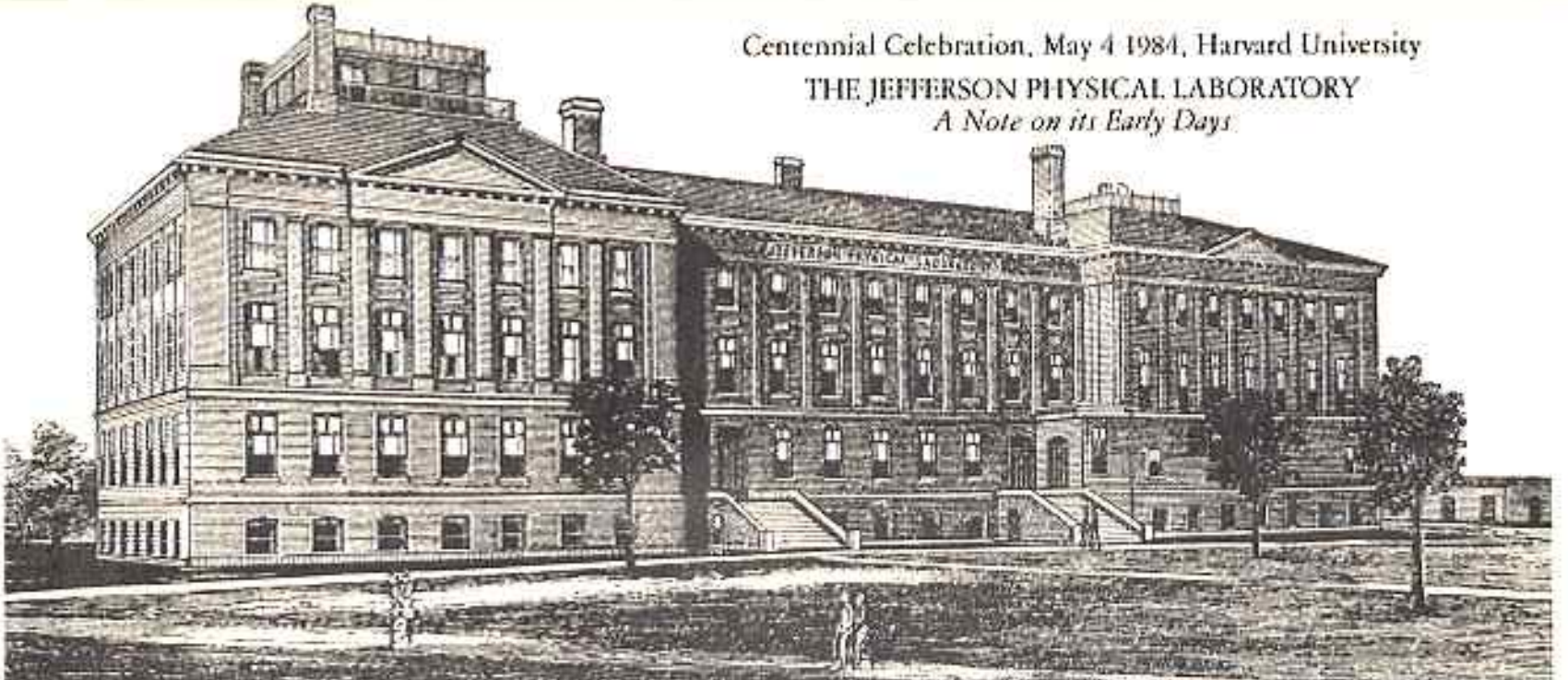
Centennial Celebration, May 4 1984, Harvard University

THE JEFFERSON PHYSICAL LABORATORY

A Note on its Early Days



The Laboratory ca. 1884, " *furnished throughout in the planned possible manner, but provided with everything to facilitate physical research which intelligent forethought could plan.*" Charles W. Eliot, *Science*, 20 March 1885

"The boldest conceptions, the most legitimate speculations, can attain body and soul only on the day when they are consecrated by observation and experiment. Laboratories and discoveries are correlative terms; if you neglect laboratories, the physical sciences will be stricken with barrenness and death. They will be merely powerless information instead of sciences of progress and futurity; give them laboratories, and life, fecundity and power will reappear . . . . I implore you, take some interest in those sacred dwellings meaningfully described as laboratories. Ask that they may be multiplied and completed. They are the temples of the future, of riches, and of well-being. There humanity grows greater, better, stronger; there she can learn to read the works of nature, works of progress and universal harmony."

Louis Pasteur, "Les Laboratoires," 1868

The Jefferson Laboratory at Harvard University was born under the ascending star of experimental inquiry, as reflected in triumphant 19th-century terms by Pasteur. As is so often the case, the whole enterprise was realized when the dream of an academic met with the encouragement of an administrator and the support of philanthropists. When the Laboratory opened its doors in 1884, it was the first of its kind in the United States, no other university possessing a building designed specifically for physics research as well as for instruction.

This innovation had its own unexpected history. When President Charles W. Eliot took office in 1869, he espoused a relatively new view – that liberal education should contain science and modern languages in addition to the classics and theology. At the time, laboratory science was taught almost exclusively at special scientific and technical schools, of which Harvard's Lawrence Scientific School (1847), Yale's Sheffield Scientific School (1847), and the Massachusetts Institute of Technology (1865) were early examples. But Eliot's vision did not yet include research: "The prime business of American professors in this generation must be regular and assiduous class teaching."

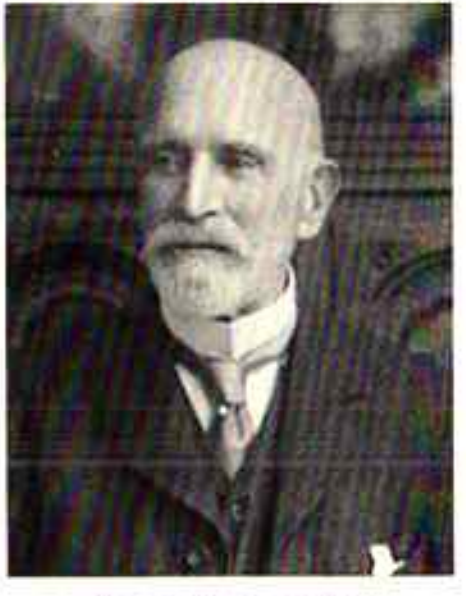
Harvard's only professor of physics at the time, Joseph Lovering (Hollis Professor of Mathematics and Natural Philosophy, since 1838) offered no challenge to Eliot on that score. As remarked by Edwin H. Hall, it was doubtful that he "ever made an original experiment, or any experiment not required for his lectures."

President Charles W. Eliot
(1834-1926)

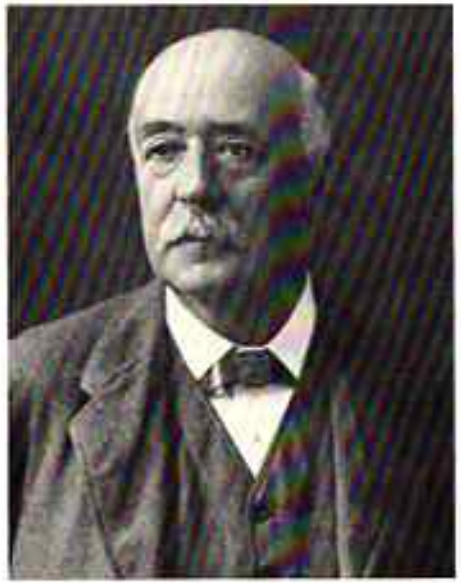
John Trowbridge
(1843-1923)

All this changed when John Trowbridge joined the faculty in 1870 as assistant professor of physics. A graduate of the Lawrence Scientific School, he brought with him the recognition of the importance of laboratory research to the future of physics. He did not mince his words: "The department of physics in a University must embrace both teaching and investigation. If it is given up entirely to teaching, the cause of science suffers, and the object of a University which is founded both to teach and increase the sum of human knowledge is defeated." (1877)

Perhaps his shrewdest move was his publication in 1879 of a collaborative paper surveying laboratory apparatus in the United States—which revealed that the newly established Johns Hopkins University owned almost seven times as much physics apparatus as did Harvard.



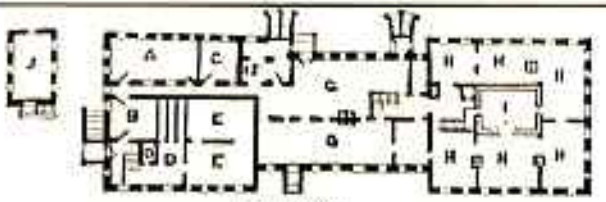
Thomas Jefferson Coolidge
(1831-1920)



Alexander Agassiz
(1835-1910)

By 1880, Eliot had come to agree with Trowbridge's idea—then strange in America—that physics instruction should not be by rote and from books, but in the laboratory, "with objects and instruments in hand"; and, moreover, that physics instruction required immersion in research as well. Planning could now begin for a new building for both purposes. An anonymous "friend of the University" came forward to give $115,000 on condition that another $75,000 would be raised to cover the running costs of the facility. The anonymous donor turned out to be the Boston businessman Thomas Jefferson Coolidge (class of 1850). The name of the building honors Coolidge's ancestor, the President who was both a supporter of and occasional contributor to science in America.

By 1883, the additional money had been raised, primarily through the generosity of Alexander Agassiz. When the building opened in the fall of 1884, its very design and "plainest possible" furnishings—down to the unpainted inside brick walls—were statements opposing the ornate European style of laboratory construction. All facilities for teaching undergraduates were kept to the east wing, to minimize vibrations in the west wing owing to "disturbances incidental to the movement of large numbers of persons."

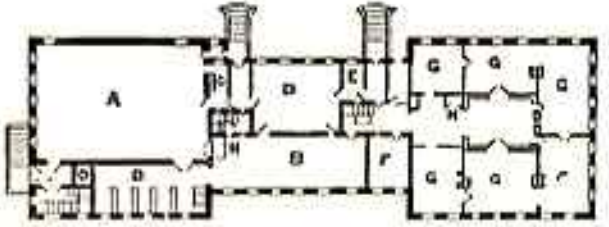


BASEMENT.

A, workshop; B, forge; C, battery-room; D, fire-room; E, coal; F, mercury-room; G, receiving-rooms; H, special investigation rooms; I, constant-temperature room; J, engine-room.

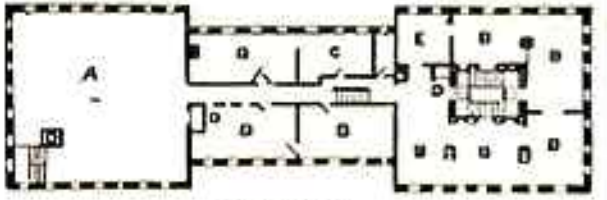
SECOND FLOOR.

A, lecture-room; B, second-story cabinets; C, professor's room; D, elevator; E, professor's room; F, library; G, optical rooms; H, Rumford lecture-room; I, sound; J, special investigation room; K, chemical laboratory; R, revolution room.



FIRST FLOOR.

A, space under lecture-room; B, first-story cabinets; C, preparation-room; D, recitation-room; E, professor's room; F, balance-room; G, special investigation rooms; H, elevators.



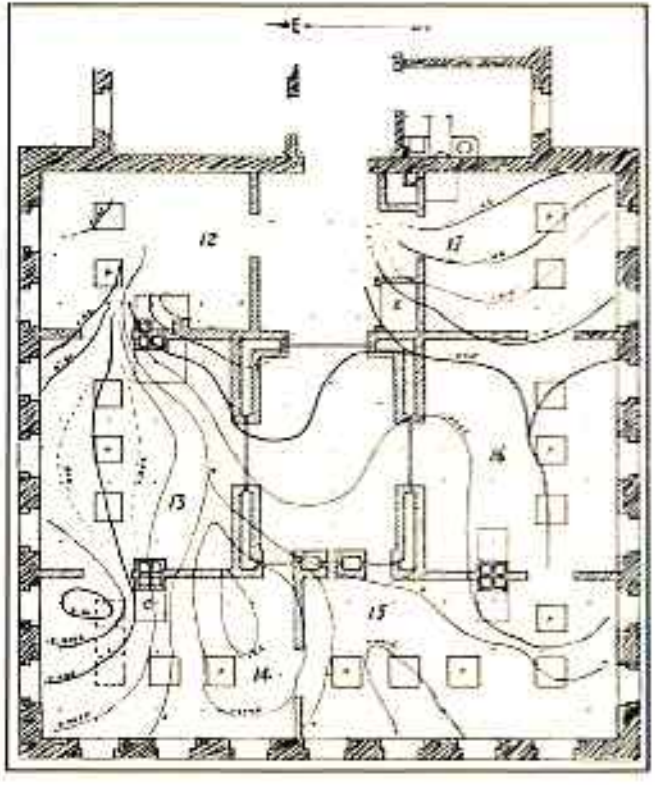
THIRD FLOOR.

A, elementary laboratory; B, special investigation rooms; C, library; D, elevators; E, photographic chamber.

Floor plan, 1884.

In order to minimize further disturbances and noise from street traffic, 300 ft. away, the central tower in the research wing was built on a separate foundation. The tower's walls, not linked to the rest of the structure, would serve to support delicate measuring instruments. All ferromagnetic materials were to be eliminated from the fixtures, pipes, and furnishings in the west wing. Thus it was hoped that the magnetic field of the earth—whose variation was a lively research topic of the day—would pervade the building unchanged.

Not everything worked as planned—and since this made research on geomagnetism less interesting, that was perhaps all to the good. The red bricks themselves turned out to be slightly magnetic, somebody had forgotten about the ferromagnetic steampipes, and the marshy ground beneath the tower proved an unsteady support. But the splendid space, the fine shop for the design and construction of apparatus, and the tradition of precision measurement prepared for the meeting of research challenges that had not even been anticipated.



Within two decades of its opening, the Laboratory and the Department had developed to the point at which Trowbridge could boast that Harvard now had "the best equipment of any Physical Laboratory, either in this country or abroad" for the purposes of research.

"Plan of west wing of the Jefferson Physical Laboratory, with lines of equal directive force in planes 5 ft. above first floor." From R.W. Willson, "The magnetic field in the Jefferson Physical Laboratory." *American Journal of Science*, 1890.

Early Figures in the Life of the Jefferson Physical Laboratory

Lovering, as the senior person, was Director of the Laboratory until his retirement in 1888. He was responsible for buying most of the apparatus during this period, but his first love remained experimental demonstrations for classroom purposes.

John Trowbridge, the guiding force behind the design of the Laboratory, was the first of the modern men in physics at Harvard. Despite heavy teaching and administrative duties, he published over 80 research papers, with the best known work on spectroanalysis and Röntgen rays. For that purpose, he designed and had constructed a storage battery consisting of 10,000 cells—giving a far larger potential difference than any other such battery at the time, and attracting research visitors from far and wide.

Joseph Lovering
(1813-1892)

Wolcott Gibbs
(1822-1908)

Benjamin Osgood Peirce
(1854-1914)

At the time of the founding of the Laboratory, Wolcott Gibbs, a chemist, taught a course on thermodynamics for the Physics Department -- although the class chiefly met in his private chemical laboratory in the Lawrence Scientific School nearby. Gibbs' research interests included work on complex inorganic acids, analytic methods, and physiological chemistry.

Benjamin O. Peirce, a Harvard undergraduate (AB 1876), was Trowbridge's first research student. His brilliance became evident early. Of a research paper on magnetism, it was said "There was not . . . in all America at that time another college Junior capable of all this." He taught both physics and mathematics, and the bulk of his research dealt with electrostatic and magnetic measurements.

Edwin H. Hall joined the faculty in 1881, having completed his PhD at Johns Hopkins University and discovered the effect which bears his name. At Harvard he turned to research on thermo-conductivity, thermodynamic behavior of liquids, and thermoelectricity. Hoping to improve physics education in secondary schools, he published a pamphlet (1887) that established a national standard of preparation and admission-level competence for several decades.

Harold Whiting, the youngest member of the Department in 1884, was said to have an agility of mind and inventiveness approaching genius. He and his whole family perished in a shipwreck in 1895. In accord with his Will, the Whiting Fellowships were established that have been supporting graduate students in this Department ever since.

Edwin H. Hall
(1855-1938)

Harold Whiting
(1855-1895)

Wallace C. Sabine, like Pierce a graduate student of Trowbridge (from 1886), might also count as one of the early discoveries made in the Jefferson building. He was made Instructor in 1890, and charged in 1895 by President Eliot to improve the acoustics in a lecture room of the newly built Fogg Art Museum. The result was the founding of a new science. In Edwin Hall's words: "Sabine's development of architectural acoustics, from a condition of gross and ineffectual empiricism to the status of a reasoned and fairly exact science, is probably the most notable single achievement in the history of the Jefferson Laboratory during its first three decades."

By about 1910, it had become clear that Trowbridge's vision was being achieved and exceeded. In addition to Sabine, the physics faculty contained such men as George Washington Pierce, Theodore Lyman, and Percy W. Bridgman. All were products of the Jefferson Laboratory, where they had done their graduate work (with Lyman and Bridgman getting their BA education there as well).

The physicist as both teacher and superb researcher—a curious and novel idea when Trowbridge had proposed it for the endorsement of Eliot and Coolidge—had indeed become a reality by the early part of our century. Soon, new facilities were to be added to the Laboratory, and as physics came of age in America, the faculty grew larger than Trowbridge could have imagined. And the rooms, too, would be put to ever changing use, with the stream of results from them continuing to alter the direction of physics itself.

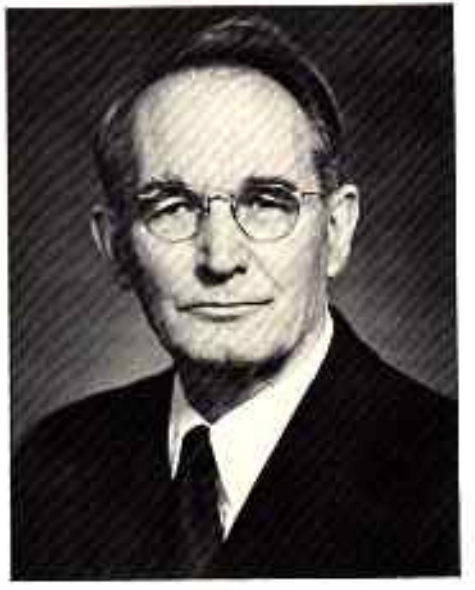
Wallace Clement Sabine
(1868-1919)

George Washington Pierce
(1872-1956)

Transmission of radio waves; piezoelectricity and magnetostriction.

Theodore Lyman
(1874-1954)

Spectroscopy in the ultraviolet region.



Percy W. Bridgman
(1882-1961)

Harvard's first Nobel Prize physicist (1946); high-pressure physics; philosophy of science.

Partial List of Senior Professors/Researchers in the Physics Department, 1884-1984

Howard Aiken (1900-1973)
Newton H. Black (1874-1961)
Percy W. Bridgman (1882-1961)
Emory Leon Chaffee (1885-1975)
William Duane (1872-1935)
Philipp Frank (1884-1966)
Edwin H. Hall (1855-1938)
Roger W. Hickman (1900-1975)
Frederick V. Hunt (1905-1972)
Edwin C. Kemble (1889-1984)
Joseph Lovering (1813-1892)
Theodore Lyman (1874-1954)
Harry Mimno (1900-1981)
Otto Oldenberg (1888-1985)

Benjamin Osgood Peirce (1854-1914)
George Washington Pierce (1872-1956)
Wallace C. Sabine (1868-1919)
Frederick A. Saunders (1875-1963)
John C. Slater (1900-1976)
John Trowbridge (1843-1923)
John H. Van Vleck (1899-1980)
David L. Webster (1888-1976)

Kenneth T. Bainbridge
Leo L. Beranek
Nicholaas Bloembergen
Harvey Brooks
Sidney Coleman
Wendell H. Furry
Howard M. Georgi
Sheldon L. Glashow
Roy J. Glauber
Bertrand I. Halperin
Gerald Holton
Paul Horowitz
Arthur M. Jaffe
Paul C. Martin
David R. Nelson
Costas D. Papaliolios
Francis M. Pipkin

Robert V. Pound
William H. Press
William Preston
Edward M. Purcell
Norman F. Ramsey
Carlo Rubbia
Julian Schwinger
Roy F. Schwittets
Irwin I. Shapiro
Isaac F. Silvera
Karl Strauch
J. Curry Street
Michael Tinkham
Steven Weinberg
Richard Wilson
Robert R. Wilson

Further Reading and Acknowledgements

Aronovitch, Lawrence I. "Towards a New Knowledge of Nature: Physics at Harvard University, 1870-1910" (AB Honors Thesis in History and Science, Siff Prize, 1983).

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Gerald Holton
(for the Departmental Committee on the
Jefferson Laboratory Centennial Celebration)