Danbury, Connecticut. See W. Walker, "The Sandemanians of New England," *Ann. Report Am. Hist. Assoc.*, **1901**, *1*, 131-162.

5. L. A. McMillon, *Restoration Roots*, Gospel Teachers Publications, Dallas, 1983.

6. Although this style of preaching has largely disappeared, it can still be heard in many of the more conservative Churches of Christ, particularly in the southern states of the United States. Churches of Christ, like the Sandemanians, are rooted in restoration principles that sprang from Scottish Presbyterianism.

7. Seventeen sermons by four Sandemanian elders, including four by Faraday, first published by James Rorie in 1910, are discussed by P. Eichman in "Selected Exortations: Sermons From a Lost Branch of the Restoration Movement", *Restoration Quarterly*, **1990**, *32 (1)*, 23-35. An undated sermon by Faraday taken down by shorthand is in the archives of The Royal Institution. Examples of two of Faraday's sermon note cards are given in Jones, reference 9, Vol. 2, p. 101. Several other note cards are in the archives of The Royal Institution.

8. Michael Faraday, "Observations on Mental Education", *Experimental Researches in Chemistry and Physics*, Taylor and Francis, London, 1859, p. 465.

9. Early biographers treated Faraday's usage of Romans 1:20 as no more than a simple affirmation of faith. More recently, Clark, Levere, and Cantor have seen Faraday as supporting natural theology, while Russell and Eichman have taken an opposing view. See H. Bence Jones, *The Life and Letters of Faraday*, Vol. 1, Longmans, Green, London, 1870, pp. 337-338; J. H. Gladstone, *Michael Faraday*, Harper, New York, NY, n.d., pp. 130-131; Thompson, reference 3, pp. 291-293; R. E. D. Clark, "Michael Faraday on Science & Religion", *The Hibbert J.*, **1967**, *65 (259)*, 144-147; T. H. Levere, "Faraday, Matter, and Natural Theology", *Brit. J. Hist. Sci.*, **1968**, *4*, 95-107; C. A. Russell, *Cross-Currents: Interactions Between Science and Faith*, Eerdmans, Grand Rapids, MI, 1985, pp. 258-259; G. N. Cantor, "Reading the Book of Nature: The Relation Between Faraday's Religion and His Science", in D. Gooding and F. A. J. L. James, eds., *Faraday Rediscovered*, Stockton Press, New York, 1985, pp. 69-81; and P. Eichman, "Michael Faraday: Man of God - Man of Science", *Perspectives on Science and Faith*, **1988**, *40(2)*, 91-97.

10. Cantor, reference 9, p. 71.

11. It can be argued that Faraday used the 1776 Bible in his youth and the 1817 Bible in later years. If so, his marking of Romans 1:20 in the 1817 Bible suggests that he found some value in natural theology later in life.

12. When asked once by Roman Catholic Cardinal Wiseman (1802-1865) if he believed that all of the Church of Christ was comprised in his little sect, Faraday replied, "Oh no! ... but I do believe from the bottom of my soul that Christ is with us." [Thompson, reference 3, pp. 297-298.]

13. Faraday to Mrs. Deacon, 12 August 1859, in Jones, reference 9, pp. 428-430.

14. Faraday to A. de la Rive, 19 September 1861, in L. P. Williams, ed., *The Selected Correspondence of Michael Faraday*, Vol. 2, Cambridge University Press, Cambridge, 1971, p. 1001.

15. G. Caroe, *The Royal Institution, An Informal History*, Murray, London, 1985, p. 67.

16. Letter, Sarah Faraday to Dr. H. Bence Jones, 22 November 1867, Archives of The Royal Institution.

17. Faraday to Schönbein, 27 March 1860, in Jones, reference 9, pp. 438-439.

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FARADAY'S HEALTH PROBLEMS

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In 1926 the German chemist Alfred Stock published a very interesting article in the *Zeitschrift für angewandte Chemie* (1). The title of the article was "The Danger of Quicksilver Vapor". Quicksilver is, of course, the common name for metallic mercury. In it Stock described his own experiences with mercury poisoning and suggested that Michael Faraday suffered the same affliction. Stock had very good credentials for making such a diagnosis about Faraday, who died in 1867.

Alfred Stock (1876-1946) is remembered for the Stock system of naming inorganic compounds. He invented the glass vacuum line to handle the very reactive silicon and boron compounds in which he was interested (2). He then proceeded to work for an extended period of time, over 25 years, with devices containing mercury: manometers, pumps, valves, etc.

Eventually Stock began to experience a series of health problems, including headaches, dizzy spells, and memory loss (3). For several years his problems were diagnosed as nasal in origin. He underwent treatment for ten years, including cauterization, electrolysis, and surgery. By 1924 his memory had gotten so bad that he could not deliver a lecture without an extensive set of notes. He found himself forgetting telephone numbers between looking them up in the directory and reaching the phone.

Stock began his 1926 article by describing his own ordeal with mercury (1):

> For almost 25 years I suffered from maladies which were at first weak and appeared only occasionally, but became gradually worse and worse, until they became finally almost unbearable, so that I doubted whether I would be able to continue my scientific work.

When an assistant, Wolfhart Siecke, developed similar

symptoms, which were diagnosed as due to mercury poisoning, Stock considered the possibility that his health problems may also have been due to exposure to mercury. He had his laboratory outfitted with seamless floors so that droplets of mercury from spills could not collect in cracks. He greatly increased the ventilation in his lab. Gradually, he began to recover and was able to report (1):

All symptoms have, if not completely disappeared, at least more or less subsided since I began two years ago, *without other treatment*, to protect myself from inhalation of mercury vapor (emphasis added).

In this way Alfred Stock demonstrated that his many health problems were due to exposure to mercury vapor. What were these health problems? In the 1926 article Stock lists over 20 symptoms which he experienced. We shall see that Michael Faraday had many of the same symptoms as Alfred Stock.

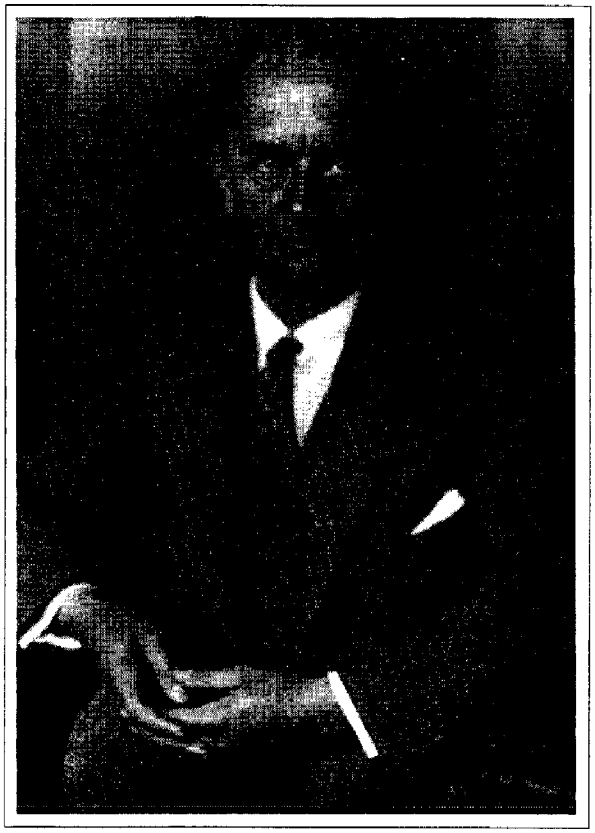
At the conclusion of the article in the *Zeitschrift für angewandte Chemie*, Stock proposed that Michael Faraday (and Blaise Pascal as well) also suffered from mercury poisoning. A number of the same symptoms that afflicted Alfred Stock at age 48 and Michael Faraday at age 49 were also experienced by Isaac Newton at age 49. Stock says nothing about Newton. Yet the possibility that Newton suffered from mercury poisoning has received more attention recently than has the Faraday hypothesis. One reason for this, perhaps, is the relatively recent publication of Newton's correspondence (4) and the subsequent mercury analyses done on his hair (5).

Is there any basis to the suggestion that Michael Faraday had mercury poisoning? At this point the claim rests on circumstantial evidence of two types. First, Michael Faraday did have health problems corresponding to those well documented by Stock as being due to mercury poisoning. Second, Faraday was exposed to mercury vapor on a long term basis. Both his exposure and his health symptoms are heavily documented in Faraday's own writings.

In 1840, at age 49, Faraday's health was bad enough that he had to stop his scientific efforts and take an extended vacation. Professor L. Pearce Williams has referred to this period as a "breakdown" (6). Faraday and wife Sarah went to the continent where she reported that he took very long walks, up to 30 or even 45 miles in a day (7). Gradually he regained his health; though as Professor Williams points out, he never fully recovered (8).

Another Faraday scholar, Geoffrey Cantor, has suggested that there were three distinct periods of crisis in Faraday's life when his mental faculties were not capable of coping with the pressures upon him. These incidents occurred in 1840, 1850, and 1864 (9). The 1840 episode is reminiscent of the breakdown mentioned by all Newton biographers and recently attributed to mercury poisoning (5).

Michael Faraday was exposed to mercury constantly for many years. This is very well documented in his own writings.



Alfred Stock

In his book, *Chemical Manipulation*, there are several passages that reveal Faraday's exposure to mercury vapor. First, a description of the mercurial trough then used to collect gases that are soluble in water (10):

Newman also has a much smaller trough for the use, though in a confined manner, of jars 1.5 inches in diameter and six inches in length; it has only 30 square inches of shelf room. It requires 20 lbs. of mercury to fill it ... A mercurial trough should always stand in a tray, and likewise have a cover to keep out dust and dirt when not in use. Its place ... should be upon the table grooved round the edge, that waste mercury may be avoided as much as possible. When the metal is spilled it is best collected by being swept together and then gathered up by a card.

A second example from *Chemical Manipulation* is Faraday's suggestion on how to fill a capped jar with liquid mercury (11):

When a capped jar is to be filled with mercury, by the assistance of the mouth, the jar should be inclined as much as possible to diminish the height of the column of air within it, as well as the labor attending the operation; then by applying the mouth to the stopcock and using it to exhaust in a manner almost the reverse of that described for blow pipe

practice, the air may be withdrawn and the mercury gradually raised until it fills the jar.

Faraday was also familiar with the use of mercury as a fluid for the attainment of high temperatures in baths (12):

To achieve bath temperatures above 212°F one can use liquid mercury as the fluid. If the experiments be made altogether in tubes, a temperature of 600°F may easily be communicated by means of it; but if the bath be an open vessel, a dish or a crucible for instance, then temperatures higher than 450°F should not be given to it; for the metal soon rises in vapor ...

A final example from *Chemical Manipulation* deals with electrical discharge machines, which were used to inflame mixtures of gases (13):

It is often advantageous, especially when the machine is required in haste, to hold a piece of silk with some amalgam upon it against the plate or cylinder, whilst it is turned, and also to rub up the surface of the amalgam upon the rubber with the same amalgamated silk.

These quotes show that Faraday used mercury in a great variety of ways; and that he was by no means afraid of or even careful about exposure to the fumes. Additional evidence of exposure to mercury comes from his diary.

Faraday near the end of his life.

Table 1. Symptoms of mercury poisoning.

*	Intermittent slight headaches
*	Continuous tormenting headaches
*	Difficulty in thinking
*	Receding of the gums
*	Loosening of the teeth
*	Trembling
*	Blurred vision
*	Dizziness; Giddiness
*	Frequent sore throats
*	Inflammation of the eyes

That Michael Faraday dealt with mercury right from the start of his scientific career is made clear in his laboratory diary. There we find the first reference to mercury on page 28 of volume 1 of the seven-volume set (14). One of his main uses for mercury was as an electrical contact. For this purpose he employed cups of mercury. The first reference to such a cup is found in his diary for the date 1 November 1832 (15). The last reference to a cup of mercury is in volume 7 for the date 15 May 1858 (16). Thus we see that he employed these cups of mercury for at least a period of 25 years. Were they constantly about, or did he take the time each day to empty the cups and cap the mercury? Given his willingness, as shown by the quotes from *Chemical Manipulation*, to be exposed to mercury, it is conceivable that the electrical contacts he needed so frequently were merely covered and not capped. Another factor relative to the cups of mercury, related by several physicists, is that insertion of electrical leads very likely would cause sparks and increased evaporation (17). Michael Faraday very probably was exposed to mercury vapor every day for over 25 years.

Faraday's writings document not only exposure to mercury, but also the presence of symptoms consistent with mercury poisoning. Table 1 lists symptoms from which Stock recovered and which Faraday mentions in his writings.

In his correspondence Faraday refers to headaches a number of times over a period of years. In 1840 he wrote to Charles Babbage telling him of vacation plans where he hoped "... to get rid of a headache there which as some people say I have enjoyed for the last four months" (18). Years later, in 1856, we find him complaining to Liebig that, "when I sit too, to think, I become headachy and giddy and think to no purpose" (19).

Of course his problems with receding of the gums, loosening of the teeth, and frequent sore throats could very easily have been mercury related (20). In 1849-50 Faraday had a persistent sore throat. Removal of five teeth in the summer of 1850 stopped the sore throats.

Faraday's struggle with memory problems are heavily documented in both his diary and correspondence. In volume

3 of the diary he discussed retaining some notes (21):

I do not know if they are of further use, but because of my bad memory would rather keep them together here, lest I may want them.

Still later in 1852, he wrote (22):

... but I want more and more distinct results, and only reason thus to preserve under the disadvantage of a sadly failing memory, the ideas that I may want to reconsider hereafter.

In 1849 Faraday wrote to Carlo Matteucci telling about redoing experiments because he had forgotten that he had already done them. In a letter to Christian Schönbein Faraday wrote, "When I try to write of Science, it comes back in confusion" (23), and in his last letter to Schönbein we read the very sad (24):

Again and again I tear up my letters, for I write nonsense. I cannot spell or write a line continuously ... I will not write anymore.

There is ample documentation in Faraday's own writings of exposure to mercury vapor and of symptoms consistent with mercury poisoning. The sources cited here are only a few of many. But is there proof? From a modern medical perspective four points can be made (25, 26):

* Headaches and memory loss are caused by too many things to be considered diagnostic for mercury poisoning. They are consistent with mercury poisoning.
* Detection of kidney problems in the 1800s was extremely difficult. The only way to detect such problems was by the appearance of blood in the urine. So the absence of a kidney diagnosis by no means rules out mercury poisoning. Today's blood serum test was not available.
* Cardiovascular insufficiency, which has been suggested as the cause of Michael Faraday's health problems, would have led to isolated strokes and Faraday would have been incapacitated for a period of time (and not gone off on 30 mile walks).
* Heavy metal poisoning would have resulted in tremors.

At this point the case for a mercury poisoning diagnosis is inconclusive. If Michael Faraday was coping with mercury problems, his already admirable achievements become even more remarkable. Perhaps some workers, motivated by Frank James efforts in compiling the complete correspondence, will seek to examine Faraday's hair so that, as with Newton, some direct chemical evidence can be had (27).

References and Notes

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