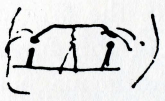
February 17, 1834

I have been looking for the apparatus you promised me when here—



your sheeps tails[5] so send me one by wednesday next if pos- [sible]—as I expect then to talk about Electro mag- to a *popular* audience.[6] Some one coming from Princeton could bring it, if put up in a small box. We are all well & do well. Resp^ts^ to Mrs H. & other friends.

Yours in haste
Jacob Green

(Philadelphia, 1869).

Surviving correspondence with Henry shows that Bancker may have aided Henry in procuring philosophical apparatus as well as loaned him instruments from his own collection. Bancker's eulogist states that "public lecturers on natural philosophy and on experimental chemistry, had always the free use of his apparatus." "Obituary Notice of Mr. Bancker by Judge Cadwalader," *Proceedings of the American Philosophical Society*, 1869, *11*:85–91. For a consideration of Bancker as a representative of a special kind of amateur contributor to America's early scientific community, see Nathan Reingold, "Definitions and Speculations: The Professionalization of Science in America in the Nineteenth Century," forthcoming in the Proceedings of the Colloquium on the Early History of Societies for Promoting Knowledge in the United States, American Academy of Arts and Sciences, held in June 1973.

[5] i.e., the rocking arm of Henry's reciprocating electrical motor. See Henry's "On a Reciprocating Motion Produced by Magnetic Attraction and Repulsion," *Silliman's Journal*, 1831, *20*:340–343.

[6] See Henry's reply below of February 17, footnote 3.

TO JACOB GREEN

Joseph Henry Collection, Firestone Library, Princeton University

Princeton Feby 17^th^ 1834

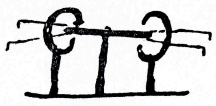
My Dear Sir

Your letter of the 13^th^ inst came to hand on saturday and agreeable to your request I have sent off a box containing my "*sheeps tail.*" Your Brother[1] took charge of it this morning and promised to forward it from Trenton by Tomorrows boat. I hope it will arrive in time for the lecture. I regret that my college duties this winter have left me no leisure for completing the one which I have commenced for you. The magnets are finished and also the stand. The batteries which I have sent are those I had constructed when last in Albany for you.[2] They are sufficiently large for exhibiting the princi-

[1] James Sproat Green. *Henry Papers*, *1*:440n.

[2] For Henry's original motor, the batteries consisted of a plate of zinc surrounded with copper, while, according to this letter, Green's batteries utilized zinc and copper cylinders, a galvanic arrangement Henry normally used for his large electromagnets. See Henry's "On a Reciprocating Motion Produced by Magnetic Attraction and Repulsion," *Silliman's Journal*, 1831, *20*:342.

pal elec-mag. phenomina, can be used separately or combined and will be found a very convenient table apparatus. I am fitting up the article for you on a some what different plan.[3] The magnets are of this form



curved so that both poles may act on the galvanic magnet instead of one. By this improvement I anticipate a moving force double of that in the other plan with the same ammount of galvanic & magnetic power. Many different forms of the instrument have suggested themselves to my mind and it would require but little ingenuity to vary the appearance of the machine by the addition of wheels &c. so as to make it appear like a new article. I believe that Mr Richee has lately reinvented my machine in this way and described it before the Royal Society. Perhaps I do him injustice.[4]

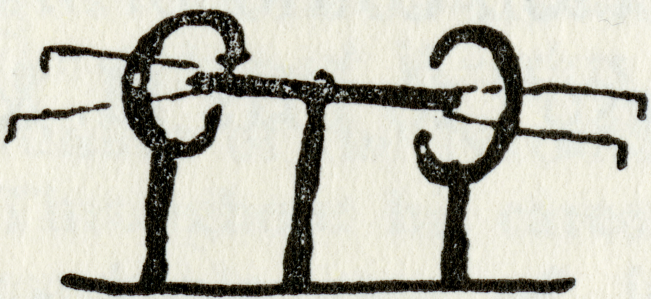
[3] Although Henry seems to be on the verge of completing the modification of his reciprocating electric motor for Green, it is unclear whether he actually achieved a finished product. We have been unable to locate either any later references to the modified motor or any example of the device itself. Whether completed or not, Henry's machine on a "different plan" deserves a place in the history of electrical technology. The episode also shows Henry seriously reevaluating the potential capacity and perhaps practical application of an invention which he had earlier described as a philosophical toy.

It is not surprising that Henry showed the improvements to Green as Green had witnessed the first demonstrations of Henry's original motor and had suggested modifications which included replacing the permanent magnets with electromagnets. Green later demonstrated the advantages of this substitution at a meeting of the Franklin Institute on May 22, 1834. See "Monthly Conversation Meetings," *Journal of the Franklin Institute*, 1834, *14*:5.

[4] A Scottish physicist who had abandoned a church career for teaching and science, William Ritchie (1790–1837; *DNB*) was a well-known experimentalist. He held concurrent professorships of Natural Philosophy at the Royal Institution (from 1829) and the University of London (from 1832). A prolific scientific publisher, his contributions included "On a New Photometer...," *Phil. Trans.*, 1825, pp. 141–146; "On a New Form of the Differential Thermometer with Some of its Applications," *Phil. Trans.*, 1827, pp. 129–131; and "On the Reduction of Mr. Faraday's Discoveries in Magneto-Electric Induction to a General Law," *Phil. Mag.*, 1834, 3d ser. *4*:11–13. Electromagnetic research, much of it built upon the work of his colleague Faraday, accounted for the bulk of his published work.

At this date Henry may have received only a verbal report of Ritchie's presentation of a rotating electromagnetic motor, which was described in the final pages of Ritchie's "Experimental Researches in Electro-Magnetism and Magneto-Electricity," *Phil. Trans.*, 1833, pp. 313–321. We know that Henry saw the printed account at least by May 2, 1834 (see the entry for that date of Henry's Notes on a Trip to Philadelphia, April 29–May 2, 1834, below). There Ritchie noted that a series of experiments on reversing the poles of an electromagnet afforded a "most beautiful result:" an electromagnet which, through interaction with an arrangement of permanent magnets, achieved "rapid rotation ... about its center" (p. 319). (At the end of the same article, Ritchie was able to obtain the reverse effect with a similar revolving apparatus producing "an almost continuous current of electricity.") One modification of his electric motor, Ritchie claimed, could lift a weight of several ounces. The basic principle involved was clearly identical with that of Henry's motor. There was no acknowledgment of Henry's prior invention, only an oblique reference to Henry in a discussion of "an electromagnet according to the American method" (p. 317), a passage which Henry carefully quoted in one of his Princeton notebooks (No. [7171], pp. 86–87) along with a general consideration of Ritchie's publication.

Henry's imputation reflected several enduring concerns: a growing awareness of his priorities, a sensitivity to plagiarism, a sense of frustration at the apparent neglect of his work



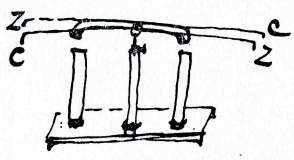
forms of the instr

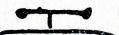
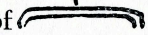
among his European peers, and, more fundamentally, long-standing convictions about the crucial elements of technological innovation. Henry's annoyance with Ritchie's claims was an intermittent concern for over two decades. Although notes from Henry's 1837 European trip show he was impressed with the "rapidity and force" of a rotary motor Ritchie demonstrated at the Royal Institution (European Diary, Henry Papers, Smithsonian Archives, entry for April 27), his continued irritation surfaced several years later in letters to his friend the Swiss scientist and editor A. A. De La Rive. In a letter of November 24, 1841 (De La Rive Papers, Bibliothèque Publique et Universitaire, Geneva), Henry asked De La Rive to retract a passage in a recent article attributing the first electromagnetic machine to Ritchie ("Coup d'oeil sur l'état actuel de nos connaissances," in A. A. De La Rive, ed., *Archives de l'électricité*, 1841, *1*:27–28). De La Rive claimed to have seen Ritchie demonstrate the machine in London in 1828. While Ritchie may well have missed Henry's article on the motor in *Silliman's Journal* and any reports that might have appeared in the European literature, Henry's letter pointed out that Faraday demonstrated a reproduction of the machine at the Royal Institution as soon as his article reached England. A May 8, 1846, letter to De La Rive in the Henry Papers, Smithsonian Archives, complained politely of the same misattribution, adding that in the 1837 Royal Institution lecture which he attended, Ritchie claimed no novelty but presented his invention as a modification of Henry's. Henry simply wanted recognition in the published record. The Henry Library contains further evidences of the apparently one-sided priority debate in Henry's copy of the English edition of De La Rive's *A Treatise on Electricity in Theory and Practice*, 3 vols. (London, 1853–1858), where Ritchie's machine again received precedence (*1*:293). In his annotations to this passage, Henry reasserted his claims and noted further that Ritchie witnessed Faraday's early demonstration of his reciprocating motor. While plagiarism was doubtless on Henry's mind, his letter to De La Rive blamed the neglect of his contribution on slow transatlantic communication as a general obstacle to the recognition of American priorities abroad.

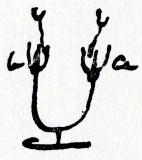
Fundamental to Henry's reaction was a personal interpretation of technology that emerged early in his scientific career. According to Henry, scientific discovery was the moving force of technology. Whatever the technological virtues of Ritchie's particular design, it was typical of Henry to emphasize underlying scientific principles and to downgrade the effect of empirical modifications. The language of his attack on Ritchie—particularly the lack of "ingenuity" he perceived in Ritchie's variation—echoed earlier attacks on American inventors. Similar language will appear below in his letter of September 10, 1835, to Benjamin Silliman. While Ritchie was far more sophisticated theoretically than the inventors and mechanics Henry condemned so vehemently, his reputation for great experimental and technical ingenuity suggests a view of technology less theoretical than Henry's. Without commenting on the propriety of Ritchie's omission of Henry's name, we suspect that Ritchie viewed his rotary design and the production of a continuous motion as an important innovation, not a mere reinvention.

King credits Ritchie with the invention of the first electric motor with a rotating electromagnet, in retrospect a technological development of first consequence. Although contemporaries such as William Sturgeon saw practical possibilities in Henry's reciprocating design, the thrust of electric motor technology followed the lines of Ritchie's approach. See *King*, p. 261; William Sturgeon, "Historical Sketch of the Rise and Progress of Electromagnetic Engines for Propelling Machinery," *The Annals of Electricity, Magnetism, and Chemistry...*, 1839, *3*:432. At this time, Henry saw few technological possibilities in electric motors of any design (see especially the abovecited letter to Silliman) and certainly no particular advantage in the addition of a few wheels for rotary motion. Any significant practical development, in Henry's view, would necessarily combine the fruit of new scientific discovery with his own innovation: the novel application of electromagnetic attraction and repulsion to a mechanical device, "a power ... never before applied in mechanics," according to Henry's 1831 article (p. 340). Henry's definition of natural "powers" and his understanding of the proprietary rights of those who first apply these powers to practice were ambiguous but crucial aspects of his technological views, which are discussed at length in terms of the patent law in *Henry Papers*, *1*:424–425. While Ritchie claimed a scientific basis for his invention in his experiments on reversing electromagnetic polarity in soft iron, Henry could point to numerous earlier experiments of his own on the same phenomenon; see, for example, *Henry Papers*, *1*:424–425.

The upright magnets[5] are too soft & do not well retain their magnetism. I retouched them this morning and they will probably answer the purpose of exhibition several times. By closely inspecting the brass bands which bind the magnets into bundles you will find on the edge of two of them markes with a file corresponding with similar markes on the edge of the brass sockets on the mahogany stand. Put each marked end of the magnets into the corresponding marked socket and the magnets will be properly placed for the motion.



In arranging the battery be careful to note that if one of the ends of the lateral conducting wire dip into a cup from the copper the other must dip into one from the Zinc as shewn in the Fig. You will find in the same paper with the "*tail piece*" a magnetic needle with a ball of pith on each end. This you may reccollect adds considerably to the effect of the exhibition by its constant motion.[6] You may contrive to place it directly above the tail  piece supported on the point of a needle attached to a stand of  cro[oked] wire thus  I found it impossib[le to] put the battery into perfect order on so short a notice. I called at the Turners immediately after the reception of your note to get two wooden rings turned to attach to the bottoms of the zinc cylenders but will not get them done in several days. You will find one ring in the box which I happened to have on hand. You can probably make them (the batteries) answer equally well by cementing some bits of cork to the bottoms of the zinc cylenders.

N.B. Do not forget to amalgamate the ends of the conducting wires and also the new brass thimbles with a solution of nitrate of mercury.[7]  If I reccollect aright I informed you that I performed Faraday's primary experiment with a battery of the kind I send you. Two wires may be made to revolve one around each of the <*two*> poles of a horse shoe magnet. Thus  *a b* are two large phials cut off at the middle and semented on the ends of the magnet. In this exp both batteries must be used. If you have a good sized magnet the exp can be made on a large scale.[8] Give my respects to my Friend Lukens & tell him if I can raise money from

[5] This paragraph follows a space in the original text where Henry started to add a bit more on the Ritchie episode but changed his mind and crossed it out; he now returns to Green's device.

[6] The revolving magnetic needle would show different patterns of interaction of the electromagnetic forces. An elaborate array of these needles can be seen in Francis Watkins's modified copy of one of Joseph Saxton's electric motors, pictured in Arthur H. Frazier's unpublished article "Joseph Saxton at London and his Magneto-Electric Devices," p. 22d, in the files of the Joseph Henry Papers.

the trustees at their next meeting for an increase of the apparatus I will purchase the remaining machine[9] but do not let him loose an oportunity of selling it on my account.

My time has been constantly occupied this winter in my college duties. It is settled that Dr Torrey returns to Princeton next summer and will continue during the whole term. I am therefore obliged to hurry my course in order that I may not interfere with his course next session as we both lecture to the same class. My battery[10] is still unfinished although I have expended about ½ a day's labour on it every week since I saw you last.

Your Friend
Jos Henry

[P.S.] Give my Respects to our friend Prof Millington[11] also to Prof Bache.

The original illustration appeared in the July-December 1835 issue of *The London and Edinburgh Philosophical Magazine and Journal of Science.*

[7] The wood was used to separate the zinc and copper, while the amalgamation improved electrical contacts. *Henry Papers, 1*:422; Henry's copy of Jacob Green's *Electro-Magnetism* (Philadelphia, 1827) describes the amalgamation techniques, pp. 173–174.

[8] We cannot specify the immediate reason for Henry's repetition of Faraday's seminal discovery in 1821 of the phenomenon of electromagnetic rotations, considered in L. Pearce Williams, *Michael Faraday* (New York, 1965), pp. 151–168. Classroom demonstration is the best possibility. The phenomenon was normally introduced as the "fourth fact" of electricity in Henry's physics lectures at Princeton. See the natural philosophy lecture notes of his student W. M. Whitehead, Lecture 47, January 19, 1837 (Rare Book and Manuscript Library, Princeton University); also Henry's 1836 "Lecture on Electromagnetism prepared for Dr Torrey," Henry Papers, Smithsonian Archives, Box 19, in folder "Electricity and Magnetism Notes." An apparent reference to the effect also occurs in an undated Albany lecture, printed in *Henry Papers, 1*:469.

Though ascribing fundamental significance to Faraday's discovery, Henry's lecture notes adduce no particular theoretical conclusions from electromagnetic rotations, beyond interpreting it as an important consequence of Ampère's electrodynamic theory. In his lectures Henry makes no reference to the initial theoretical controversy surrounding electromagnetic rotations, which opposed Faraday's circular construction of electromagnetic forces to Ampère's linear, action-at-a-distance interpretation. An avowed Ampèrian, Henry probably took Ampère's theoretical resolution of the problem for granted and considered the matter generally settled. In any event, Henry's handling of the effect was altogether typical. His first inclination, as with the electromagnet, was to conduct new experiments on the largest possible scale.

Though obviously struck by surface similarities between Faraday's revolving wires and his own electromagnetic motor, Henry drew no theoretical connection between the devices. Ampère offered a unifying theoretical framework, but Henry seemed unaware of the continuous line of development seen by modern historians from electromagnetic rotations to the electric motor (see Williams, *Faraday*, p. 156; *King*, p. 260).

[9] There is no record of such a purchase in the Trustees' minutes nor does a Saxton machine appear in Henry's accounts of apparatus purchased for Princeton (see "J. Henry's a/c with Philosophical Hall previous to 1837" in the Princeton University Archives). The latter does list a similar magnetoelectric machine by Saxton's rival Edward M. Clarke of London. See also Allen G. Shenstone, "Joseph Henry's Bills . . . ," *The Princeton University Library Chronicle*, 1967, *28*:150–155. Nevertheless, Henry later experimented extensively with one of Saxton's devices, whether his own or borrowed. See the May 14, 1840, entry in Henry's "Record of Experiments" (in the Smithsonian Archives), to appear in a future volume of *The Papers of Joseph Henry.*

[10] See above, Henry to George Maclean, October 9, 1833.

[11] See Millington to Henry, December 31, 1832, footnote 1.

March 3, 1834

I finish my course of lectures on electricity tomorrow. It occupies in all 12 lectures. I have been deeply engaged for some weeks past studying the x + y of electricity.[12]

[P.P.S.] You have probably seen by the papers that Mr *Benedict* Jaëger[13] has become a married man.

[12] Henry may refer to the basics of electricity covered in his lectures or, perhaps, to the use of algebra in the electrical course, mentioned by Henry in his letter to Rogers of March 9, 1835, below, footnote 7.

[13] See above, Henry to Harriet Henry, April 6, 1833, footnote 4. Henry underlined Jaeger's first name because of its meaning from Shakespeare's *Much Ado About Nothing*, an old bachelor, now newly married.

FROM PARKER CLEAVELAND[1]

Henry Papers, Smithsonian Archives

Brunswick March 3, 1834.

My dear Sir,

Day after day for nearly a year I have been intending to write you, to thank you for your friendly attention in helping me to an electro magnet, and to trouble you with a few queries.

I was not able to put it in operation until last May,[2] when its performance gave great satisfaction to the class. I put on about 1500 lbs (all I could conveniently obtain), which remained suspended, until I had withdrawn more than half the Battery.

[1] Parker Cleaveland (1780–1858, *DAB* and *Henry Papers*, *1*:373), scientist, author, and educator at Bowdoin College, Brunswick, Maine. This is the first letter to pass between Cleaveland and Henry since Cleaveland's of June 18, 1832, in which he reimbursed Henry for expenses in constructing a magnet for Bowdoin. (See *Henry Papers*, *1*:420–426 for Henry's description of the electromagnetic apparatus and some experimental procedures.)

As he revealed in the text of this letter, Cleaveland was previously unaware that Henry had moved to Princeton, although he apparently suspected that Henry no longer lived in Albany. Addressing the letter to Henry in Albany, Cleaveland wrote on the cover, "If Prof. H. has left Albany, this P[ost] M[aster] will please forward this to him." In turn the cover sheet was stamped "FORWARDED" and "ALBANY MAR 10." Determining the date of Henry's receipt of the letter is problematical. In a letter to James Henry of February 9, 1835, below, nearly a year later, Henry thanked his brother for forwarding Professor Cleaveland's letter on magnetism which had been sent to Albany. Could this forwarded letter have been mislaid in the mails for eleven months? Or might there have been a second Cleaveland letter, also sent to Albany, now not found? Surviving Cleaveland-Henry correspondence is certainly fragmentary, but it may not have been voluminous to begin with. No Henry response to this letter has been located.

[2] Cleaveland informed Henry in June of 1832 that other business would prevent his assembling the apparatus until autumn. See *Henry Papers*, *1*:432–433.