THE HARE-CLARKE CONTROVERSY OVER THE INVENTION OF THE IMPROVED GAS BLOWPIPE

Martin D. Saltzman, Providence College

Credit for the initial invention of the gas blowpipe has been marked by an unusually large amount of controversy (1), involving bitter charges of plagiarism and intellectual dishonesty. An example of this involves the American chemist Robert Hare,1781-1858 (2), who claimed that Edward Clarke, Professor of Mineralogy at Cambridge University (3), had falsely taken credit for the invention of the improved gas blowpipe. Edward Daniel Clarke, LLD (1769-1822), had published, in 1819, *The Gas Blowpipe; or, Art of Fusion by Burning the Gaseous Constituents of Water* (4), in which he staked out his claim for the primary credit for the invention of this apparatus. Hare maintained that he had published the details of its construction fifteen years earlier then that of Clarke. This led Hare to ask the question in 1820, "Will Briton's tolerate such conduct in their professors?"

Hare maintained that he had developed a similar gas blowpipe (5) in 1802 and therefore deserved sole credit. Benjamin Silliman Jr., Professor of Chemistry at Yale University, in his 1874 history of chemistry in the United States as part of the celebrations marking the centennial of Priestley's discovery of oxygen, described the development of the Hare blowpipe as follows (6):

> Probably no chemical discovery made in this country has been more generally cited or less generally understood in its scientific significance, than the oxy-hydrogen blowpipe of Dr. Hare.

Who deserves priority for the invention of this most important piece of laboratory equipment? Did Clarke knowingly appropriate the work of Hare without giving him the proper credit? An examination of the claims and counter claims will shed some light on this question.

The development of the mouth blowpipe has been attributed to Florentine glass blowers in the middle of the seventeenth century. In the works of Robert Boyle, according to Partington, one can find the following description of the blowpipe and its uses (7):

> The small crooked pipe of either metal or glass, such as tradesmen for its use call a blowpipe gives a jet of air which when directed on the flame of a lamp or candle produces a pointed flame which melts silver and even copper.

The blowpipe was first introduced into analytical chemistry in 1750 by the Swedish chemist A. F. Cronstedt (1722-1765). Tobar Bergman (1735-1784) was the first to describe the blowpipe extensively as a tool for the analytical chemist. He also gave directions for its use with various reagents such as soda, borax, and phosphate for the study of earths, salts, combustible materials, metals, and ores. Bergman's student J. G. Gahn (1745-1818) made further improvements in the design and use, and Berzelius was the foremost advocate of its use in the early nineteenth century.

According to Hare's own account, he developed his improved blowpipe in Philadelphia in 1801. The impetus behind this invention was the need to produce higher temperatures than could be obtained by any contemporary apparatus. The principal means of producing high temperatures at this time were through the use of magnifying glasses or furnaces (1). Lavoisier in 1782 had constructed an apparatus that allowed him to direct a stream of oxygen or hydrogen or a combination of both at a hollow piece of charcoal, to produce an intense source of heat. In a dramatic demonstration in April, 1782, Lavoisier, using a jet of oxygen directed at charcoal containing a piece of platinum, was able to melt it: a feat that had never been possible before. This experiment was repeated again on June 6, 1782 at Versailles to an audience that included Louis XVI, Marie Antoinette, The Grand Duke Paul of Russia, and Benjamin Franklin. The details of the apparatus and the experiments performed were reported to the *Academie* in a paper read in 1782 (8). Although Lavoisier mentioned the possibility of using the oxygen-hydrogen mixture, there is no description of this type of blowpipe in his *Traite de Chemie* of 1790 (9).

Robert Hare

Gonzalez contends that the credit for the invention of the oxy-hydrogen blowpipe belongs to Lavoisier's contemporary, J. B. G. Bochard de Saron (1730-1794) because of Lavoisier's mention in his 1782 paper of the device having been made by Bochard de Saron. Bochard claimed that if two streams of gas—one being oxygen and the other hydrogen—were directed at charcoal, a very intense flame could be produced. However, Bochard de Saron never published his work, as he was to meet the same fate as Lavoisier. The apparatus designed by Lavoisier was too complex and expensive to be of any real practical value; and the details of the Bochard device, which may have been simpler and easier to use, were never published. Thus a practical instrument which could produce the intense heat needed for many laboratory situations was not available when Hare began his work in 1801.

What led Hare to believe that he could combine hydrogen and oxygen together under controlled conditions to produce a flame hotter than any known at the time? The inspiration for the improved blowpipe came from the lectures Hare attended, beginning in 1798, given by James Woodhouse (1770-1809) at the University of Pennsylvania Medical School (10). Hare, the son of a Philadelphia brewer, had become interested in chemistry at a very young age. This interest was further peaked when he attended the lectures of Woodhouse, one of the small group of American chemists who had wholeheartedly embraced the new chemistry of Lavoisier. He was one of the leading critics, along with John Maclean, of Joseph Priestley, proponent of the "old chemistry." Although Priestley disagreed with Woodhouse, he nevertheless greatly admired his experimental abilities and considered him as the equal in skill and dexterity of any chemist he knew in England and France. Maclean may also have influenced Woodhouse to adopt the new chemistry as the result of his lectures on the new chemistry, published in 1797 as *Two Lectures on Combustion*, which contained *Considerations on the Doctrine of Phlogiston and the Decomposition of Water* (11). Woodhouse performed numerous studies on the synthesis and decomposition of water following the principles laid down by Lavoisier. The commonly accepted belief was that, when hydrogen combined with oxygen, a large amount of caloric (heat) was released. Hare probably heard of this explanation in one of Woodhouse's lectures, and this provided the inspiration for his blowpipe.

Hare believed that if he could somehow introduce a stream of pure oxygen and hydrogen, the ignition of these two gases would produce temperatures not previously obtainable. Lavoisier had developed a gasometer that would allow the use of oxygen and hydrogen but was inconvenient, as Hare noted (5):

> (It) is too unwieldy and expensive, for ordinary use...Being sensible of the advantage which would result, from the invention of a more perfect method of supplying the Blow-Pipe, with pure or atmospheric air, I was induced to search for means of accomplishing this object.

Hare's years in the brewery were put to good use, as he realized how the humble brewer's keg, being rugged, tight, and cheap, could form the basis of the new improved blowpipe. Hare divided a barrel approximately eighteen inches wide and thirty-two inches high into two compartments, the upper being fourteen inches and the lower sixteen inches. A sheet of copper containing a copper tube and had a set of water tight leather bellows comprised the bottom compartment. An iron rod was attached to the bellows via the copper pipe, which could be raised or lowered by a handle attached to the rod and thus act as a pump. The upper portions of the apparatus were separated into two chambers that could be filled with oxygen and hydrogen, which could be compressed by the built-in pump. Two pipes were used to carry the gases, and the streams met at a burning candle or lamp placed on a stand. Examples of the tips used by Hare are illustrated in Footnote 12 of Ref. 1. Hare had designed and constructed the prototype of what would become the oxygen-hydrogen blowtorch, still used today for welding and cutting metals (12). Miles writes of Hare's invention as follows (13):

> …New methods of attaining high temperatures had been interesting chemists for a third of a century; oxygen and hydrogen had been known for a quarter of a century; and Hare lived in an age of giants. Lavoisier, Priestley, Black, and others had the facts needed to construct an oxy-hydrogen blowtorch, but none of them experienced the flash of genius that came to Hare.

Hare estimated that his blowpipe could be made for about twenty dollars, and a simplified version that would be more efficient than the mouth blowpipe or the enameler's lamp for about four dollars. The significance of this invention and its usefulness prompted the reprinting *verbatim* of Hare's 1802 *Memoir of the Supply and Application of the Blowpipe* in Tilloch's *Philosophical Magazine* in London (14) and in the *Annales de Chemie* (15) in France. Thus, there can be little question that the claims made by Hare have a great deal of validity. It should be noted that Hare's description of the blowpipe was also printed in pamphlet form, and there is no way to judge how many copies were published and what the extent of the distribution was at the time. Just how many read the description of Hare's device in Tilloch's publication or in the *Annales de Chemie* is also impossible to gauge.

E. D. Clarke

Daniel Edward Clarke, the second son of a country vicar, entered Jesus College, Cambridge in 1786. He graduated in 1790 and was then employed as the tutor and companion to the sons of several wealthy families. As a student, Clarke developed an interest in mineralogy, which he fostered as the result of the travels in Europe in his role as companion and tutor. He collected many different types of specimens of minerals and plants and produced several volumes describing his travels. The mouth blowpipe would have been known to Clarke as it was a primary tool used in mineralogical analysis. Clarke's travels took him also to Greece, Egypt, Turkey, and Palestine; and he was abroad when Hare's paper describing his blowpipe was published. Clarke donated many of the artifacts he had collected, which included several marble statues, to Cambridge University. Cambridge University awarded Clarke the degree of LLD in 1803, and Jesus College appointed him as a senior tutor in 1805. In the same year Clarke became an ordained priest in the Anglican Church, which was a usual prerequisite for appointment to a professorship at Cambridge and Oxford Universities. Clarke was the vicar of two parishes until 1808, when a university professorship in mineralogy was created and he was appointed to the chair. It is most unlikely that Clarke may have come upon the Hare's original 1802 paper as well as subsequent papers of Hare and his collaborators. Abstracts as well as indexes were nonexistent in this era and it would have been only by chance that Clarke may have been aware of Hare's work.

It seems clear that the motivation for Clarke's interest in the blowpipe came as the result of his research in mineralogy rather than, in the case of Hare, as a result of his study of chemistry. In the preface to Clarke's *The Gas Blowpipe,* he writes the following (3):

> The public is already in possession of the principal facts, which have led to the history of the Gas Blowpipe. The different claims made on the part of the Chemists of this Country and of America, as to the originality of the invention, have rendered it desirable to remove a few existing doubts, and to show,

> by a summary memorial, the progressive steps by which the philosophical apparatus, here delineated and described, has reach its present state of utility.

Clarke stated that his particular blowpipe design was the result of a conversation he had with the instrument maker, Mr. Newman of Lisle Street, Leicester Square, London, in early 1816. Mr. Newman had constructed a blowpipe for a Mr. Brooke, who described the design in the May, 1816 *Annals of Philosophy* (16). Brooke stated that he had produced this new blowpipe because of the great inconvenience he had experienced with the common mouth blowpipe. Brooke's design consisted of using either a copper or iron vessel in which air was forced by a plunger and allowed to escape through a very narrow stopcock. This stream of air when ignited then produced an intense source of heat. Newman modified Brooke's original design so that gases like oxygen could be introduced. This, Brooke concluded would (16):

> render it more extensive in its application to chemical purposes, and probably so as to supersede the use of the common gasometer.

In his design Clarke used the principle "of an explosive mixture of gases propelled through a common aperture found from a common reservoir (3)." This principle, Clarke stated, was well-known and the result of an investigation made of gas illumination by Professor Tennant and Dr. William Wollaston and presented in a public lecture delivered in Spring, 1814. Thomas Thomson in a letter to Clarke dated April 9, 1817 wrote that he, Thomson, had done experiments in 1800 that formed the basis of Hare's blowpipe. Thomson had abandoned his work because of the problem of explosions, which wrecked his apparatus; and the work was never published. In addition, Clarke stated that the principle of the oxy-hydrogen blowpipe had been demonstrated in chemical lectures at Cambridge for at least a dozen years prior to the publication of his book. As to who was demonstrating the blowpipe is not clear from Clarke's book.

The danger of an explosion from a retrograde movement of the flame was well known, and Wollaston had warned Clarke that his experiments could put him in great danger. Clarke "persisted in making them, narrowly escaped being killed by frequent bursting of his apparatus (3)." Clarke also consulted Sir Humphrey Davy in May, 1816 with his idea of mixing oxygen and hydrogen and passing the mixture through a capillary tube prior to ignition. Davy, who had developed the miner's safety lamp using the narrow capillary principle, replied on July 8, 1816. Davy stated that he had tried the experiment and that "there would be no danger in burning the compressed gases by suffering them to pass through a fine thermometer tube, 1/80 of an inch diameter, and three inches in length (17)." The inherent explosive nature of the oxygen-hydrogen mixture required a container that could withstand an explosion. A colleague of Clarke at Cambridge, the Rev. J. Cumming, the Professor of Chemistry, developed a safety cylinder, which made the device much safer to use (3):

> It becomes therefore a duty of gratitude to lay greater stress upon that part of the invention to which, beyond all doubt, he is indebted for his present safety. Had it not been for the circumstance, it would have fallen to the lot of some other person to have written the history of the Gas Blow-pipe, and to have rendered it rather tragical than amusing.

Just because Hare had reported experiments he performed in 1802 with a device of his own design, which happened to use hydrogen and oxygen, was not sufficient in Clarke's opinion to negate his own claim of originality.

The significant difference in the Clarke apparatus is that the oxygen and hydrogen are premixed. In Hare's blowpipe they were in separate containers and flowed through two different apertures before combining. As Clarke stated (3):

> But the intensity of the heat is incomparably greater when the gases, after compression, are propelled and burned in a mixed state; because the due proportion necessary for forming water is then constantly and equally maintained: whereas an excess, whether on the side of the hydrogen or of the oxygen, not only tends to diminish the temperature, but, if it be much increased on the side of the oxygen, infallibly extinguishes the flame.

This greatly improved device with all the improvements that had been made by Clarke, he insisted, should have the name of "Gas Blowpipe." Robert Hare cried foul because in his 1802 paper he had not only described the design of the blowpipe but also reported the results of many of the experiments that had been performed with the blowpipe. Further modifications of the original design of the blowpipe as well as additional experiments were the subject of a paper read by Hare on June 17, 1803 at the Chemical Society of Philadelphia and published in 1804 (18). Hare pointed out in 1820 that he had reported experiments using his blowpipe in 1802 that Clarke claimed were new results (4):

> Hence, until plagiarism had given them a new shape, and perhaps false gilding, they were totally over-

> looked in his compilations. He neither treated of the pure earths as susceptible of fusion, nor of platinum as susceptible of volatilization, until many years after I had proved them to be so, and promulgated my observations.

One example from Hare's work that was also reported by Clarke as his own original work was the fusion of lime and magnesia (magnesium oxide) using anthracite coal as the reducing agent. By exposure to the gaseous flame of the coal, both magnesia and lime exhibited strong symptoms of fusion. The former assumed a glazed and somewhat globular appearance; the latter became converted into a brownish semi-vitreous mass.

Benjamin Silliman in 1812 (19) reported that with Hare's blowpipe he was also able to fuse lime and magnesia ignited in a covered platinum crucible (20). Clarke obtained similar results but failed to credit the work of Hare and Silliman. Hare noted (4):

> Notwithstanding the previous publicity of these results obtained by my friend and myself, Dr. Clarke in the following note endeavors to convey an impression of the incompetency of my apparatus to fuse lime and magnesia. Note 5, page 46. Professor Hare in America could not accomplish the fusion either of lime or magnesia by means of his hydrostatic blowpipe. See *Annales de Chimie*, tome 45 page 126. But why overlook Silliman's experiments? It is moreover strange that an English writer should refer his readers to the French *Annales* in preference to a London magazine, for a memoir which he knew to be published in both.

What is one to make of these conflicting counter-claims concerning the blowpipe? Benjamin Silliman, Jr., writing in 1874 (6), made the point that a distinction needs to be made between discovery of the principle and the actual invention. Certainly, Hare deserves credit for the development of a device based upon the use of sound chemical principles. The production of copious amounts of heat by the combination of oxygen and hydrogen also formed the basis of Clarke's invention. However, Clarke's rationalization based upon the chemical nature of volcanism was certainly wrong.

Chemical theories of volcanism were very much in vogue in the first half of the nineteenth century. Clarke, as well as many of his contemporaries, believed that the volcanic fire, as he referred to it, led to the decomposition of water. According to him, these gases were compressed and their subsequent combustion produced the energy associated with the violent events that occur in a volcanic eruption. Thus the volcano is really a giant blowpipe, according to Clarke. Humphrey Davy suggested that the origin of volcanic activity and subterranean heat was the action of water on sodium and potassium in the interior of the earth

Hare also realized that Lavoisier had overlooked an important point in his investigations, in that he considered the greatest amount of caloric would be released if the substance were placed upon charcoal and only a jet of oxygen gas introduced. Hare had reasoned that an even greater amount of heat would be produced if the substance were burned on a solid support in a stream of hydrogen and oxygen gas. As Hare wrote in 1802 (5):

> It soon occurred that these desiderata might be attained by means of a flame, supported by the hydrogen and oxygen gasses; for it was conceived that, according to the admirable theory of the French chemists, more caloric ought to be extricated by this than any other condition.

In hindsight we can see an error in Hare's work concerning the concept of heat. It must be remembered that Rumford's paper on the origin of heat had not been published until 1800 in the *Transactions of the Royal Society* and was only slowly being accepted. Hare can be faulted on this point but not his basic chemical insight, which Clarke lacked.

Clarke deserves credit for the design of his blowpipe. The relative ease of the use of the Clarke blowpipe and the contributions stemming from its use in chemistry and mineralogy redeem somewhat his scandalous disregard and diminution of the work of Hare.

ACKNOWLEDGMENT

I am most grateful to Dr. W. A. Smeaton, Emeritus Reader in the History of Science, University of London, for all of his help in preparing this paper. Bill Smeaton passed away on January 22, 2001. He will be missed by all his friends in the chemical history community.

REFERENCES AND NOTES

1. E. L. Gonzalez, "Bochard de Saron and the Oxy-Hydrogen Blowpipe," *Bull. Hist. Chem.*, **1989**, *4*, 11-15.
2. For a biography of Clarke see: W. Wroth, "Edward Daniel Clarke," *The Dictionary of National Biography,* Oxford University Press, Oxford, 1917, Vol. 4, 421-24. A recent paper dealing with Clarke and Davy may be of interest: B. P. Dolan, Blowpipes and Batteries:

Humphrey Davy, Edward Daniel Clarke, and Experimental Chemistry in Early Nineteenth-Century Britain," *Ambix*, **1998**, *45*, 137-162.

3. E. D. Clarke, *The Gas Blowpipe or the Art of Fusion by Burning the Constituents of Water,* Cadell and Davies, London, 1819.
4. R. Hare, *Strictures on a Publication entitled, Clarke's Gas Blowpipe*, R. DeSilver, Philadelphia, PA, 1820, 15; simultaneously also published in *Am. J. Sci*., **1820**, *2*, 281-302.
5. R. Hare, *Memoir on the Supply and Application of the Blowpipe*, Chemical Society of Philadelphia, Philadelphia, PA, 1802; reprinted in E. F. Smith, *Chemistry in America,* D. Appleton & Co., New York, 1914, 152-178.
6. B. Silliman, Jr., "American Contributions to Chemistry," *American Chemist*, **1874**, *5*, 70-114,195-209.
7. R. Partington, *A History of Chemistry*, Macmillan, London, 1962, Vol. 2, 535.
8. A. L. Lavoisier, "Sur un moyen d'augmenter considerablement l'action du feu et de la chaleur, dans les operations chimiques," *Mem. Acad. Roy. Sci. Paris*, **1782**, 457-476.
9. A. L. Lavoisier, *Traite elementaire de chimie presente dans un ordre noveau d 'apres les couvertes modernes*, English translation of 1790 by R. Kerr, reprinted by Dover Publications, New York, 1965, 474-479.
10. For a biography of Woodhouse, see: E. F. Smith, *Chemistry in America,* D Appleton & Co., New York, 1914, 76-108. For Maclean see: M. D. Saltzman, "John Maclean," *American National Biography,* Oxford University Press, New York and Oxford, 1999, Vol. 14, 267-268.
11. J. Maclean, *Two Lectures on Combustion*..., Dobson, Philadelphia, PA, 1797.
12. For a diagram of Hare's blowpipe see Ref. 1.
13. W. D. Miles in E. Farber, Ed, *Great Chemists*, Interscience, New York and London, 1961, 419-434.
14. R. Hare, "Memoir on the Supply and Application of the Blowpipe," *Tilloch's Philos. Mag.*, **1802**, *14*, 238-245,298-308.
15. R. Hare, "Memoire sur l'usage du chalumeau, et les moyens de l'alimenter d'air ....,Extrait par P. A. Adet," *Ann. Chim.*, **1802**, *65*, 113-138.
16. H. I. Brooke, "Description of a New Blowpipe," *Annals of Philosophy*, **1816**, *7*, 367.
17. E. D. Clarke, "Account of Some Experiments made with Newman's Blowpipe...,"*J. Sci. Arts*, **1817**, *2*, 104-123.
18. R. Hare, "Account of the Fusion of Strontites and Volatilization of Platinum...," *Trans. Am. Philos. Soc.*, **1804**, *6*, 99-105.
19. B. Silliman, "Experiments on the Fusion of Various Refractory Bodies by the Compound Blowpipe of Dr. Hare," *Trans. Am. Philos. Soc*., **1812**, *3*, 328-399.
20. The melting points of lime and magnesia are 2614 and 2852^{o}C, respectively. W. A. Smeaton has pointed out to me that such temperatures were not obtainable in an anthracite furnace. Even platinum with a melting point of 1772^{o} C was very difficult to melt when these experiments were performed. The results of Hare, Silliman, and Clarke may have been affected by impurities in their samples.

ABOUT THE AUTHOR

Dr. Martin D. Saltzman is Professor of Natural Science, Providence College, Providence, RI 02918.