Partners in time: William Bond & son of Boston and the Harvard College Observatory

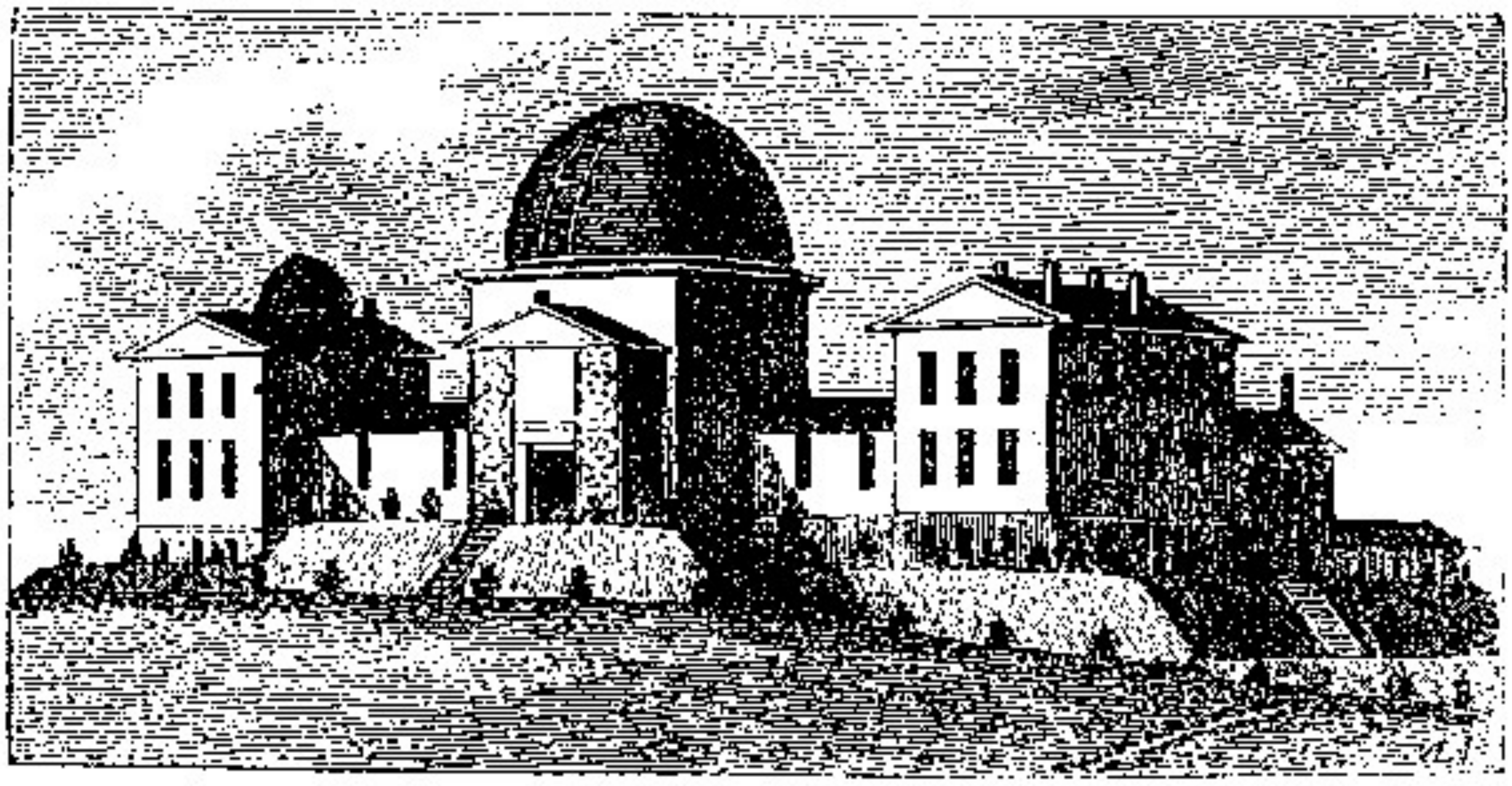
Partners in Time: William Bond & Son of Boston and the Harvard College Observatory

Carlene E. Stephens

In the mid-nineteenth century, the Boston firm of William Bond & Son developed a unique partnership with the Harvard College Observatory in which the activities of one sustained and influenced the direction of the other. From roughly 1830 to 1890, the Bond firm traded mainly in marine chronometers, the timekeepers that had become indispensable for determining longitude at sea. During nearly half that period, from 1839 to 1865, William Cranch Bond (1789–1859) and his son George Phillips Bond (1825–1865) served as the first two directors of the Harvard College Observatory. Much of the Bonds' work at the observatory focused on two practical aspects of astronomy, determining longitude and distributing standardized accurate time. This essay focuses on the collaboration between firm and observatory and offers a reinterpretation of the Bond years at Harvard.[1]

This essay accompanies an exhibition held at the Collection of Historical Scientific Instruments, Harvard University, from 10 January through 9 June 1989. The exhibition, "The Most Reliable Time," commemorates the 150th anniversary of the Harvard College Observatory and the 200th birthday of the founding director William Cranch Bond. The Collection and the Department of the History of Science and Technology, National Museum of American History, Smithsonian Institution, jointly organized the exhibition, which was funded in part by the Perkin Fund. The author completed the research for the exhibition and this essay with a Smithsonian Scholarly Studies grant.

[1] This essay derives from a larger work-in-progress on William Bond & Son and the Harvard College Observatory by the author and her colleague Wm. David Todd. The Bonds' astronomy and their administrative contributions to the observatory are described in Bessie Zaban Jones and Lyle Gifford Boyd, *The Harvard College Observatory: The First Four Directorships, 1839–1919* (Cambridge, Mass.: Belknap Press of Harvard University Press, 1971), and in Solon I. Bailey, *The History and Work of Harvard Observatory, 1839 to 1927* (New York: McGraw-Hill Book Company, 1931), pp. 217-236. Excerpts from Bond papers are in Edward S. Holden, *Memorials of William Cranch Bond and his Son George Phillips Bond* (New York: Lemcke and Buechner, 1897).

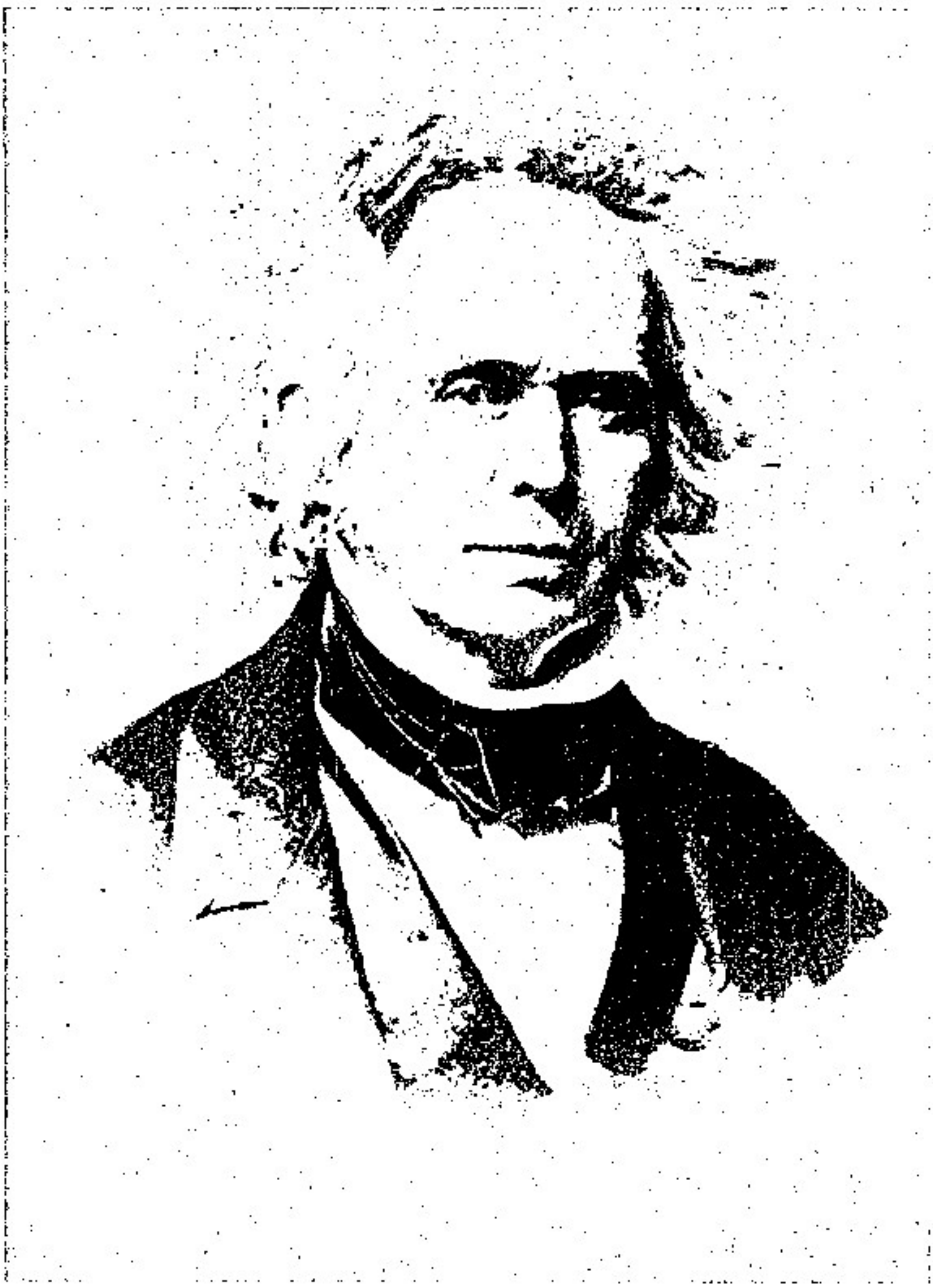


Harvard College Observatory, 1851
From Jones & Boyd, *The Harvard College Observatory (1971)*

A remarkable body of three-dimensional evidence survives to document the partnership and directly inspired this fresh look at the Bonds' work.[2] Although the telescope has long been the most visible symbol and tool of astronomy, nineteenth-century observatories also depended on clockwork technology — precision regulators, marine chronometers, scientific instruments with clockwork drives, and the highly specialized horological tools to produce them. The Bonds designed, made, altered, or used such objects at either the firm, the observatory, or both. These objects, examined together with the extensive surviving documentary evidence, underscore the interdependence of firm and observatory and illustrate the interaction of science, technology, and commerce in the shadowy borderland they occupied together in antebellum America.[3]

[2] Two large collections of Bond artifacts survive. The Collection of Historical Scientific Instruments, Harvard University, includes numerous regulators, family memorabilia, and the company papers; the other collection, tools and products from the shop of William Bond & Son, is at the National Museum of American History, Smithsonian Institution, Washington, D.C.

[3] The present-day consensus about the nature of the science-technology relationship holds that the relationship is a symbiotic coequal one, not a hierarchical one in which technology is the lesser partner. For a summary of the historiography and additional commentary, see Edwin T. Layton, Jr., "Presidential Address: Through the Looking Glass, of News from Lake Mirror Image," *Technology and Culture*, 28 (1987), 594-607. For general background on the science-technology relationship, see Robert V. Bruce, *The Launching of Modern American Science* (New York: Alfred A. Knopf, 1987), pp. 115-165.



William Cranch Bond, 1849
From a daguerreotype

Clearly, each object is a mechanical marvel, an eloquent testament to the maker's skill, worthy of study simply for its technical elegance. The intriguing conical-pendulum regulators that W. C. Bond's son Richard designed, for example, stood at the pinnacle of nineteenth-century horological accuracy. To watch the complex escapement move is hypnotic. To analyze how it moves gives entrée to the mind of the designer, bent on solving the vexing problem of providing precisely equal impulses to keep the pendulum oscillating constantly.[4] But only when examined in context do the objects offer insights into their origins and their impact on American science and commerce.

Studying the Bond artifacts and their use reveals the vital role precision instruments played in astronomy's discoveries. William Cranch Bond systematically sought to refine the technology and techniques of observation to eliminate instrument and human error. He relied on other craftsmen for telescope lenses, but designed the observer's chair, made improvements in telescope mountings, customized recording instruments and clock parts, even the observatory's rotating dome to insure the most precise observations obtainable. His son George's faith in the potential of celestial photography, when the technology was in its trying infancy, inspired others to make the camera an indispensable tool for astronomy. Even astronomer Benjamin Gould, who was no friend of the Bonds and who valued mathematical over practical astronomy, admitted in 1856, "It is the mechanical artist to whom . . . we owe the chief advances of modern astronomy."[5]

The Bonds' work with timekeeping and clockwork technology had an impact far beyond Boston. Their practical astronomy intersected dramatically with the commercial interests of New England and the rest of the country. The Bonds not only made and sold clocks, chronometers, and other clockwork instruments. They used them to determine and distribute standardized accurate time. William C. Bond began the world's first public time service based on telegraphed clock beats. All over New England railroad conductors and seamen in port

[4] Workmen at William Bond & Son made three of these regulators shortly after Richard Bond's death in 1866. The first became the Harvard College Observatory's mean-time regulator. The second stood in the window of the Bond firm, and the third went to the Liverpool Observatory.

[5] *American Journal of Science*, 73 (1857), 408, quoted in Bruce, *Launching of Modern American Science* (note 3), p. 102.

set their timepieces to the synchronizing beats of the observatory's clock.

Inextricably linked to the observatory's timekeeping programs were observations for longitude. Unlike Europe, mid-nineteenth-century America had no national prime meridian to serve as starting point for longitude calculations and standard time. William C. Bond determined the position of the Cambridge observatory relative to Greenwich, England, and made Cambridge for a time the de facto North American prime meridian. Cambridge served as reference meridian and time source for the empire-extending expeditions of the U.S. Topographical Engineers, the U.S. Navy, and the U.S. Coast Survey.[6]

The Bonds' origins in the Anglo-American commercial world set them at odds with influential members of the American astronomical community. Although both William Cranch Bond and George Phillips Bond became professional astronomers, neither was able to dissolve a fundamental attachment to the world of Boston's tradesmen-mechanics. Both their business and breeding bound them to England in an era when other American "scientifics" strove to import German research methods. Mainstream American academic astronomy had a mathematical bias, and the Bonds emphasized practical astronomy.[7]

Yet these very factors that set the Bonds apart from other American men of science also worked to further the Bonds' goals for astronomy at the Harvard observatory. Because of William Cranch Bond's obsession with precision instruments, his family and commercial ties to England, and the generous backing of Boston's shipping interests, the Bonds came to preside over the best equipped, most generously funded private scientific institution in antebellum America.

The Firm

The firm of William Bond & Son grew out of misfortune and poverty to become one of the most prominent instrument makers and

[6] Craig B. Waff, "Charles Henry Davis, the Foundation of the American Nautical Almanac, and the Establishment of an American Prime Meridian," *Vistas in Astronomy*, 28 (1985), 61-66; Derek Howse, *Greenwich Time and the Discovery of the Longitude* (Oxford: Oxford University Press, 1980), pp. 138-151.

[7] For a discussion of issues in antebellum astronomy, see Deborah Jean Warner, "Astronomy in Antebellum America," in *The Sciences in the American Context: New Perspectives*, ed. Nathan Reingold (Washington, D.C.: Smithsonian Institution, 1979), pp. 55-75.

suppliers of the nineteenth century. Founder William Bond, an immigrant silversmith-watchmaker from Cornwall, arrived in America with his family in 1786 and set up a lumber business in Falmouth (now Portland), Maine. In 1790, when a ship carrying the entire season's cuttings went down, Bond lost his capital and moved his family south to Boston. In 1793, the Cornishman set up a watch and jewelry business on Marlboro Street.[8]

In the second quarter of the nineteenth century the firm's activities expanded from the watch and jewelry trade to include marine chronometers. Due to the energy and mechanical skill of the founder's son, William Cranch Bond, the firm provided extensive instrument service to private shipping, the U.S. Navy, the U.S. Coast Survey, and the U.S. Topographical Engineers.

The Bonds sold instruments of their own manufacture, retailed and lent British imports, and rated and serviced chronometers for government and commercial customers. Their principal suppliers were English chronometer and horological parts makers, and their main customers were New England ship captains, who were required by the shipping companies employing them to purchase their own instruments.

Chronometers were expensive, and the price of a new instrument changed little between about 1835 and 1890. Depending upon quality, a new chronometer purchased from the Bonds could cost between \$220 to \$300. Even a used one might cost nearly \$200. Rentals averaged \$5 per month of voyage and offered an attractive alternative to purchase. Repair costs depended on the complexity of the task, but in 1833, for example, adjusting a chronometer spring, which demands a high level of skill, cost \$5, nearly as much as the Bonds' lower-paid shop employees earned in a week.[9]

[8] Holden, *Memorials* (note 1), pp. 2, 4.

[9] In 1833, for example, the Bonds sold the following chronometers for the prices indicated: M. Tobias No. 127, \$240; Parkinson & Frodsham No. 900, \$260; Hornby No. 384, \$220; Parkinson & Frodsham No. 1771, \$300. The Bonds were not a discount house. One customer complained to them in 1848 that he could purchase new Parkinson & Frodsham chronometers from dealers in Salem and New York for about \$200 to \$215, but this claim is unsubstantiated. In 1850, the Bonds quoted another customer a price of between \$275 and \$300 for a "first-rate" instrument. An advertisement from 1889 offers new mean-time and sidereal chronometers for \$250 to \$300. William Bond & Son Daybooks, 1833–1835 and 1848–1852, Harvard Collection of Historical Scientific Instruments (hereafter HCHSI).

CHRONOMETER MANUFACTORY.

WM. BOND & SON,

NO. 17 CONGRESS STREET, BOSTON,

ESTABLISHED IN 1793,

CHRONOMETER MAKERS TO THE UNITED STATES GOVERNMENT,

Offer for sale a complete assortment of

MARINE AND SIDEREAL CHRONOMETERS

of their own manufacture, and also those made to their special order in England. All of these instruments are carefully tested before being offered for sale.

Messrs. Bond & Son are provided with every facility for ensuring the greatest accuracy in ascertaining the *Rates* and *Errors* of Chronometers, and *Time* for Railway regulation. Their connection, by means of the Electric Telegraph, with the Astronomical Observatory of Harvard College, combined with their apparatus in Boston, *enables them to determine local, Washington, or Greenwich time, with the utmost precision.* All the public Clocks of the City of Boston, and the Railroads of New England, are regulated by the Standard time of Messrs. William Bond & Son.

Particular attention paid to the repairing and adjusting of Chronometers. Old Chronometers restored, so far as the nature of the case will admit.

Chronometers loaned for long or short voyages.

WATCHES AND CLOCKS CAREFULLY REPAIRED.

Gold and Silver compensated Watches, of the most approved construction and quality, for sale, as well as those, both French and English, of a less expensive class.

Astronomical Clocks and Spring-Governor Electrical Recording Apparatus, made to order.

Telescopes and other Astronomical Instruments imported.

☞ Messrs. Bond & Son have had awarded to them the Gold and the Silver Medals of the Massachusetts Charitable Mechanic Association, and the Great Council Medal of the World's Exhibition at London in 1851; these medals being the highest distinction conferred by those bodies for original useful inventions.

Boston, July 1, 1859.

Collection of Historical Scientific Instruments

Advertisement for William Bond & Son, 1859

ESTABLISHED IN BOSTON, A. D. 1793.

WILLIAM BOND & SON,

134

State Street,

BOSTON, MASS.

CHRONOMETER MAKERS TO THE U. S. GOVERNMENT,

AND SOLE AGENTS FOR

THE CELEBRATED WATCHES

MADE BY VICTOR KULLBERG, AND JAMES POOLE & CO., LONDON.

ORIGINAL, AND ONLY MANUFACTURERS IN NEW ENGLAND OF

SUPERIOR

MARINE AND SIDEREAL CHRONOMETERS,

ASTRONOMICAL CLOCKS,

AND

IMPROVED

Electric Break Circuit Chronometers,

Which are acknowledged by Scientific men to be the best in use.

IMPORTERS OF

The Best Chronometers and Watches,

made expressly to their order in London and Geneva, all of which are carefully tested before being offered for sale.

Particular attention paid to the **Repairing** and **Adjusting** of CHRONOMETERS, WATCHES AND CLOCKS.

CHRONOMETERS RATED

with the greatest care, and the error given from any desired Meridian, and in any language, the utmost accuracy being obtained by constant Telegraphic communication with the **Astronomical Observatory of Harvard College.**

RELIABLE CHRONOMETERS CONSTANTLY ON HAND TO LET.

☞ Messrs. WM. BOND & SON have received the GOLD AND SILVER MEDALS of the MASS. CHARITABLE MECHANIC ASSOCIATION, at the Exhibitions in 1850—1856—1860—1874; the GREAT COUNCIL MEDAL of the WORLD'S EXHIBITION, in London, in 1851, and the PARIS EXPOSITION, in 1867, each being the HIGHEST DISTINCTION conferred by those bodies for original useful inventions.

Collection of Historical Scientific Instruments

Advertisement for William Bond & Son, 1889

In most of their advertising literature the Bonds repeatedly claimed that they made their own chronometers, which was not always literally so. In the horological trades, both here and abroad, a longstanding practice permitted the finisher-retailer of the timepiece to put his name on it. One commentator observed the custom was already well-established in the eighteenth century:

> The Watch-Maker, properly so called, scarce makes anything belonging to a watch; he only employs the different Tradesmen among whom the Art is divided, and puts the several Pieces of the Movement together and adjusts and finishes it. . . . The Watch Maker puts his name upon the plate and is esteemed the Maker though he has not made in his shop the smallest wheel belonging to it.[10]

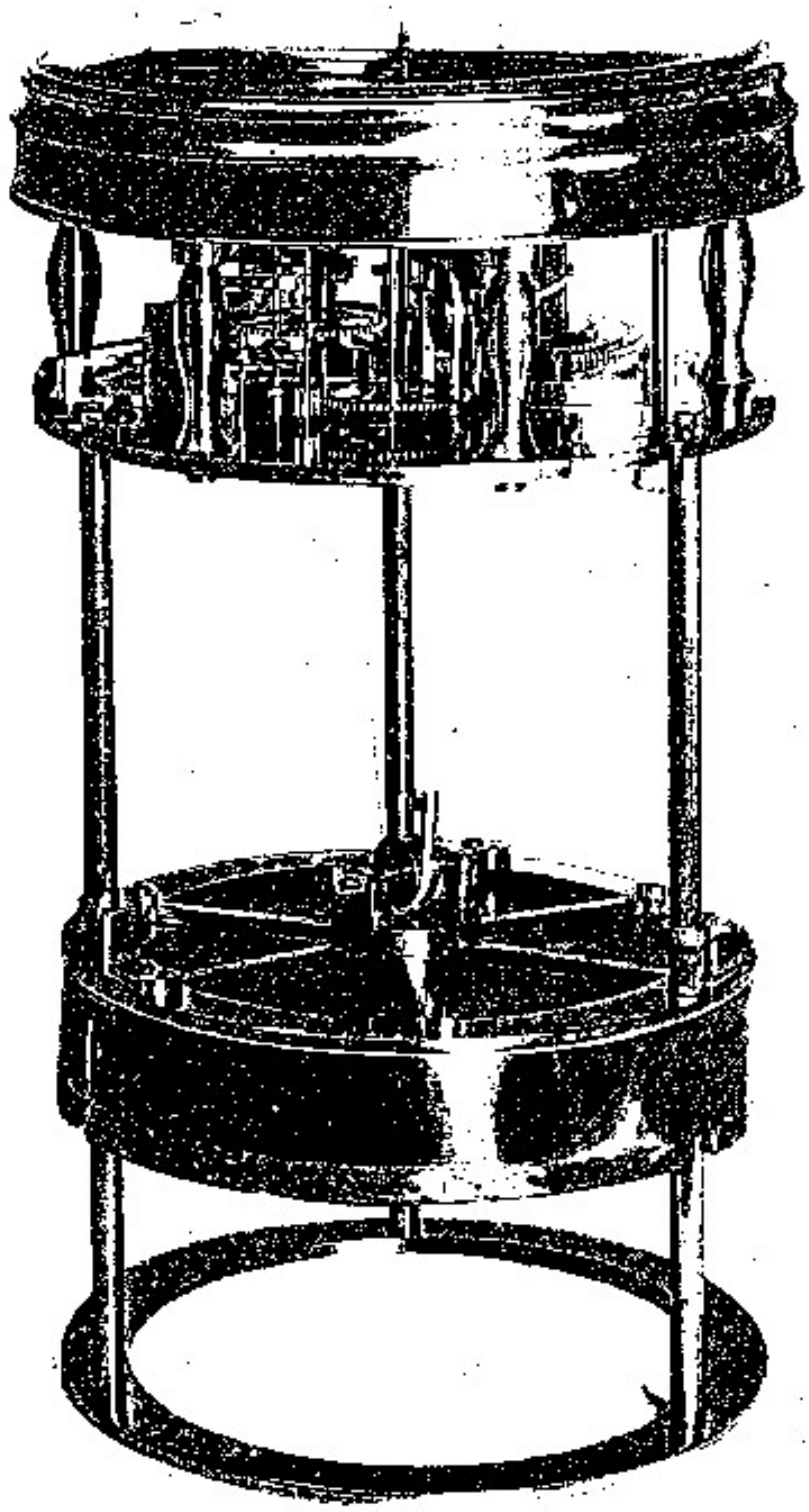
In keeping with this tradition the Bonds made few chronometers entirely on their own.

The most significant exception and earliest known surviving example with a Bond signature is one William Cranch Bond made himself in 1815. The most striking feature of this instrument is its unconventional weight drive. By the beginning of the nineteenth century, the most common means of driving a marine timekeeper was the force provided from an unwinding mainspring. But Bond began construction of his timekeeper during the War of 1812, when a trade embargo prevented him from procuring British spring steel. Bond constructed his chronometer to run with a falling lead weight after reading about the eighteenth-century marine timekeepers of Ferdinand Berthoud in the sea journals of French navigator Jean François de Galaup, Comte de La Perouse.[11]

Tradition says that Bond's 1815 marine timekeeper was the first sea-going chronometer made in America. The instrument went to sea only once, though, on a voyage to Sumatra in 1818 aboard the U.S. Navy ship *Cyrus*. After numerous opportunities to test it against lunar observations, the ship's captain, Thomas B. Curtis, found that the timekeeper performed "with utmost regularity." But chronometers were uncommon equipment aboard American vessels in this period, and Curtis warned Bond to "please remember that I am not

[10] R. Campbell, *The London Tradesman* (London, 1747), quoted in Roy Porter et al., eds., *Science and Profit in 18th-Century London* (Cambridge, Eng.: The Whipple Museum of the History of Science), p. 21.

[11] Thomas Bond to George P. Bond, 21 February 1859, quoted in Edward S. Holden, *Memorials* (note 1), pp. 7-8; G. P. Bond, Memoranda relating to W. C. Bond, quoted in *ibid.*, pp. 11-12; *Ferdinand Berthoud, 1727–1807* (La Chaux-de-Fonds, Switzerland: Musée International d'Horlogerie, 1984), pp. 43, 207; "La Perouse," *Grand Larousse*, VI, 603.



Smithsonian Institution

Marine timekeeper made by William Cranch Bond, 1812–1815 experienced in the use of the instrument, and attribute any errors you may discover to this cause."[12]

Most chronometers with Bond labels examined to date have punch marks for initials of Lancashire makers under the dial plate. In mid-nineteenth-century England, the region around Liverpool supplied most of the world's horological needs. The Lancashire workshops, with labor minutely divided according to task, could sell thousands of partially complete chronometer movements to retailer-finishers at relatively low cost. The Bonds probably imported these unfinished Lancashire movements, assembled the delicate balance and balance spring, made the fine adjustments, and retailed them under their own name.[13]

The Bonds had the skilled craftsmen to do this kind of precision work. Richard Bond trained in England to learn "springing," the meticulous process of making the helical balance spring with exact length and terminal curves and adjusting these individually to each timekeeper. The firm employed varying numbers of skilled workers, with a maximum of twelve in 1869. The majority came from Switzerland and England, already trained and with their own tools.[14]

The Bonds' business in precision astronomical regulators equalled their chronometer trade in significance, if not in volume. These clocks were not mass-produced domestic products destined for the homes of New Englanders. They were for an elite clientele — college and university astronomical observatories, railroad terminals, and government surveyors. Like their chronometers, a regulator purchased from the Bonds might have been an imported British movement with the Bond name on it, a special Bond-made escapement, or, save for the case, an instrument made entirely in the Bond shop. Indisputable evidence that the firm actually made certain pieces comes from an

[12] Thomas B. Curtis to William C. Bond, 25 December 1818 and 21 August 1819, Bond Papers, HCHSI.

[13] Alun C. Davies, "The Life and Death of a Scientific Instrument: The Marine Chronometer, 1770–1920," *Annals of Science*, 35 (1978), 509-527. The author is grateful to John Griffiths, Curator of the Prescot Museum, Prescot, England, for examining numerous Bond chronometer movements and for providing information on Lancashire chronometer makers.

[14] David Harries describes the springing process in his Foreword to Tony Mercer, *Mercer Chronometers: Radical Tom Mercer and the House He Founded* (Ashford, Kent, England: Brant Wright Associates, 1978), p. x; *Webb's New England Railway and Manufacturers' Statistical Gazetteer* (Providence, R.I.: Webb Bros. & Co., 1869), p. 165; regarding Bond employees, see, for example, the articles of agreement between R. F. Bond and English immigrant William Hiatt, 9 May 1859, Bond Papers, HCHSI.

extremely rare collection of Bond casting patterns that match existing Bond clocks, chronometer gimbals, and other scientific instruments.[15]

Their trade with Britain, mainly importing, was sufficiently great that they employed Joseph Cranch, William Cranch Bond's brother-in-law, nearly full time as a trading agent.[16] The ties with England were, of course, much deeper. Founder William Bond was notorious for his "mean opinion of Yankee manufacturing." His son and grandsons were avowed Anglophiles. William Cranch Bond, about the time his mother died in 1828, even decided to emigrate with most of his family to Kingsbridge in Devonshire, where his kinsmen still lived. Like his father, he was disenchanted with the American world of commerce. "I am deeply disgusted," he wrote his brother-in-law, "with the manner in which business is conducted here, so much trickery — double dealing & deceit." His visions of greener pastures dissolved, though, when he lost all his savings in a failed New York oil venture.[17] A few years later he received opportunities to work, first, for the U.S. Navy and then for Harvard.

The Harvard College Observatory

William Cranch Bond initiated the firm's first contacts with Harvard. Set to work with his father before he finished formal schooling, William was largely a self-taught astronomer, although he received some instruction from Harvard's mathematics professor, John Farrar, and New England's most famous self-taught astronomer, Nathaniel Bowditch. Bond's observations of the comet of 1811 impressed Farrar; and when Bond scheduled a trip to England in 1815, Farrar recommended that Harvard ask him to survey British observatories with a view to building one on campus. Bond returned with details about structures and instruments, but, for lack of funds the college dropped the matter.

Harvard had no observatory until late in 1839, when the college's president, Josiah Quincy, convinced the fifty-year-old Bond to become the school's astronomer. Bond got no salary, but living quarters and space for instruments were freely provided in Dana

[15] These casting patterns survive in HCHSI.

[16] Massachusetts, vol. 69, p. 439, R. G. Dun & Co. Collection, Baker Library, Harvard University Graduate School of Business Administration, cited here by permission.

[17] W. C. Bond to John Willcox, 16 March 1828, 28 September 1828, 26 August 1830; W. C. Bond to Joseph Cranch, 19 July 1829, Cranch Papers, Boston Public Library.

House. Here on 31 December Bond made his first observations for Harvard.[18]

Bond had again attracted Harvard's attention in the late 1830s by providing meteorological and astronomical observations for the U.S. Exploring Expedition, headed by Charles Wilkes. Beginning in 1834, a series of contracts with the U.S. Navy gave Bond the opportunity to rate, clean, repair, insure, and deliver ships' chronometers for the ports of Boston and Portsmouth.[19] From 1838 to 1842, he contracted to provide observations of eclipses and moon culminations and occultations specifically for Wilkes.

Bond enthusiastically applied himself to his first paying job as a government astronomer. For his home observatory in Dorchester he quickly overspent his contract fee to buy new, more accurate instruments specifically for expedition observations. He brought these very instruments with him when he moved to Dana House.[20]

This early work for the navy had important and long-lasting consequences for Bond. Through the Wilkes Expedition he earned a reputation as a first-rate observer at one of the few fixed observatories in the country at the time. In 1845 the navy asked Bond to head the Naval Observatory in Washington, but he declined. Federal contracts for astronomical work followed from the Topographical Engineers for important nineteenth-century boundary surveys, including the U.S.-Mexican border, the U.S.-Canadian border in the Northwest, and the Great Lakes Survey.[21]

The dazzling comet of 1843 stirred an outpouring of public inquiries and revealed the inadequacies of Bond's Dana House instruments

[18] For details about the college's attempt to found an observatory before 1839 and the measures taken immediately before William Cranch Bond became the observatory's director, see Jones and Boyd, *Harvard College Observatory* (note 1), pp. 1-39, and William Cranch Bond, "History and Description of the Astronomical Observatory of Harvard College," in *Annals of the Astronomical Observatory of Harvard College*, 1 (1856), i-vi.

[19] Although marine chronometers meet high standards of reliability and accuracy, any mechanical timekeeper will gain or lose time. The error of a chronometer is the time it has gained or lost at any given time; the daily rate is the time it gains or loses in the course of a day. To rate chronometers, Bond made astronomical observations to obtain the local time and compared that with the time shown on the instruments.

[20] Bond, "History and Description" (note 18), pp. v-vi; George P. Bond to Edward Everett, 9 March 1859, and William C. Bond to George Bancroft, 14 May 1845, Bond Papers, Harvard University Archives (used here by permission and cited hereafter BP, HUA).

[21] G. P. Bond, "History of the H.C.O. 1840–1850," draft sent to William Mitchell, 19 December 1850, BP, HUA.

for plotting the comet's orbit and computing its period. In "the interests of science and commerce" Harvard's science professors joined local merchants, manufacturers, and marine insurers to raise funds to purchase a first-rate refracting telescope. Citizens from Boston, Salem, New Bedford, and Nantucket contributed $20,000 in short order. Businessman David Sears donated $5,000 to build the telescope's great stone pier. By 1855 outlays by Harvard, additional community subscriptions, and three endowments laid a stable financial base for the observatory.[22]

In 1843, construction began on a new observatory on Garden Street, then on the outskirts of Cambridge but today one of the buildings of the Harvard-Smithsonian Center for Astrophysics. Four years later the Bonds erected a fifteen-inch refracting telescope. This "Great Equatorial," equal in size to the largest telescope in the world at Pulkova Observatory, Russia, consisted of an object lens from the Munich firm of Merz & Mahler and mounting apparatus from the British firm Troughton & Simms.

In his published account of the comet of 1811, John Farrar, had characterized young William Cranch Bond as "an ingenious mechanic of Dorchester."[23] Throughout Bond's life, both as businessman and as observatory director, he never escaped his origins in the Anglo-American horological world and the subculture of Boston mechanics, the artisan-entrepreneurs who were to form the basis of Boston's middle class. He was not only a long-time member of the American Academy of Arts and Sciences, but also a faithful supporter of the Massachusetts Charitable Mechanic Association. He won several prizes at the MCMA industrial fairs and served as vice president in 1851–52. Although he eventually immersed himself in the observatory full time and gave up his partnership in the family firm, the observatory during his directorship nevertheless bore the imprint of his mechanic origins.

Bond's most significant contributions to American science were his innovations in administrative and technical systems for research, not

[22] Jones and Boyd, *Harvard College Observatory* (note 1), pp. 49-50; Bond, "History and Description" (note 18), pp. xiv-xv; Howard S. Miller, *Dollars for Research: Science and Its Patrons in Nineteenth-Century America* (Seattle: University of Washington Press, 1970, pp. 34-38.

[23] John Farrar, "On the Comet of 1811," *Memoirs of the American Academy of Arts and Sciences*, 3 (1815), 308, quoted in Jones and Boyd, *Harvard College Observatory* (note 1), p. 28.

astronomical discoveries. Both William Cranch Bond and his son George, who succeeded him as director at the observatory were, above all, technical experimenters.

The Bonds did spend thousands of punishing hours in the unheated, dimly lit dome observing the heavens and in the tedious mathematics of reducing their observations. In the process they uncovered important new information about the physical features of planets, comets, and nebulae. Saturn's seventh satellite and eighth ring were among their discoveries. G. P. Bond's life-long interest in comets culminated in his internationally acclaimed volume about Donati's Comet of 1858, publication of which prompted England's Royal Astronomical Society to award him their first medal offered to an American. William Cranch Bond had become the society's first American fellow in 1849. Of the two Bonds, George expended more energy computing and publishing results of observations. William's first priority was institution-building, which he did with scrupulous attention to the technology of astronomy.

Photography at Harvard's Observatory

Almost as soon as the Great Refractor stood in place, the Bonds and Boston photographers John A. Whipple, William B. Jones, and James Black, stretched the limits of the nascent art and science of photography. They first experimented with daguerreotypy. In this process, named after Frenchman Louis Daguerre, a light-sensitive copper plate is treated with silver iodine or silver bromine exposed in the camera, developed with warmed mercury vapor, and fixed with sodium thiosulphate.[24] Together the innovators made a number of important breakthroughs, despite nearly continuous difficulties with the telescope's clockwork drive.

With energy, enterprise, and expertise, John Whipple (1822–1891) built his photographic business into one of the city's best known studios between 1840 to 1860, the daguerrean age. He was also among the first in the country to make paper prints from glass negatives (his patented crystalotypes) and to experiment with the wet-plate collodion process. Although he most frequently photographed ordinary

[24] John Lankford, "The Impact of Photography on Astronomy," in *Astrophysics and Twentieth-Century Astronomy to 1950*, vol. 4 of *The General History of Astronomy*, ed. Owen Gingerich (Cambridge: Cambridge University Press, 1984), p. 16.

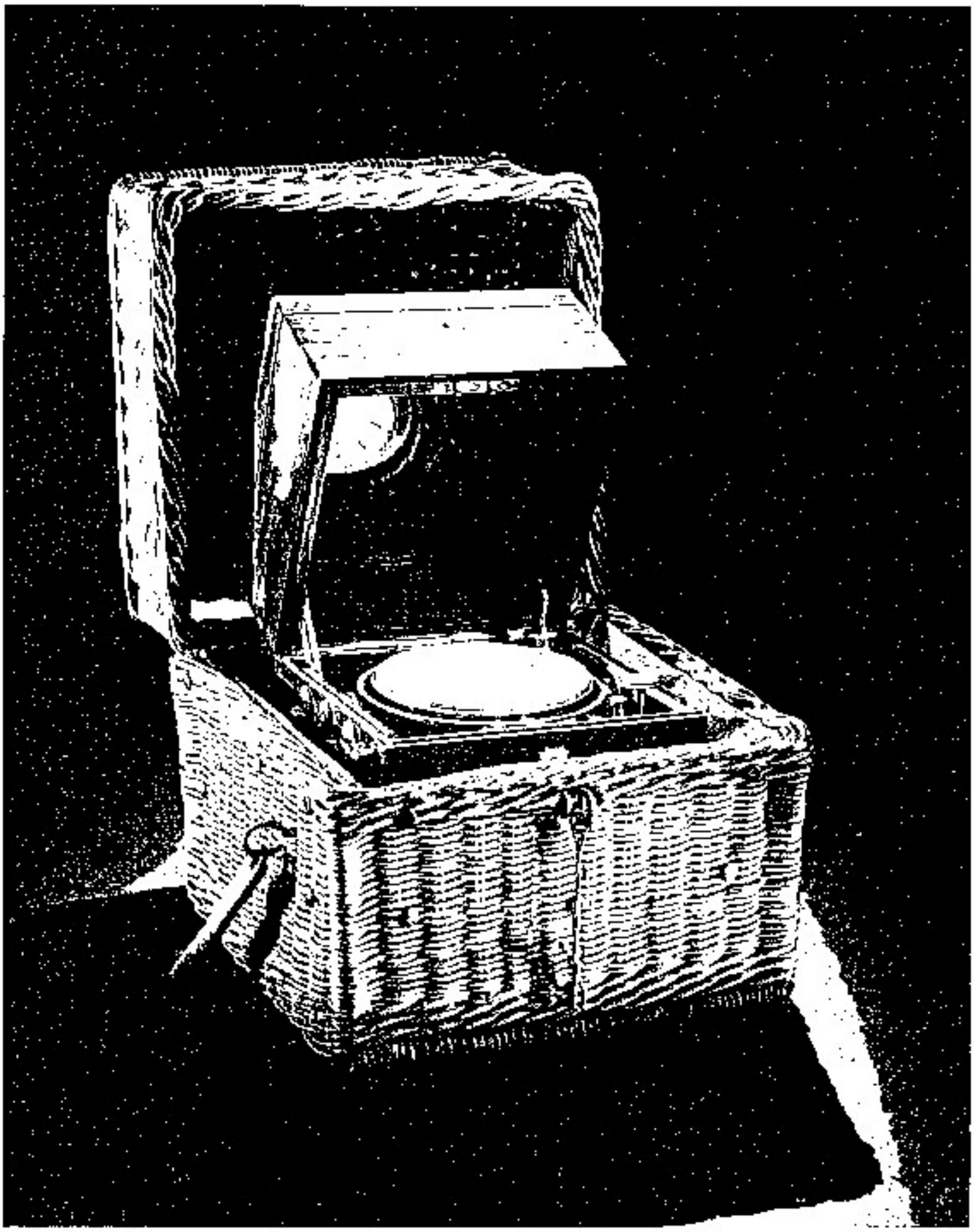


Photo: Dane Penland, Smithsonian Institution

Marine chronometer in transportation basket,
William Bond & Son No. 521

people, to promote his business he also photographed the famous (Jenny Lind on her world tour) and the amazing (minuscule insects shot through the lens of a microscope in 1846). Whipple's work demonstrated his unmatched technical expertise, and his experiments extended the capabilities of photography.[25]

Whipple convinced the Bonds to let him use the revered Great Refractor for experiments. William Cranch Bond grasped the advantages of photography for astronomy. Recording the heavens with a camera fitted the notion of self-registration, the ideal promoted for scientific instruments in the nineteenth century. Self-registering instruments could record data automatically, eliminating a source of human error and producing more accurate observational results. Rather than finding Whipple's profit motive offensive, Bond, a tradesman himself, understood it. Both were tinkerer-scientists: Bond in astronomy, Whipple in chemistry. George Bond shared their fascination, and the notes on daguerreotyping and collodion photography found in the record books for the 15-inch telescope are mostly in his handwriting.[26]

In October 1847, Whipple first took his apparatus to the observatory to try a daguerreotype of the moon through the Great Refractor. The setting sun's rays, focused through the eyepiece, instantly burned a hole in W. C. Bond's coat sleeve, and the incident ended further trials with the instrument for a time. On the same night, though, with the smaller 7-inch reflecting telescope Whipple produced a daguerreotype of the moon. The silvery image on the plate had only a disappointing 5/8th-inch diameter. Nevertheless, the possibilities for future work tantalized the men.[27]

Two years later, in December 1849, Whipple and his associate William Jones again tried without success to capture the moon with the Great Refractor. When they turned their attention from the moon to the stars, on the night of 16–17 July 1850, the team got the first

[25] Sally Pierce, *Whipple and Black: Commercial Photographers in Boston* (Boston: The Boston Athenaeum, 1987), pp. 3, 17.

[26] Holden, *Memorials* (note 1), p. 262; Dorrit Hoffleit, *Some Firsts in Astronomical Photography* (Cambridge, Mass.: Harvard College Observatory, 1950), p. 28.

[27] New Yorker John Draper took the first daguerreotype of the moon ever made in 1840. W. C. Bond and G. P. Bond diary for 1846–49, BP, HUA; Letter from John Whipple, *The Photographic Art-Journal*, 6 (July 1853), 66.

successful photograph of a star. The subject was first-magnitude Lyrae; the exposure, 100 seconds.[28]

During these trials, two problems recurred. The lack of sensitivity of the photographic plates forced extremely long exposures. Long exposure, for the first time, revealed the uneven rotating rate of the Munich-made telescope clockwork. Because of the clockwork, stars appeared as elongated blurs, rather than symmetrically round images.[29]

In 1851, shorter exposures brought success. In that year the team took shots of Jupiter and a solar eclipse, but their most impressive daguerreotypes were of the moon. After two nights of trying different exposures, discovering that the photographic focus differed from the visual focus, and waiting for clouds and the unsteady atmosphere to clear, Whipple and Jones got a dramatically clear series. This time, with the moon's image nearly filling the photographic plate, the lunar mountains and craters showed with amazing clarity. These daguerreotypes excited praise both at home and abroad, won numerous medals, and inspired British astronomers to attempt the same experiments.[30]

Whipple's struggles to capture a "clear, well-defined, beautiful" image prompted him to describe the process to fellow photographers. "The governor," he wrote, "had a tendency to move the instrument a little too fast, then to fall slightly behind." By exposing his plates during the few moments when the telescope followed the moon exactly, he could get a clear picture. "But a more serious obstacle to my success," he continued, "was the usual state of the atmosphere in the locality . . . when the moon was viewed through the telescope it had the same appearance as objects when seen through the heated air from a chimney, in constant tremor. . . ."[31]

The severity of the problems with the governor prevented further experiments until 1857 when the Bonds installed a replacement, made

[28] Hoffleit, *Some Firsts* (note 26), pp. 24-27.

[29] Annual Report for 1850, quoted in Hoffleit, *Some Firsts* (note 26), pp. 24-25.

[30] Letter from John Whipple, *Photographic Art-Journal*, 6 (July 1853), 66; "Important Experiment. Daguerreotype of the Sun," *The Daguerreian Journal*, 2 (1851), 210; entry for 22 March 1851, Equatorial Record Book, Harvard College Observatory, quoted in Hoffleit, *Some Firsts* (note 26), p. 28. Lankford, "Impact of Photography on Astronomy" (note 24), pp. 17-18.

[31] Letter from Whipple, *The Photographic Art-Journal* (note 30), p. 66.

to their specifications by Alvan Clark and Sons of nearby Cambridgeport. Alvan Clark, Sr., was a painter by profession and an amateur astronomer. His sons went on to become the premier telescope makers of nineteenth-century America. The Clarks also made Whipple's camera lenses.[32]

In January 1857, with the new governor in place, Whipple returned to the observatory with a new colleague, James Black, and a new photographic technology, the wet-plate collodion process. Whipple and Black pioneered wet-plate photography in the United States. Collodion was the name given to a solution of guncotton, potassium iodide, alcohol, and ether. The photographer coated a glass plate with the chemicals, dried it, and then dipped it in a silver nitrate solution. The plates were ten times more sensitive than the daguerreotype but had to be exposed while still wet, within roughly ten or fifteen minutes of preparation.[33] Over the next three years Whipple, Black, and the Bonds took numerous collodion plates with multiple exposures of the double star Mizar and its companion Alcor.

By one count the Bonds and the Boston photographers took about 70 daguerreotypes and between 200 and 300 collodion plates of celestial bodies. The permanence and accuracy of their photographic record was indisputable. They raised the magnitude of photographable stars from first to sixth magnitude, and made preliminary attempts to measure stellar distances and intensity with the images on the plates. But photography as a research tool for astronomy became widely used only in the 1880s, when more sensitive dry plates became common. Although George Bond found photographing the heavens fraught with "trouble, vexation and fatigue," he nevertheless saw great promise in the new technology. He predicted a day when the clear air of mountaintop observatories would make photography a workable tool for astronomy.[34]

[32] Neither the Clark drive nor the Bonds' specifications for it survives. Deborah Jean Warner, *Alvan Clark & Sons: Artists in Optics* (Washington, D.C.: Smithsonian Institution Press, 1968) and Marcus A. Root, *The Camera and the Pencil* (Philadelphia: Published by the author, 1864), p. 365.

[33] Lankford, "Impact of Photography on Astronomy" (note 24), pp. 16-17.

[34] Hoffleit, *Some Firsts* (note 26), p. 32; G. P. Bond to William Mitchell, 6 July 1857, BP, HUA; Lankford, "Impact of Photography on Astronomy" (note 24), p. 16; George Bond to G. B. Airy, 28 September 1857, BP, HUA; G. P. Bond to J. Ingersoll Bowditch, 31 March 1860, quoted in Bailey, *Harvard Observatory* (note 1), p. 235.

Finding Longitude

In mid-nineteenth-century America, no central national observatory served as the prime meridian, or "longitude zero." Over the course of nearly two decades William C. Bond repeatedly refined the longitude of Cambridge, Mass., relative to Greenwich, England, by way of Liverpool. By 1859, the Bonds had calculated the longitude so closely that George wrote Edward Everett, president of Harvard: "Cambridge is now the central geographical point of this Continent. The charts of the British Admiralty, and the most remote scientific station in this hemisphere, Santiago in Chile, recognize this fact. Our longitude has, undoubtedly, been investigated with more care than that of any other spot on the globe."[35]

Longitude, time, and astronomy are inseparably linked. The difference between the local times of any two places is the difference in their longitudes. Since the Earth rotates 360° in 24 hours, 15° longitude equals one hour. Observers at two distant points, then, can compare their locations by comparing their local times, which are based on altitude observations of sun or stars.

By the nineteenth century, there were numerous workable methods for finding longitude. Navigation manuals of the period frequently explained determining longitude with the aid of astronomy. Observing the eclipses of Jupiter's moons was one such method. Another was measuring lunar distances, or measuring the angle between the earth's moon and certain stars and comparing these distances in a nautical almanac's table locally and distantly. Astronomers at fixed observatories and some navigators used such methods, which required skills in observation and mathematics. On land, surveyors located sites by triangulation, a technique using the angles and length of one side of a triangle to calculate the lengths of the other two. Comparing timekeepers, another common method for determining longitude, involved transportation of marine chronometers from a place of known longitude to a place of unknown longitude. In the mid-1840s experiments for determining longitude with the infant American telegraph system demonstrated the new technology's utility for science. With the telegraph two observers at widely distant points could compare time almost instantaneously.

[35] Memorandum, G. P. Bond to Edward Everett, 9 March 1859, BP, HUA.

The Chronometer Expeditions

By the mid-1840s government observatories in Denmark, Russia, and England had already established their latitudes and longitudes relative to each other by transporting marine chronometers. William C. Bond had begun his own informal determinations of Cambridge's position in the mid-1840s. Two events made such work possible at that time: the opening of a new observatory at Liverpool, from which Bond could derive Greenwich time, and the first steam mail packets, with chronometers aboard, running between Liverpool and Boston. "It now therefore becomes our duty," he wrote, "to form the connecting link which shall bind us in closer harmony with the observatories of the Old World."[36]

In 1849, Alexander Dallas Bache, superintendent of the U.S. Coast Survey, agreed with Bond and gave him formal survey sponsorship and funding for the enterprise. Between 1849 and 1855, the Bonds transported groups of chronometers back and forth to England in three separate trials. Close relations developed with the British astronomers who assisted them, in particular John Hartnup at the Liverpool Observatory, and the enterprise resulted in the determination of Cambridge's longitude so accurately that it became the reference point for the western surveys conducted by the U.S. Topographical Engineers.

"The American Method of Astronomical Observation"

The telegraph revolutionized geodesy and astronomy. In the mid-1840s, experiments with the new American telegraph demonstrated that it could accurately transmit time, obtained from observing star transits, between two distant places. This technology made the everyday operations of longitude expeditions significantly easier and, for the first time, gave astronomers a way of recording all sorts of observations with electricity.

The U.S. Coast Survey began experimenting with the telegraph for exploring vast stretches of uncharted coastline almost as soon as the first lines stretched between Baltimore and Washington. The Survey's system attracted the attention of the British Astronomer Royal, who called it "the American method of astronomical observation" and installed his own version of the instruments in the Royal

[36] W. C. Bond to Pres. of Assoc. (unidentified), draft, n.d., BP, HUA.

Instruments for the "American Method of Astronomical Observation"
From Charles Rodgers, *American Superiority at the World's Fair* (1853)

Greenwich Observatory. By the early 1850s, the Survey's methods and instruments had acquired an international reputation for "superior simplicity, practical facility, and accuracy of results," according to one commentator who was eager to assert America's claim to the invention, an "honorable position, which not even prejudice can deny our young nation."[37]

At first, Coast Survey longitude teams used traditional, labor-intensive measures to determine longitude. Observers tracked celestial phenomena by "eye and ear," that is, by observing the instant of transit of certain predicted clock stars through the wires of the transit eyepiece while listening to the beats of a clock. An assistant to the observer recorded discrepancies between star time and clock time. The Coast Survey recognized their enormous task and began experimenting with a quicker method — determining longitude by the telegraphic exchange of time signals.

Their innovative system combined old and new technology. Tapping into existing commercial telegraph lines, an observer pressed a telegraph key at the moment of transit. A break-circuit device attached to the movement of the mechanical timekeeper transmitted the beats of the clock automatically along the telegraph wire. Finally, a registering instrument received signals from both the observer and the clock, thus providing a record of the instant of transit in a time scale.

The first recording instrument was simply a Morse telegraph register that embossed a paper strip. Survey personnel experimented with other recording devices as well, and eventually favored registers with paper-wrapped cylinders, especially the "spring governor" perfected by the Bonds, an early version of what was to be known as the drum chronograph. From the start, telegraph sounders in the system beat in time to the clock, and time signals were audible not only in the room where the clock stood, but also miles down the line.

The Survey employed notable astronomers and mechanicians to develop a system of special instruments for determining longitude. Under Assistant Sears C. Walker, Survey personnel and outside contractors perfected the method and devised most of the basic instrumentation for electric time-distribution systems. But the telegraph

[37] B. Silliman, Jr., and C. S. Goodrich, eds., *The World of Science, Art, and Industry Illustrated from Examples in the New-York-Exhibition, 1853–54* (New York: G. P. Putnam and Company, 1854), p. 131.

Photo: Dane Penland, Smithsonian Institution

Council Medal Award to William Bond & Son, 1851, by the judges at the Crystal Palace Exhibition, London did not immediately succeed as a scientific tool. Each system component posed stubborn technical problems. The evolution of the instruments and the method, fraught with frustrations and a ferocious dispute over priority of invention, took about a decade of arduous experiment.

The Bonds — William Cranch and his sons George and Richard — were central to this process. They perfected a break-circuit device for attachment to the escapement of the clock and the drum chronograph for recording the instant of an astronomical event in a time scale. The Bonds promoted the apparatus at home and abroad, and at the London Crystal Palace Exhibition in 1851 they won a Council Medal, the exhibition's highest award.[38]

Bond's Standard Time

In December 1851, William C. Bond started the world's first public time service based on clock beats telegraphed from the observatory, an innovation resulting directly from his work with the U.S. Coast Survey. In antebellum America there was no uniform national time. Each local community set its own standard based on its meridian. At the Harvard College Observatory Bond began not only to determine time for his own astronomical purposes, but also to distribute time telegraphically to the surrounding countryside as a public service.

The Visiting Committee to the Harvard College Observatory, consisting of seven Boston-area notables, reported the time service's general usefulness in 1854:

> The apparatus and arrangements for communicating the time by the telegraphic wires are now so complete, that the beats of the Observatory clock are now practically 'heard at every station along the line . . .,' and that the error of even two tenths of a second is very unlikely to occur. The Observatory time is thus communicated, for the regulation of marine chronometers for the port of Boston, the arrangements of railroads, and for the general convenience of the people through a large part of New England.
>
> The importance of such a system to the business operations for the community can hardly be over-estimated.[39]

Time, as one financial journal pointed out in 1850, was "the great item with commercial men." From the unprecedented speed of telegraphed information, they reaped commercial benefits. In addition,

[38] London Great Exhibition of the Works of Industry of All Nations, *Reports by the Juries* (London, 1852), p. 251.

[39] W. C. Bond, "History and Description" (note 18), p. clxviii.

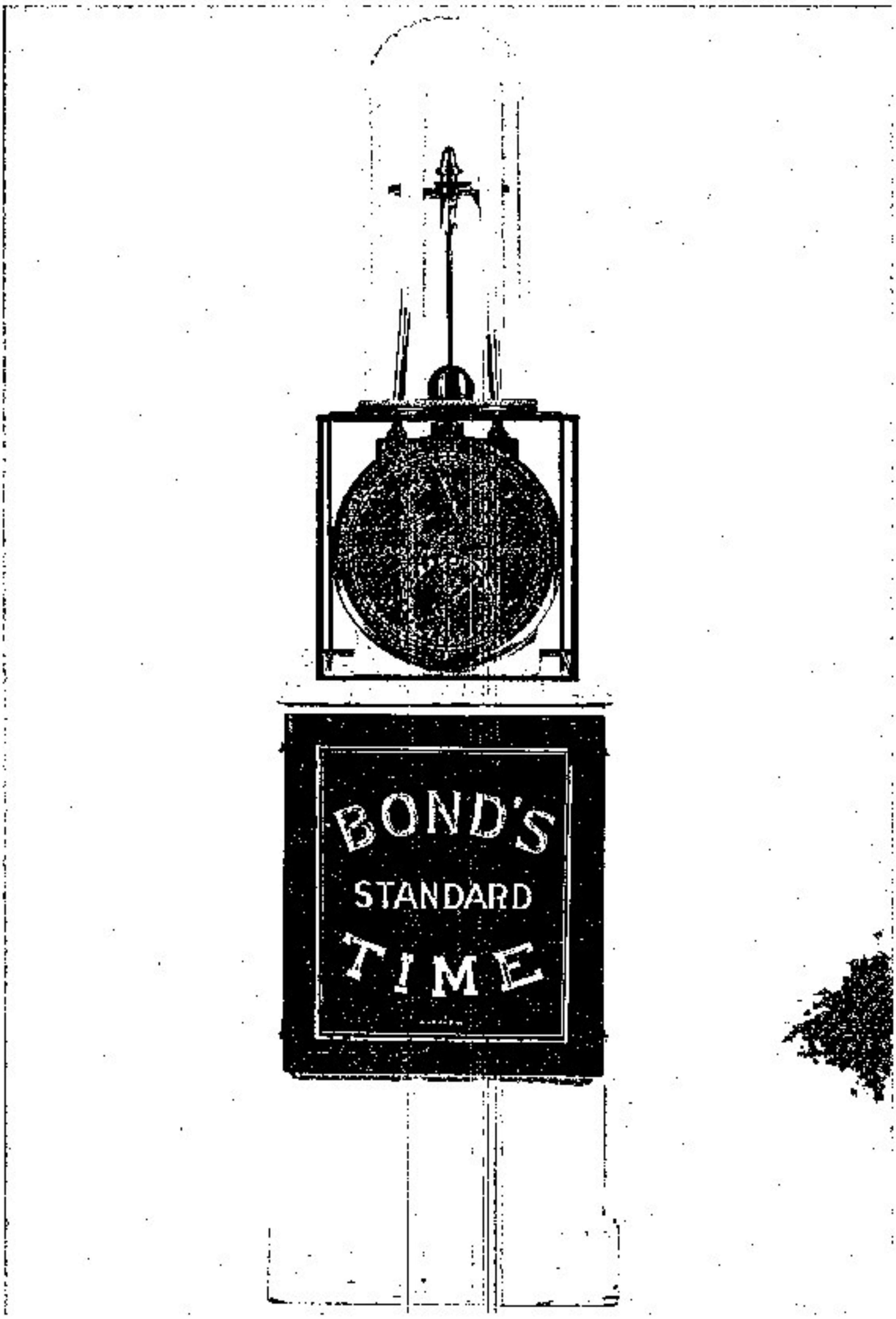


Photo: Dave Penland, Smithsonian Institution

Astronomical Regulator made by William Bond & Son, ca. 1866 interurban transactions required that businessmen have access to detailed information — the standard time on which a distant market town operated, its transportation schedules, newspaper deadlines, and the opening and closing hours of its banks, stock and commodity exchanges. Not surprisingly, Bond targeted the commercial world for the Harvard time signals. In Bond's opinion, at least, time had "become such an important element in the rapid movement & business operations of the Community, that it will not rest satisfied with anything short of the utmost attainable accuracy."[40]

Bond's principal customers for his free service were the New England railroads. Every Monday and Thursday he sent out signals for mean solar time from the observatory "to various stations in town and country."[41]

As the railroads spread across New England in the 1840s, the managers of competing lines consulted each other on common problems. A number of the lines banded together in 1848 to form the New England Association of Railroad Superintendents. Their avowed mission was "the increase and diffusion of knowledge upon scientific and practical subjects connected with railroads and the promotion of harmony among the rail road companies of New England." More specifically, they were interested in matters relating to railroad hardware and operating procedures.[42]

One of the earliest of their cooperative ventures occurred in late October 1849 at a meeting in Boston, at which time the companies voted to adopt a single standard time for their operations. They decided:

[40] *DeBow's Review*, 8 (1850), 447, quoted in Allan Pred, *Urban Growth and City Systems in the United States, 1840–1860* (Cambridge, Mass.: Harvard University Press, 1980), p. 151; Richard B. DuBoff, "Business Demand and the Development of the Telegraph in the United States, 1844–1860," *Business History Review*, 54 (1980), 461; and W. C. Bond, Report for 1853, BP, HUA.

[41] Bond, "History and Description" (note 18), p. clxv. The following material on Bond and railroad time in New England is used by permission of University of Chicago Press, publishers of C. Stephens, "'The Most Reliable Time': William Bond, the New England Railroads, and Time Awareness in 19th-Century America," *Technology and Culture*, 30 (January 1989), 1ff.

[42] *Records of the New England Association of Railway Superintendents, Organized in Boston, Mass. April 15, 1848, Dissolved, October 1, 1857* (Washington, D.C.: Gibson Brothers, 1910), p. 8; Edward C. Kirkland, *Men, Cities, and Transportation: A Study in New England History, 1820–1900* (Cambridge, Mass.: Harvard University Press, 1948), I, 307-308.

to recommend to all the Railroad Companies in New England, the adoption . . . of a time two minutes after the true time at Boston as given by William Bond & Son, No. 26 Congress St., and that on or after the 5th of November, 1849, all station clocks, conductors' watches, and all time tables and trains should be regulated accordingly.[43]

This standard railway time became the first formal regional time in the United States.

Although the resolution credited William Bond & Son as the time source, the ultimate source was the Harvard College Observatory. To Jared Sparks, president of Harvard, Bond explained the association's agreement and his own role in lobbying the railroads to adopt the observatory's time: "Cambridge observatory is not mentioned but it is perfectly well understood. I had conversations about it with Directors and Superintendents, before they came to the resolution."[44]

Supplied by the observatory, astronomical time, derived from the observation of predicted celestial events, was uniform and quantifiable, "scientific" and endowed with a supposedly disinterested authority. The norm elsewhere in the country was a profusion of competing local times, variously determined and variously maintained. Most often a local jeweler, who might also be an amateur astronomer, kept the community time standard.

Evidence suggests that the railroads' defense of sectional commercial interests was the underlying motive for their adoption of Bond's standard time. A dispute over the location of an American prime meridian prompted their vote. In response to pressure from Bond, the railroads adopted a time just slightly east of Boston to coincide with a meridian that Bond had calculated west from Greenwich, rather than east from Washington, D.C. Bond in turn was reacting to agitation for the establishment of a uniquely American prime meridian, a proposal that Bond and the New England shipping interests sided solidly *against*.[45]

[43] See *Pathfinder Railway Guide for the New England States* (Boston: Geo. K. Snow & Co., November 1849), p. 70; and *Records of the New England Association of Railway Superintendents* (note 42), pp. 23, 28, 37.

[44] W. C. Bond to Jared Sparks, 6 January 1851, BP, HUA.

[45] The resolution contains language sufficiently vague to make it almost impossible to determine where — that is, at what longitude — "two minutes later than Boston" actually was. In the usage of the day, the "true time" of Boston was the sun time, which would vary daily and seasonally. The accepted longitude of Boston at the time of the adoption — according to *Appleton's Railroad and Steamboat Companion* (New York: D. Appleton & Co., 1848), 27 — was 71° 4′ 9″ west of Greenwich, that is, just slightly west of the 71st meridian

The Bond firm not only supplied time, but also timekeepers. A fatal wreck on the Providence & Worcester line caused by a careless conductor and his faulty watch highlighted a life-threatening state of affairs: timekeepers in use on the railroads varied wildly in quality, and they were not always available to employees. An organized effort to provide employees with accurate timekeepers came in September 1855, after the Providence & Worcester wreck. Within days of each other, three New England railroad superintendents showed up at the Bond shop in Boston to arrange for the inspection of conductors' watches and to buy station clocks and "the best silver watches."[46]

Of these visitors, William Raymond Lee, railroad entrepreneur and superintendent of the Boston & Providence, set up the most formal arrangement with the Bonds. Lee had authority to buy watches and clocks for the Boston & Providence, the Ogdenburg, the Rutland & Burlington, the Vermont Central, and the Northern Railroads.[47] He went so far as to print up a circular for the Boston & Providence employees that outlined how time was to be kept on the line: standard time to be two minutes later than the Bond clock in Boston; the Boston & Providence station clocks, purchased from William Bond & Son, to be regulated to the standard time; conductors to receive watches and compare them to these clocks and to each other; ticket clerks to make certain the comparisons were made. In what is most likely the first watch inspection system in the United States, conductors were to "submit their watches to Bond & Son . . . for examination and procure from them a certificate of reliability, which will be handed to the Superintendent." The railroad corporation bore the expense for all this activity.[48]

---

west of Greenwich. Two minutes of time *later* than Boston is a half degree of longitude (or 30 minutes of longitude) east of Boston. Calculations based on a literal reading of the resolution, then, place the line of longitude for the standard time in the middle of Massachusetts Bay.

[46] Entries for 1 September 1853 and 7 September 1853, daybook of William Bond & Son, Bond Papers, HCHSI. The railroad officials represented the Taunton Branch, the Western Railroad, and the Boston & Providence.

[47] Entries for 27 September 1853 and 5 January 1855, daybook of William Bond & Son, HCHSI. In one year in the mid-1850s, Lee was president of the Northern, the Rutland & Burlington, and the Vermont Central, according to Kirkland, *Men, Cities, and Transportation* (note 42), I, 185.

[48] Circular dated 31 August 1853, Letter book 1816–1855 of William Bond & Son, HCHSI.

Boston and Providence Railroad.

STANDARD TIME.

1. STANDARD TIME is two minutes later than BOND & SONS' clock, No. 17 Congress street, Boston.
2. The inside clocks, Boston and Providence stations, will be regulated by Standard Time.
3. The Ticket Clerk, Boston station, and the Ticket Clerk, Providence station, are charged with the duty of regulating Station Time. The former will daily compare it with Standard Time, and the latter will daily compare it with Conductor's time; and the agreement of any two Conductors upon a variation in Station Time shall justify him in changing it.
4. Conductors will compare their watches with Standard time in the following order.

MONDAY,............	Conductor of	Steamboat Train.	
TUESDAY,..........	"	Accom'n Train No.	1
WEDNESDAY,......	"	"	2
THURSDAY,........	"	"	3
FRIDAY,............	"	Dedham Train	1
SATURDAY,........	"	"	2

5. All Conductors of Passenger and Freight trains will compare their time with Station time, Boston and Providence, every day, and report any variations to Superintendent of Transportation.
6. A record will be made by the Ticket Clerk, or in his absence, by the Baggage Master, of the comparisons required by Art. 5, to which they will certify by their signature or initials.
7. Conductors will submit their watches to Bond & Sons, 17 Congress street, Boston, for examination, and procure from them a certificate of reliability, which will be handed to the Superintendent.
8. Conductors will report to Messrs Bond any irregularity in the movements of their watches, and they will clean, repair and regulate them, at the expense of the Corporation, furnishing Conductors with reliable watches in the interim.

W. RAYMOND LEE, SUP'T.

BOSTON, AUGUST 31ST, 1853.

See Vote of the Directors of all the RR Companys which leave Boston = Nov 5/49

Collection of Historical Scientific Instruments

Standard time circular for the Boston & Providence Railroad, 1853

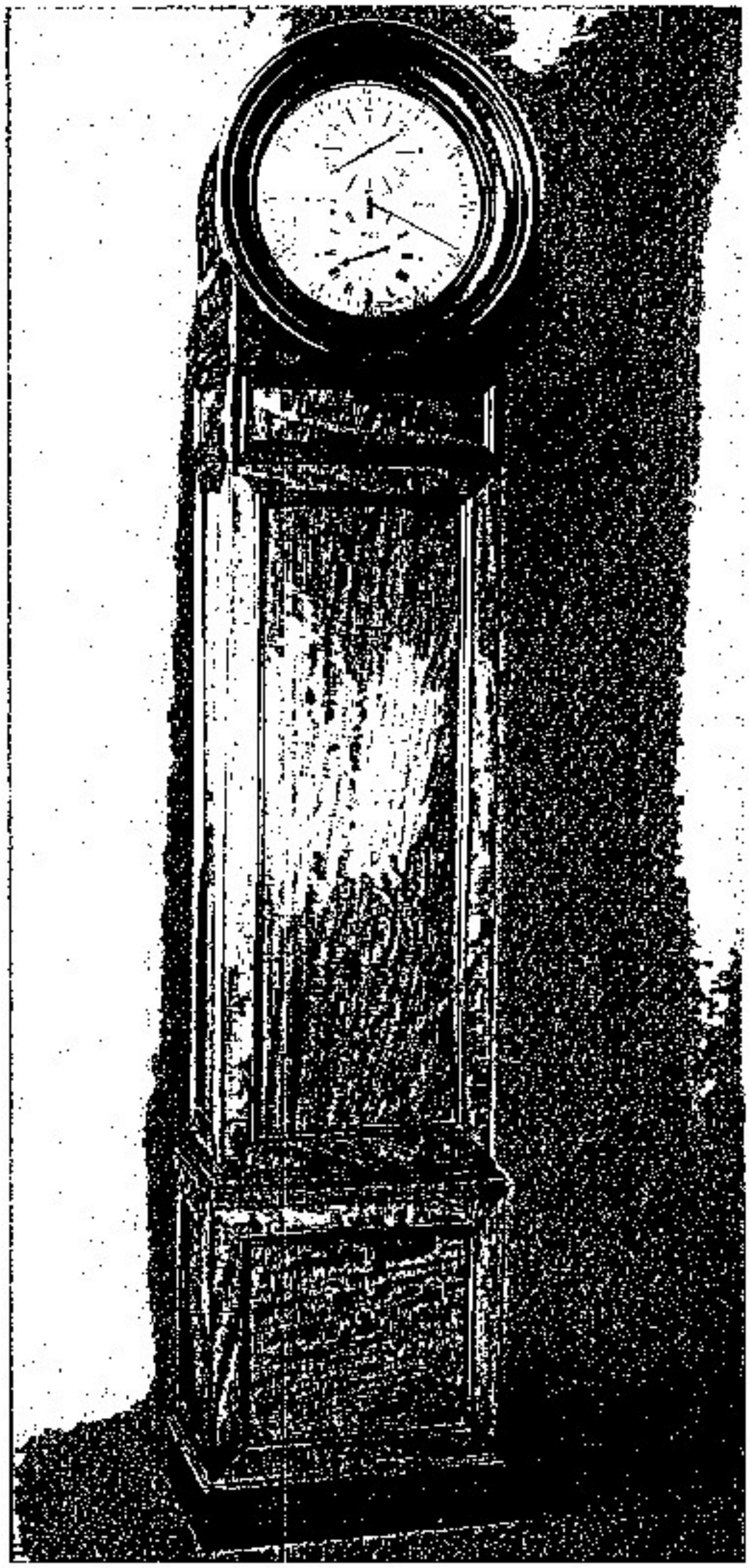


Photo: Dane Penland, Smithsonian Institution

Astronomical Regulator sold by William Bond & Son to the Boston & Providence Railroad for its Boston terminal, 1853

When the Boston & Providence took delivery of the first standard clocks, the Bond & Son daybook contained a notice of the event:

It is Mr. Lee's intention to introduce this Class of Clocks on all Rail Roads — so far as it is in his power. The object is to give every Officer connected with the Road the most reliable time. Each Officer having charge of a Train — and such officers as it is thought advisable are to be provided with a best chronometrically adjusted watch, by this arrangement the Conductors of Trains will have no excuse for the want of correct time — to bring their Trains in at the various stations — at the specified time on the Time Tables.

It is believed that by this arrangement the loss of a great number of *lives* will be prevented as well as a large amount of property — every year.[49]

Railroad managers in New England responded to public criticisms and instituted other immediate and long-term reforms. The Providence & Worcester immediately put a signal man on the blind curve and, ignoring their industry paper's advice, bought watches for their employees. The New England roads tightened up operating rules and the enforcement of them.[50]

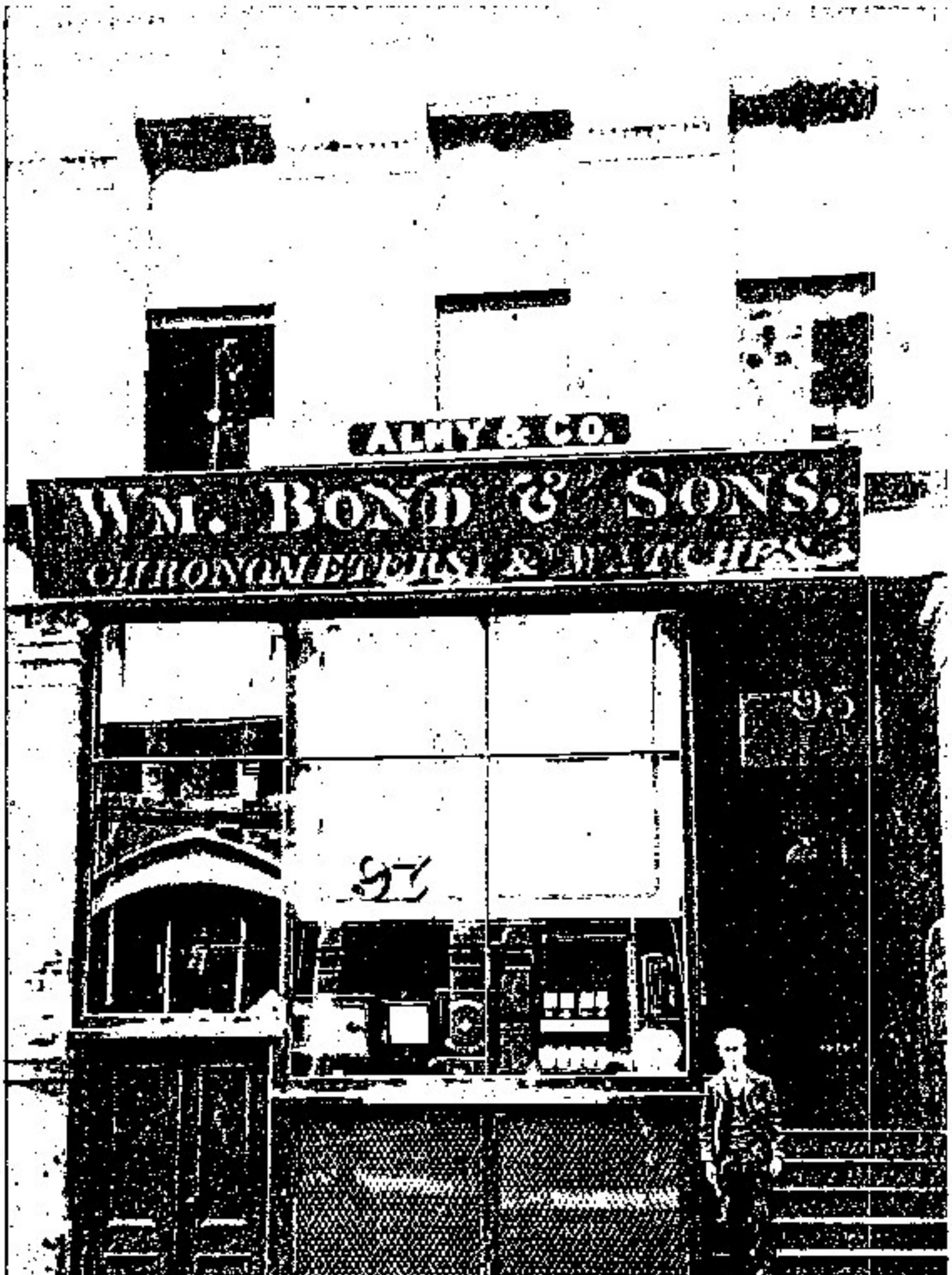
In implementing standard time, a time service based on telegraphy, and an inspection system for railroad timekeepers, Bond and the New England railroads anticipated practices that in the future became universally accepted on American railroads. Every railroad's rule book specified that the line was to run to time, and that employees — conductors, and often engineers as well — should keep and consult reliable timekeepers and have them inspected regularly. In the second half of the nineteenth century numerous private observatories, emulating the Harvard experience, began to earn money to support their operations from the sale of time signals to steady customers like the railroads. And the railroads adopted a nationwide zoned system of standard time in 1883.

Afterwards

By 1866 William Cranch, George, and Richard Bond had all died, within less than a decade of each other. In the 1880s, a worldwide

[49] Entry for 5 January 1855, daybook of William Bond & Son, HCHSI.

[50] An industry-wide response came gradually. Double tracking and the use of telegraphy, both of which were more complex and more expensive technical solutions, grew more common in the next few years. By the Civil War, time-related collisions of this sort were, for the most part, things of the past. Unfortunately, other causes kept the accident rate at about the 1853 level for the next fifty years; see Robert B. Shaw, *A History of Railroad Accidents, Safety Precautions amd Operating Practices*, 2d ed., (n.p.: Vail-Ballou Press, 1978), p. 33 and appendix.



Collection of Historical Scientific Instruments

William Bond & Son, ca. 1880, at 97 Water Street, Boston decline in demand for new chronometers and chronometer maintenance caused the firm to refocus on the clock, watch, and jewelry trade. In Bond family hands until the 1930s, ownership of the business then passed to Armenian immigrant brothers named Hekimian. The firm closed in 1977 after nearly two hundred years in business.

The time service from the observatory ended temporarily under George Bond's directorship in 1862, but resumed ten years later under Director Joseph Winlock. Bond-made regulators served as the principal transmitters of time during this period. Harvard permanently discontinued its signals in 1892 when faced with crushing competition from Western Union's time service.[51]

[51] "The Harvard Observatory Time Service." Undated brochure, BP, HUA.

CONTRIBUTORS TO THIS ISSUE

I. Bernard Cohen is Victor S. Thomas Professor of the History of Science, *Emeritus*, Harvard University.

Carlene E. Stephens is Curator, Division of Engineering and Industry, National Museum of American History, Smithsonian Institution, Washington, D.C.

Ellery Sedgwick is Associate Professor of English at Longwood College, Farmville, Virginia.