York Times, October 18, 1868; *Washington Star,* February 15, 1869.

3. The account of Lemercier's lectures in Washington is uninformative. In Boston and New York, he lectured on human anatomy and physiology, the anatomy of the gorilla compared with man, the anatomy and physiology of the horse, and the anatomy and physiology of plants. *New York Times,* November 10, 1868; "Popular Lectures" (cited above).

4. Théodore Louis Auzoux (ca. 1797–1880), a partner of Lemercier, developed a technique of making accurate casts of human organs, enabling him to manufacture exact models for educational purposes. His casts were known as "anatomie clastique" (in English, "clastique models"). Lloyd C. Sanders, ed., *Celebrities of the Century: Being a Dictionary of Men and Women of the Nineteenth Century* (London, 1887); "Popular Lectures" (cited above).

5. Hun did write Lemercier, telling him that this was not an opportune time, but offering to see if lectures could be arranged for a later date. Lemercier to Henry, March 5, 1869, RU 26, Smithsonian Archives.

6. The herbarium had been organized by John Torrey from the collections of the Wilkes Expedition, the collections of the North Pacific Exploring Expedition, the specimens gathered during the Pacific Railroad surveys and the Mexican boundary survey, as well as miscellaneous collections donated by scientists and travelers. It included a number of type specimens. It was transferred to the Department of Agriculture under an agreement signed by Henry on January 1, 1868. *Smithsonian Report for 1868,* pp. 14–16; *1870,* pp. 36–40; *Henry Papers, 10:*79n.

112. TO BARTON STONE ALEXANDER[1]

Smithsonian Institution
Wash[n] February. 27, 1869

Dear Sir:

Your letter of Dec. 17[2] was duly received but a press of business has prevented an earlier reply.

I do not think a detailed account of the experiments on building materials which have been made at this Institution[3] would be of much importance in San Francisco. The materials consisted ↑principally↓ of different kinds of marbles and stone and brick, now in use in this part of the United states, but which there is no possibility will ever be ~~transf[d]~~ transported to California, or which if sent there, ought not to be used for building purposes, in view of ~~the~~ ↑a↓ recurrence of Earthquakes.

The proper material for the construction of edifices, in places of unstable foundation, such as experience has proved San Francisco to be, is, in my opinion, wrought iron. This material, however, should not be used in a style of architecture derived from stone or wood, but in that of a light, airy structure resembling somewhat the arabesque—

There is nothing in the ~~construction~~ ↑constitution↓ of the human mind that determines, a priori, the relative size of pillars and entablatures. From experience, however, we have derived a knowledge of the fact that a slender column of stone cannot safely support a very heavy superstructure, and we may, in time, become familiar with the equally important fact that a small pillar of iron may be safer than a larger one of granite or brick, and from this conviction derive pleasure akin to that from beauty in the association of the perfect adaptation of means to an end.

Iron pillars as well as entablatures may be made of lattice work, the walls of corrugated sheet-iron filled in with some non conducting material, the roof of copper, and thus buildings may be erected which would defy ~~two~~ the action of at least two of the ancient elements—viz, Earth and Fire.

The subject of Earthquakes though long studied, is in a very imperfect condition. The only approximation ↑to a↓ plausible hypothesis is, that which assumes the interior of the Earth to be in a liquid state, and the crust, as a whole, of a yielding nature, capable of bending in at one point while protruding equally at another. In a globe thus constituted changes in the level of the surface must constantly be going on, though at a very slow rate, by the accumulation of materials on some parts of the surface and the removal of them from others. For example, the abraded portions of mountain chains are constantly being carried towards the sea by winds and rains. This transfer of material must in time produce a bending and consequently a tension of the inner surface of the crust, and thus give rise to, at intervals, ~~to~~ the sudden breaking of interior strata, at the weakest points, particularly along mountain ranges, and these ruptures will suddenly occur when the tensile strain just equals or exceeds the tenacity of the rocks. Besides this, there are ↑probably↓ caverns in the interior of mountain chains, into which the molten mass may be forced, and this, coming in contact with rock containing a large amount of water of crystallization or of carbonic acid, may [---] produce ~~gasses~~ ↑gases↓ or vapor, of enormous tension, sufficient to give rise to extensive upheavings as well as to volcanic eruptions.[4]

It appears to me probable, from the facts which have been recorded, that in most cases of violent Earthquakes, the whole district of country over which the Earthquake phenomena are experienced, is suddenly elevated, perhaps many feet perpendicularly and ↑as↓ suddenly returned to its normal position. We can only account in this way for the immense ocean wave which sweeps over the land. As all parts of the district are elevated simultaneously the whole effect which is produced on the surface of the Earth would be so slight as to be imperceptible, even should the elevation of the apex or crest measure many feet. An elevation of this kind under the <u>land</u> would give rise, at first, to a receding wave of the ocean, & afterwards to an advancing one,—if the elevation took place under the <u>water</u> the occurrence of the waves would be reversed.

It is ~~not~~ probable[A] that the Pacific Coast will furnish an admirable locality for studying the phenomena of Earthquakes, and its savans, therefore, should give special attention to the subject.

The records of the Tide-Gauges, established by the Coast Survey, have already done good service in indicating the arrival of Earthquake waves across the Pacific Ocean, and self-registering instruments denoting the time, direction & intensity of Earthquake shocks should be established at various points throughout the country.

Much might be learned from an exact determination of the time (by means of the clock movement of the self-recording instruments) of the shock at different places, as compared with its intensity. If the time is nearly the same at many places widely separated, the inference would be that the point of disturbance was deeply seated and that the shock was propagated in radial lines in the form of a cone. If, on the other hand, the time is found to vary in every direction from a given centre, the indication would be that the seat of disturbance was near the surface.[5]

In conclusion, I would ~~state~~ urge the importance, both in a scientific and practical point of view, of procuring the funds necessary for the establishment and maintenance of a series of self-registering Earthquake instruments, ↑along the western coast of↓ of the most approved plan, and among these, of a few stations for determining the variations of the different elements of the weather,—since it is not improbable that Earthquakes are, in some cases, connected with a change in the barometrical pressure.[6]

Yours, very truly,
Joseph Henry
Sect'y Smithn. Instn.

B. S. Alexander.
San Francisco.

Letterpress Copy, RU 33, Smithsonian Archives.
In a clerk's hand, except for the signature.

1. Alexander, an army engineer who had overseen the completion of the Smithsonian Building in 1855 and assisted with reconstruction after the 1865 fire, had been stationed in California since 1867 as senior army engineer on the West Coast. According to one assessment of his time in California, "His engineering skills, broad interests, and political and social connections made him an influential leader in the professional community." *Henry Papers, 8*:463n–464n; *10*:463; W. Turrentine Jackson, Rand F. Herbert, and Stephen R. Wee, eds., *Engineers and Irrigation: Report of the Board of Commissioners on the Irrigation of the San Joaquin, Tulare, and the Sacramento Valleys of the State of California, 1873* (Washington, 1990), p. 20 (quotation).

2. RU 26, Smithsonian Archives. Alexander had written Henry for information on the strength of various building materials and clarification of the latest views on earthquakes. He was writing in the wake of what contemporaries called "the most severe earthquake" the city of San Francisco had suffered to date, on October

21, 1868. Approximately thirty people were killed. There were immediate calls for the establishment of laws mandating the construction of earthquake-proof buildings. The San Francisco Chamber of Commerce established a committee on earthquakes, with five working subcommittees. These subcommittees focused on building materials, bonds and cements, structural design, scientific information, and legal issues. Alexander was named to two subcommittees: building materials and structural design.

No report was ever published by the committee or any of its subcommittees. Although some geologists and historians have argued that the committee's report was suppressed to avoid negative economic consequences for San Francisco, later research has rejected this claim. Lack of funds, coupled with the death in the spring of 1869 of George Gordon, the individual who proposed the committee and served as its chair, led to its dissolution and the absence of a report.

San Francisco Morning Call, October 22 (quotation) and 23, 1868; *Daily Alta California,* November 25, 1868; Michele L. Aldrich, Bruce A. Bolt, Alan E. Leviton, and Peter U. Rodda, "The 'Report' of the 1868 Haywards Earthquake," *Bulletin of the Seismological Society of America,* 1986, *76:*71–76; web site of the United States Geological Survey Earthquakes Hazard Program.

3. Alexander had asked Henry about experiments he had conducted in conjunction with the extension of the United States Capitol Building. Henry, "On the Mode of Testing Building Materials, and an Account of the Marble Used in the Extension of the United States Capitol," *Smithsonian Report for 1856,* pp. 303–310.

4. In his letter, Alexander had mentioned that he had been reading the work of Robert Mallet (1810–1881, *DSB*) on the Neapolitan earthquake of 1857 (*Great Neapolitan Earthquake of 1857: The First Principles of Observational Seismology,* 2 vols. [London, 1862]), and was unsatisfied with Mallet's descriptions and explanations. Mallet's study, which J. D. Whitney, the director of the California State Geological Survey, called, in a review article, "the first really thorough investigation in the department of Seismology" (Whitney, p. 606), provided a great deal of quantitative data about earthquakes. Mallet, in common with most geologists, saw a link between earthquakes and volcanoes. He also suggested that other possible causes of earthquakes might be "sudden upheaval or depression of a limited area, or sudden fracture of bent and strained strata," or the underground evolution of steam (Mallet, p. 411). Not until 1883 did Grove Karl Gilbert argue that earthquakes were the result of movement along faults. Concerning the subject of Alexander's query, Mallet had argued (and Whitney had emphasized) that the loss of human life in earthquakes could be greatly reduced if buildings were constructed properly. Robert Mallet, "On Observation of Earthquake Phenomena," *Smithsonian Report for 1859,* pp. 408–433; J. D. Whitney, "Earthquakes," *The North American Review,* 1869, *108:*578–610; Peter U. Rodda and Alan E. Leviton, "Nineteenth Century Earthquake Investigations in California," *Earth Sciences History,* 1983, *2:*49.

5. Henry had a long-standing interest in earthquakes, going back to his lectures on geology at Princeton. At the Smithsonian, he encouraged and collected observations. *Henry Papers, 5:*361; *7:*510–511; *8:*333–334; *9:*201–202, 203n–204n.

6. Mallet (p. 431) urged the importance of observing "collateral conditions," including barometric pressure, temperature, electrical state of the atmosphere, terrestrial magnetism, and the impact on living things.

Seismological observations in California up to this point had been relatively haphazard, although there were excellent compilations of the occurrences of earthquakes. Whitney took the opportunity of his review to call upon those thinking about establishing an astronomical observatory in northern California to instead establish a physical observatory focusing on seismology. Although an astronomical observatory, the Lick Observatory, was established, its first director, E. S. Holden, created the first seismographic stations in the Western Hemisphere at the observatory and at Berkeley. Whitney, pp. 609–610; Rodda and Leviton, p. 52.