15.

SMITHSON'S LAMP AND THE "SAPPARE"

In 1822 Smithson began to write about the scientific tools he designed and used. Most of his remarks were asides in articles about other topics, but two of his articles were more focused. One, titled "Some Improvements of Lamps," consisted mostly of observations about oil lamps, and as he began Smithson clearly felt the need to explain why he was writing on such a commonplace topic.

"It is, I think, to be regretted," he wrote, "that those who cultivate science frequently withhold improvements in their apparatus and processes, from which they themselves derive advantage, not deeming them of sufficient magnitude for publication." But, he argued, all useful information should be imparted, "however small may appear the merit which attaches to it." He then made some observations about the wicks used in oil lamps. A wick is a length of braided cotton, much like a string or a rope, that works by capillary action to draw fuel up from a lamp's reservoir to feed its flame. He gave two reasons why the common practice of putting long wicks in lamps was "extremely inconvenient." First, the long wick took up space in the lamp, thereby reducing the amount of fuel it could hold, and second, it tended to collect dirt and other impurities found in the lamp's oil, which could make the flame burn erratically.

Under ideal conditions the fuel in a lamp burns, not the wick, and the oils used today are so highly refined that wicks rarely need attention. In Smithson's time the best available fuels were whale oil, colza (rapeseed) oil, or olive oil, none of which were particularly refined. By modern standards they did not burn cleanly, and this made the flame sputter, which in turn burned the wick, causing the lamp to smoke. When this happened the lamp needed to be extinguished, the wick pulled out a bit, and the burnt parts on the end of the wick cut off. In Smithson's time this kind of maintenance was an almost daily occurrence, and the constant trimming they required was the reason that lamps were furnished with such long wicks.

But Smithson had an idea. He recommended replacing the long wicks with a short metal tube, filled with either a tightly fitting cotton wick or wadded up cotton wool. As long as it could reach the bottom of the reservoir, this cotton-filled tube would draw fuel to the flame just like the wick it replaced. But what happened if the cotton in the tube got burned? Smithson solved this by leaving a space at the top of the tube, which he filled with a loose piece of wick, explaining that "this loose end receives [a] supply of oil from the cotton under it with which it is put into contact, and when it becomes burned, it is easily removed [and replaced]." It was a clever—if somewhat fussy—solution, and although never widely adopted, it appears to have worked.

Now Smithson turned to the problem of fuel. "Oil," he wrote, "is a disagreeable combustible for small experimental purposes, and more especially when lamps are to be carried in travelling." At a time when all land travel of any distance was either on horseback or in horse-drawn carriages, oil was almost certain to spill and leave a greasy film on everything it encountered. For a man like Smithson, who spent large parts of his life on the road, this must have been a constant problem. One possible solution would have been to forego lamps entirely and use candles. Candles provide a workable flame, but that flame constantly lowers as the candle burns down, which is extremely inconvenient for blowpipe work. The blowpipe needs a flame that stays in a fixed position. It was a problem that Smithson solved by designing a lamp that burned wax.

Smithson described two kinds of wax lamps, the first being basically what we now call a container candle. These do not seem to have been common in the early nineteenth century, so Smithson described how to make one. The first step was to prepare the wick, which he did by drawing it slowly through melted wax. After it dried, he placed one end "in a burner made of a bit of tinned iron sheet." This "burner" was then placed in the bottom of a small china cup, and the wick was held vertical while the cup was packed with "fragments of wax" pressed down to hold everything in place.

Fig. 1.

Fig. 2.

Smithson's drawings of the parts of the metal tube assembly he designed to replace the long wick. On the left is the metal tube, shown partially filled with cotton wick, and with a space at the end. (Note that in this drawing the tube is shown upside down, just as it was in Smithson's article.) The image on the right is identified as the loose piece of wick placed in the end of the tube, which, when necessary, could easily be replaced. Courtesy of the Smithsonian Libraries.

This lamp was surprisingly small. The wick was simply a cotton thread, and the whole assembly, including the wax, fit in a china cup "about 1.65 inches in diameter and 0.6 in. deep." Given the tiny size of the samples Smithson worked with, this small flame was all he needed, and a lamp like this offered advantages for a traveler. The lamp's construction meant it could be reused almost indefinitely. As it burned down, new pieces of wax could be added to keep it going, and Smithson tells us that if the wick got burned it could simply be dug out "with a large pin down to the burner, and a fresh bit of waxed cotton introduced."

Smithson informs us that he used a second kind of wax lamp with the blowpipe. While he provided an uncharacteristic amount of detail about the other topics in this article, he chose to reveal almost nothing about his blowpipe lamp. All he wrote was that it "has, of course, a much larger wick, and this wick has a detached end to it."

Despite his failure to describe it, Smithson was careful to provide instructions on his special method of lighting the blowpipe lamp. He wrote that "great care must be taken that each time the lamp is lighted, bits of wax are heaped up in contact with the wick, so that the flame shall immediately obtain a supply of melted wax." What Smithson did not make clear was that once his blowpipe lamp was warmed up, it worked by using some of the flame's heat to melt additional wax to keep it going, and it could keep going until all the wax was consumed. The problem was to get it going in the first place without burning the wick. Packing wax around the wick before lighting it was Smithson's way of preventing this, and he wrote that this was "the great secret on which the burning of wax lamps depends."

Smithson's final remarks addressed the best way of extinguishing a wax lamp, and for this he recommended placing a solid piece of wax in contact with the wick and then quickly blowing it out. "This preserves the wick entire for future lighting again." He also recommended this method for extinguishing ordinary candles, arguing that it was "much preferable to the use of an extinguisher."

Fig. 3.

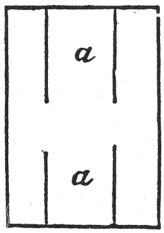
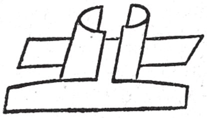


Fig. 4.



Smithson's drawings of how to make a "burner" for his wax lamps. The image on the left shows the four cuts made on a piece of "tinned iron sheet," and on the right is the "burner" produced when the middle sections were bent up and inward. The wick was held between the bent pieces. Smithson's larger lamp also used this type of burner with a tube assembly. The size of the burner was not specified. Courtesy of the Smithsonian Libraries.

Smithson had clearly devoted considerable thought to the subject of lamps, but the changes he proposed seemed to offer few practical advantages. As a result, reaction to the article was tepid at best. It was briefly noted in a few European scientific journals, and one writer recommended it to travelers—to heat water for coffee and shaving—but there is no evidence that it was actually used.

Smithson failed to describe the wax lamp that may have been of greatest scientific interest—his blowpipe lamp. Other than instructions about how to light it, the only details he gave were that it had "a much larger wick" than his small lamp, and that it had "a detached end to it." Fortunately, this is enough to make some educated guesses about how the lamp could have worked. If the lamp's wick had a detached end, the only way this makes sense is if he was also using a cotton-filled metal tube, similar to what he recommended for oil lamps. And this, in turn, would have needed to be held in place by a metal "burner," similar to the one he used in his small lamp. Studying Smithson's illustrations allows us to visualize how this could have worked.

The flame needs to be elevated in any lamp used with a blowpipe. There has to be enough room for the blowpipe to be positioned on one side, toward the bottom of the flame, and for the sample (along with whatever is being used to hold it) to be on the other side, a bit lower. In Smithson's lamp this requirement was easy to meet: the metal tube holding the wick simply needed to stand above the lamp's container.

As to the container itself Smithson gives no clues, but he mentions that he assembled his other wax lamp in a tiny china cup. Assuming he also used tableware for the blowpipe lamp, one possible container would have been an egg cup.

The author's re-creation of the wax lamp Smithson used with the blowpipe. The wick, brass tube, and metal burner are all embedded in wax in the cup. Once lit and warmed up, part of the flame's heat is conducted down to the burner, where it melts enough wax to keep the lamp going. This lamp has a quarter-inch wick, and, using beeswax as a fuel, it can burn for several hours. The heat it produces and the size of the flame both compare favorably with an oil lamp of similar size. When the flame is extinguished, the wax immediately begins to harden. In a short time, the lamp can be transported with no possibility of a spill. Photograph by James Gleason.

Tests showed that a quarter-inch diameter wick is about as large as is practical with a wax lamp, and that size fits comfortably in an egg cup. Tests also showed that beeswax works the best with Smithson's design. Paraffin, the ubiquitous modern wax, was unknown in Smithson's time, but several plant-based waxes would have been available, notably rapeseed wax. Rapeseed oil was known to burn with a particularly bright (and presumably hot) flame, which made it a likely candidate. In actual use beeswax melts more readily (which makes lighting the lamp easier) and is significantly softer, which makes it easier to work with.

Ultimately, the importance of Smithson's article on lamps seems to lie mostly in what it reveals about him. Instruments were critical to the practice of chemistry, and chemists in Smithson's time were often highly individualistic in their instruments and in the ways they used them. They were reflections of lifestyle and temperament as much as science. Smithson's lamps were optimized for both travel and microchemistry, a form of chemical analysis that he helped establish.

Smithson described another tool he had developed in his article "A Method of Fixing Particles on the Sappare" (1823). This was about ways he had developed to hold mineral samples in the flame of the blowpipe, but there was more to the article than just practical tips. The new methods Smithson described extended the range of what the blowpipe could do and provided a number of new tests that could be used to identify and analyze minerals.

One of the problems that mineralogists faced during Smithson's time was the destructive nature of their tests. Analyzing a mineral could easily use up the entire stock of it, and this was particularly true with chemical tests, which subjected the sample to liquid acids and alkalis. As Smithson wrote, "The chemical method justly boasts its certainty; but it carries destruction with it, and often bestows the knowledge of an object only at the expense of its existence."

In the late eighteenth century, the geologist and sometime mineralogist Horace de Saussure had addressed this problem, proposing a system of identifying minerals by the way they melted. Saussure had developed a system for categorizing minerals by the appearances they presented in the blowpipe flame, and the beauty of his method was that it used very small samples. The problem, however, was finding a way to hold the little bits of mineral in the flame without it simply blowing them away—as it did when the sample was placed on a piece of charcoal. Saussure's initial solution was to embed the sample on the end of a small glass rod, heating the end just enough to soften it, and then gently placing the sample on top. Once the glass cooled, the sample would effectively be glued in place and the rod would serve as a holder, allowing the sample to be securely held in the intense heat of the flame. It was an effective technique, and Smithson reported using it for some of the tests in his analysis of tabasheer. To make the delicate task of mounting the sample easier, Saussure designed a special blowpipe holder that Smithson may also have used.

Saussure would go on to develop other blowpipe improvements, but the most promising was a method he developed for holding samples in the fire. The glass rod worked fairly well, but Saussure found that for minerals with a high melting point, or for minerals that simply needed to be held in the heat for a long time, the glass would soften and the sample sink down into it, making it impossible to continue the test. For these minerals he developed another holding method, one that used a bluish, highly heat-resistant mineral that he called "sappare," now known as kyanite. In addition to being very difficult to melt, sappare could be split into long, thin fragments with pointed ends. Saussure mounted his samples on those ends, often embedding the other end of the fragment into a glass tube used as a holder. To attach the sample to the sappare, he recommended either "saliva or slightly gummy water" or just plain water, but Smithson reported having great difficulty in making any of these adhesives work. "A splinter of sappare," he wrote, "appeared to fulfill the conditions of this problem, and to have accomplished all that could be desired. It has, however, been scarcely at all employed, owing to the excessive difficulty in general of making the particles adhere; and in consequence the almost unpossessed degree of patience required for, and the time consumed by, nearly interminable failures." Smithson's solution to this difficulty furnished the title of this paper.

Smithson had been working on this problem for a long time. As early as 1804, in a letter to the editor of the *Journal de Physique*, he mentioned having substituted a form of flint, "la pierre à fusil," for the troublesome sappare. He may have been referring to the flint used in flintlock rifles, because he noted that it was also called "rifle stone" and was readily available. He made no mention of this mineral in his 1823 article because he had found even better materials and methods. He described replacing the sappare with "small triangles, or slender strips of baked clay," and using "a mixture of water and refractory clay" to attach the tiny sample to them. In a further refinement, he described using the end of a platinum wire as a holder: "almost the least quantity of clay and water is put on the *very end* of a platina wire, filed flat there. With this, the particle of mineral lying on the table can be touched in any part chosen; for a moment or two it is dry, and may be taken up, and put in the flame." Barely visible particles could be tested in this manner, and if there was a concern that using clay might interfere with the test, he described making a paste from the sample's powder and water and using this as the adhesive.

This was what Smithson wanted to convey, and he ended the article with just a few observations about what he had learned with this method. Flint, he reported, melts easily this way while also frothing and giving off a distinctive smell. "Does flint, like pitchstone, contain bitumen," he asked. (It is now known that it often does.) Smithson also described a simple test for distinguishing between a fragment of diamond and one of quartz, which can look almost identical. The solution was to attach a piece of each to one of his small clay strips and test them simultaneously in the flame. He reported that "the diamond was most luminous while under the action of the flame, and longer so after removal from it." A method of comparing two different substances in the same blowpipe flame had not been previously described.

Not surprisingly, the reaction to this article was confined mostly to technical publications, but for the many users of the blowpipe, Smithson's new methods were of considerable interest. His entire article was reprinted in the *Technical Repository* (1824), and summaries of it appeared in journals such as the *Quarterly Journal of Science* (1823), the *Bulletin des Sciences* (1824), and the *Annales des Mines* (1826). An article praising Smithson and expanding on his techniques was read to the newly founded Lyceum in New York and quickly published in its journal.

The greatest impact probably came from the inclusion of Smithson's methods in nineteenth-century blowpipe manuals. Berzelius, for example, in his *Use of the Blowpipe in Chemistry and Mineralogy* (1845), characterized Smithson's use of clay strips and platinum wires as common methods of support, and he credited Smithson for having made "important additions" to the use of the blowpipe. Michael Faraday described how to use Smithson's clay strips in his textbook *Chemical Manipulation* (1842).

One of the characteristics of Smithson's science was his almost relentless effort to improve the tools and methodology of his work. In this case, his efforts to improve on the sappare spanned nearly two decades, and even after that, he continued to look for new methods. He mentioned in his article that he had "only recently" begun to use the end of the platinum wire as a method of support. These developments consistently allowed him to work with smaller and smaller samples, which was in keeping with his role as one of the pioneers of what would come to be known as microchemistry.