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(*b*. Salem, Massachusetts, 4 April 1809; *d*. Cambridge, Massachusetts, 6 October 1880)

mathematics, astronomy.

In an address before the American Mathematical Society during the semicentennial celebration of its founding in 1888 as the New York Mathematical Society, G. D. Birkhoff spoke of Benjamin Peirce as having been "by far the most influential scientific personage in America" and "a kind of father of pure mathematics in our country."

Peirce's background and training were completely American. The family was established in America by John Peirce (Pers), a weaver from Norwich, England, who settled in Watertown, Massachusetts, in 1637. His father, Benjamin Peirce, graduated from Harvard College in 1801, and served for several years as representative from Salem in the Massachusetts legislature; he was Harvard librarian from 1826 until 1831, prepared a printed catalog of the Harvard library (1830–1831), and left a manuscript history of the university from its founding to the period of the American Revolution (published 1833). Peirce's mother, Lydia Ropes Nichols of Salem, was a first cousin of her husband. On 23 July 1833 Peirce married Sarch Hunt Mills, daughter of Harriette Blake and Elijah Hunt Mills of Northampton, Massachusetts. They had a daughter, Helen, and four sons: James Mills Peirce, professor of mathematics and an administrator at Harvard for fifty years; Charles Sanders Peirce, geodesist, mathematician, logician, and philosopher; Benjamin Mills Peirce, a mining engineer who wrote the U.S. government report on mineral resources and conditions in Iceland and Greenland; and Herbert Henry Davis Peirce, a diplomat who served on the staff of the legation in St Petersburg and who later arranged for the negotiations between Russia and Japan that led to the Treaty of Portsmouth on 5 September 1905.

Peirce attended the Salem Private Grammar School, where Henry Ingersoll Bowditch was a classmate. This relationship influenced the entire course of Peirce's life, since Ingersoll Bowditch's father, Nathaniel Bowditch, discovered Peirce's unusual talent for mathematics. During Peirce's undergraduate career at Harvard College (1825–1829), the elder Bowditch enlisted Peric's aid in reading the proof-sheets of his translation of Laplace's *Traité de mécanique céleste* Peirce gave evidence of his own mathematical powers in his revision and correction of Bowditch's translation and commentary on the first four volumes (1829–1839), and also with his proof (in 1832) that there is no odd perfect number that has fewer than four prime factros.

Peirce taught at Bancroft's Round Hill School at Northampton, Massachusetts, from 1829 until 1831, when he was appointed tutor in mathematics at Harvard College; he recevied his M.A. from that insitution in 1833. At Harvard he became University professor of mathematics and natural philosophy (1833–1842), then Perkins professor of astronomy and mathematics (1842–1880). During the early days of his teaching at Harvard, Peirce published a popular series of textbooks on elementary branches of mathematics.

Peirce's continued interest in the theory of astronomy was apparent in his study of comets. Around 1840 he made observations in the old Harvard College observatory; his 1843 Boston lectures on the great comet of that year stimulated the support that led to the installation of the new telescope at the Harvard Observatory in June 1847. Since 1842 Peirce had also supervised the perparation of mathematics section of the ten-volume *American Almanac and Repository of Useful Knowledge*, and in 1847 he published therein a list of known orbits of comets. In 1849 Charles Henry Davis a brother-in-law of Peirce's wife, was apponited superintendent of the newly created *American Ephemeris and Nautical Almanac*, and Peirce was appointed consulting astronomer (1849–1867).

Peirce was not only helpful to Davis in planning the general form of the *Ephemeris*, but he also began a revision of the theory of planets. He had become deeply interested in the work of Le Verrier and John Couch Adams that had permitted Galle's discovery of the planet Neptune on 23 September 1846. In cooperation with Sears Walker, Peirce determined the orbit of Neptune and its perturbation of Uranus. Simon Newcomb wrote in his *Popular Astrononmy* (1878) that the investigation of the motion of the new planet was left in the hands of Walker and Peirce for several years, and that Peirce was "the first one to compute the perturbations of Neptune produced by the action of the other planets." Peirce was led to believe that Galle's "happily" discovered Neptune and Le Verrier's calculated theoretical planet were not the same body and that the latter did not exist—an opinion that led to considerable controversy.

In conjunction with his work on the solar system, Peirce became interested in the mathematical theory of the rings of Saturn. In 1850 George Phillips Bond, assistant in the Harvard College observatory, discovered Saturn's dusky ring and on 15 April 1851 announced to a meeting of the American Academy of Arts and Sciences his belief that the rings were fluid, multiple, and

variable in number. Peirce published several mathematical papers on the constitution of the rings in which he reached the same conclsion concerning their fluidity. His review of the problem at that time led to a most unfortunate priority dispute.

Peirce also enjoyed a distinguished career in the U. S. Coast Survey. In 1852 he accepted a commission —at the request of Alexander Dallas Bache, who was then superintendent—to work on the determination of longitude for the Survey. This project involved Peirce in a thorough investigation of the question of errors of observation; his article "Criterion for the Rection of Doubtful Observations" appeared in B. A. Gould's *Astronomical Journal* in July 1852. The criterion was designed to determine the most probable hypothesis whereby a set of observations might be divided into normal and abnormal, when "the greater part is to be regarded as normal and subject to the ordinary law of error adopted in the method of least squares, while a smaller unknown portion is abnormal and subject to some obscure soucre of error." Some authorities regarded "Peirce's criterion"—which gave good discrimination and acceptable practical results—as one of his most important contributions, although it has since been demonstrated to be invalid.

After Bache's death Peirce became superintendent of the Coast Survey (1867–1874), while maintaining his association with Harvard. He arranged to carry forward Bache's plans for a geodetic system that would extend from the Atlantic to the Gulf. This project laid the foundation for a general map of the country independent of detached local surveys. Peirce's principal contribution to the development of the Survey is thought to have been the initiation of a geodetic connection between the surveys of the Atlantic and Pacific coasts. He superintended the measurement of the arc of the thirty-ninth parallel in order to join the Atlantic and Pacific systems of triangulation.

Peirce also took personal charge of the U.S. expedition that went to Sicily to observe the solar eclipse of 22 December 1870, and, as a member of the transit of Venus commission, sent out two Survey parties—one to Nagasaki and the other to Chatham Island—in 1874. Peirce also played a role in the acquisition of Alaska by the United States in 1867, since in that year he sent out a reconaissance party, whose reports were important aids to proponents of the purchase of that region. In 1869 he sent parties to observe the eclipse of the sun in Alaska and in the central United States.

Peirce's eminence made him influential in the founding of scientific institutions in the United States. In 1847 the American Academy of Arts and Sciences appointed him to a committee of five in order to draw up a program for the organization of the Smithsonian Institution. From 1855 to 1858 he served with Bache and Joseph Hery on a council to organize the Dudley observatory at Albany, New York, under the direction of B. A. Gould. In 1863 he became one of the fifty incorporators of the National Academy of Sciences.

Despite his many administrative obligations, Peirce continued to do mathematics in the 1860's. He read before the National Academy of Sciences a number of papers on algebra, which had resulted from his interest in Hamilton's calculus of quaternions and finally led to Peirce's study of possible systems of multiple algebras. In 1870 his *Linear Associative Algebra* appeared as a memoir for the National Academy and was lithographed in one hundred copies for private circulation. The opening sentence states that "Mathematics is the science which draws necessary conclusions." George Bancroft received the fifty-second copy of the work, and in an accompanying letter (preserved in the manuscript division of the New York Public Library) Peirce explained that.

This work undertakes the investigation of all possible single, double, triple, quadruple, and quintuple Algebras which are subject to certain simple and almost indispensable conditions. The conditions are those wellknown to algebraists by the terms of *distributive* and *associative* which are defined on p. 21. It also contains the investigation of all sextuple algebras of a certain class, i.e., of those which contain what is called in this treatise an *idempotent* element.

D. E. Smith and J. Ginsburg, in their *History of Mathematics Before 1900,* speak of Peirce's memoir as "one of the few noteworthy achievements in the field of mathematics in American before the last quarter of the century." It was published posthumously in 1881 under the editorship of his son Charles Sanders Peirce *American Journal of Mathematics*, **4** no. 2, 97–229).

In *A System of Analytic Mechanics* (1855) Peirce again set forth the principles and methods of the science as a branch of mathematical thethod, a subject he development from the idea of the "potential." The book has been described as the most important mathematical treatise that had been produced in the United States up to that time. Peirce's treatment of mechanics has also been said, by Victor Lenzen, to be "on the highest level of any work in the field in English until the appearance of Whittaker's *Analytical Dynamics"* in 1904. Peirce was widely honored by both American and foreign scholarly and scientific soieties.

BIBLIOGRAPHY

I. Original Works. Peirce's works include *An Elementary Treatise on Sound* (Boston, 1836); *An Elementary Treatise on Algebra* (Boston, 1837), to which are added exponential equations and logarithms; *An Elementary Treatise on Plane and Solid Geomerty (Boston, 1837); An Elementary Treatise on Plane and Spherical Trigonometry. . . Particularly Adapted to Explaining the Construction of Bowditch's Navigator and the Natuical Almanac* (Boston, 1840); *An Elementary Treatise on Curves,Functions, and Forces, 2 vols. (Boston, 1841, 1846); and Tables of the Moon* (Washington, D. C. 1853) for the *American Ephemeries and Naturical Almanac. Tables of theMoon* was used in taking the *Ephemeris* up to the volume for 1883

and was constructed from Plana's theory, with Airy's and Longstreth's corrections, Hansen's two inequalities of long period arising from the action of Venus, and Hansen's values of the secular variations of the mean motion and of the motion of the perigee.

Later works are *A System of Analytic Mechanics* (Boston, 1855); *Linear Associative Algebra* (1870), edited by C. S. Peirce, which appeared in *American Journal of Mathematics*, **4** (1881), 97–229, and in a separate vol. (New York, 1882); and James Mills Peirce, ed., *Ideality in the Physical Sciences,* Lowell Institute Lectures of 1879 (Boston, 1881).

Peirce's unpublished letters are in the National Archives, Washington, D. C. and in the Benjamin Peirce and Charles S. Peirce collections of Harvard University.

II. Secondary Literature. On Peirce and his work, see reminiscences by Charles W. Eliot, A. Lawrence Lowell, W. E. Byerly, Arnold B. Chace, and a biographical sketch by R. C. Archibald, in *American Mathematical Monthly*, **32** (1925), repr. as a monograph, with four new portraits and addenda (Oberlin, 1925), which contains in sec. 6 a listing with occasional commentary of Peirce's writings and massive references to writings about him. See also Bessie Zaban Jones and Lyle Gifford Boyd, *The Harvard College Observatory* (Cambridge, Mass., 1971), esp. the chap. entitled "The Two Bonds," which gives a detailed description of the unhappy relationship that developed between Peirce and George and William Bond.

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