the plus pole on the middle of this and the negative pole on one side and also immediately over the surface but the motion of the water did not take place as in the case of the mercury

TO BENJAMIN PEIRCE

Peirce Papers, Houghton Library, Harvard University[1]

Princeton Dec 30th 1845

My dear Sir

I owe you many thanks for your very kind communication relative to the new descovery of Dr. Faraday and I would have acknowledged the receipt of your letter[2] immediately had I not concluded to attempt to reproduce the phenomenon and hoped to be able to send you an account of my results in the course of a day or two. I had previously heard of the descovery through a note from my much esteemed friend Dr. Gray[3] and I had seen the title of Dr. Faradays paper to the Royal Society in the London Literary Gazette.[4] I had from these sources formed an idea of the nature of the principal experiment and suspected, what I have since found to be the case from your communication, that it was one which I had myself attempted some years ago but without success on account as I now find of a want of sufficient galvanic power.

[1] Partial drafts of both the beginning and the end of this letter are found in the Henry Papers, Smithsonian Archives, differing slightly in order of material and in language. Henry's letter represented a semi-public record of his reproduction of the Faraday effect (as did similar communications to Daniel B. Smith, Charles N. Bancker, and John F. Frazer; see the "Record of Experiments," December 27, 1845, above, note 7).

[2] Not found. Peirce had gotten this information from a long letter of November 28 from Benjamin Apthorp Gould in England (Peirce Papers, Houghton Library, Harvard University). Gould's letter, which was postmarked in New York on December 20, described the Faraday effect as he had heard it explained at the Royal Society meetings the previous two weeks. Peirce had evidently passed the information on to Henry, who reported having received it on Christmas. See Henry to the *New York Evening Post*, February 28, 1846, below.

Gould's letter was extensive, running to eight manuscript pages, of which the majority dealt with the Faraday effect. He described the experimental results and speculated on their theoretical basis, giving particulars of the set-up, the behavior of different materials when tested, and the form of the empirical law linking galvanic power, the length of the light ray, and the degree of polarization. In advance of the full publication of Faraday's results, Gould's letter was the primary source on the Faraday effect for scientists in the United States.

[3] Asa Gray's letter, dated mid-December 1845, is printed above.

[4] "Electricity, Magnetism, and Light," *The Literary Gazette and Journal of Belles Lettres, Arts, Sciences, &c.*, November 8, 1845, p. 737. Faraday's title per se was not given in this short notice, but the "magnetisation of light" was alluded to, as the "deflection in diaphanous solid or liquid bodies of a ray of polarised light to the lines of magnetic force; or in the converse, the illumination or development by light of the magnetic curves."

I have long had my attention fixed on circular polarization as a means of <*affecting*> detecting changes in matter induced by electrical and magnetic action and in conformity with this I passed a beam of polarized light through a hollow galvanic magnet, a tourmaline being placed at each end, one acting as a polarizer and the other as an analyser with the hope of perceiving some change in the plane of polarization, but in this I was disappointed.[5] I also transmitted a beam of polarized light through a glass tube containing water around which was <*transmitted*> passed a current of galvanism but the result was still negative.[6] I do not mention this fact to claim any of the merit of Dr Faradays interesting descovery but merely to show you that my mind was in a fit state to readily conceive the nature of the expermt and to reproduce the phenomenon. I agree with your friend and yourself in thinking that the results of Dr. Faradays labours on this subject so far as we have yet learned any thing of them do not establish the identity of light and electricity but merely show a new condition of matter produced by electrical induction.[7] The results however in themselves are highly interesting and open a new field of inquiry but I suspect Mr F. has something more in reserve than what he has yet given to the public on which he grounds the idea of the identity of the two principles.[8]

But I presume you will be better pleased to learn the result of my attempts to reproduce the effects obtained by Dr Faraday than with any of my speculations on the subject. Immediatly after the receipt of your letter

[5] *Henry Papers*, *4*:17.

[6] Ibid., p. 273.

[7] Gould had written Peirce:

> The natural response which I should imagine would present itself to every one, & which Prof. Faraday cannot be supposed to have overlooked is this—May not all this magnetic effect upon light be simply a physical action upon the molecules of the diamagnetic, thereby changing the nature of their effect upon the rays of light—the tension perhaps disposing their arrangement to tend to the crystalline.

[8] Faraday indeed followed up these experiments with work on diamagnetism (his Twentieth and Twenty-first Series) and with a speculative piece called "Thoughts on Ray Vibrations." (*Phil. Mag.*, 1846, 3d ser. *28*:345–350.) He considered the possibility that light may not be vibrations in a crystalline or elastic solid ether—a common speculation of British optical theorists—but that the lines of magnetic force themselves vibrate to produce light. Thus Faraday had thought that the magneto-optical effect served to disprove the Newtonian theory of matter—in Gould's words, paraphrasing Faraday, "solid, massy, hard impenetrable particles"—in favor of the Boscovichean theory of "mathematical centres of force." Faraday's "Thoughts on Ray Vibrations" strongly pushed this point. (In the American context, "Thoughts on Ray Vibrations" was picked up by *Silliman's Journal*, 1846, 2d ser. *2*:118, 401–405.)

The relation of Faraday's ideas to those of Boscovich has generated a controversy, starting with L. Pearce Williams's *Michael Faraday: A Biography* (New York, 1965), which asserted a close relationship, and countered by J. Brookes Spencer and Peter Harman (formerly Heimann), who strongly qualified Williams's assertion. J. Brookes Spencer, "Boscovich's Theory and Its Relation to Faraday's Researches: An Analytic Approach," *Archive for History of Exact Sciences*, 1967, *4*:184–202; P. M. Heimann, "Faraday's Theories of Matter and Electricity," *British Journal for the History of Science*, 1971, *5*:235–257.

which was the day after my return from Philadelphia I set about repeating my original experiments with the apparatus I had prepared for the purpose several years ago but although I took every precaution I could think of to insure success yet I was unable to perceive any result. I therefore commenced the construction of a much more powerful apparatus on the same plan, which with the means at command in a country village like Princeton was not competed until this morning.

This apparatus is formed by coiling about 800 feet of stout copper bell wire around a gun barrel which had previously been turned down to about half the usual thickness of the metal, the several spires of wire are well insulated from each other and the whole forms a cylindrical coil of about 20 inches long and four inches in external diameter. In one end of the gun barrel is placed a cork through the axis of which passes a Nicol's prism which may serve as a polarizer and the other end is also stopped with a similar cork which contains a tourmaline to serve as an analyser. The galvanic battery used for generating the current to be passed through this coil consists of 20 cups on Daniel's plan excited with sulphuric acid on one side of the diaphragm and Sulphate of copper on the other; it was arranged in two parallel series so as to form a compound battery of 10 elements. The capacity of each cup is about a quart and the whole was in pretty active operation. The apparatus being properly arranged with the end of the gun barrel containing the Nicol's prism pointed towards the clear sky and a glass tube filled with pure water of nearly the same length and interior diameter of the barrel placed in its axis the current from the battery was passed through the wire from the coil while the tourmaline was so placed as to exhibit nearly a dark field of view. At the instant the circuit was completed the field was seen to become illuminated and at the breaking of the circuit the field was again darkened. The effect was most interestingly exhibited by rapidly making and breaking the circuit with the battery. The same result was obtained but not with the same degree of intensity when the gun barrel was withdrawn from the axis of the coil and the tube of water occupied the same place. The magnetism of the iron therefore increases the effect or I should rather say produces a greater effect than the coil because in accordance with a series of experiments I made a number of years ago on the magnetism of hollow bars the action within a tube is adverse to that of the coil without[9] hence I would attribute the polarization of the water within the gun barrel entirely to the interior magnetism of the iron. This idea strikes me while I am writing and therefore I did not verify it by experiment. It may however readily be brought to the test by observing

[9] See especially *Henry Papers*, 5:111–114, 117–118.

wether the twist of the plane of polarization is in the same direction in the two cases.

In repeating the experiment care must be taken that the tube is entirely filled with water so that the sight may not be obstructed with bubbles of air and this is easily effected [by] grinding each end of the tube perfectly flat in a plane at right angles to its axis; cementing a plate of thin glass across one end hold this downward and pour in the liqud until it stands in a convex surface above the level of the end of the tube and then slide across this a plate of glass so as to cut off the projecting portion of water; the tube will thus be entirely filled and the upper plate may be fastened in place by a few touches of melted sealing wax on its different sides. I have been thus minute in describing the apparatus and the method of manipulation inorder that should you think fit to repeat the experiment you may be able to succeed without the necessity of several preliminary trials.[10]

I do not intend to do any thing more in the way of experimenting on this subject until after the publication of Dr Faraday's papers for should I continue the investigation I would probably only be reproducing his results without materially advancing the cause of science. Besides this I do not think it perfectly inaccordance with scientific etiquette to enter on a new field of investigation before the author of the primary discovery has had time to give his own results to the world.[11]

I may add to what I have said in reference to the mode of exhibiting the polarization of water that the experiment may readily be exhibited to a large class by a slight variation in the arrangement I have described. For this purpose a beam of sun light being passed through the tube by means of the ordinary window reflector used for directing a beam into a dark room a magnified image of the opening in the tube is thrown on a screen by placing a magnifying lens behind the end of the tube. The effect is shown by the appearance and disappearance of the image at the moment of completing and interrupting the circuit of the current of the battery.[12]

I am now engaged during the college vacation in repeating some of my older experiments and in preparing for the press the results I have obtained on the subject of induction during the four or five years past. My college duties are such that I can do nothing in the way of investigation

[10] No published evidence exists that Peirce (or anyone else in Cambridge) experimented on the Faraday effect.

[11] For similar ethical considerations, see Henry's letter to the *New York Evening Post*, February 28, 1846, below.

[12] Henry repeated these experiments to his class the following April; they became part of his course thereafter, in his treatment of polarized light. See the John R. Buhler diary entry excerpt for April 25, 1846, the "Record of Experiments" entry for May 1, 1846, both below, and the natural philosophy notebook of Theodore W. Tallmadge, Class of 1846, p. 221 (Princeton University Archives). Weiner discusses the Faraday effect in his "Joseph Henry's Lectures," pp. 228–235.

during the term and at the end of the vacation I often find my self in the midst of an interesting course of experiments which I am obliged to put aside and before I can return to them my mind has become occupied with other objects. In this way I have gone on accumulating almost a volume of new results which will require much time and labour to prepare for publication. Indeed I find so much pleasure in the prosecution of these researches that the publication of them in comparison becomes a task. I have become careless of reputation and have suffered a number of my results to be rediscovered abroad merely from the reluctance I feel to the trouble of preparing them for the press.

Please give my kind regards to Dr. Gray Professor Tredwell[13] and Mr Bond.[14] I am indebted to Prof. T. for the copy of a very interesting pamphlet on his method of making wrought iron guns for which permit me to request that you will give him my thanks.[15] It would give me much pleasure to receive a visit from you at Princeton and when you again go to Philadelphia if you do not stop a day or two with me on the way I shall be much disappointed.

With much respect and
esteem I remain
Yours truly
Joseph Henry

[13] Daniel Treadwell (1791–1872), Rumford Professor on the Application of Science to the Useful Arts at Harvard, 1834–1845. *DAB. Elliott.* Treadwell was an inventor in a variety of manufacturing enterprises. From 1842 on he was involved in the Steel Cannon Company in the Boston area.

[14] William Cranch Bond.

[15] Daniel Treadwell, *A Short Account of an Improved Cannon, and of the Machinery and Processes Employed in Its Manufacture* (Cambridge, Massachusetts, 1845). The presentation copy survives in the Henry Library.

1846

TO HENRY M. ALEXANDER

Retained Copy, Henry Papers, Smithsonian Archives

Princeton Jany 6th 1846

My Dear Sir

I am so confident but[1] you will cheerfu[lly] render me any service in your power within reasonable limits that I do not hesitate to call on you at this time to attend to a little business for me at the New-York Custom

[1] Perhaps "that."