Of 'Small Men,' Big Science, and Bigger Business," p. 142.

[75] As Kevles has noted: "Bush believed that the nation's prosperity would depend on small business applying new technologies in a useful manner. He thus endorsed governmental curbs on the domination of markets by large industrial combinations through patents or any other device." Kevles, *Physicists,* p. 345. Leslie also claims that Bush "always considered OSRD a strictly emergency operation and dismantled it promptly at the end of the war, despite considerable opposition from the Pentagon and the White House": Leslie, *Cold War and American Science* (cit. n. 8), p. 7.

patents compulsorily purchased. This was the reason why he (and Fermi) had supported the Johnson bill, which would have maintained military control over atomic energy but provided no specific patent provisions, in preference to McMahon's proposed law. Passage of the Johnson bill would have left the management of patents in the hands of the military, which—as Lavender clearly stated before the JCAE—already possessed sufficient authority to take these matters to a successful conclusion. And, consistent with these intentions, the initial act proposed by Bush and others that sought to establish the National Science Foundation (NSF) did not contain patent provisions either. Bush's support for a settlement of Fermi's patent at a reasonable price (Lavender may have delayed compensation or "bargained" for a better deal, but he was not hostile in principle) followed the same general idea.

Yet Bush's plan was opposed in the Congress by the competing bills of McMahon (establishing the AEC) and Kilgore (establishing the NSF). Both embodied a "socialist" vision of patent legislation pushed forward by liberals and the progressive left alike: the first included provisions that demanded a government monopoly on atomic patents and the second demanded public ownership of patents.[76] As the "socialist" vision became more powerful in Congress, it combined with the idea that all the innovations essential to industrial and military uses of atomic energy should be put under governmental control. Yet it was not this new legislation as such that obstructed the possibility of a settlement but, rather, the new administrators' approach to patent issues. Those within the AEC who took control of patent matters were far less well disposed than Bush to settle the claim. They certainly foresaw that no economic advantage could derive from the acquisition of Fermi's and others' patents, since the processes described were already used in the nuclear program. Acquisition was necessary only to prevent or avoid charges of infringement or unlawful use of patented processes. In any event, these administrators' interpretation of the new legislation and their consequent reluctance to compensate the inventors "slowed down" the whole settlement process.

Developments relating to domestic anti-Communism, and real or alleged spying activities, also cast a shadow over the resolution of these controversies. The unpredictable consequences of this situation, including Giannini's inflated judicial claim for $10 million, reflected both dissatisfaction with the negotiations and new fears and anxieties deriving from the Cold War. The history of Fermi's patent adds a new dimension to studies of political persecution in the United States during the 1950s. It shows that some of the scientists who were subjected to scrutiny during the "witch hunts" also had ongoing legal and financial issues with the U.S. government. One might then ask whether there was a connection between political repression and ongoing disputes of a legal-financial nature. The case of Bruno Pontecorvo may be an exception, as it is unlikely that other scientists

[76] Wang has correctly noted that the final NSF bill was no victory for Bush and his allies or for their adversaries: "the NSF, weakened by years of legislative delay, fell far short of the intentions of both the Bush and Kilgore camps": Wang, "Liberals, the Progressive Left, and the Political Economy of Postwar American Science" (cit. n. 8), p. 147. The system put in place demanded public ownership of patents. This functioned as a disincentive to patenting research—a complication that, as Rasmussen and Washburn have noticed, continued through the 1970s; the 1980 Bayh-Dole Act and the curtailing of public funding restored links between scientists, academia, and industrial sponsors. See Rasmussen, "Of 'Small Men,' Big Science, and Bigger Business" (cit. n. 5), p. 145; and Washburn, *University, Inc.* (cit. n. 3), p. 63. However, in an attempt to reveal the controversies that the Bayh-Dole Act has generated, this work suggests that until the new act was passed, existing patent provisions kept research free from proprietary control. My research shows that this was true only to a limited extent, as governmental control of intellectual rights greatly favored contracting corporations over the scientists working under contracts.

suspected of spying activities also had similar interests in intellectual property rights.[77] Even so, the Pontecorvo case was influential in limiting the negotiating power of Fermi and his associates, and the AEC administrators were quick to exploit it to gain more favorable conditions for the patent purchase. This suggests that political repression may well have informed similar legal arguments between scientists and the government.[78]

A final settlement occurred—by and large—because of "Atoms for Peace" and the growing interest in exploiting atomic energy for industrial purposes. Giannini's 1950 petition received considerable media coverage. Clearly, the presence of such a controversy would have upset the campaign, as well as its political and economic goals. But the settlement did little to reverse the existing trend to secure intellectual property rights in the field of atomic energy. Most "atomic patents" continued to be military secrets under AEC control until the late 1950s. Certainly, more patents could be produced, yet none could be subject to trade and their sale to the AEC was compulsory. Requesting compensation for atomic patents filed in the 1930s and 1940s was the only viable option, but the case of Fermi's patent shows the difficulties of obtaining it. Only one other set of patents (those filed by Segrè and his Berkeley associates on plutonium) were compensated by the PCB; all the other claims were rejected.[79] The final acquisition of all patents for which claims were filed was achieved by the AEC at a total cost of $700,000. The agency could then license corporations such as General Electric and Westinghouse for the trade of nuclear radioisotopes and nuclear reactors alike. This meant that costs for intellectual property rights amounted to as little as 0.005 percent of the total revenues derived from selling nuclear products abroad, whereas prewar contracts had ensured inventors no less than 5 percent of total revenues. On the whole, the governmental monopoly system on atomic patents had not diminished the contractual power of corporations; indeed, it augmented it. It did not reverse the practices of the prewar years but actually reinforced them. If a "socialist" patent regime had been put in place, then it seemed to accrue only to the advantage of big firms that exploited it once the AEC had secured intellectual property rights at bargain prices.[80]

[77] However, Wang has pointed out that some of those scientists who had originally supported the new patent provisions experienced political repression in the 1940s and 1950s. See Wang, "Liberals, the Progressive Left, and the Political Economy of Postwar American Science" (cit. n. 8), pp. 165–166.

[78] Two other interesting cases mixed political persecution and financial controversies. One relates to Hans Von Halban, who was considered a security risk by American military officers but also had interests in the patents on nuclear fission. The dismissal of Von Halban from the Anglo-Canadian nuclear program was officially attributed to the fact that he had disclosed secret information while traveling to France. Yet according to Halban this disclosure was necessary, as he had to reveal to Joliot the content of patent agreements between himself, Kowarski, and Britain's nuclear administrators; see Gowing, *Britain and Atomic Energy, 1939–1945* (cit. n. 6), pp. 209–215. The other case is that of Boris Pregel, the Russian-born U.S. sales agent involved in trading uranium during the war. On 13 February 1946 warrants were issued against Pregel on a charge of conspiracy to defraud Eldoardo, the Canadian Crown company that had supplied some of the uranium used during the Manhattan Project. The accusation came out at about the same time as the discovery of the Canadian spy ring. In this case, though the media were quick to link the two events, the Canadian government was interested in keeping the Pregel scandal, which involved financial issues, from being confused with the spying activities of covert agents. See Robert Bothwell, *Eldorado: Canada's National Uranium Company* (Toronto: Univ. Toronto Press, 1984), pp. 152–158.

[79] Even the plutonium patents' owners received compensation only after the AEC tried to acquire their patents "free of charge": Emilio Segrè, *A Mind Always in Motion* (Berkeley: Univ. California Press, 1993), pp. 246–247. Similar claims for patents on nuclear fission filed by Joliot and others were also rejected after a long court case that opposed the AEC to the French Commissariat à l'Energie Atomique; see Gilguy, "Good Example of Protection in the Nuclear Field" (cit. n. 6).

[80] This does not mean that corporations associated with the AEC were satisfied with the "socialist" patent provisions. If these provisions allowed them to dispose freely of some scientists' inventions, they still prohibited them from receiving royalties for new patents. "Atoms for Peace" also coincided with a revision of the McMahon Act that actually provided several incentives to corporations willing to invest in the nuclear industry.

The history of the neutron patent has thus been entangled with that of the atomic energy program in its military and industrial developments. If it is true—as the historian David Noble claimed in 1977—that "patents petrified the process of science" and that the "frozen fragments of genius became weapons in the armories of science-based industry," then this essay shows that the "petrification process" was a controversial one that had profound implications for the balance of economic power between atomic scientists, industry, and the nuclear state in the twentieth century.[81]

[81] David Noble, *America by Design* (New York: Knopf, 1977), p. 111.