Nominating Bridgman for the Nobel Prize: The Motives and Strategy of the Harvard Scientists

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Abstract

Percy Williams Bridgman, known for his high pressure experiment and publications in the philosophy of science, received the Nobel Prize in Physics in 1946. Although the nominators of his home institution Harvard University recognized his achievements' apparent unfitness for the prize—results of a lifelong incremental pursuit outside quantum physics—, having failed to catch up with the contemporary trend of physical research, they found Bridgman to be almost the only candidate from the university. The nomination letters, especially those by the Harvard and MIT physicists, reveal not only their esteem of their candidate's scientific research but also their evaluation of his philosophical work and contribution to solid state physics, thereby disclosing unknown aspects of the interaction between Bridgman and his colleagues.

Keywords: High Pressure Physics, Operationalism, Harlow Shapley, Massachusetts Institute of Technology

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1. Introduction

Percy Williams Bridgman (1882–1961) was a high pressure experimental physicist, known also as an originator of a tenet of the philosophy of science called operationalism, and the Nobel Laureate in Physics for 1946. Bridgman's experimental work, philosophical scrutiny of modern physics, and effort to establish theoretical research have attracted historians' attention.[1] Not much, however, has been written on how the Nobel Committee had evaluated his work until 1946, how they made decision in 1946, or who had nominated him until 1946; the fact that Bridgman's contribution was by far the largest among his contemporary high pressure scientists probably makes one lose interest in further study, though the award to a high pressure experimentalist as late as in 1946, when novel results were accumulating in nuclear and elementary particle physics, may appear somewhat unnatural.

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[1] Albert E. Moyer, "P.W. Bridgman's Operational Perspective on Physics: Part I: Origins and Development," *Studies in History and Philosophy of Science*, 22 (1991), pp. 231–258; *idem*, "P.W. Bridgman's Operational Perspective on Physics: Part II: Refinements, Publication, and Reception," *Studies in History and Philosophy of Science*, 22 (1991), pp. 373–397; Maila L. Walter, *Science and Cultural Crisis: An Intellectual Biography of Percy Williams Bridgman (1882–1961)* (Stanford, CA.: Stanford University Press, 1990); Takuji OKAMOTO, "Percy Williams Bridgman and the Evolution of Operationalism," Ph.D. dissertation submitted to The University of Tokyo, 2004, pp. 9–70. http://doi.org/10.15083/00002596

Meanwhile, the list of nominators for Bridgman for the Nobel Prize presents the notable activities concerning the Prizes for the years 1933 and 1939 (Table 1): the majority of the faculty members of the Departments of Physics at Harvard University and the Massachusetts Institute of Technology jointly nominated Bridgman. Furthermore, since these physicists stopped nominating Bridgman in 1940, the Harvard astronomer Harlow Shapley had kept nominating him almost every year until 1946. Collective or coordinated nominations like these were not rare in the history of the Prize; Elisabeth Crawford has described these activities of multiple countries and institutes, and their successes and failures.[2] However, those familiar with the development of physics in the United States in the 1930s and 1940s may find these nominations of Bridgman intriguing. In the 1930s and 1940s, when the new leaders of physical research were producing startling results in quantum physics, the Harvard scientists considered Bridgman, a classical physicist whose experimental work had little to do with fashionable contemporary theories, as their only candidate for the Nobel Prize.

In fact, since the first nomination for him for the 1919 Prize in Physics, Bridgman had remained to be almost the only candidate for the Nobel Prize from Harvard, not just in physics but also in chemistry, until 1946, when Bridgman received the prize and Harlow Shapley nominated William von Eggers Doering and Robert Burns Woodward.[3] In these boom years of physical science, scientists in and outside Harvard found only one member of the university worthy of nomination for the Nobel Prize, whether in Physics or in Chemistry, except Theodore Lyman, who was nominated in 1918 and 1926. This fact leads one to infer that the analysis of nominations of Bridgman and their institutional background may clarify his position at his home institution and the interaction between his scientific activities and their institutional milieu.

In this article, I will first show the challenges that the Harvard Physics Department faced in the 1930s and then describe how the coordinated nominations for the Nobel Prize developed at the department and the university, contrasting them with Stockholm's evaluations and the judgments of the scientists outside Harvard. By examining how Bridgman's colleagues regarded this high pressure experimentalist, how diverse the evaluations of his scholarly merit were, and how different the nominators' estimations could be from the Nobel Committee's assessments, one will come to understand better the characteristics of Bridgman's work, both experimental and philosophical, and the institutional and intellectual environment that surrounded it.

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[2] Elisabeth Crawford, *The Beginning of the Nobel Institution: The Science Prizes, 1901–1915* (Cambridge: Cambridge University Press; Paris: Editions de la maison des sciences de l'homme, 1984), pp. 87–149.

[3] *Protokoll vid Kungl. Vetenskapsakademiens sammankomster för behandling av ärenden rörande Nobelstiftelsen* (Minutes at meetings of the Royal Academy of Sciences on matters concerning the Nobel Foundation, abbreviated as *Protokoll*), 1919–1946. Courtesy of the Center for History of Science, the Royal Swedish Academy of Sciences, Stockholm.

Table 1. Nominators of Bridgman for the Nobel Prize, 1919–1946

YEAR, FIELD	NOMINATOR(S)	SPECIALITY, AFFILIATION
1919, Physics	E. C. Pickering	Director, Harvard College Observatory; Foreign Member of the Royal Swedish Academy of Sciences
1924, Physics	T. W. Richards	Harvard University, Chemistry Dept.; Nobel Laureate in Chemistry for 1914
1928, Physics	T. W. Richards	
1929, Physics	V. Carlheim-Gyllensköld H. Crew	Member of the Nobel Committee on Physics; The Stockholm Högskola Northwestern University, Physics Dept.
1930, Chemistry	C. W. Oseen	Member of the Nobel Committee on Physics; Uppsala University
1933, Physics	E. H. Hall T. Lyman G. W. Pierce F. A. Saunders E. L. Chaffee E. C. Kemble O. Oldenberg J. C. Slater G. R. Harrison M. S. Vallarta H. Nagaoka	Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. MIT, Physics Dept. MIT, Physics Dept. MIT, Physics Dept. Institute of Physical and Chemical Research, Tokyo
1934, Physics	H. W. Farwell	Columbia University, Physics Dept.
1936, Physics	R. A. Daly	Harvard University, the Sturgis Hooper Professor of geology; Foreign Member of the Royal Swedish Academy of Sciences
1939, Physics	T. Lyman F. A. Saunders E. L. Chaffee E. C. Kemble O. Oldenberg J. H. Van Vleck J. C. Slater M. S. Vallarta G. R. Harrison H. M. Goodwin	Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. Harvard University, Physics Dept. MIT, Physics Dept. MIT, Physics Dept. MIT, Physics Dept. MIT, Physics Dept.
1940, Physics	E.N.da Costa Andrade H. Shapley	University College, Physics Dept. Director, Harvard College Observatory; Foreign Member of the Royal Swedish Academy of Sciences
1941, Physics	R. A. Daly H. Shapley	
1942, Physics	E.N.da Costa Andrade W. B. Cannon	 Harvard University, Physiology Dept.; Foreign Member of the Royal Swedish Academy of Sciences
1943, Physics	H. Alfvén H. Shapley	Royal Institute of Technology
1945, Physics	G. Borelius J. R. Roebuck H. Shapley	Royal Institute of Technology; Member of the Royal Swedish Academy of Sciences Univ. of Wisconsin, Physics Dept.
1946, Physics	H. Shapley E. P. Wigner	 Princeton University

Source: *Protokoll vid Kungl. Vetenskapsakademiens sammankomster för behandling av ärenden rörande Nobelstiftelsen*, 1919–1946.

2. The Harvard Physics Department in the 1930s

The criteria for the reputation of a scientific department may vary, but the simplest and most trustful one is, in the end, the quality of research conducted by the scientists affiliated with it. At least until 1930, the research performed by the physicists at Harvard University had shown steady progress.[4] Edwin H. Hall, whose research on electric conduction in metals in 1879 resulted in the discovery of the so-called Hall Effect, was active even after his retirement from Rumford Professorship of Physics in 1921, invited to the Solvay Congress at Brussels in 1924 and the Volta Congress at Como in 1927. Theodore Lyman, who developed probing techniques in the ultra-violet region of the spectrum, also left his name in spectroscopy by discovering between 1906 and 1914 the series of hydrogen lines corresponding to the $n = 1$ quantum state, later to be called the Lyman series. F. A. Saunders was also a spectroscopist, whose work with the Princeton astrophysicist H. N. Russell introduced the concept of electron coupling in 1925, inevitably dubbed Russell-Saunders coupling, into quantum physics. William Duane remained to be a leading expert on X-ray experiment and its applications to medicine until his retirement in 1934. Theoretical physicists, the newest profession in physics in the United States, were also active at Harvard. E. C. Kemble was known for his study of quantum theory of molecular structure, and John Slater was among the few Americans who contributed to the establishment of the foundations of quantum mechanics. Both were recognized as specialists in the physics of molecules and the solid state in and outside the United States. These Harvard physicists' works, mostly related to the new development of quantum physics, obscured Bridgman's old-fashioned mechanical work in the field of high pressure, although its quality and uniqueness attracted the attention of scientists and engineers working in close fields.

Outside Harvard, however, the progress of physical research was even more remarkable. The year of 1932 might have been a year when the Harvard physicists had to face the reality that they were becoming out of fashion. Historians of modern physics often call this year "annus mirabilis"[5] because of the five startling discoveries in nuclear physics: Harold Urey at Columbia University discovered the hydrogen isotope "deuterium"; James Chadwick, the assistant director of radioactive research at the Cavendish Laboratory, demonstrated the existence of the neutron as a new constituent of the nucleus; at the same laboratory, John Cockcroft and E. T. S. Walton for the first time in the world artificially disintegrated the nuclei by bombarding light elements with accelerated protons; Carl Anderson at the California Institute of Technology found in his

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[4] Takuji OKAMOTO, "Percy Williams Bridgman and the Establishment of Theoretical Physics at Harvard," *Historia Scientiarum*, 14:1 (2004), pp. 1–48.

[5] Charles Weiner, "1932—Moving into the New Physics," *Physics Today*, 25: 5 (May 1972), pp. 40–49.

picture of cosmic rays a positively charged electron, the "positron"; and in summer, Ernest O. Lawrence, Stanley Livingston, and Milton White at Berkeley disintegrated nuclei with the cyclotron in the Radiation Laboratory. Three out of five were American scientists' achievements; furthermore, those by Anderson and Lawrence indicated the rise of the new wealthy institutions in California.

The Harvard physicists played no role in the discoveries made in 1932. Their work lay mostly in the field of atomic and molecular physics, while the novel experimental results were accumulating in nuclear physics. In theoretical physics, as well, the theory of nuclei was one of the two main concerns for physicists, the other being the formulation of quantum electrodynamics. None of the above-mentioned Harvard physicists, including Bridgman, followed these lines of research.

In 1935, while discussing the Department's budget and appointments with Saunders, then the Chairman of the Department, James B. Conant, who had been President since 1932, erupted[6]:

> It would be only fair for me to state frankly that you undoubtedly realize the Physics Department is one of the two or three in this University which have not at present a good reputation, —quite the contrary. I know I do not have to tell you that this does not represent merely a personal opinion but, unfortunately, one that is widespread.

Conant continued to point to the Department's failures in appointments he had observed, writing, "Your record of calling people to this University and of holding the best people you have had here has been very unsatisfactory." "The standing of the Physics Department in the country," added Conant, "has sunk very low."

By these harsh words, however, Conant did not intend to hint his wish to abandon the Physics Department; on the contrary, he was willingly poking his nose into the department's administration:

> You will understand, therefore, that I shall have to scrutinize every recommendation made from your Department with much more care than those from many of the others and that I shall have to bring to bear on each of your problems all the help I can muster from those outside the University as well as those inside. I hope you will excuse this somewhat unpleasant paragraph, but it is best that we be frank on such matters.

[6] Conant to Saunders, Jan. 28, 1935, "President–Appointments, etc. [1934–1935]," Box 16, Harvard University, Department of Physics, Record of the Harvard University Department of Physics (abbreviated as RHUDP), the Harvard University Archives, Harvard University, Cambridge, Mass., call number: UAV 691. Courtesy of the Harvard University Archives, Harvard University.

Conant would actively invite prominent physicists in and outside the United States to Harvard without consulting with his physicist colleagues.

The reputation of the Harvard physicists was declining, as Conant observed, because they had not followed to any degree the fashion in physics outside Harvard that had undergone rapid transformation both in its style and content. During the twenties, most of the works at the Harvard Physics Department had direct connection with the current physical theories. This was less so during the 1930s. Since roughly 1930, atomic and molecular physics had become an applied field of quantum physics, where problems left were how to apply the already established fundamental principles to each particular phenomenon. The leading edge of physical research had shifted to nuclear physics that was producing new principles and experimental facilities almost monthly.

Outside nuclear physics, the construction of quantum theory of the solid state, although less flamboyant, could have appeared fascinating to ambitious scientists. Harvard had one of a few pioneers in this field, John C. Slater.[7] However, offered by the new MIT president K. T. Compton a chance to build a new physics department as its chairman, he left Harvard in 1930. Losing his former student and excellent colleague, Bridgman expressed his impression in a letter to Lyman[8]: "it seemed to me rather strange way to begin about this laudable endeavor by taking away from us our strongest theoretical man." He was even more honest to an old friend of his[9]: "Compton stole away from us to be the head of his new physics department in M. I. T. our young Slater, who is our most brilliant member and whom it will be very difficult to replace."

In this situation, one way to update the Harvard Physics Department was to import or transplant already well-known nuclear physicists, which Conant suggested and the department eventually failed.[10] The other less costly but time-consuming way was to keep and support promising young fellows and let them pursue their own research topics. Although the department eventually opted to do this, mainly because of the influence of World War II, they would see the expected result after the war.[11]

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[7] John C. Slater, *Solid-State and Molecular Theory: A Scientific Biography* (New York: John Wiley and Sons, 1975).

[8] Bridgman to Lyman, June 29, 1930, Percy Williams Bridgman Papers (abbreviated as PWBP), the Harvard University Archives, Harvard University, Cambridge, Mass., call number: HUG 4234.8. Courtesy of the Harvard University Archives, Harvard University.

[9] Bridgman to Bobby [Robert Chandler], Aug. 31, 1930, PWBP, HUG 4234.8.

[10] Saunders to the Committee of Eight, Nov. 3, 1937, "Committees–General [1936–1937]," Box 21, RHUDP, UAV 691.

[11] Mark Gerstein, "Purcell's Role in the Discovery of Nuclear Magnetic Resonance: Contingency versus Inevitability," *American Journal of Physics*, 62 (1994), pp. 596–601. Robert V. Pound, "Edward Mills Purcell, August 30, 1912–March 7, 1997," *National Academy of Sciences of the United States*, *Biographical Memoirs*, 78 (2000), pp. 183–204. K. T. Bainbridge, E. M. Purcell, N. F. Ramsey, and K. Strauch, "Jabez Curry Street, May 5, 1906–November 7, 1989," *National Academy of Sciences of the United States of America*, *Biographical Memoirs*, 71 (1997), pp. 347–355.

In the 1930s, a possible development strategy for the Harvard Physics Department to raise their prestige and survive among the leading institutions was to utilize more effectively its own intellectual resources instead of bringing in talent from outside. If they had a colleague whose work could possibly attract general and academic attention, they would strive to promote that person's work until it would receive unquestionable evaluations and thereby improve the status of their department. This they did, and it also seems to have worked. Right before the young generation of Harvard physicists started enjoying the limelight, most welcome news reached Harvard in 1946; Bridgman received the Nobel Prize in physics for that year.

In the following, I will describe a "prehistory" of Bridgman as a nominee and then go on to analyze the development of the institutional endeavors of both the Physics Department and Harvard University.

3. The Early Nominations

Scientists working in close fields to Bridgman's held his experimental work in the highest regard, as the prizes awarded to him show: The Rumford Medal of the American Academy of Arts and Sciences in 1917, the Cresson Medal of the Franklin Institute in 1932, the Roozenboom Medal of the Netherlands Royal Academy and the Comstock Prize of the National Academy of Sciences in 1933, and the Research Corporation of America Award in 1937. Furthermore, alongside with Hall, he was one of the two American scientists invited to the Fourth Solvay Conference in 1924. In 1927, although he could not attend, he was invited to the Volta Centenary in Como, again with Hall.[12]

The Harvard scientists started nominating Bridgman for the Nobel Prize in the late 1910s. Edward C. Pickering, Director of the Harvard College Observatory, was the first to nominate Bridgman for the Nobel Prize in Physics. Between 1917, when he became a foreign member of the Royal Swedish Academy of Sciences,[13] and 1919, the year of his death, he qualified to nominate candidates every year. Although for both 1918 and 1919 Pickering nominated Bridgman for the Physics Prize, the first nomination letter arrived in Stockholm after the deadline (the end of January) and was applied to the following year.[14] For that same year, Pickering and another Harvard scientist T. W. Richards, who was the Nobel Laureate in Chemistry for 1914, nominated an Oxford scientist W. H. Perkin for the Chemistry Prize.

Having attempted to secure financial aid for Bridgman since he was a graduate

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[12] Edwin C. Kemble and Francis Birch, "Percy Williams Bridgman, 1882–1961," *National Academy of Sciences of the United States*, *Biographical Memoirs*, 41 (1970), pp. 23–67

[13] C. Skottsberg, *Kungl. Svenska Vetenskapsakademien*, *Personförteckningar 1916–1955* (Stockholm: Almqvist & Wiksells Boktryckeri AB, 1957), p. 36.

[14] E. C. Pickering, Dec. 18, 1917; Nov. 20, 1918, *Protokoll*, 1919.

student,[15] Pickering comprehended Bridgman's work well. During World War I, while serving as an advisor to the U. S. Navy, Pickering had a chance to recognize other aspects of Bridgman's scientific expertise, which he applied for sound detection for antisubmarine warfare.[16] Pickering attached to his recommendation letters a brief summary of Bridgman's work with high hydrostatic pressures until 1913, describing the maximum pressures the candidate had reached (30,000–40,000 kg/cm^2) and several results of his measurement, including his discovery of the five kinds of ice. Pickering added that Bridgman was the type of man Alfred Nobel would have liked to aid. However, he might have misunderstood the character of the prize: The Nobel Foundation had made clear that the prize would be awarded for established results, not for promising but uncompleted research. In 1919, although the Nobel Physics Committee took note of Pickering's nomination of Bridgman, it suspected that the value of his research had not yet become clear enough.[17]

In 1924, T. W. Richards nominated Bridgman for the Physics Prize for the first time. Since 1909 until his death in 1928, Richards had faithfully responded to the Nobel Committee's invitations to nominate candidates. After R. A. Millikan, whom Richards nominated for the Physics Prize for the years 1919, 1920, and 1922, finally received the prize in 1923, Richards nominated Bridgman in 1924 and 1928.[18] His 1924 nomination letter described Bridgman's discovery of new modifications of several substances under high pressures, including the very dense form of phosphorus called "black phosphorus." Yet Richards might have overemphasized the chemical aspects of the candidate's research. On September 13, 1924, the Physics Committee reported that Bridgman's research was more important in chemistry than in physics.[19]

Unsatisfied with the failure of his 1924 nomination, Richards further detailed in his 1928 letter the merits of Bridgman's research, mentioning its implication in the theoretical considerations on the nature of cohesion, which an influential Swedish chemist and Nobel Chemistry Committee member Svante Arrhenius had presented to Richards at the meeting of the Royal Swedish Academy in September 1922. Responding to Richards' second nomination of Bridgman, a member of the Nobel Physics Committee and geophysicist at the Stockholm Högskola, Vilhelm Carlheim-Gyllensköld, submitted a long report on Bridgman's research to the committee.[20] Although in 1928 the committee

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[15] Walter, *Science and Cultural Crisis*, *op. cit*., p. 47.

[16] Peggy Aldrich Kidwell, "Harvard Astronomers and World War II—Disruption and Opportunity," in Clark A. Elliott and Margaret W. Rossiter, eds., *Science at Harvard University: Historical Perspectives* (Bethlehem: Lehigh University Press; London and Toronto: Associated University Press, 1992), pp. 285–302, p. 286.

[17] Nobel Committee for Physics, "Till Kugl. Vetenskapsakademien," Sept. 15, 1919, p. 1, *Protokoll*, 1919.

[18] T. W. Richards, Jan. 3, 1924, *Protokoll*, 1924; Jan. 5, 1928, *Protokoll*, 1928.

[19] Nobel Committee for Physics, "Till Kungl. Vetenskapsakademien," Sept. 13, 1924, p. 4, *Protokoll*, 1924.

[20] V. Carlheim-Gyllensköld, "Kort översikt av P. W. Bridgmans undersökningar av flytande och fasta kroppars förhållande under höga tryck," *Protokoll*, 1928.

reported that since the last nomination in 1924 Bridgman had not achieved any new result worthy of the prize, the following year Carlheim-Gyllensköld, probably having recognized the significance of Bridgman's research while preparing a report on it, nominated Bridgman.

Besides Carlheim-Gyllensköld, Henry Crew, Fayerweather Professor of Physics at Northwestern University,[21] nominated Bridgman for the 1929 Physics Prize.[22] As the Chairman of the Physics Department, Crew responded to the Nobel Physics Committee's invitation to the nomination for that year. While Crew only briefly outlined Bridgman's work, Carlheim-Gyllensköld's nomination letter compared Bridgman's achievement with that of Gustav Tamman, a German chemist at Göttingen known for his high pressurse experiment and frequently nominated for the Chemistry Prize, and underlined the former's systematic approach.[23] This year, Carlheim-Gyllensköld again submitted a short report on Bridgman's research.[24] The Physics Committee, nevertheless, doubted whether the significance of Bridgman's results would remain stable in the light of rapid development of atomic and electronic physics.[25]

The following year, having judged Bridgman's work as belonging to chemistry, another member of the Physics Committee and physicist at Uppsala University, C. W. Oseen, nominated Bridgman for the Chemistry Prize.[26] Oseen attached Carlheim-Gyllensköld's report on Bridgman's research to his own nomination letter. This recommendation of the members of the Physics Committee only seems to have dismayed the Chemistry Committee.[27]

As Carlheim-Gyllensköld's nominations show, by the late 1920s, not only the Harvard scientists but physicists outside Harvard and America had recognized the significance of Bridgman's research. Furthermore, among the physical scientists at Harvard, Bridgman was almost the only candidate for the Nobel Prizes in physics and chemistry. Other than Bridgman, only Lyman was nominated for the prize in 1918 and 1926. During the 1920s, however, favoring atomic and electronic physics, the majority of the Nobel Physics Committee and the nominators for the Physics Prize did not seriously consider Bridgman as a strong candidate. They would remain so for the following decade, as even more noticeable results appeared successively outside high pressure physics. Bridgman's colleague at Harvard, Theodore Lyman, also followed this tendency during the 1920s: Responding to the Nobel Committee's invitations as the Director of the

[21] William F. Meggers, "Henry Crew, June 4, 1859-February 17, 1953," *National Academy of Sciences of the United States of America*, *Biographical Memoirs*, 37 (1964), pp. 33–54.

[22] Henry Crew, Nov. 5, 1928, *Protokoll*, 1929.

[23] V. Carlheim-Gyllensköld, Jan. 30, 1929, *Protokoll*, 1929.

[24] V. Carlheim-Gyllensköld, "Kompletterande utredning om P. W. Bridgman," *Protokoll*, 1929.

[25] Nobel Committee for Physics, "Till Kugl. Vetenskapsakademien," Sept. 27, 1929, p. 9, *Protokoll*, 1929.

[26] C. W. Oseen, Dec. 14, 1929, *Protokoll*, 1930.

[27] Nobel Committee for Chemistry, "Till K. Vetenskapsakademien," Sept. 30, 1930, pp. 3–4, *Protokoll*, 1930.

Jefferson Laboratory, Lyman nominated Einstein for 1921, R. W. Wood for 1924 and 1927.

The nominators for Bridgman in the 1920s did not oversensitively react to newly emerging research topics in physics: Pickering was an astronomer born in 1846, and Richards a chemist born in 1868. Carlheim-Gyllensköld, born in 1859, was old enough to maintain his own standard without being distracted by the current trend in physics, as shown by the proposal of his dismissal in 1930 from the Nobel Physics Committee, submitted by two other committee members, Oseen and Manne Siegbahn.[28]

4. Bridgman and the Harvard Physics Department in the 1930s

In the 1930s, Bridgman started to modify his high pressure apparatus and entered a new phase of research. In 1935, he reached 50,000 kg/cm^2 by making the external surface of the pressure vessel conical like a wedge and pushing the whole vessel into an external conical supporting sleeve (Figure 1).[29] In 1940, he produced 100,000 kg/cm^2 and even higher pressures by immersing the entire pressure apparatus in a fluid bearing a hydrostatic pressure as high as 30,000 kg/cm^2.[30] Since no steel stood this pressure range, he adopted a cemented-carbide alloy called Carboloy for making pistons.[31] The new apparatus enabled him to collect systematic data of volumetric effects and to determine the thermodynamics parameters of the transitions of some 75 substances by 1942.[32]

Having discovered new forms of various substances under high pressures, Bridgman realized that few of the minerals common at the earth's surface remain stable under the even higher pressures of its interior. The Harvard geologist Reginald A. Daly, who happened to be Bridgman's friend and neighbor,[33] frequently visited Bridgman's

[28] Robert Marc Friedman, *The Politics of Excellence: Behind the Nobel Prize in Science* (New York: Times Books, Henry Holt and Company, 2001), pp. 169–170.

[29] P. W. Bridgman, "Polymorphism, Principally of the Elements, up to 50,000 kg/cm^2," *Physical Review*, 48 (1935), pp. 893–906.

[30] P. W. Bridgman, "New High Pressures Reached with Multiple Apparatus," *Physical Review*, 57 (1940), pp. 342–343. The maximum pressure Bridgman actually produced would later prove to be 70,000 kg/cm^2. Because of his erroneous gauge, Bridgman systematically overestimated the pressures he reached.

[31] For Carboloy, see, William D. Nix, "Zay Jeffries, April 22, 1888–May 21, 1965," *National Academy of Sciences of the United States of America*, *Biographical Memoirs*, 2013 (http://www.nasonline.org/publications/biographical-memoirs/memoir-pdfs/jeffries-zay.pdf), p. 9, (accessed 8 Aug. 2020).

[32] P. W. Bridgman, "Polymorphic transitions of inorganic compounds to 50,000 kg/cm^2," *Proceedings of the National Academy of Sciences of the United States*, 23 (1937), pp. 202–205; "Polymorphic Transitions of 35 Substances to 50,000 kg/cm^2," *Proceedings of the American Academy of Arts and Sciences*, 72 (1937), pp. 45–136; "Rough Compressibilities of Fourteen Substances to 45,000 kg/cm^2," *Proceedings of the American Academy of Arts and Sciences*, 72 (1938), pp. 207–225; "Compressions and Polymorphic Transitions of Seventeen Elements to 100,000 kg/cm^2," *Physical Review*, 60 (1941), pp. 351–354; "Pressure-Volume Relations for Seventeen Elements to 100,000 kg/cm^2," *Proceedings of the American Academy of Arts and Sciences*, 74 (1942), pp. 425–440.

[33] Francis Birch, "Reginald Aldworth Daly, May 19, 1871-September 19, 1957," *National Academy of Sciences of the United States of America*, *Biographical Memoirs*, 34 (1960), pp. 31–64.

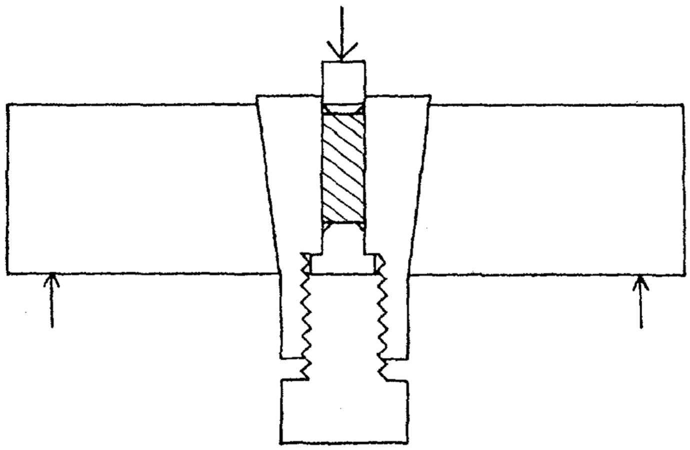

Fig. 1. The New Arrangement of the Conical Pressure Vessel and the External Sleeve
The internal vessel behaves like a wedge with its side pressed by the external sleeve.
Source: P.W. Bridgeman, "Polymorphism, Principally of the Elements, up to 50,000 kg/cm^2," *Physical Review*, 48 (1935), pp. 893–906, p. 894.

laboratory and raised the physicist's awareness of the importance of his high pressure experiments for geology and geophysics. In 1930, the Committee for Experimental Geology and Geophysics was formed at Harvard, whose members included Daly, Harlow Shapley, geologists L. C. Graton and D. H. McLaughlin, and a chemist G. P. Baxter. Bridgman also took an active part in this committee, while he seldom attended any other committee meetings. Some of Bridgman's doctoral students became high pressure specialists in geophysics and geology. In 1933, for example, having acquired high-pressure technique at Bridgman's laboratory, Francis Birch started to lead the geophysics program at Harvard.[34]

Since its beginning, Bridgman's research had been progressing outside major contemporary research interests.[35] While the other Harvard physicists' works were fashionable during the twenties and became obsolete after that, Bridgman's work did not undergo such vicissitudes. Bridgman continued to be almost the only pioneer in his field. Launched with an accidental discovery that had little to do with the interests of contemporary scientists, his research developed with minimal contact with other fields in physics. The advent of quantum mechanics did not immediately induce theoretical research referring to physical phenomena under high pressures. In another light, nevertheless, this characteristic of his research was merit. Although it stayed unfashionable, Bridgman's research, recognized as technically challenging by specialists

[34] Thomas J. Ahrens, "Albert Francis Birch, 1903–1992," *National Academy of Sciences of the United States of America*, *Biographical Memoirs*, 74 (1998), pp. 3–24.

[35] Okamoto, "Percy Williams Bridgman and the Evolution of Operationalism," *op. cit.*, pp. 9–70.

in related fields, never experienced the embarrassment of becoming outdated, always keeping the attention of a certain, albeit not large, number of scientists and engineers. He could conduct and enjoy his research at his own pace.

Furthermore, the results of Bridgman's work were easier to understand than other types of research, especially to the general public, since it dealt with one of the physical quantities most familiar to human beings, pressure. He therefore did not have to suffer from being totally neglected. His main scientific contribution rested on his skills in reaching unprecedentedly high pressures that one could comprehend as easily as the feats of the Wright Brothers or Thomas Edison.

In the late 1920s, Bridgman started another activity that might enhance his reputation even more than his experimental work did. In 1927, Bridgman published *The Logic of Modern Physics*,[36] which was to make his name known during the thirties outside the academic community. Even before this, in 1922, he published his criticism of the fundamental concepts of physics, *Dimensional Analysis*,[37] also read widely among scientists. *The Logic of Modern Physics* received mostly favorable response from a large variety of critics, chosen "among the 40 most important books selected by the American Library Association."[38] The readers were not just in the English speaking population. The German translation appeared in 1932.[39] Furthermore, philosophers like Herbert Feigl, who found the similarities between Bridgman's operationalism and logical positivism, made Bridgman's name and work known to scholars outside natural science.[40]

After *The Logic of Modern Physics* was published, Bridgman was sometimes invited to deliver lectures on the philosophy of science, a rare honor for an experimental physicist. During the summer of 1928, he gave lectures at Columbia University at the invitation of George Pegram,[41] and, although he declined, in 1930 he was offered a one-semester lectureship at the Department of Philosophy at the University of California, Berkeley.[42] Whether he liked it or not, Bridgman started to be recognized also as a philosopher of science.

By 1930, when the Harvard Physics Department was already aware that Bridgman was the best-known Harvard physicist, an event took place that highlighted this fact more vividly. Since this year K. T. Compton agreed to serve as the President at MIT and left Princeton University, the latter offered Bridgman a research professorship with no regular teaching duties.[43] Bridgman did not accept this offer, but used the opportunity to get an

[36] Percy Williams Bridgman, *The Logic of Modern Physics* (New York: Macmillan, 1927).
[37] Percy Williams Bridgman, *Dimensional Analysis* (New Haven: Yale University Press, 1922, 1931).
[38] Walter, *Science and Cultural Crisis*, *op. cit*., p. 113.
[39] W. Kampf trans. *Die Logik der heutigen Physik* (Munich: Max Huebner, 1932).
[40] Okamoto, "Percy Williams Bridgman and the Evolution of Operationalism," *op. cit*., pp. 290–292.
[41] Walter, *Science and Cultural Crisis*, *op. cit*., p. 130.
[42] Wilson to Bridgman, May 6, 1930, PWBP, HUG 4234.8.
[43] Bridgman to Bobby (Robert Chandler), Aug. 31, 1930, PWBP, HUG 4234.8.

explicit statement from the university administration that he be awarded the position he had long wanted, a professorship without teaching and an increase in his salary, from $8,500 to $12,000. This is an example of his own efforts to secure a favorable position at the Department for his research.

The Physics Department strived to support every aspect of Bridgman's activity. For example, it strenuously protected Bridgman's special habit of teaching. Bridgman regularly held his courses between 8:30 and 10:00 in the morning against a Faculty rule of long-standing that no classes should be held between 8:40 and 9:00, so that classes would not conflict with the chapel service.[44] Bridgman, who did not go to church, did not observe this rule. The university authorities had several times asked the chairman of the department, Saunders, to tell Bridgman to find some other hours for his classes. Every time the Dean of the Faculty warned him, Saunders explained Bridgman's special position at the department and asked for permission for him not to change the hours. For example, in 1935, Saunders wrote[45]:

> Professor Bridgman is in a peculiar situation in that he is not required to do any teaching and he tells me that these are the only hours at which he is willing to teach. We consider him to be our best man and think it would be very unfortunate to do anything to diminish the hours of teaching we secure from him, and I do not see that any sensible objection can be raised to allowing him to choose these hours.

Recognizing Bridgman as the best researcher and best teacher for the courses he taught, the department let him choose the hours at his convenience.

Furthermore, the department backed up Bridgman's research despite the continuing financial problems it faced. In 1930, when Frank B. Jewett, the Chairman of the Milton Fund Committee, asked Lyman to reduce the number of the applicants from the Harvard Physics Department for the fund, Lyman replied[46]: "I beg of you most earnestly to continue the grant of the Milton Committee to Professor Bridgman; I am perfectly sure that the money of the Committee cannot possibly be better invested." In 1932, he again sent a letter in the same tone[47]: "As far as I can learn, Bridgman's application is the only one from this Department this year. If you take this into consideration and add to it the fact that Bridgman is probably one of the most distinguished scientific men we have in the whole university, I hope you will feel that the Committee can make the grant which

[44] Moore to Lyman, April 6, 1921, "Physics Laboratories Director's Correspondence, 1910–1938," (abbreviated as PLDC), M, 1910–1938, Boxes 123–124, RHUDP, UAV 691.

[45] Saunders to Murdock, Jan. 25, 1935, "Dean of Faculty of Arts and Sciences [1934–1935]," Box 15, RHUDP, UAV 691.

[46] Lyman to Jewett, Jan. 24, 1930, PLDC, J, 1910–1938, Box 121, RHUDP, UAV 691.

[47] Lyman to Jewett, Jan. 14, 1932, PLDC, J, 1910–1938, Box 121, RHUDP, UAV 691.

Professor Bridgman requests." Jewett also admitted that he personally had "the very highest regard for him and his work."[48] On April 14, 1934, when Lyman applied to the fund of the Carnegie Corporation to pay the salary of Bridgman's trained laboratory assistant, he numbered Bridgman "among the first half dozen scientific men of this county."[49] On April 20, he changed his words and numbered him "among the first eight or ten leading scientists of this country."[50] He also explained that "The President of the University [Conant] recognizes the importance of the matter and in the future I have every reason to believe that the University will assume the burden [of sustaining Bridgman's research]."

5. The Nominations by the Department

The most telling fact that depicts the departmental effort to support Bridgman's research and raise his status would be that for the years 1933 and 1939 the Physics Department almost unanimously recommended him for the Noble Prize. To the invitations for the Harvard Physics Department to join the nomination for the years 1921, 1924, and 1927, the Director of the Jefferson Laboratory, Lyman responded by himself. For the invitations for the years 1933 and 1939, however, the department changed the interpretation of the word "invitation" and included members other than the chairman in the nomination of Bridgman. Moreover, both nominations involved the MIT Physics Department, which happened to be invited for the same years. The chairman of the MIT Physics Department was Slater, who had earned his Ph. D. under Bridgman's auspices and had cooperated with him in constructing a theoretical group at Harvard until 1930.

In order to counter its continuing downturn in status during the 1930s, the Harvard Physics Department needed to take countermeasures. Their strategy was to raise Bridgman's prestige as a physicist and thereby reverse the department's decline in the American academic community. The Harvard physicists regarded Bridgman as the most hopeful candidate for the Nobel Prize among them. The MIT physicists cooperated with its neighbor physics department in the effort of winning the prize for Bridgman.

Among the Harvard and MIT physicists, those who were not actively attending the administrative meetings did not join this Harvard–MIT lobbying. For the 1933 prize, K. T. Compton, then the President of MIT, recommended Irving Langmuir, and William Duane, a senior member of the Harvard Department, nominated C. J. Davisson. Compton was busy with the administrative matters, and Duane, having had diabetes for a long time, had not been able to join the meetings at the department.[51] For the 1939 prize, G. W.

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[48] Jewett to Lyman, Jan. 15, 1932, PLDC, J, 1910–1938, Box 121, RHUDP, UAV 691.

[49] Lyman to Janes, April 14, 1934, PLDC, J, 1910–1938, Box 121, RHUDP, UAV 691.

[50] Lyman to Keppel, April 20, 1934, PLDC, K, 1910–1938, Box 121–122, RHUDP, UAV 691.

[51] Percy Williams Bridgman, "William Duane, 1872–1935," *National Academy of Sciences of the United States of America*, *Biographical Memoirs*, 18 (1938), pp. 23–41.

Pierce, who was to retire soon, did not join the nomination, and Compton recommended E. O. Lawrence.

The Harvard physicists' nomination letter for the 1933 prize[52] explained that they recommended the award to Bridgman "not because of any one discovery or determination of fact" that he had made, but "rather upon the broad ground of his great achievements in experimental research of a fundamental character" and "his outstanding contributions to scientific theory and philosophy." In support of their recommendation, they listed the following books Bridgman had written: *Dimensional Analysis* and its German translation,[53] *A Condensed Collection of Thermodynamics Formulas* and its French translation,[54] *The Logic of Modern Physics* and its German translation,[55] and *The Physics of High Pressure*.[56] The Harvard Physics Department counted Bridgman's philosophical contributions as scientific achievements.

The letter described Bridgman's experimental work by following *The Physics of High Pressure*, explaining the "principle of the unsupported area" and pointing to his discoveries and measurements. They specified no single discovery as responsible for the recommendation but considered the whole of his long-standing experimental research as worthy of the nomination. As "testimony to the extraordinary esteem in which Bridgman's experimental work is held," the faculty indicated that "the Handbuch Der [*sic*] Experimental Physik, in Band 8, Teil 2, devotes more than 150 pages, pp. 245–400, to an account of his high pressure investigations." The letter further emphasized his fame outside the scientific community: "But if he had never done any experimental work his books on Dimensional Analysis and The Logic of Physics [*sic*] would be enough to bring him world-wide fame, as one of the profoundest and most stimulating thinkers in the field of modern science."

Hall showed the letter to Bridgman, writing, "Whether you receive the Nobel prize or not, the letter itself will, I hope, give you and your family a measure of permanent satisfaction."[57] He might also have sent a notice to the science editor of the *New York Times* to distribute information of Bridgman outside Harvard: In November 1933, the news that he was to be kept on file against a possible Noble Prize award spread in the United States.[58]

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[52] E. H. Hall, Theodore Lyman, George W. Pierce, Frederick Saunders, E. Leon Chaffee, Edwin C. Kemble, and Otto Oldenberg to the Nobel-Committee for Physics, Nov. 9, 1932, "Bridgman, P. W. [1932–1934]," Box 11, RHUDP, UAV 691.

[53] P. W. Bridgman, *Dimensional Analysis* (Yale University Press, 1922, reprinted in 1931); German translation, Teubner, 1932.

[54] P. W. Bridgman, *A Condensed Collection of Thermodynamics Formulas* (Harvard University Press, 1925); French translation, Camus et Carnet, Lyon, 1927.

[55] Bridgman, *The Logic of Modern Physics*, *op. cit*.; German translation, Max Huebner, Munich, 1932.

[56] *The Physics of High Pressure* (London: Bell & Sons; New York, Macmillan, 1931).

[57] Hall to Bridgman, Nov. 21, 1932, "Bridgman, P. W. [1932–1934]," Box 11, RHUDP, UAV 691.

[58] Saunders to Nichols, Nov. 3, 1933, "Bridgman, P. W. [1932–1934]," Box 11, RHUDP, UAV 691.

The nomination letter of the MIT physicists, probably written by Slater, specified Bridgman's discoveries concerning the properties of metals and crystals under high pressures as the most notable among his achievements, while pointing the Nobel Physics Committee to such issues as the compressibility of liquids and gases, polymorphic transitions, and the remarkable small discontinuities in the physical properties of substances, which the nominee's experimental research had recently elucidated.[59] Observing that physics was turning toward "chemistry and the properties of matter," the letter further summarized the "immediate importance of Bridgman's work":

> Both theoretical physics, wave mechanics and its applications, and experimental physics, with its many new techniques, are making rapid strides in that direction. Many investigators are working along the line of matter under unusual conditions—in gaseous discharges, for instance. But some of the most fundamental questions which we may expect to have solved in the next few years, on which much theoretical labor is now being expended, are those of ordinary matter, solids, liquids, gases, and their physical and chemical properties. Progress in the theory of these questions must be based on experiment. And in the experimental investigation of matter in bulk, matter of all sorts, under all sorts of external influence, Bridgman is, in our opinion, one of the most distinguished of living physicists, with as fine a list of achievements, and as great promise of still further contributions in the future, as any.

The MIT physicists, including Slater, a specialist in chemical and solid state physics, could single out no specific connection between Bridgman's work and the rapid progress of theoretical research, only presenting a general principle that progress in physical theory "must be based on experiment." Even they found it difficult to relate Bridgman's work directly to the current growth of theoretical research induced by the advent of quantum mechanics.

The MIT physicists explicitly admitted their cooperation with their neighbor: Their letter did not accompany Bridgman's publications, since, as they explained, they knew of their Harvard colleagues' nomination of Bridgman.

For the 1933 prize in physics, a Japanese physicist Hantaro Nagaoka also nominated Bridgman. Nagaoka had been familiar with Bridgman's research since he had a mechanic of the Institute of Physical and Chemical Research sent to Bridgman's laboratory to learn the high pressure technique a few years after World War I. Nagaoka, known for his theory of atomic structure, had also been active in seismology and geophysics. In the late 1920s

[59] George R. Harrison, John C. Slater, and M. S. Vallarta, Jan. 12, 1933, *Protokoll*, 1933.

and early 1930s, he had an opportunity to appreciate Bridgman's high pressure research more thoroughly, as the researchers of his laboratory measured densities of metals and minerals under the pressure of 20,000 kg/m^2.[60] In his nomination letter, Nagaoka praised Bridgman for his "assiduous toil" and "pertinacity of work," though he pointed out that there was "no startling achievement" in his candidate's career.[61]

From 1914 to 1940, Nagaoka nominated ten candidates for the Nobel Prize in Physics. Eager to gather a wide range of nominations, the Nobel Physics Committee trusted this internationally well-known Japanese physicist and invited him to the nomination every year between 1930 and 1950. Notably, all of Nagaoka's candidates, from H. Kammerlingh Onnes, whom Nagaoka, responding to the invitation to the Physics Department at Tokyo Imperial University, nominated for the prize for the first time in 1914, to Hideki Yukawa, the only Japanese Nagaoka ever nominated, eventually received the prize. The nomination by Nagaoka, a non-Western physicist with a critical eye, shows the worldwide high esteem of Bridgman's work.

Observing the sudden increase in the nominators for Bridgman in 1933, the Nobel Physics Committee again asked Carlheim-Gyllensköld to submit a report on the candidate's work. Although Carlheim-Gyllensköld, quoting Bridgman's own words, explained that his work had given ample data for the contemporary theoretical research,[62] the committee judged the candidate's contribution to atomic physics as unclear and therefore not worthy of the prize.[63] Their conclusion this time was that Bridgman's research was of little relevance to the latest theoretical development.

The nominations of Bridgman by Harmon W. Farwell at Columbia University in 1934 and by Daly in 1936 and 1941 reflected the importance of high pressure experiment in geophysics. Farwell's letter referred to Bridgman's activity in the study of the earth's interior.[64] While in 1936 Daly merely described Bridgman's results as fundamental, explaining that "all but an insignificant fraction of the matter of the universe is at high pressure,"[65] in 1941 he praised that Bridgman had been providing useful data for geophysicists in general.[66] Moreover, Daly's nominations prove that Harvard's effort for winning the prize for Bridgman could continue even when the Physics Department did not receive the invitation from Stockholm. Daly had been a foreign member of the Royal Swedish Academy of Sciences, therefore qualifying to nominate candidates for the Nobel

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[60] Kiyonobu Itakura, Tosaku Kimura, and Eri Yagi, *Nagaoka Hantaro Den* (Tokyo: Asahi Shimbun Sha, 1973), pp. 440, 530.

[61] Hantaro Nagaoka, Dec. 29, 1932, *Protokoll*, 1933.

[62] V. Carlheim-Gyllensköld, "Utredning beträffande P. W. Bridgmans till pris föreslagna arbeten," *Protokoll*, 1933.

[63] Nobel Committee for Physics, "Till Kugl. Vetenskapsakademien," pp. 5–6, *Protokoll*, 1929.

[64] H. W. Farwell, Jan. 1, 1934, *Protokoll*, 1934.

[65] R. A. Daly, Jan. 31, 1935, *Protokoll*, 1936.

[66] R. A. Daly, Dec. 4, 1940, *Protokoll*, 1941.

Physics and Chemistry Prizes every year since 1934. In the 1940s, after the Harvard and MIT physicists stopped nominating Bridgman, the Harvard scientists outside the Physics Department who were foreign members of the Swedish Academy as well would take up the lobbying for Bridgman's prize.

In 1938, before giving up on the plan totally, the Harvard Physics Department again made a coordinated effort for Bridgman's Nobel Prize for the year of 1939. The Department's nomination letter[67] pointed to Bridgman's discoveries made in 1932: the discovery of the occurrence of explosive chemical reactions due to the simultaneous application of hydrostatic pressure and shearing stress; the discovery of a complex "fine structure" of second order changes in the compressibility of various substances under pressure; and finally his pressure record, 50,000 kg/cm^2, reached around 1932. Struggling to correlate the candidate's research with recent developments in theoretical physics, the letter ended up with blaming the immaturity of quantum physics: "His experimental work at high pressures is of the greatest importance for the development of our understanding of the solid state, but until recently the modern quantum-mechanical theory of solids has not been sufficiently advanced to make much use of his extended data." Although it explained that Bridgman's work had not been concentrated in any single astonishing discovery, the Harvard physicists, who were more cautious than in 1932, attached a commentary: "For that reason a narrow interpretation of the statutes of the Nobel Foundation might exclude him. Nevertheless we feel that the value and significance of his total achievement are so extraordinary that his case merits the serious consideration of the Committee."

The three books Bridgman published after 1932 were listed in the letter, and two out three were on philosophical and social subjects: *The Nature of Physical Theory*[68] and *The Intelligent Individual and Society*.[69] The letter valued Bridgman's work in these lines:

> Along with this experimental work Professor Bridgman has exerted a powerful influence on the development of physics by his penetrating critical papers. His first great contribution in this direction was the rescue of the subject of dimensional analysis from the realm of mysticism by his book on that subject. This was the beginning of an extended series of papers and books analyzing fundamental concepts in physics, mathematics, etc., from the standpoint of their operational meaning. These contributions have attracted wide-spread attention and have had a clarifying influence, expecially [*sic*] in physics.

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[67] Lyman, Saunders, Chaffee, Kemble, Oldenberg, and Van Vleck to The Nobel-Committee for Physics, Dec. 21, 1938,"Bridgman, P. W. [1938–1939]," Box 27, RHUDP, UAV 691.

[68] Percy Williams Bridgman, *The Nature of Physical Theory* (Princeton: Princeton University Press, 1936).

[69] Percy Williams Bridgman, *The Intelligent Individual and Society* (New York: Macmillan, 1938).

This time, possibly aware of Bridgman's interaction with European philosophers, the Harvard physicists specifically mentioned their candidate's operational stance.

The MIT physicists again cooperated. They started their letter by contending the importance of solid state physics, complaining the Nobel Committee's relative disregard of this field as compared with nuclear physics. During the 1930s, before nuclear physicists joined in, the MIT Physics Department, mainly organized by Slater, was one of the two centers of solid state physics in the United States. Observing that "[n]o recent awards of the Nobel Prize have been made to workers in the field of solids," they nominated Bridgman as the experimentalist who had made the greatest contribution to this branch of natural science.[70] To them, Bridgman was the most hopeful candidate from solid state physics, whether theoretical or experimental. Besides the intrinsic value of the candidate's work and possible consideration of the institutional, geographical, and personal closeness to Harvard, the MIT physicists found boosting solid state physics as their own inducement to join in the nomination of Bridgman. This time again, nevertheless, they failed to indicate any direct connection between Bridgman's experiment and the contemporary achievements in quantum theory of solid state.

Receiving the second coordinated nomination letters for Bridgman from Harvard and MIT, the Nobel Committee assigned C. W. Oseen to survey the candidate's work. Oseen reported on Bridgman's experimental and philosophical activities, concluding that Bridgman's results did not contain a major "discovery or invention" that Alfred Nobel had specified in his will as prize-worthy.[71] Furthermore, three months later Oseen submitted another short notice that Thomas C. Poulter and Watson Davis in the United States and James Basset in France had achieved the pressure of 100,000 kg/cm^2 after Oseen had sent the first report in March, concluding that Bridgman was no longer the only leading figure in high pressure physics.[72]

6. The University's Strategy for Winning the Prize

After the two failures in lobbying, the Harvard Physics Department stopped nominating Bridgman. In 1943, to the invitation for nomination by the Nobel Committee, only Van Vleck, who was to succeed Kemble in 1945 as the Chairman of the Department, responded and recommended Wolfgang Pauli for the Physics Prize, since, he explained, no law of nature seemed to him more basic than Pauli's Exclusion Principle. In his nomination letter, Van Vleck clearly stated his understanding of the Nobel Prize that it is awarded for a discovery of fundamental importance, not for "merely a sustained research

[70] John C. Slater, Manuel S. Vallarta, George R. Harrison, and Harry M. Goodwin, Nov. 29, 1938, *Protokoll*, 1939.

[71] C. W. Oseen, "Kompletterande utredning om P. W. Bridgman," Mar. 24, 1939, *Protokoll*, 1939.

[72] C. W. Oseen, "Tillägg," July 12, 1939, *Protokoll*, 1939.

program."[73] One can infer what Van Vleck intended to imply by "a sustained research program" by reading a sentence in an obituary he would write almost two decades later: "It is notable that this award [the Nobel Prize] to him [Bridgman] was for a sustained research program over a period of years rather than one particular sudden discovery."[74] By 1943, the Harvard physicists had recognized that Bridgman's had little chance to win the Nobel Prize because of the lifework nature of his research. Moreover, since 1941, the research and teaching for the defense work had occupied most of the Harvard and MIT physicists' time, having turned away their attention from the lobbying for the prize.

Another factor that discouraged the Harvard Physics Department from repeating a nomination of Bridgman may have been that no one at the Department had a permanent nominating right for the Nobel Prize: Among the Americans, only previous winners of a Nobel Prize in Physics or Chemistry and foreign members of the Royal Swedish Academy of Sciences were entitled to nominate candidates every year without being invited by the Nobel Committees. The Harvard and MIT Physics Departments could send nomination letters only for the years when the Nobel Committee invited them. Coordinating an effective lobbying was unreachable for the Harvard physicists, since they could not previously know when the invitation would come. There were, however, a few foreign members of the Academy at Harvard, as we have already seen. The most influential scientist among them, Harlow Shapley, would take up the lobbying during the first half of 1940s.

Having become foreign member of the Royal Swedish Academy of Sciences in 1938, Shapley sent a nomination of Bridgman for the Nobel Prize in Physics for every year from 1940 to 1945, though his nominations for the years 1942, 1944, and 1945, like the others' letters sent during the same period, were carried over to the following years, because of the postal delays caused by the war. Shapley used almost all the resources available at Harvard. In the winter of 1940, he emphasized Bridgman's contribution to geophysical research and asked Daly, a Harvard geophysicist and foreign member of the Swedish Academy, to write to the Nobel Committee directly.[75] In the same winter, Walter B. Cannon, a Harvard physiologist who had become foreign member of the Swedish Academy about one year earlier, sent a nomination of Bridgman to the Nobel Physics Committee, without detailing his candidate's work since he had little knowledge of high pressure research and had already learned of his colleagues' previous nominations of Bridgman.[76] Shapley did not forget to mention J. B. Conant's endorsement of his nomination of Bridgman, as the President of Harvard University became internationally

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[73] Van Vleck, Dec. 21, 1943, *Protokoll*, 1945.

[74] John H. Van Vleck, "Percy Williams Bridgman," *The American Philosophical Society*, *Year Book 1962* (1963), pp. 106–110.

[75] Harlow Shapley, Nov. 26, 1940, *Protokoll*, 1941.

[76] W. B. Cannon, Dec. 18, 1940, *Protokoll*, 1942.

famous for his activity as a scientific advisor during the war.[77] Immediately after the war, the relationship between Conant and Shapley would worsen because of their sharply opposing political views of the Cold War.[78] In the prewar years, however, the Harvard scientists tightly cooperated for the purpose of raising their university's prestige.

Daly, Shapley, and Cannon started to send nominations of Bridgman immediately after they acquired a permanent nominating right. This fact leads one to reason that in the 1940s, Harvard as a whole was eager to see another faculty member bring worldwide prestige to the university. Although the Harvard medical scientists William Parry Murphy and George Richards Minot shared the Nobel Prize for Physiology or Medicine for 1934 with George Hoyt Whipple at Rochester University, no Harvard scientist had been awarded a Nobel Prize in Physics or Chemistry since T. W. Richards, Conant's mentor and father-in-law, received the Chemistry Prize for 1914. Even after the Physics Department had abandoned the plan for winning the prize for Bridgman, the Harvard scientists had their own motive to continue an effort in the same line in the 1940s.

Bridgman's experimental work was not the only reason the Harvard scientists favored him as a nominee. During the thirties, Harvard had neither shrewd fundraising politico-scientists like R. A. Millikan or the Compton Brothers, nor ingenious physicists in quantum physics like Ernest O. Lawrence or Carl Anderson. However, when asked, the Harvard scientists could refer to Bridgman's philosophical work as almost the only homespun guideline in the recent crisis of interpretation of physical theory, brought about by quantum mechanics and Heisenberg's principle of uncertainty. Multiple letters recommending Bridgman for the Nobel Prize naturally mentioned his works in the philosophy of science. Even if Harvard could not be confident in its financial condition or style of research, it could be proud of its philosopher of science and originator of operationalism, Bridgman.

Kemble, one of the advocates of Bridgman's operational analysis, during the interview conducted by T. S. Kuhn and J. H. Van Vleck, described his feelings toward philosophical perspectives of the older generation of physicists outside Harvard[79]:

> I always thought that both Compton and Millikan were very naïve. They were not either of them men in whose philosophic judgments about science I would place any particular reliance. They had great ingenuity and imagination. Millikan's chief characteristic to me was always the fact that any time he found

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[77] Harlow Shapley, Jan. 14, 1944, *Protokoll*, 1945.

[78] Peggy Aldrich Kidwell, "Harvard Astronomers and World War II—Disruption and Opportunity," in Clark A. Elliot and Margaret W. Rossiter, eds., *Science at Harvard University: Historical Perspectives* (Bethlehem: Lehigh University Press; London and Toronto: Associated University Press, 1992), pp. 285–302.

[79] Interview with E. C. Kemble, conducted by T. S. Kuhn and J. H. Van Vleck on October 1 and 2, 1963, Archives for the History of Quantum Physics.

> out something new, he was sure of his interpretation and extremely enthusiastic about what was just around the corner. Perhaps two weeks later he would have changed his mind and be off on a new track with the same abounding energy and enthusiasm. There's great difference between scientific creativity and philosophic judgment in the area of the sciences.

In terms of philosophical judgment, Kemble found very few scientists trustworthy. Bridgman was an exception. Though not particularly praising Bridgman as a philosopher during this interview, in the 1930s, Kemble invoked Bridgman's operational analysis as almost the only reliable guideline in the interpretation of physical theory.[80]

Notably, the staff members at the Physics Department mentioned Bridgman's work in the philosophy of science as theoretical work on general question in science, the legitimate task for scientists.[81] Philosophical work in science is not always expected from physicists, especially from experimentalists. However, Harvard was supportive and encouraging, when it came to Bridgman's work.

The Harvard Physics Department was in a unique position in the United States during the thirties. It failed to establish a reliable financial basis mainly because no one at the Department was competent enough. The Department kept the habit of the "good old days," respecting each one's independence in research and not allowing any single researcher to interfere with the others' works. This practice prevented attempts at group research like those established at Caltech, Berkeley, or MIT.[82] The rise of a young generation of physicists was one of the characteristics of this period, represented by the leadership of J. R. Oppenheimer and Lawrence at Berkeley and Slater at MIT. Young ambitious physicists could not have fitted into the Harvard Physics Department, that amicable community of old gentlemen, as Slater's move to MIT implies. The influx of refugee physicists, especially after 1933, benefited some American universities, but not Harvard. As a result, the Harvard physicists in the 1930s failed to catch up with the new development in physics, especially in nuclear physics, suffering from criticisms from both inside and outside that its reputation was sinking continuously. However, it was almost the only American institute where noteworthy works of criticism on contemporary

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[80] E. C. Kemble, *The Fundamental Principles of Quantum Mechanics* (New York and London: McGraw-Hill, 1937), p. 58; "Operational Reasoning, Reality, and Quantum Mechanics," *Journal of the Franklin Institute*, 225 (1938), pp. 263–275.

[81] Questionnaire for budgetary officers, April 11, 1934, "President–Appointments, 1932–1933 and 1933–1934," Box 13, RHUDP, UAV 691.

[82] Daniel J. Kevles, *The Physicists: The History of a Scientific Community in Modern America* (Cambridge, Mass, and London: Harvard University Press, 1987), pp. 200–235. Charles Weiner, "1932—Moving into the New Physics," *Physics Today*, 25: 5 (May 1972), pp. 40–49; "A New Site for Seminar: the Refugees and American Physics in the Thirties," in Donald Fleming and Bernard Bailyn, eds., *The Intellectual Migration: Europe and America, 1930–1960* (Cambridge, Mass.: Harvard University Press, 1969), pp. 190–233.

physics emerged. While historians have pointed out American physicists' indifference to the philosophical aspects of science, Bridgman has always been an exception.[83] During the thirties, if there was anything in scientific achievements Harvard could be proud of, it would have been Bridgman's unique works in the philosophy of science and his experimental research in high pressure physics.

Bridgman was also the beneficiary of a situation at Harvard in which the entire university had to support his works in experimental research and philosophical work. Bridgman's philosophy of science itself no doubt has points that would make it favored by American scientists. However, one can still infer that the unique position Bridgman occupied at Harvard enabled him to pursue his interest in the philosophy of science freely and disseminate his thoughts among American physicists, while continuing his high-pressure experiments.

With this freedom in interdisciplinary activity, Bridgman often appeared in the scene that characterized the intellectual atmosphere surrounding Harvard under the presidency of Conant, one of the best friends of his. For instance, with a young philosopher, W. V. Quine, Bridgman welcomed European refugee philosophers including Rudolf Carnap and Philipp Frank as the chairman of the Fifth International Congress for the Unity of Science, held in September 1939 at Harvard with support from Conant.[84] He was instrumental in Frank's getting a position at Harvard, and after Frank founded the Institute for the Unity of Science at the American Academy of Arts and Sciences, he became one of the most frequent participants in the meeting. There he enjoyed discussion with philosophers and psychologists, including the American originator of behaviorism, B. F. Skinner.[85] Bridgman's operationalism, together with logical positivism in philosophy and behaviorism in psychology, began to merge at Harvard in the 1930s. While Conant's strict administration directly and indirectly pushed the Harvard scientists into the collective nomination of Bridgman for the Nobel Prize, multicultural interactions involving Bridgman represented an intellectually productive portion of Conant's presidency.

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[83] S. S. Schweber, "The Empiricist Temper Regnant: Theoretical Physics in the United States 1920–1950," *Historical Studies in the Physical and Biological Sciences*, 17 (1986), pp. 55–98; Katherine Russell Sopka, *Quantum Physics in America*, *1920–1935* (New York: Arno Press, 1980); Gerald Holton, "On the Hesitant Rise of Quantum Physics Research in the United States," in Stanley Goldberg and Roger H. Stuewer eds., *The Michelson Era in American Science 1870–1930* (New York: American Institute of Physics, 1988), pp. 177–205.

[84] "The Fifth International Congress for the Unity of Science at Harvard University," *Science*, 88 (2292), Dec. 2, 1938, p. 519.

[85] George A. Reisch, *How the Cold War Transformed Philosophy of Science: to the Icy Slopes of Logic* (Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo: Cambridge University Press, 2005).

7. Shapley, Bridgman, and the Physics Department

Harlow Shapley, a key figure in Harvard's efforts for winning the Nobel Prize for Bridgman during the 1940s, appeared the best choice as Harvard's lobbyist, when one considers his international activity and fame. Having been well-known for the application of the luminosity-period law of Cepheid variation to the estimation of stellar distances that he established in 1917 and the fierce debate with Heber D. Curtis on the size of the universe in 1920, Shapley had been striving to make the Harvard College Observatory into a mecca for international astronomers since he accepted its directorship in 1921.[86] In the late 1930s, he started to use his observatory as a refuge for European scientists who were escaping from totalitarian regimes. One of his obituaries reports that Richard Prager of Berlin Observatory once told that "every night at least a thousand Jewish scientists were saying a prayer of thanks for Harlow Shapley's humanitarian efforts, which had helped to save them and their families."[87] Shapley was also active in connection with the American Association of Scientific Workers, an organization formed in the late 1930s, and wrote a series of articles for a paper-bound book distributed to American GIs while they spent several weeks in transit across the Atlantic or Pacific Ocean.

Being an influential scientist at Harvard who had once been rumored to run for the presidency of the university,[88] Shapley was supportive for the Physics Department's efforts to secure funds, raise its status, and protect its personnel. For instance, for the Tercentenary Celebration of Harvard University held in 1936, Shapley cooperated with Bridgman in programming the symposia on atomic structure and designed them "to exhibit local talent and present an opportunity also for the young giants of America to train for the top position in 2036."[89] During Conant's prewar and wartime presidency, Shapley offered useful suggestions to the Physics Department as a member of the Committee of Eight, a committee in charge of reform of the appointment policy at Harvard, and the Chairman of Harvard's Resources Committee.[90] Furthermore, Shapley and Bridgman were close friends and shared interest in fundamental problems of science.[91] Shapley was one of the few who reacted to Bridgman's unpopular article, "The

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86 Bart Bok, "Harlow Shapley, November 2, 1885–October 20, 1972," *National Academy of Sciences of the United States of America*, *Biographical Memoirs*, 49 (1978), pp. 241–291; Bart Bok, "Harlow Shapley, Cosmographer," *American Scholar*, 40 (1971), pp. 470–474; Kirtley F. Mather, "Harlow Shapley, Man of the World," *American Scholar*, 40 (1971), pp. 475–481.

87 Bok, "Harlow Shapley, November 2, 1885–October 20, 1972," *op. cit.*, p. 253.

88 James Hershberg, *James B. Conant: Harvard to Hiroshima and the Making of the Nuclear Age* (New York: Knopf, 1993), p. 72.

89 Harlow Shapley to P. W. Bridgman, Dec. 16, 1935, "Tercentenary Celebration [1935–1936]," Box 19, RHUDP, UAV 691.

90 F. A. Saunders to Nathan Hayward, Dec. 28, 1938; F. A. Saunders to Nathan Hayward, March 21, 1939, "Committee of Overseers [1938–1939]," Box 27, RHUDP, UAV 691.

91 P. W. Bridgman to A. N. Hitchcock, Dec. 27, 1929; P. W. Bridgman to Harlow Shapley, March 5, 1929,

New Vision of Science," published in *Harper's* in 1929,[92] though he was critical to Bridgman's view shown in the article.

After the breakout of World War II, the relationship between Bridgman and Shapley continuously worsened.[93] However, their political and sometimes personal conflicts did not influence Shapley's judgment about Bridgman as a candidate for the Nobel Prize. Shapley faithfully repeated nominating Bridgman for the prize in the middle of their exchange of merciless criticisms of each other over the issues concerning scientists' wartime activities.

8. The Judgment in Stockholm

Meanwhile, nominations by scientists outside Harvard continued to arrive in Stockholm in the 1940s. Edward Neville Da Costa Andrade, Quain Professor of Physics at University College, nominated Bridgman in 1940 and 1942. Closely knowing Bridgman's work through his own research interest,[94] Andrade had an inclination to favor subjects other than nuclear and particle physics.[95] In his nomination for the year of 1946, after having nominated Bridgman twice, Andrade switched to another physicist in a field outside nuclear physics, Edward Victor Appleton, who was to receive the prize the next year for his discovery in atmospheric physics. Two American physicists whose research fields were close to Bridgman's also sent nominations of Bridgman during the 1940s: John R. Roebuck[96] for 1945 and Eugene P. Wigner[97] for 1946.

The Nobel Physics Committee's evaluation of Bridgman's work in the 1940s reflected a growing interest in high pressure physics in the scientific and engineering community in Sweden. Bridgman reported the new high pressures reached with a nest of pressure vessels in 1940, and the results of measurement under those pressures in 1941.[98] Although the committee noticed this new development in Bridgman's research through Daly's nomination letter, its judgment of Bridgman's work had not changed since 1939: Bridgman's achievement was not especially meritorious, since other physicists in the United States and France were conducting experiments under the similar magnitude of

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PWBP, HUG 4234.8.

92 P. W. Bridgman to L. F. Hartman, Jan. 1, 1929, PWBP, HUG 4234.8.

93 Okamoto, "Percy Williams Bridgman and the Evolution of Operationalism," *op. cit*., pp. 441–453.

94 Alan Cottrell, "Edward Neville Da Costa Andrade," *Biographical Memoirs of Fellows of the Royal Society*, 18 (1972), pp. 1–20.

95 E. N. Da Costa Andrade, Jan. 7, 1942, *Protokoll*, 1942.

96 J. R. Roebuck and E. E. Miller, "Viewing Tubes for High Pressure," *Review of Scientific Instruments*, 10 (1939), pp. 179–180.

97 John Bardeen had been working with Wigner before moving to Harvard for theoretical study of high-pressure phenomena.

98 P. W. Bridgman, "New High Pressures Reached with Multiple Apparatus," *Physical Review*, 57 (1940), pp. 342–343; P. W. Bridgman, "Compressions and Polymorphic Transitions of Seventeen Elements to 100,000 kg/cm^2," *Physical Review*, 60 (1941), pp. 351–354.

pressures. Furthermore, in 1942, following C. W. Oseen's report on Bridgman and other high pressure experimentalists,[99] the committee started adding a comment that since August 1941, Bridgman's results had been attainable in Sweden, as well as in the United States and France.

In the early 1940s, when GE inaugurated a project for the artificial diamond, Allmänna Svenska Elektriska Aktiebolaget (ASEA, the Swedish General Electric Company, Ltd.), approached by an industrial engineer Baltzar von Platen, started a similar effort for the synthesis of gem-quality diamonds.[100] Although ASEA tried to keep its joint research and development a secret even after its final but somewhat unsatisfactory success in 1953, the Swedish scientists did not fail to notice this large-scale project going on in their country. While mostly concerned with theoretical research, Oseen apparently grasped a part of the ASEA project and its confidential character. His March 1942 report to the Nobel Committee only briefly stated that Bridgman's results had been within reach in Sweden since August 1941, without citing any name or article of Swedish scientists, specifying only the American and French physicists, Davis, Poulton, and Basset, who were conducting experiments in the same pressure level as Bridgman's.[101]

In the 1940s, two Swedish physicists nominated Bridgman. Their nominations, however, had little to do with the ASEA's project. Hannes Alfvén, a competent experimentalist in plasma physics who would receive the Nobel Prize in Physics for 1970, nominated Bridgman for the prize for 1943, immediately after he was appointed a professor at the Royal Institute of Technology in Stockholm and acquired a permanent nominating right for the Physics and Chemistry Prizes.[102] Even if the committee paid little attention to this young professor's nomination, they could not dismiss a nomination by Gudmund Borelius, who had been professor of physics at the Royal Institute of Technology in Stockholm since 1922. Having become a member of the Royal Swedish Academy of Sciences in 1942, Borelius sent his first nomination letter in 1945 and recommended Bridgman. This time the Committee assigned Axel Lindh to submit a report on Bridgman's recent work. Oseen, who had played a dominant role in the Committee's evaluation of theoretical work and had repeatedly denied Bridgman's suitability for the Prize, had passed away the year before. Lindh was an experimental physicist who succeeded Carlheim-Gyllensköld in 1934 as a member of the Nobel

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[99] C. W. Oseen, "Kompletterande Utredning om P. W. Bridgmans till Belöning Föreslagna Arbeten," March 19, 1942, *Protokoll*, 1942.

[100] Baltzar von Platen, "A Multiple Piston, High Pressure, High Temperature Apparatus," in R. H. Wentorf, Jr. ed., *Modern Very High Pressure Technique* (London: Butterworths, 1962), pp. 118–136.

[101] C. W. Oseen, "Kompletterande Utredning om P. W. Bridgmans till Belöning Föreslagna Arbeten," March 19, 1942, *Protokoll*, 1942.

[102] H. Alfvén, Jan. 16, 1943, *Protokoll*, 1943.

Physics Committee.

In evaluating Bridgman's work, Lindh followed Carlheim-Gyllensköld's favor of experimental research.[103] Referring to Bridgman's reviews of current high pressure experiments,[104] Lindh introduced to the committee the new results of the candidate's research that had not reached Sweden yet, including the attainment of pressures between 400,000 and 500,000 kg/cm^2. Furthermore, examining the results of the other prominent high pressure physicists Basset and Poulton, Lindh confirmed Bridgman's pioneering and leading position in the high pressure experimentation and stressed the need to reevaluate his work. Although in conclusion Lindh did not recommend Bridgman for the prize for 1945, he suggested that the committee wait for more information of Bridgman's current research to arrive.

The Nobel Committee were active and quick in gathering information of Bridgman's research. Early in 1946, Bridgman sent reprints describing his recent work to a Swedish friend of his, Carl A. F. Benedicks, professor of metallurgy at the Stockholm Högskola who had been President of the Royal Swedish Academy of Sciences during 1934–5.[105] On August 5, 1946, Axel Lindh submitted to the committee a report on Bridgman's work, citing the candidate's publications that had not been available the year before.[106] In September, Bridgman sent Benedicks literature on the American scientists' activities to abolish war and to outlaw nuclear weapons, clarifying his own support for them.[107] In reply, Benedicks implied that they would soon see each other in Stockholm.[108] On September 4, the Nobel Committee reported to the Academy's Physics Section that they would recommend Bridgman for the Nobel Prize in Physics for 1946. Benedicks learned of the committee's recommendation while he joined the discussion in the Physics Section over its recommendation concerning the prizewinner, which was usually only an endorsement of the committee's decision. That year the Physics Section as usual supported the committee's recommendation, although in its discussion one of the Section's members Oskar Klein strongly accused the committee's failure in evaluating Lise Meitner's contribution to the discovery of the fission of heavy nuclei, the achievement that brought the Chemistry Prize for 1944 to Otto Hahn.[109] On November 14, following the Physics Section's decision, the entire Academy approved to award the

[103] Axel E. Lindh, "Kompletterande trending över P. W. Bridgmans arbeten," June 9, 1945, *Protokoll*, 1945.

[104] P. W. Bridgman, "Exploration toward the Limit of Utilizable Pressures," *Journal of Applied Physics*, 12 (1941), pp. 461–469; "Recent Work in the Field of High Pressures," *American Scientist*, 31 (1943), pp. 1035.

[105] P. W. Bridgman to C. A. F. Benedicks, Sept. 4, 1946, PWBP, HUG 4234.10.

[106] A. Lindh, "Utredning av P. W. Bridgmans arbeten," August 5, 1946, *Protokoll*, 1946. Lindh referred to Bridgman's latest review, published in January 1946, "Recent work in the Field of High Pressure," *Reviews of Modern Physics*, 18 (1946), pp. 1–93.

[107] P. W. Bridgman to C. Benedicks, Sept. 4, 1946, PWBP, HUG 4234.10.

[108] C. Benedicks to P. W. Bridgman, Sept. 21, 1946; C. Benedicks to P. W. Bridgman, Oct. 31, 1946, PWBP, HUG 4234.10.

[109] Friedman, *The Politics of Excellence*, *op. cit*., pp. 244–250.

prize for 1946 to Bridgman.

Bridgman received the Nobel Prize "for the invention of an apparatus to produce extremely high pressures, and for the discoveries he made therewith in the field of high-pressure physics."[110] The award to this unfashionable experimental research as late as in 1946 can appear enigmatic, especially when one considers various discoveries that had until then taken place in more colorful fields. As has been partly hinted above, the fact is that after Oseen's death in 1944 and the end of World War II, the Nobel Physics Committee started to award the prize to those who had unduly been in the waiting list for decades, including Bridgman. In 1944, for example, Otto Stern was awarded the prize for 1943. In the early 1920s, improving a molecular beam method, Stern and Walther Gerlach demonstrated spatial quantization and measured the magnetic moment of the silver atom. In 1933, with a similar method, he measured the magnetic moment of protons. Although nominations for him had kept flowing to the committee since 1927, Oseen, who played a dominant role in the committee's evaluation of atomic physics, had never approved to award him a prize. Furthermore, during the 1930s, the committee was reluctant to take Stern's candidacy seriously, possibly because they did not want to stimulate the Nazi regime in Germany by awarding Stern, a refugee Jewish physicist who had left Germany in 1933 and found a position at the Carnegie-Mellon University in Pittsburgh. Stern was awarded the prize after Oseen's death and the end of World War II, just before his retirement in 1945.[111]

The Academy had continued to award the prize for decades-old contributions[112] until 1948. In 1945, Ivar Waller, who succeeded Oseen as a committee member, persuaded the committee to award Wolfgang Pauli the prize for his almost two-decades-old discovery. Until then Oseen had been blocking Pauli's prize, dismissing Pauli's theoretical achievements as "philosophical constructions."[113] In 1947, the committee decided to award the prize to E. V. Appleton for his contributions to atmospheric physics, mainly because they wanted to show some respect to the last wish of its retiring member, Henning Pleijel. Although Appleton had been repeatedly passed over since 1935, Pleijel, just before his retirement, submitted a special report on Appleton with a conclusion to recommend him for the prize. In 1948, receiving nomination letters by Arthur Compton and J. D. Bernal that made the committee to reconsider Patrick M. S. Blackett as "a highly gifted researcher, a wartime hero, and a spokesman for democratic science policy,"[114] they decided to award the undivided prize to Blackett, though they had once

[110] *Nobel Lectures: Physics*, *1942–1962* (Amsterdam: Elsevier Publishing Company for the Nobel Foundation, 1964), p. 50.

[111] Friedman, *The Politics of Excellence*, *op. cit.*, pp. 222–223.

[112] Friedman, *The Politics of Excellence*, *op. cit.*, pp. 252–257.

[113] Friedman, *The Politics of Excellence*, *op. cit.*, p. 252.

[114] Friedman, *The Politics of Excellence*, *op. cit.*, p. 257.

passed him over in 1936 as the discoverer of the positron. In 1949, when the discovery of the π meson urged the committee to consider seriously the postwar development in physics, it finally stopped the habit of rewarding candidates who had waited too long.

In Bridgman's case, Oseen's death and the subsequent reevaluation by Lindh, who shared with his predecessor Carlheim-Gyllensköld high esteem for Bridgman's research, were of crucial importance. Having been submitting reports discrediting Bridgman's originality and merits, Oseen had been responsible for the committee's decisions to pass Bridgman's case over until in 1944, the year of Oseen's death. In 1945, Lindh examined Bridgman's candidacy more carefully than before and recommended that the committee continue further survey. The next year, based on sufficient information of Bridgman's current work that arrived in Sweden after the war, the committee judged his contributions meritorious enough for the Nobel Prize.

9. Concluding Remarks

Neither the nominations by the Harvard and MIT Physics Departments nor Shapley's continuous effort was especially influential upon the committee's judgments, like many other collective or coordinated nominations. After the war, Shapley's international activities and his reputation as a progressive leftist may have attracted attention of some committee members who supported the Social Democrats in Sweden. Bridgman's express support of the international anti-war and anti-nuclear activities may have also helped the committee make decision for the 1946 prize. But all these were far less decisive than the change in the Nobel Committee's composition.

Nevertheless, when Bridgman received the prize, few at Harvard and in the United States understood the details of the decision-making process in the Nobel Committee. Those who knew of the entire Harvard's lobbying for Bridgman's Nobel Prize may have interpreted it in their own ways. As has been mentioned, more than fifteen years later, Van Vleck reservedly expressed his wonder at the award to Bridgman's "sustained research program over a period of years,"[115] perhaps implying the involvement of factors other than the laureate's scientific achievements.

Around the same time, Conant described Bridgman as "one of the twentieth-century jewels"[116] in the crown of the university at the memorial meeting for Bridgman, held on October 24, 1961. "His reputation in universities throughout the world," added Conant, "enhanced the reputation of his alma mater." This was the occasion on which the participants cordially praised the deceased. So did Conant, but the words of this President Emeritus, who had once pointedly criticized the sinking status of the Physics Department, might have reminded the nominators of Bridgman for the Nobel Prize of their endeavors

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115 J. H. Van Vleck, "Percy Williams Bridgman," *op. cit.*, p. 107.

116 J. B. Conant, "A Truly Extraordinary Man," Expressions of Appreciation, PWBP, HUG 4234.25.

to raise the reputation of the department and the university.

Bridgman's achievements in high pressure physics no doubt deserved the Nobel Prize. No single person had broadened the range of attainable pressures and measurements of physical properties under them as vastly as he did. The nature of his research, however, made the award to him appear exceptional. Nominators for Bridgman all failed to specify their candidate's distinctly prizeworthy discoveries or relate his experiment to the contemporary development of quantum physics. No one had been sure of the award to him until 1946; Bridgman himself was preparing for retirement when he received the news from Stockholm.[117]

The nominators therefore found it necessary to reinforce their rationale. The Harvard physicists praised Bridgman's publications in the philosophy of science as contribution to theoretical research that compensated missing connection between the nominee's experiment and quantum physics. To the MIT physicists, Bridgman was a candidate from solid state physics, a field opened by quantum theory but remaining less rewarded than nuclear physics. Shapley mobilized his Harvard colleagues qualified to nominate and invoked Conant's endorsement, making the nomination of Bridgman a university-wide affair. All these reflect facets of Bridgman his colleagues and home institution found admirable: Besides being a pioneering high pressure experimentalist, he was the originator of homespun philosophy of science who also represented unflamboyant but significant realms of science.

By conveying information that is not found elsewhere, nomination letters can offer clues to profound comprehension of the relation between nominees and nominators. Cases of relatively unknown figures like Bridgman may still offer rich sources for historical study.

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[117] P. W. Bridgman, "Memorandum to Professor Kemble," Dec. 10, 1943, "Staff–Miscellaneous [1943–1944]," Box 46, RHUDP, UAV 691.