magnetic apparatus to mechanics. . . .[2] Will you be so good as to communicate to me *here* the truth. If there is anything in it I must try to find room for you in the October no. if possible although it is chiefly pledged to Ohio coal.[3]

Another matter. I am to give a popular course of chemistry in Boston next March and April[4] & I wish to do justice to your discoveries. I shall have a calorimotor there of considerable power. I wish to know whether the poles of this could be conveniently adapted to your galvanic magnet, so as to supersede the necessity of having a distinct battery appended. . . . I would take care to do justice to your discovery that a small battery will answer the purpose. . . . Are there any improvements in winding the wire? I shall wish to give minute directions to a practical man in Boston that I may have everything ready early in season. An immediate answer will oblige me as I am to leave this for Boston on the morning of the 23. inst. & I wish to give the directions there in person. I remain dear Sir Yours very truly

B. Silliman

[2] A report on the electromagnetic machine of Thomas Davenport. See Henry's response, below, of September 10, 1835.

[3] See Ten Eyck's letter to Henry of December 7, 1835, footnote 4, printed below.

[4] See above, Silliman to Henry, May 27, 1835.

TO BENJAMIN SILLIMAN, SR.

Daniel C. Gilman Collection, Library, Johns Hopkins University

Princeton Sept 10th 1835

My Dear Sir

Your letter of the 4th inst came to hand this morning and I answer it by the return post. The great importance of the invention of the Brandon blacksmith exists principally in the fertile immagination of Professor Eaton who is said to be the writer of the article you have seen and who probably intends to edify the public with an account of the wonder. I was somewhat displeased with the article and think it calculated to injure the inventor of the machine who appears to be a modest unassuming and ingenious young man. He came to Princeton about a month since with a letter to me from the Patroon (Mr Van Renssaler) of albany with a request that I would give an opinion on the merits of the article. I stated in a certificat that as the production of a person but little acquainted with the subject of electromagnetism the machine evinced much ingenuity but that I did not believe

that electro magnetic power would be found sufficiently cheap for mechanical purposes.[1]

I felt considerably interested in the welfare of the Inventor and with friendly motives advised him to abandon the invention as I was fully convinced that he never could do anything with it except in the way of exhibition as a curiosity. I gave him a letter to Mr Peale of the Museum of Philadelphia that he might make something by exhibiting it for money and thus indemnify himself for the time he had expended in the construction.

The truth is that there is nothing new in the whole affair. Every <*principle*> part of the machine has been invented before and in fact it differs nothing in principle from the first one of the kind which I described in the Journal, as you will reccollect, about 1831.[2] I have been pestered with let-

[1] At this point we pick up the account of Thomas Davenport, the Brandon, Vermont, blacksmith, who invented an electromagnetic motor (see footnote 1 of Van Rensselaer's letter to Henry of June 29, 1835, above, for the sources of this note). In this letter Henry gives the only report by him known to us about what transpired in Princeton in early July of 1835. It differs in certain respects from the two versions deriving from Davenport, his autobiography and the biography by his descendent, Walter Rice Davenport.

In the former, A. D. Bache is at Princeton; in the latter Davenport meets Bache later in Philadelphia. Henry's "certificat" does not survive. The two Davenport accounts do not give Henry's rather patronizing evaluation of the invention, mentioning only Henry's praise of the originality of the device. The autobiography—the obvious source of the later account—quotes Henry's advice to build on a small scale to minimize the public reaction in case of failure. Neither account mentions Peale's Museum (see below). Instead, Bache has Davenport exhibit the invention at the Franklin Institute. On July 15 Bache gives the Brandon blacksmith a warmer certificate than Henry's—the text is given in the Davenport autobiography—which suggests continuing the work on a full-size model. Davenport then continues to Washington but, owing to the 1836 fire in the Patent Office, only receives his patent in 1837. After returning home in 1835, a newspaper story by Amos Eaton praised the invention. News of this had apparently reached Silliman. Henry was not impressed by Eaton's prose.

[2] Henry's sensitivity on this particular priority problem is apparent in his reaction to William Ritchie which is given in his letter to Jacob Green of February 17, 1834 (and especially footnote 4), above. During his lifetime, Henry's achievement was recognized by at least some of his peers. In 1839 Sturgeon noted that ". . . it is to the ingenious American philosopher, above named [Henry], that we are indebted for the first form of a working model of an engine upon the principle of reciprocating polarity of soft iron by electro-dynamic agency." In Hare's *Compendium*, the section on Electro-Magnetism, Hare gives Henry credit for "more fully" presenting the "susceptibility of opposite magnetization," while giving Ritchie credit for the first rotary motion (pp. 120–122 in "Of Galvanism, or Voltaic Electricity," supplement to *A Compendium of the Course of Chemical Instruction. . . ,* 4th ed. [Philadelphia, 1840–1843]). In Brewster's article in the *Britannica* on "Voltaic Electricity" (8th ed., p. 641) Henry's reciprocating apparatus is cited as the source of Davenport's invention. While balming his pride, these references did not compensate for the neglect of his work by others. Sturgeon's remarks are in "Historical Sketch of the Rise and Progress of Electro-magnetic Engines for Propelling Machinery," Sturgeon's *Annals of Electricity, Magnetism, and Chemistry,* 1839, *3*:429–479. The quotation is from page 429. Sturgeon himself claimed to have made a motor in 1832 and demonstrated it in the following year.

A recent work (*King*, pp. 260–261) states "Henry's apparatus was the first clear-cut instance of a motor capable of further mechanical development. It had the essentials of a modern DC motor: a magnet to provide the field, an electromagnet as armature, and a commutator to apply the mechanical forces at the right time. . . ."

ters from almost every state in the Union since my first paper on Electro magnetism appeared in the Journal, containing discriptions and plans of machines to be moved by the magnetic power. I have uniformly referred them to the description of my little machine in the Journal and stated that I freely renounced all right to the invention as I consider the machine in the present state of the science only a philosophical toy.[3] It is surprising how many times this machine has been reinvented and described with slight modifications since my first description of it. One invention of this kind was made in Germany[4] another in France[5] and in the last No of the

[3] See, for example, the fragment of Henry's reply to S. Belknap, July 26, 1834, above. As in similar instances in volume one, we lack the letters Henry received from inventors. From his replies, we know some conceived of electromagnetism as a source of perpetual motion. Others, such as Davenport, did not have that aim, being sincerely interested in developing a new motive power. In this period —let us say, 1832–1835—a number of men in Europe and America began seeking ways of practical application of electromagnetism. In contrast, having demonstrated a particular scientific effect in his reciprocating motor, Joseph Henry turned to other scientific problems in electromagnetism.

[4] Most likely a reference to Moritz Hermann von Jacobi, *DSB* (1801–1874), brother of the eminent mathematician C. G. J. Jacobi (1804–1851). Originally an architect, M. H. von Jacobi had constructed an electromagnetic motor in May 1834. In 1834 Jacobi was at Königsberg practicing his profession. Jacobi submitted a report to the French Academy and the first publication of his work known to us appeared in France in that year in *L'Institut, journal général des sociétés et travaux scientifiques*, December 2, 1834, 2:394–395. As we shall see in footnote 6, word of Jacobi's device was out, in print or otherwise, before this publication. In 1835 he became a Professor of Civil Engineering at Dorpat in the Russian Empire. In 1837 he became associated with the Imperial Academy of Sciences at St. Petersburg. After 1840 he was solely at the Academy. With the support of the Russian government, Jacobi in 1838 constructed and ran a motor-propelled boat. He was an active investigator in both the theory and the application of electromagnetism.

After his removal to Russia, Jacobi's work, including his first full description of the motor, appeared often under the auspices of the Imperial Academy. A partial English translation appeared in 1837 in Sturgeon's *Annals* (1:408–415, 419–444). By that date Jacobi was aware of competing claims for priority by Italian investigators (but not by Joseph Henry) which he dismissed (p. 409):

> A discussion of priority has only a historical interest. It is not surprising that men between whom there is scarcely any communication, should study the same subject nearly at the same time. But we ought not to deceive ourselves that after the great discovery of M. Oersted, and the essays of Mr. Sturgeon . . . it was not difficult to conceive the idea that some motion or some mechanical work might be produced by the electromagnetic excitation of soft iron.

One experiment Jacobi reports is footnoted by Sturgeon (p. 440) as having been originally done by Henry.

In the same piece, he displayed an attitude towards applications and pure science quite different from Henry's:

> I was first struck with these considerations when the means of putting them into execution were yet unknown, but I always had their practical application in view, and the object appeared to me of too great importance, to exhaust my powers in the construction of playthings which could only claim the honour of being put in the rank of electric chimes in relation to their effect, and still more with regard to the noise with which they are accompanied.

Another but less likely possibility is that Henry has heard of the Swiss-German Rudolph Schulthess (1802–1833?, *Poggendorff*). He had suggested the idea of an electromagnetic motor in a December 10, 1832, lecture to the Zurich Philosophical Society. At the start of the next year, he heard of the Italian Dal Negro's work which he criticized in a February 18, 1833, talk before the Society. This

Edinburgh Journal (Jameson's) but one, a detailed account is given of one by a person in Milan almost precisely the same as mine except, that it vibrates like a pendulum instead of moving like the working beam of a steam engine.[6] The plan of the Brandon Blacksmith, is however the best although not the most simple which I have seen. It is still however nothing more than a philosophical toy—a new power cannot be introduced as a moving principle in mechanics unless it be cheaper in its production, or more convenient in some respect than steam.[7]

In answer to the inquiries relative to the calorimotor &c &c, there is no

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lecture described his own device. (See Taylor's *Scientific Memoirs*, 1837, *1*:534–540.) Although Henry was not named, Schulthess was aware of Henry's work on the great lifting magnet.

[5] Unknown to us unless this is a confusion with Jacobi because of the French publication.

[6] G. M. Botto's "On the Application of Electro-Magnetic Power to Mechanics" is in the *Edinburgh New Philosophical Journal*, 1834–1835, *18*:151–154. Botto published this article after reading a reference to Jacobi's work. Botto (1791–1865, *Poggendorff*) was on the faculty at Turin and not from Milan. Two other Italian scientists producing motors (loosely speaking) in this period, Salvatore Dal Negro (1768–1839, *Poggendorff*) and Giuseppi Zamboni (1776–1846, *Poggendorff*) are from Padua and Verona, respectively. We are uncertain if Henry simply confused Turin and Milan or if he had heard of still another Italian working on electromagnetic motors.

[7] Discoveries in electromagnetism stimulated interest in applications among both scientists and inventors. Accompanying this interest in many instances were optimistic expectations, sometimes verging on technological hubris. Henry was a hardheaded dissenter, stressing very real practical difficulties. Although inventors and ingenious mechanics aroused his ire, fellow scientists were not immune to a facile optimism disregarding legitimate objections.

Consider the matter of perpetual motion. The translation of the Botto article in the *Edinburgh New Philosophical Journal* (see footnote 6) has Botto responding to word of Jacobi's development of perpetual motion. The original of Botto's article in the *Bibliothèque universelle, sciences et arts*, 1834, n.s. *2*:312, says Jacobi obtained "un phenomène de mouvement continu," a far different matter, which the editor of a leading scientific journal apparently did not notice. Jacobi himself, in the 1834 article in *L'Institut* (see footnote 4), asserts, "Dans la machine électrique, la vitesse ne coûte pas d'argent." Henry's ire against inventors and untutored mechanics might equally apply to a number of very eminent fellow scientists.

Henry's cool reaction came down ultimately to the recognition that coal and water were cheaper than metals and acids, a fact recognized by many of his contemporaries. *King*, pp. 269–271, in his discussion of this point, also notes that the absence of a means of distributing electricity over long distances was a handicap. Even Jacobi's initial optimism waned. Brewster, reporting a conversation with Bassel, states that Jacobi abandoned his efforts because of induced "counter-currents generated by the very motion of the machine." More typical were investigations comparing the work performed by electric and steam power. As late as 1876 Henry was repeating these arguments. And Theodore du Moncel's *Exposé des applications de l'électricité* (3d ed., Paris, 1878) continued in this vein at the point where the recent invention of the dynamo would change the situation drastically.

Reading the arguments for and against electrical power in the first three quarters of the last century is reminiscent of the contemporary experience with atomic energy. Sanguine hopes for the new source of power were not immediately borne out. Not only were scientific and technological problems involved in the new technology underrated but so also was the competitive resiliency of the older power technologies.

Brewster's comments are in the *Britannica*, "Voltaic Electricity," 8th ed., pp. 645–646. Henry's late views are in the Smithsonian Institution, *Annual Report*, 1876, p. 39.

difficulty in attaching temporarily the terminations of the wires[8] which envelope the magnet to the poles of an ordinary calorimotor. This may either be done by cups of mercury or by means of the two vises usually attached to the instrument. If you are about constructing a new calorimotor I would advise that all the plates be well soldered to broad slips of thick copper instead of the lead bars described by Dr Hare. Much of the power of this apparatus depends on the perfect conduction of the "*connectors*" of the several parts. The only precautions in making the electro-magnetic magnet is that all the wires should be of the same length and that they do not touch either in the different spires of the same wire or in the spires of different wires. If the spires of the same wire touch each other the effect produced is the same as that of shortening the strand of wire so touching this causes it to conduct more than its share of the galvanism. If the spires of different wires touch the galvanism may pass from one to the other and not circulate around the magnet. The strands should be about 50 feet long and well covered with silk. Another very important precaution is that the electricity pass in the same direction through each wire or that no two wires neutralize each other by transmitting adverse currents. To guard against this it will be proper before soldering all the projecting ends together that each be tried by a small battery the poles of which are furnished with cups of mercury. If each wire gives the same polarity to the same leg of the magnet (which may be tried with a [common?] compass needle) then they must be all soldered together in the order in which they have been tested; if not then the one which is found to give a contrary polarity must have its ends reversed in reference to the terminations of the other wires.

I have shown to my class with my large battery some of the most magnificent experiments on electromagnets which I believe have ever been exhibited. I form a hoop of copper ribbon of about the size of the small wheel of a waggon by rolling on its self in the same plane about 100 feet of copper ribbon one inch wide well covered with silk. When this circle of copper ribbon is supported horizontally about 8 or 9 inches from the lecture table and a large apparatus like Amperes revolving cylender[9] is placed in the centre the cylender begins to move as if by magic when the current is passed through the copper ribbon. If a large plate filled with mercury be placed on a short cylender of iron & these placed in the middle of the coil the

[8] This account by Joseph Henry is essentially similar to those appearing in *Henry Papers, 1*: 400–402, 420–425. As we shall see below, this account did not answer all the questions in Silliman's mind.

[9] Although Henry had reason to believe Silliman was familiar with this piece of apparatus, Silliman claimed he was "not acquainted" with it in his reply of September 19, 1835, below. See especially footnote 9.

mercury commences a gyratory motion; and in this way a variety of experiments of the most surprising kind are shown. The most astonishing exhibition however of the power of galvanism [in] developing magnetism in soft iron is made by placing the large coil before mentioned perpendicularly to the horizon and holding in its centre the lifter of my large magnet (which, the lifter, weighs 25 lbs.) and when the galvanic current is passed through the coil the iron in its center becomes so powerfully magnetic as to support itself and three or 4 times its own weight from the ends of a piece of bar iron bent thus  or like a *U* with two long legs which pass over the coil and reach down  as far as the centre of the coil on each side. These experiments belong to a series which I have intended to publish as a continuation of my papers in the Phil. Transactions.[10] I would be pleased that you should exhibit this and will give you any information necessary for that purpose. I owe you many thanks for the favour you have done me in making my experiments known; that my labours are appreciated and commended by those who are capable of judging in such matters is very greateful to my feelings but I must confess that I have become somewhat too fastidious to relish the newspaper puffing which has become so common and disgusting in this country.[11]

I wrote you a letter some weeks since about the accounts of the Journal, also informing you that I had been elected to the Chair of N. Philos in the University of Virginia but had declined the appointment. I also stated that James Chilton of New York had succeeded in making a powerful magnet on my plan for West Point and that he will furnish them of any power at a short notice.[12]

The Trustees of the College at the last meeting ordered the erection of

[10] "Contributions III: Electro-Dynamic Induction" does not specifically go into these experiments. The closest to these topics are paragraphs 50 and 51 which appear almost as asides to the main argument. In the latter, Henry notes that induction at a distance provides "astonishing experiments, in the line of *physique amusante*." Experiments with hoops of copper ribbon were a common part of Henry's laboratory work; a variation of the experiment on the gyration of mercury is dealt with in experiment 5 of the "Record of Experiments" for September 8, 1834, above. In an extended letter of March 2, 1836, to appear in volume three, Henry goes into considerable detail on the experimental setups and on his explanations of the effects.

Another possibility is that Henry is referring to the proposed, but never realized, publication discussed in his letter to Harriet Henry of May 1, 1835, above. See especially footnote 4.

[11] Perhaps a reference again to the newspaper publicity for Davenport. This theme will recur in the *Henry Papers* (for an earlier comment, see Henry's letter to Cooper of November 26, 1833, above). Joseph Henry felt strongly that new discoveries and scientific controversies were matters for consideration first within learned organizations and scientific journals, not in the popular press. Subsequent dissemination of scientific findings in the popular press was unobjectionable; Henry himself wrote some such articles for newspapers.

[12] See Henry's letter to Silliman of August 29, 1835, above.

an addition to the Philosophical Hall. This has interrupted all my researches for 4 months past & I fear I will loose nearly the whole semester.[13]

Yours sincerely
Joseph Henry

[13] In his March 2, 1836, letter Henry explains he had not had time to develop the experiments in this letter. Between May 1835 and March 1836 the reconstruction of Philosophical Hall effectively stopped Henry's experimentation. The March 2, 1836, letter signals the return to the laboratory. In the "Record of Experiments" he magnetizes a soft iron cylinder by a coil (March 18, 1836) and the next day magnetizes steel by electricity. From this point Joseph Henry goes into the work forming the bulk of "Contributions III."

FROM BENJAMIN SILLIMAN, SR.

Henry Papers, Smithsonian Archives

Nantucket Sept[r] 19, 1835

My dear Sir

After I wrote to you from this place I received from N Hav[en] your obliging letter of Aug 29[1] & yesterday I received that of Sept[r] 10[2] for both of which I render you my best thanks. I duly received the Journals that were returned—also the money from M[r] Wines & M[rs] Silliman received your draft $25, $20 for M[r] G. D. Olmsted & 5$ for yourself: when I return I will see all these things correctly entered. I had supposed that M[r] G D. O. might be the same gentleman who used to write to me from Tennessee which was the cause of sending more n[os] than were wanted & the sending them twice was my own blunder. As to M[r] D'Hart he may as well send back the N[os] in his hands. I could never obtain from him any satisfactory returns & rarely any returns at all. When I get home I will see if I can make any statement that is exact. I know in general that several copies—three I believe—were sent to him year after year for subscribers & I think I received only one small remittance. I suppose of course that the rest must be lost. It will give me much pleasure to aid *your* I may say *our* friend M[r] Johnson should it be in my power & I will keep him in view for that purpose. I have the same opinion of him which you express & have placed a high value on his communications. It would be a great pity should he be lost to science. You will be the best judge of the importance of the errata in your late notices in the Journal;[3] I will insert them in the ensuing N[o] should you desire it & I think

[1] See above. [2] See above. [3] See Henry's August 29, 1835 letter, above.