TO BENJAMIN SILLIMAN, SR.

Silliman Family Papers, Sterling Library, Yale University[1]

Princeton March 2nd 1836

My Dear Sir

I have been prevented by ill health from sending before this the account of the experiments which I promised.[2] I have been afflicted for several weeks with a slow feaver and pain in the head which although not confining me to my room have prevented my applica[tion] to any thing of a mental kind. Want of exercise during the long continuance of snow and too close attention to the business of my lectures have produced the attack. I am now however much better and hope soon to recover my usual health and spirits.

I intended before sending the account to have made some experiments for the express purpose of adding to the number and interest of those I send as these have been exhibited with scarcely any previous trial or preparation on the spur of the moment before the meeting of my class.

If my health will permit I will probably do something in this way at the time I am lecturing on the subject of electro magnetism which will be in about two weeks from this time. I regret that I did not meet with you in New York as I could have exhibited some of the experiments then and thus saved you the trouble of working out some of the minutia by your own experience. I have given as detailed an account as I think is necessary to the comprehension of the arrangements and I trust you will find but little difficulty in producing the results described.

I was much pleased with the accounts I received from New York of the unheard of success of your course of lectures in that city not only because the result must have been highly gratifying to you but because I believe that it will have a very favourable influence on the cause of science itself not only in that city but throuought our country.

Davey was doing nearly as much for the cause of English science when attracting by his eloquence to the Theatre of the Royal Institution the

[1] This is Henry's outgoing letter. The first part, through the paragraph after Henry's signature, is in Henry's handwriting. The second part, a description of experiments, is in Harriet Henry's handwriting, with corrections made by Henry. Henry may have drawn the sketches himself, although they are unusually neat for him.

A partial draft of the section on experiments, in Harriet Henry's hand with corrections by Henry, is in the Henry Papers, Smithsonian Archives. The recopying of the draft for this outgoing letter suggests Henry was trying to produce a very neat and accurate copy. Also in the Henry Papers, Smithsonian Archives, is a copy of the partial draft. This is in the handwriting of W. L. Nicholson who was working with Henry's papers in the 1880s.

[2] Silliman had originally asked for this information in a letter of October 31, 1835 (*Henry Papers*, 2:474).

Wealthy and Fashionable of the Metropolis as when engaged in the profound researches of his laboratory and much undoubtedly of the present popularity of the British Association is due to the taste for science which at that time began to be diffused among the higher classes of the English Nation.[3]

[3] Henry's praise for Silliman's lecturing and for the activities of contemporary British scientific societies again raises the issue of scientific popularization, this time from a comparative perspective. Aristocratic and fashionable clientele had been a conspicuous feature of the Royal Institution in London since its earliest years. The Institution was originally established in 1799 to diffuse science, useful knowledge, and news of the latest improvements among working-class mechanics as well as among England's upper classes. In 1802 the idea of a practical mechanics' school was dropped, leaving what Thomas Carlyle called "a kind of sublime *Mechanics' Institute* for the upper classes" (quoted on p. 7 of Foote's article, cited below).

Silliman himself was struck by the visible presence of London's elite at Royal Institution lectures on visits early in the century. His travel diary recorded the allure of the Institution's lecture hall for London high society, evidenced most visibly by the number of fashionable ladies in attendance. Silliman applauded the popularization effort, noting that "there can be no danger that the dignity of science will be degraded so long as this duty is committed to able hands"—an observation Henry would have endorsed. Aside from enhancing the image of science among groups that were potential sources of support, the popular discourses had for Silliman the added social benefit of diverting aristocratic London from more frivolous or cruder amusements. Silliman, *A Journal of Travels in England, Holland and Scotland, and of Two Passages over the Atlantic, in the Years 1805 and 1806* (New York, 1810), 2:219.

The socially prominent audience was catered to by an eminent staff of science professors that over the years gave the Institution the highest scientific reputation. Envisioning aristocrats yawning through learned discourses, skeptical contemporaries questioned the value of placing research scientists before such audiences. Yet, professors such as Davy, Faraday, and Thomas Young excelled at their public function as in research, Davy most of all. Brilliantly intermixing technical material, spectacular demonstration, and sheer entertainment, Davy gave lectures of substance that engaged the attention of his aristocratic following. Audiences were most impressed with lectures on the applications of science to the useful arts and human welfare. But doses of basic science were also successfully administered, especially in chemistry which enjoyed the advantage of spectacular experiments. Celebrated in London for his performances in the lecture hall, Davy both tapped and enhanced the prevalent amateur interest in science in England. The high quality of research conducted at the Royal Institution depended on the fortunate choice of professors but also on the support it won among well-placed members of society. George A. Foote, "Sir Humphry Davy and his Audience at the Royal Institution," *Isis*, 1952, *43*:6–12. For an alternative interpretation of Davy's popular lecturing as fulfilling the agricultural concerns of the Institution's landed founders, see Morris Berman, "The Early Years of the Royal Institution, 1799–1810: A Re-evaluation," *Science Studies*, 1972, 2:205–240.

No doubt, as Henry suggests, other British scientific organizations benefited from the conspicuous social success of the Royal Institution. More accurately, societies like the British Association for the Advancement of Science, founded in 1831, drew upon the same widespread enthusiasm for science that underpinned the Royal Institution. Yet, the social and geographic setting of the British Association was quite different from the London society. The former was a migratory organization catering to commercial and industrializing provincial centers, not to upper-class groups in London. Popularization was an avowed primary goal of the Royal Institution. While the British Association also purported to diffuse knowledge, it functioned chiefly as a vehicle for scientific communication among professional scientists and lay cultivators participating directly in its activities. The itinerant BAAS knit together existing learned societies outside of London founded in the late eighteenth and early nineteenth centuries. According to recent research, the most active elements in the provincial network were scientists allied with middle-class entrepreneurs and

You mention in your last letter that you can have the use of a magneto-electrical machine. I am glad of this since Professor Bache informs me that Mr Lukens has not yet returned to Philadelphia and may be absent for some months to come.[4]

In the experiments with the coil the battery may be placed at the distance of two or three yards from the table on which the coil rests and this will render the effect more surprising.

In order to exhibit the effects of a spiral conductor in increasing the intensity of a galvanic battery of a single element as explained in my last paper in your journal[5] it is necessary that the coil should be formed into a close spiral that is, with no opening in the center. When you break the communication of the coil with the poles of the battery as you will be required to do, a spark and perhaps a loud snap will be perceived. This is caused by the induction of the spiral conductor.

With the highest respect Yours
Jos. Henry

In this apparatus Fig 7 the zinc cylender alone revolves when the iron is not employed. When it is required that the zinc cylender alone should revolve then the other parts of the apparatus may be made much stouter and the moveable part of the apparatus alone of thin materials.

The following is a description of the Electro-magnetic experiments which

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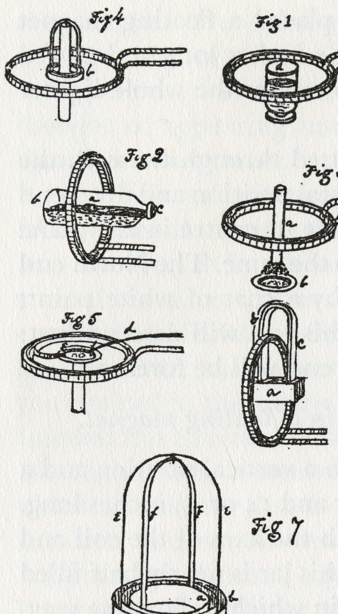
professional men with serious intellectual aspirations. See A. D. Orange, "The British Association for the Advancement of Science: The Provincial Background," *Science Studies*, 1971, *1*:315–329.

From his experience in Albany, an American provincial center, Henry was accustomed to cultivating lay support for science. Although ambivalent about his own suitability for scientific popularization, his praise for Silliman, Davy, and other gifted popularizers was genuine. At the Albany Institute and in other contexts, Henry worked easily with concerned amateurs and willingly courted political influence and moneyed interests. When called upon, he was able to summon forceful public remarks designed to impress as well as edify. Although in dealing with lay groups Henry was probably most comfortable addressing those with serious interests in learning, the lessons of the Royal Institution were not lost on him. He recognized the pragmatic value of reaching fashionable and influential audiences, regardless of their scientific sophistication. Even after years of dealing with obstructionist amateurs, Henry remained impressed by the accomplishment of the Royal Institution in supporting science of the first rank. Urging the British physicist John Tyndall to go ahead with plans for a Baltimore lecture, Henry invoked the example of the Royal Institution in reiterating the importance of communicating physical principles to the wealthy and refined members of that community. Henry to Tyndall, October 6, 1876, letterpress copy, Henry Papers, Smithsonian Archives.

On his trip to Europe in the following year, Henry attended Royal Institution lectures, including Faraday's. Diary entries on these occasions appear below.

[4] The Philadelphia mechanic Isaiah Lukens (*Henry Papers*, *2*:158–159) was the principal maker and purveyor of Joseph Saxton's magnetoelectric machines in America.

[5] "Facts in Reference to the Spark, &c. from a Long Conductor Uniting the Poles of a Galvanic Battery," *Silliman's Journal*, 1835, *28*: 327–331, containing an abstract of "Contributions II: Spiral Conductor" as well as an appendix with new material.



I mentioned to you as having been exhibited before my class with a large coil of copper ribbon.[6]

The ribbon is formed of slips of sheet copper, one inch wide and soldered together end to end so as to make an entire length of from one to two hundred feet. The whole is covered with strips of silk and wound on itself so as to form a circular coil of from 12 to 24 inches in diameter according to the size of the battery employed. The length of the ribbon forming the coil depends on the *intensity* of the Electricity used: if the battery employed be one of a single element the length of ribbon must not exceed one hundred feet, but if the battery be composed of several elements the electricity will have a greater projectile force and the coil in order to produce the same magnetic effects should have a corresponding increase of length. The length of ribbon proper to produce the maximum effect can only be determined by actual experiment in a given case with battery of a given force. The connection of the coil with the battery should be formed by dipping the ends well amalgamated into cups of mercury in order that the current may be passed through the coil at once with its full energy.

Exp. 1st.[7] To *exhibit the action of the coil in producing motion* in a *floating magnet.*[8]

Fig. 1st. represents the coil in a horizontal position *e f* are the ends which form the connection with the battery, *d* is a glass vessel (the article used in my experiments is a common air pump receiver inverted on a wooden foot) placed in the centre of the coil and

[6] Background for Henry's unique "ribbon coils" and his accompanying explanation of their effects are provided in the second volume of the *Henry Papers*, as well as in "Contributions II: Spiral Conductor."

[7] The following is a rather simple set of experiments chosen for their potential impact on a general audience. Characteristically, Henry emphasized strength or largeness of effect and the action of invisible forces at a distance. For some experiments, the principles involved were elementary. Others reflected fairly recent research interests of Henry.

[8] In 1834, using similar apparatus, Henry began a series of experiments on the patterns of magnetic force in and around coils. *Henry Papers*, 2:225–227. Experiments 2 and 3 below illustrate similar electromagnetic effects.

nearly filled with water, on which is placed a floating magnet formed of a piece of rat tail file about 5 inches long and passed through a cork just sufficient in size to render the whole lighter than water.

When a galvanic current is transmitted through the coil, the magnet starts from its quiescent horizontal position and dives end foremost beneath the water so as to place its centre in the plane of the coil and its axes at right angles to the same. The North end of the magnet may be distinguished by a coat of white paint; when the current is in one direction, this end will descend first; when the current is reversed, the other end will be foremost.

Exp. 2nd. *Another method of exhibiting motion in a floating magnet.*

Fig. 2nd. In this arrangement the coil is placed in a vertical position and a glass jar *b, c* about 6 inches in diameter and 14 or 15 inches long, supported so that its axis coincides with the axes of the coil and its middle with the plane of the same; this jar is nearly half filled with water and thus serves as a trough in which to float the magnet *a* described in the last experiment. Perhaps, it would add to the interest of the experiment, if, a large (toy) magnetic fish were used in place of the magnet.

When a current is transmitted through the coil, the magnet if it be near one end of the jar, suddenly darts to the middle and after a few oscillations settles in this place; if, the current be now reversed it darts towards the end, turns half round and again takes up its position in the middle of the jar, with its north end in an opposite direction to that which it had in its first position. The action of the coil in these experiments is much more energetic, if the circle be made smaller, but the effect is not as striking in reference to these motions being produced by an invisible cause.

Exp. 3d *To exhibit the action of the coil in developing magnetism in soft iron.*

Fig 3d In this experiment, the coil is placed horizontally and a cylender of soft iron *a* about 10 inches long and 1½ or 1¾ inches in diameter held vertically in the centre. When the galvanic current is transmitted, this becomes so magnetic that it will support from its lower end another iron cylender of equal dimensions. The developement of magnetism is also strikingly shown by placing under the cylender a plate *b* containing a quantity of clean iron filings mixed with pieces of fine iron wire of about an inch in length. When the coil is in action the filings and wire adhere to the end of the cylinder so as to form a large bunch which instantly falls off when the galvanic action ceases, or when the cylender is withdrawn from the magic circle.

Another variation of this experiment is to place the cylender perpendicularly on the table and the plate with filings on the top of this. At each contact of the ends of the coil with the poles of the battery the filings and pieces of wire bristle up on the surface of the plate as if suddenly animated.

Exp. 4th. To *shew the revolution of a large Ampere's cylender by means of the coil.*[9]

Fig 4th. The coil remains in its horizontal position and a large Ampere's cylender or bucket *b* is placed in the centre. When the bucket is charged with a strong solution of acid (Nitric) and the current transmitted through the coil, the moveable part of the apparatus begins to revolve with considerable velocity; when the direction of the current is reversed, the motion stops and then recommences in an opposite direction. The motion will be a little more rapid, if the bucket be supported as shewn in the figure, on the end of the iron cylender described in the last exp, this becoming magnetic reacts on the revolving apparatus and increases the effect. The experiment however is more pleasant without the use of the iron, although the motion is less rapid.

This is a highly interesting experiment when the motion is properly produced. The bucket I have used is nearly 6 inches in external diameter. The space between (*a* & b Fig 7)* the internal and external cylender for the reception of the acid and the moveable zinc cylender is about ¾ of an inch wide and about an inch deep. The two metalic arches *e, f* are made of thin sheet copper nearly ¼ of an inch wide and painted white so that their motion may be distinctly seen at a distance. The whole height of the apparatus is between 8 and 9 inches. Every part should be made as light as possible, the bucket of very thin copper and the zinc

* Fig 7 represents the revolving bucket of Ampere on a larger scale.

[9] For the operation of this popular piece of demonstration apparatus see *Henry Papers, 1*:317.

cylender of thin zinc plate which can be easily renewed. The one employed by me is so light that it makes several revolutions when strong acid is first poured in by the action of the magnetism of the earth, alone.

Exp. 5th. To *exhibit the revolutions of mercury with the coil*[10]

Fig. 5th. Place a plate of mercury in the centre of the coil on the top of the iron cylender mentioned in Exp. 3d. Also, place an end of the coil in the mercury at the side of the plate at *e;* the other end of the coil being in connection with one pole of the battery and the current completed by means of the wire *d,* which also dips into the plate of mercury on the oposit side at f. When the battery is put in action the mercury begins to revolve in a whirlpool around the point of its surface which is immediately above the end of the iron cylender on which the plate rests. When the current is reversed, the motion of the mercury is changed. The revolutions may be shown at a distance by throwing on the surface of the metal some pieces of light substance which will partake of its motion and render it more perceptible.

Exp. 6th. *To exhibit powerful magnetic induction with the coil.*

Fig. 6th. represents the coil placed vertically with a large piece of iron *a* (the lifter of my large magnet weighs 27 lbs.) in the centre. *b, c* represents a piece of bar iron about 3½ feet long bent into the form of a horse shoe and placed over the sides of the coil so as to support the weight in the centre by the magnetism developed when a current is transmitted through the coil. The face of the horse shoe and the iron should be ground to each other. The great power may be shown by suspending weights to the lifter from below.

NB The results will be more energetic with a large battery than a small one. I have ex[ecuted] these experiments with a battery of a single element exposing about 50 feet of zinc surface to the action of the acid.

[10] Henry touched on this effect in prior laboratory research. *Henry Papers,* 2:246–247.