The Fire Piston and Its Origins in Europe

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I. *Introduction*

In previous accounts of the ingenious fire-making device usually known as the fire piston,[1] anthropologists and historians of technology alike have paid special attention to those specimens of the instrument which have been found in use in southeast Asia over the last hundred years. Understandably enough, they have been attracted above all by the intriguing possibility that the device was invented in that region quite independently of European influences and possibly long before the 1860's, when it appears to have been first observed there by European travelers. Consequently they have tended to regard the fire piston's appearance in Europe in the early years of the nineteenth century as the result either of a separate, though rather less interesting, process of invention in the West[2] or, alternatively, of direct importation from those parts of Asia where the device was already commonly used.[3] Although such accounts have been valuable, if only in preserving the fire piston from neglect, they have conveyed a view of the instrument's history which is not only incomplete (by virtue of their scant treatment of the European version of the instrument) but which is also supported by inadequate evidence on certain important points.

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[1] Other names which have been applied to the fire piston include the tachypyrion, the aerophore, the pyrophorus, and the fire syringe.

[2] This is the view to which Henry Balfour inclines in his classic paper "The fire-piston," in *Anthropological Essays Presented to Edward Burnett Tylor in Honour of his 75th Birthday, Oct. 2, 1907*, hereafter cited as *Anthropological Essays* (Oxford, 1907), pp. 17–49, of which see especially pp. 39–46. Balfour's conclusion is tentatively adopted also in C. Singer *et al., A History of Technology* (Oxford, 1954), I, p. 228, and in A. Leroi-Gourhan, *Évolution et techniques. L'homme et la matière* (Paris, 1943), pp. 68–69.

[3] The view adopted in J. Needham, *Science and Civilisation in China* (Cambridge, 1965), IV, Part 2, p. 140 n., and with rather less conviction in W. Hough, *Fire as an Agent in Human Culture*, United States National Museum Bulletin 139 (Washington, 1926), p. 110.

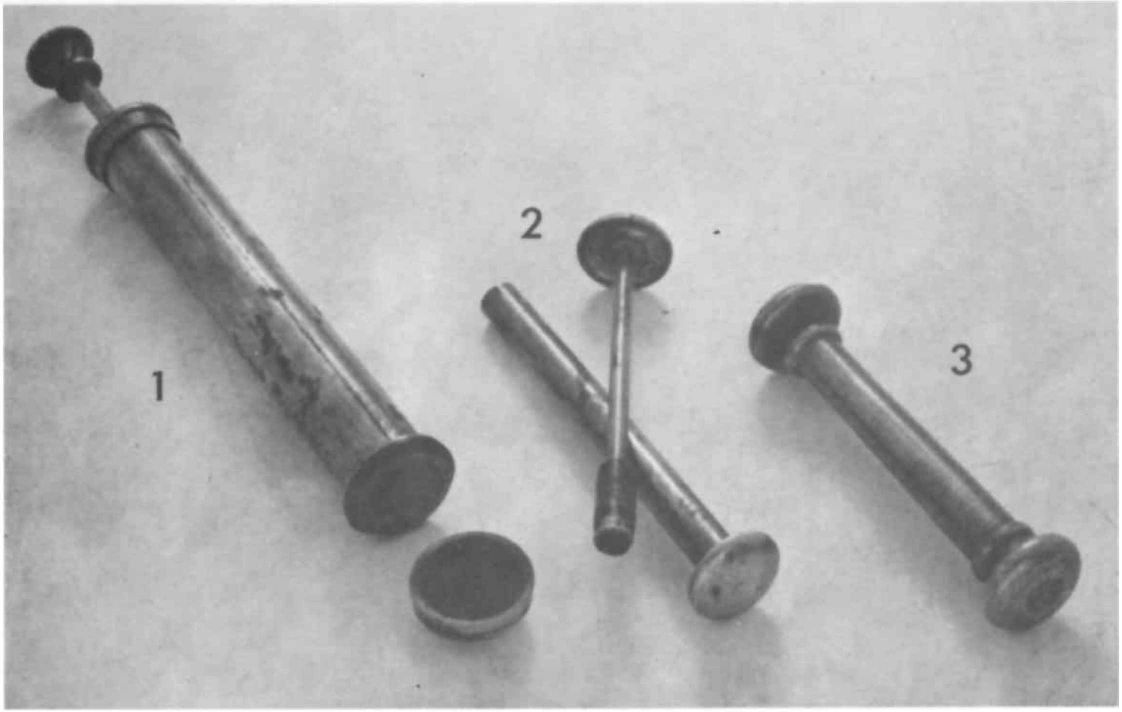
Of course, the almost complete absence of documentation concerning even nineteenth-century technology in southeast Asia makes it virtually impossible to dismiss the traditional accounts entirely, and this I shall not attempt to do. But although my conclusions concerning the origins of the fire piston in Asia are somewhat conjectural for this reason, I shall discuss, rather more sympathetically than most earlier writers on the subject, the case for believing that the instrument's appearance in Asia was the result of European influences. My chief concern in this paper, however, is with the early history of the fire piston in Europe and, more specifically, with the task of establishing beyond doubt that the device was not imported but invented there independently.

II. *The Scientific Background*

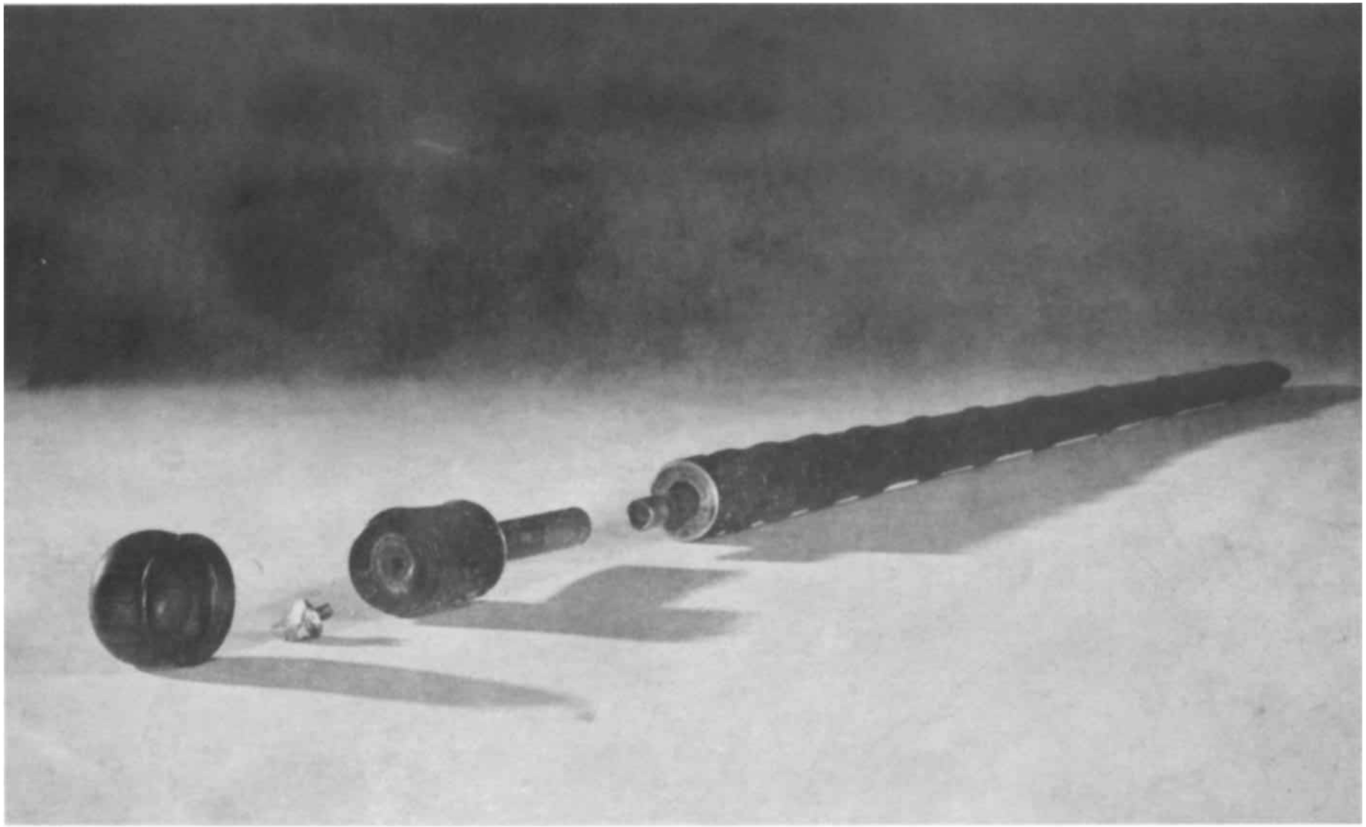
In its commonest form (see Plate I, items 2 and 3) the European fire piston consists of a metal cylinder, closed at one end and usually no more than 6 inches in length and ½ inch in diameter, in which air can be compressed by means of a closely fitting piston. In an efficient instrument a single rapid stroke of the piston compresses and hence also heats the air sufficiently for a piece of dry tinder placed in a cavity in the end of the piston to be ignited, whereupon the piston is quickly withdrawn and the glowing tinder is applied as required. To modern eyes the process provides a striking demonstration of the conversion of mechanical work into heat, the work in this case being performed in the compression of the air. And in fact it was as a demonstration experiment in physics that the fire piston survived long after it had fallen out of common use as a fire-making device.[4]

Yet the invention of the fire piston in Europe took place some fifty years before the establishment of the principle of the conservation of energy, at a time when the possibility that work might be converted into heat was perceived only dimly and incoherently, if at all, by a few men such as Count Rumford and Humphry Davy. Indeed, it came at a time when the view that heat was a weightless, highly elastic fluid known as caloric had won an almost total victory over its main rival, according to which the phenomena of heat were explained in terms of the vibrations or, as in the case of gases, the rectilinear motion of the particles of ordinary ponderable matter. It might be expected that this situation

[4] See, for example, A. Ganot, *Traité élémentaire de physique expérimentale et appliquée* (Paris, 1851), pp. 321–22; and J. Tyndall, *Heat Considered as a Mode of Motion* (London, 1863), p. 29. Large glass fire pistons made specifically for demonstration purposes exist in the Science Museum, London (which has two examples), and in the museum of the Conservatoire National des Arts et Métiers, Paris (which has one).



PL. I.—Fire pistons of the early nineteenth century. Instruments 2 and 3 are of conventional design, with the tinder held in the end of the piston. In number 1 the air passes through a number of small holes in the end of the cylinder before encountering the tinder, which is placed in the removable cap. (Crown Copyright. Science Museum, London. By courtesy of Bryant & May Ltd.)



Pl. II.—Fire piston contained in a walking stick. For a full description see Appendix, item 5. (Crown Copyright. Science Museum, London. By courtesy of Bryant & May Ltd.)

would have inhibited the study of the heating and cooling effects of which a knowledge was fundamental to the understanding, if not to the discovery, of the fire-piston principle, but, as Thomas S. Kuhn has shown,[5] this was by no means the case. The effects had been known and studied, though they had often been misinterpreted, since the middle of the eighteenth century, and in the early years of the nineteenth century they were attracting an intense and unprecedented interest. As I shall argue, this interest seems to form an important part of the general intellectual background against which the fire piston was invented in Europe, so that the fact that it was most evident in France and the fact that the fire piston first appeared there and not elsewhere in Europe are almost certainly related.

It was in 1802 that the thermal effects to which I have referred began to attract serious attention in France. In April of that year Jean-Baptiste Biot, then a young protégé of the great French mathematician Pierre Simon Laplace, read before the First Class of the Institute in Paris a paper[6] in which he put forward a highly plausible (and essentially correct) explanation of the notorious discrepancy between the experimental value for the velocity of sound in air and the figure obtained by applying Newton's theoretical expression.[7] Laplace, it seems, had asked Biot to investigate how the theoretical figure would be affected by the heat and cold which he suggested might be produced in the successive regions of compression and rarefaction constituting the sound wave. Hence it is Laplace and not Biot who must take the greater credit for the resulting demonstration that theory and experiment could be brought into agreement by the assumption that slight temperature changes did in fact occur or, in other words, that Boyle's law, the truth of which had been axiomatic in nearly all earlier work on the subject, could not be applied to a gas through which a sound wave was passing. Laplace's masterly insight was very properly acclaimed, above all, for its bearing on the velocity of sound problem; yet his work exerted a great influence in other respects also, and it

[5] T. S. Kuhn, "The caloric theory of adiabatic compression," *Isis,* XLIX (1958), 132–40.

[6] J. B. Biot, "Sur la théorie du son," *Journal de Physique,* LV (1802), 173–82. Thus the paper was not published until the month of Fructidor of the republican year X (August-September 1802). On the date of the reading of the paper see *Académie des Sciences. Procès-verbaux des séances de l'Académie tenues depuis la fondation de l'Institut jusqu'au mois d'aôut 1835,* II, 487 (11 Germinal, an XI). The latter work, published in ten volumes at Hendaye between 1910 and 1922, is cited hereafter as *Procès-verbaux.*

[7] As given in the *Philosophiae naturalis principia mathematica* (London, 1687), pp. 369–72. In subsequent editions the proof remained unchanged.

is this latter, rather less obvious influence which seems especially relevant to the events described in this paper.

In the first place, Laplace's discovery provided striking confirmation of the fact that changes in temperature did occur when gases underwent rapid expansion or compression. In view of the numerous investigations which had been undertaken by the British, Swiss, and Germans since the temperature changes had first been observed by the Scottish chemist William Cullen in 1755,[8] it may be thought that such evidence would have been unnecessary. But there were still those who doubted whether the fluctuations in the thermometer reading really were the result of a rise or fall in temperature, as opposed, for example, to some mechanical effect due to variations in gas pressure.[9] Moreover, it is a curious fact that the effect, whether interpreted correctly or not, appears to have been almost completely unknown in French scientific circles until the very end of the eighteenth century, in fact until 1798, when Marc Auguste Pictet, professor of natural philosophy at the University of Geneva but a regular visitor to Paris, communicated to the French *Journal de Physique* an account of the cold observed on suddenly releasing air from a compression pump. It is a measure of the ignorance on the matter which prevailed in France that the editor of the journal, J. C. Delamétherie, who was presumably the author of the unsigned note describing Pictet's communication,[10] treated the observation as a case of cooling by evaporation, having apparently missed the point entirely. The correct interpretations of this and other similar observations which did appear, very occasionally, in the French scientific literature during the three years preceding Laplace's great discovery[11] probably did little to remedy this situation. It can hardly be doubted, therefore, that the paper of 1802, apart from solving a notorious problem, was also drawing attention to an effect of which the great majority of readers were ignorant.

There is one other respect in which Biot's paper seems to have been

[8] On which see Kuhn, *Isis*, XLIX (1958), 133–35.

[9] Thus John Dalton, speaking in June 1800, felt it necessary to refute this suggestion explicitly by reference to experiments which he had conducted for the purpose. See *Memoirs of the Literary and Philosophical Society of Manchester*, V, Part 2 (1802), 523–24. *Cf.* also the objections which were raised against Joseph Mollet's interpretation of his early experiments (see below, Section III).

[10] [J. C. Delamétherie], "Note sur un froid considérable produit par la sortie prompte de l'air atmosphérique fortement comprimé," *Journal de Physique*, XLVII (1798), 186. The note was in the issue for Fructidor, an VI (August–September 1798).

[11] See, for example, A. N. Baillet, "Lettre . . . sur la glace produite par l'expansion de l'air comprimé," *Journal de Physique*, XLVIII (1799), 166–67.

relevant to the emergence of the fire piston. This is that it gave the first intimation of the true magnitude of the temperature changes taking place in expansion and compression, a magnitude which had previously been masked by heat exchange between the gas and its surroundings. According to Biot's calculation,[12] if the experimental and theoretical figures for the velocity of sound were to agree, it followed that the compression of a mass of air to, say, one-half of its initial volume, under conditions such that no heat exchange occurred, would produce a rise in temperature of the order of 100° C. Since most experiments performed before this date had suggested that the temperature change in such a case would not exceed a few degrees at the most,[13] Biot's conclusion was a startling one and it was not likely to be overlooked. As it happened, any slight possibility that it might be ignored soon disappeared completely when, toward the end of 1802, experimental confirmation that the temperature changes had indeed been grossly underestimated by eighteenth-century writers became available in an important and widely read paper by John Dalton of Manchester.[14]

III. *The Discovery of the Principle*

It was just at the time when the temperature changes accompanying the expansion and compression of gases were attracting a great deal of attention in France and when the true magnitude of the changes was beginning to be recognized that the fire piston emerged. Clearly the fact that its invention was, as we shall see, the direct consequence of a chance observation rather than a deliberate attempt to apply newly acquired scientific knowledge to the long-established problem of fire making, must diminish to a certain extent the importance of this scientific background. But the background cannot be ignored completely. Without it the ignition (by the rapid compression of air) of a small piece of linen lodged in the exit tube of the condensing pump of

[12] Biot, *Journal de Physique*, LV (1802), 182.

[13] See, for example, M. A. Pictet, *Essais de physique* (Geneva, 1790), p. 20.

[14] J. Dalton, "Experiments and observations on the heat and cold produced by the mechanical condensation and rarefaction of air," *Memoirs of the Literary and Philosophical Society of Manchester*, V, Part 2 (1802), 515–26 (read June 27, 1800). The first extracts to appear in French journals were those in *Journal des Mines*, XIII, 257–60, and in *Annales de Chimie*, XLV, 103–7, both published in the issues for Nivôse, an XI (December 1802–January 1803). On the date of publication in England see T. Thomson, *A System of Chemistry* (4th ed.; Edinburgh, 1810), I, 488. In his paper Dalton described experiments by which he claimed to have shown that a rise in temperature of 50° F resulted when air was allowed to rush into a space evacuated to one quarter of atmospheric pressure and that a fall in temperature of a similar magnitude occurred when air at a pressure twice that of the atmosphere was allowed to escape rapidly from a closed vessel.

an air gun, which was noticed by a workman at the armory in Saint-Étienne (Loire) in 1802, might well have been overlooked or at least misinterpreted. Moreover, it was almost certainly the background of growing interest and understanding that encouraged the subsequent development of the fire piston after this initial chance observation had been made.

It was Joseph Mollet, at this time professor of physics at the École Centrale in Lyons,[15] who brought the workman's observation to the attention of the scientific world by a letter which he sent to the Institute in Paris and which was read before the First Class on December 29, 1802.[16] In the letter Mollet described not only the ignition of the piece of linen in the compression pump but also another observation made by the same workman at Saint-Étienne, namely, the appearance of a flash of light whenever an air gun was discharged in the dark. Mollet's communication was probably received with some skepticism, and his case was certainly not helped by the fact that the two referees appointed by the Institute, J. A. C. Charles and L. Lefèvre-Gineau, were unable to reproduce either of the observations.[17] Only Pictet, who submitted a brief report on Mollet's letter to Alexander Tilloch's *Philosophical Magazine* in London,[18] appears to have thought the matter

[15] For brief biographical sketches of Mollet (1758–1829) see J. B. Dumas, *Histoire de l'Académie Royale des Sciences, Belles-Lettres et Arts de Lyon,* hereafter cited as *Histoire de l'Académie* (Lyons, 1839), II, 149–50, and *Biographie universelle, ancienne et moderne* (Michaud), (85 vols., Paris, 1811–1862), LXIV, 173. Dumas's *Histoire* also contains lists of Mollet's writings, both published and unpublished, in Vol. II, pp. 23–24 and 605.

[16] *Procès-verbaux,* II, 606 (8 Nivôse, an XI). On the contents of the letter see J. Mollet, *Mémoire sur deux faits nouveaux, l'inflammation des matières combustibles, et l'apparition d'une vive lumière, obtenues par la seule compression de l'air,* hereafter cited as *Mémoire sur deux faits* (Lyons, 1811), especially pp. 3 and 6. The workman is identified as Citizen Chauvain in *Procès-verbaux,* III, 96 (17 Floréal, an XII).

[17] Mollet, *Mémoire sur deux faits,* p. 3. That the mere discharge of compressed air from an air gun did not in fact cause the appearance of light was demonstrated by Thenard in 1823 (see L. J. Thenard, "Sur la lumière produite par la décharge du fusil à vent," *Annales de Chimie et de Physique,* XXII [1823], 436–39).

[18] M. A. Pictet, *Philosophical Magazine,* XIV (1803), 363–64. Pictet was in Paris at the time and, as an associate member of the First Class, he may well have heard Mollet's letter read (see "Journal d'un Genevois à Paris," *Mémoires et documents publiés par la Société d'Histoire et d'Archéologie de Genève,* 2d series, V [1893–1901], 109). Unfortunately Pictet's diary covering this period contains no entry for December 29, 1802. A copy of the diary made by Edmond Pictet, which is in the possession of the *Société d'Histoire et d'Archéologie de Genève,* was consulted on my behalf by Monsieur Ph. Monnier, keeper of manuscripts at the *Bibliothèque publique et universitaire,* Geneva.

worthy of public comment, but even this summary provoked nothing more than a statement from William Nicholson to the effect that the flash produced on discharging the air gun had been observed about eighteen months previously by a Mr. Fletcher at a weekly meeting "for philosophical experiments and conversations" held at Nicholson's house.[19]

Apparently undeterred by the general neglect of his communication, Mollet continued his experiments in collaboration with Ennemond Eynard, a doctor and member of the science section of the *Académie des Sciences, Belles-Lettres et Arts* in Lyons,[20] and with two other residents of Lyons–Haex[21] and Gensoul.[22] Although he never managed to reproduce the flash associated with the discharge of the air gun to his complete satisfaction. Mollet now discovered that a similar flash occurred when air was compressed in a cylinder by means of a closely fitting piston.[23] He described the new observation and the already well-established ignition of an inflammable material, such as tinder, by the same method, first in a communication to the Institute in Paris in November 1803, then to the Lyons Academy in January 1804, and finally

[19] W. Nicholson, "Flash from an air-gun," in Nicholson's *Journal of Natural Philosophy, Chemistry, and the Arts*, 2d series, IV (1803), 280.

[20] For a brief biographical sketch of Eynard (1749–1837) see *Le deuxième centenaire de l'Académie Nationale des Sciences, Belles-Lettres et Arts de Lyon, 1700–1900* (Lyons, 1900), p. 113. Lists of Eynard's published and unpublished writings appear in Dumas, *Histoire de l'Académie*, II, 29–31 and 607.

[21] Little is known of Haex, although he is described in the *Bulletin de Lyon*, No. 55 (10 Germinal, an XII), 218, as an "artiste," his name there being spelled "Haez." Monsieur H. Hours, archivist of the city of Lyons and general secretary of the *Classes des Lettres* of the Lyons Academy, has suggested to me that this Haex may be Thibaud Haess, a German-born turner who died in Lyons in 1812 at the age of 67.

[22] It was these three colleagues who were responsible for the earliest experiments and also for bringing the workman's observations to the notice of Mollet. See Dumas, *Histoire de l'Académie*, II, 233 n., and Mollet, *Mémoire sur deux faits*, pp. 7–8. In a private communication Monsieur Hours of Lyons, referred to in note 21, has identified Gensoul as Joseph Ferdinand Gensoul, who was born at Conaux (Gard) and who died in Lyons in 1833 at the age of 67. The work of Gensoul, who was an engineer especially noted for his work in copper, is described briefly in F. F. A. Potton, *Notice historique sur la vie et les travaux du docteur Joseph Gensoul* (Lyons, 1861), pp. 11–12. I am indebted to Monsieur Hours for this reference.

[23] Mollet, *Mémoire sur deux faits*, pp. 25–27. That the appearance of light was not the result of the compression of air was demonstrated by Thenard in 1830 (see L. J. Thenard, "Observations sur la lumière qui jaillit de l'air et de l'oxigène par compression," *Annales de Chimie et de Physique*, XLIV [1830], 181–88).

at the Academy's public meeting on March 27 of the same year.[24] In Paris, the Institute's referees, Charles and A. F. Fourcroy, reported favorably on this occasion, and the reading of their report in May 1804 was even accompanied by a successful performance of Mollet's experiments.[25] In Lyons, on the other hand, there was still some skepticism, but Mollet seems to have been successful in answering suggestions that the cause of the ignition of the tinder was something other than a rise in temperature of the air undergoing compression.[26] That heating resulted from friction either between the piston and the cylinder or between the tinder and the air rushing over its surface was among the alternative explanations which were offered about this time. Others were that the compression brought about oxidation of the surface of the metal cylinder and hence also the emission of heat, and that the ignition of the tinder was to be associated with the presence of the lubricating oil used to facilitate the movement of the piston. That such objections, however few, should have been raised at all may seem somewhat surprising, but they do serve to emphasize the ease with which Mollet's experiments could be misinterpreted and hence also the importance of the scientific background described above. It is significant, perhaps, that such objections as were made came apparently from the scientific community of Lyons rather than from that of Paris, where the impact of Laplace's success with the velocity-of-sound problem was almost certainly more keenly felt.

IV. *Commercial Manufacture*

The principle of the fire piston, as we have seen, was discovered accidentally in the course of work on the condensing pump of an air gun, an instrument which itself was not suitable for the purpose of fire making. Yet it was not long before apparatus for the ignition of tinder by compression began to be devised specially. In January 1804, for example, in the course of Mollet's paper to the Lyons Academy, Haex demonstrated a simple pump consisting of a piston and a cylinder,

[24] On these three communications see *Procès-verbaux*, III, 28 (6 Frimaire, an XII); Dumas, *Histoire de l'Académie*, II, 232–35; and *Bulletin de Lyon*, No. 55 (10 Germinal, an XII), 218. Successful practical demonstrations by Haex accompanied the reading of Mollet's papers in both January and March 1804. The text of the paper read on March 27, 1804 appeared in 1811 as the *Mémoire sur deux faits* cited fully in note 16 above. There is no evidence that changes had been made since the paper had been delivered, although brief introductory and concluding notes were added.

[25] *Procès-verbaux*, III, 95–96 (17 Floréal, an XII).

[26] See Dumas, *Histoire de l'Académie*, II, 234–36; and Mollet, *Mémoire sur deux faits*, pp. 8–14 and 30.

the closed end of which could be unscrewed after the compression stroke to expose the glowing tinder.[27] Whether at this stage there was any thought that such an instrument might be used specifically for fire making is not known, although the possibility was certainly mentioned in March 1804 by Mollet.[28] However, it seems that it was not until 1806 that the fire piston became available commercially.

In February 1806 the *Journal de Physique* contained a brief announcement that the celebrated instrument maker Dumotiez of Paris[29] was producing what was termed the "briquet pneumatique" in various sizes and designs.[30] That Dumotiez was the manufacturer is hardly surprising when we note that it was in his workshop, in February 1804, that tinder was first successfully ignited in Paris by the compression of air.[31] Since the experiment of February 1804 seems to have been conducted strictly in accordance with Mollet's instructions, it is reasonable to suppose that the apparatus used was similar to that which Haex had demonstrated before the Lyons Academy in the previous month, and this would certainly account for the fact that, in Dumotiez's early models at least, the tinder was held in the closed end of the cylinder, which therefore had to be rapidly unscrewed before a light was obtained.[32]

Although no example of a fire piston by Dumotiez seems to have survived, his early instruments were probably similar to one patented in London by Richard Lorentz of Brook Green, near Hammersmith, in February 1807,[33] and the "foreigners residing abroad" who communicated the invention to Lorentz may well have been connected with Dumotiez. Lorentz's version was unusual not merely for its size (the working part was contained inside a walking stick, and the length

[27] Dumas, *Histoire de l'Académie,* II, 233.

[28] Mollet, *Mémoire sur deux faits,* p. 13.

[29] "Briquet pneumatique par Dumotiez," *Journal de Physique,* LXII (1806), 189. See also Mollet, *Mémoire sur deux faits,* p. 30.

[30] According to the announcement Dumotiez's first pistons were typically 6 inches in length and approximately ⅓ inch in diameter, but in 1811 Mollet wrote that one model sold by Dumotiez was in the form of a walking stick (see Mollet, *Mémoire sur deux faits,* p. 30. Also *cf.* Lorentz's first piston, described below, and the English instrument shown in Plate II). The identity of the "M. Dumotiez" referred to in the announcement is not entirely clear, since the firm of Dumotiez was in fact controlled by two brothers, Louis Joseph and Pierre François Dumotiez, who seem to have worked in close collaboration. On the Dumotiez brothers see M. Daumas, *Les instruments scientifiques aux XVII^e^ et XVIII^e^ siècles* (Paris, 1953), pp. 378–79.

[31] Mollet, *Mémoire sur deux faits,* p. 3.

[32] *Ibid.,* p. 30.

[33] The patent specification, the reference number of which is 3007 (1807), has been consulted by courtesy of the Patent Office, London.

of the piston stroke was about 12 inches) but also for the fact that the compressed air passed through a narrow aperture before meeting the tinder. Only two surviving examples of fire pistons constructed on this principle are known, and even in these cases there are certain important departures from the patent specification.[34] We may be certain therefore, that Lorentz's designs, like Dumotiez's, never came into common use and that Mollet's preference for a second type, which he expressed in 1811,[35] was widely shared even by that date.

In this second type, which became easily the most common, the tinder was contained in a small cavity in the end of the piston, so that after the compression stroke it was necessary simply to withdraw the piston before the glowing tinder could be applied. The credit for this design, no less than for that adopted by Dumotiez and Lorentz, lies with the men of Lyons, although who should be named as its inventor is not entirely clear. Certainly the first man to patent and manufacture fire pistons of the second type was a metalfounder of the Rue St. François in Lyons by the name of Dubois, who worked from a particularly efficient prototype constructed by Eynard and demonstrated by him at a public meeting of the Lyons Academy on August 26, 1806.[36] Whether Eynard had lodged the tinder in the piston rather than in the end of the cylinder or whether this was an innovation by Dubois is unfortunately not known, but, as has already been mentioned, we may be sure that the superiority of instruments of the type constructed by Dubois quickly became apparent. Thus the fact that in 1811 Dumotiez's fire pistons could be cited by an independent observer as the best known[37] may indicate only that Dumotiez, even by that date, had already adopted Dubois's design in preference to his own.

The extent to which fire pistons were used in Europe is extremely difficult to ascertain, but there is every reason to believe that they never displaced the conventional tinder box as the most popular fire-making device and that they remained something of a scientific curiosity. The fact that so few instruments of European origin are to be found in British museums today (see Appendix) is striking evidence for this conclusion, the more so when we consider that the European fire piston was virtually indestructible, being constructed entirely of metal with the exception of some padding around the piston. On the other hand, it must be pointed out that in scientific books and papers,

[34] The instruments referred to are shown in Plate I (item 1) and Plate II. See also Appendix, items 1 and 5.

[35] Mollet, *Mémoire sur deux faits*, p. 31.

[36] Dumas, *Histoire de l'Académie*, II, 236.

[37] J. P. Dessaignes, *Journal de Physique*, LXXIII (1811), 50.

if not in other literature, frequent references to the fire piston continued to be made until about 1830. Such authors as Humphry Davy, Louis Jacques Thenard, Sadi Carnot, and Jöns Jacob Berzelius[38] all mention the instrument in terms which imply considerable familiarity. However, the fact that the fire piston was well known to the scientists of the day is almost certainly an indication not of its widespread use for domestic purposes but rather of its suitability as a means of illustrating an effect which would have formed part of any early nineteenth-century course on heat.

The introduction in Europe of cheap and efficient friction matches in the late 1820's dealt a severe blow to the fire piston, which by comparison with the new matches was both clumsy and unreliable.[39] Quite suddenly references to the fire piston became far less frequent, and there is some evidence for believing that even by the early 1830's the instrument was beginning to be forgotten, at least in England.[40] Somewhat later, probably about the middle of the century, it appears to have been in common use in certain rural parts of England, notably among shepherds in the Lake District and to a lesser extent in the Yorkshire Dales,[41] and about 1900 manufacture of the instrument was briefly resumed in France.[42] But such evidence of its use after 1830 is rare,

38 H. Davy, *Elements of Chemical Philosophy* (London, 1812), p. 90; L. J. Thenard, *Traité de chimie élémentaire* (Paris, 1813), I, 82; N. L. S. Carnot, *Réflexions sur la puissance motrice du feu* (Paris, 1824), p. 30 n.; J. J. Berzelius, *Lehrbuch der Chemie*, trans. F. Wöhler (Dresden, 1825), I, 60.

39 The main defects of the fire piston as a domestic fire-making device were summarized very neatly in 1834 by the author of the unsigned article on "Fire" cited in the Appendix, under item 1. On p. 286 of the article it is stated: "Some modification of this instrument may be found useful, but in its present state it is inferior to the common tinder-box:—it requires considerable strength,—is equally slow in getting a light,—requires a match to be lighted after the tinder has taken fire, and is easily put out of order." To this list we may add the fact that the tinder has to be very dry before the fire piston will operate effectively.

40 This seems to be implied by a letter from E. J. Mitchell of Bradford, Yorkshire, published in *Mechanics' Magazine*, XVII (1832), 328–29. In the letter Mitchell described what he termed the "instantaneous light-giving syringe" (*i.e.* the fire piston) as an invention which "though not new, is, perhaps, not generally known." Mitchell believed (probably correctly) that the instrument was better known on the Continent.

41 J. Greenop, "A contrivance for producing fire, formerly used in the English Lake District," *Transactions of the Cumberland & Westmorland Antiquarian & Archaeological Society*, n.s., VII (1907), 206–8. I am grateful to John Anstee, assistant curator of the Museum of Lakeland Life and Industry, Abbot Hall, Kendal, for drawing my attention to this paper.

42 See Appendix, item 7. According to Balfour (*Anthropological Essays*, p. 47) this fire piston was purchased in Paris, apparently about 1900.

so that the history of the fire piston as a useful fire-making device effectively ends in Europe only a quarter of a century after its invention.

V. *An Outstanding Problem*

The familiarity of the fire piston to Europeans is clearly a relevant factor in one major problem to which reference has already been made, namely, how a similar device, usually somewhat smaller than its European counterpart and made of wood or horn, came to be in common use in parts of southeast Asia later in the nineteenth century and certainly before 1865.[43] If the fire piston really was well known before that date in Europe, albeit chiefly in scientific circles, it seems difficult to discount quite so readily, as most anthropologists in the past have done, the possibility that the instrument was introduced from the West. It is surely significant that the British, by virtue either of trade or conquest, exerted a very considerable influence in southeast Asia in general during the first three decades of the nineteenth century, at the time when we might reasonably expect the fire piston to have been introduced there by Europeans. And, to take the point still further, we cannot overlook the fact that the fire pistons observed by visitors to the area later in the nineteenth century were found only in Java, which was occupied by the British from 1811 until 1816, and in parts of Burma, Laos, the Malay peninsula, Sumatra, North Borneo, and the Philippines, which either had been under direct British influence themselves or which, alternatively, had been in close contact with regions that had.[44]

This, of course, in no way implies that the possibility of an independent process of invention in Asia can be ruled out. Certainly, in the light of the well defined and clearly documented pattern of discovery and early development which has been outlined above for the European fire piston, we can now hardly accept the extreme view of this problem, according to which the fire piston was not only invented independently in Asia but was also introduced from there into Europe.[45] Yet the more moderate claims, such as those of Henry Balfour,[46] which allow that the fire piston could have emerged quite independently in

[43] On the dates of the earliest accounts of the fire piston in Asia see Balfour, *Anthropological Essays*, pp. 27–28.

[44] On the exact provenance of the Asian fire pistons see Balfour, *Anthropological Essays*, pp. 23–29 and 46–49. The possibility that the French were responsible for introducing the fire piston into southeast Asia has not been considered here. By comparison with that of the British, French influence in the region was slight at the time when the instrument was most probably introduced.

[45] For references see note 3.

[46] For reference see note 2.

the West as well as in Asia, are far more difficult, if not impossible, to eliminate and they still deserve very serious attention.

In considering the circumstances which might have led to the discovery of the fire-piston principle in southeast Asia, we shall not expect to find anything resembling the tradition of purely scientific inquiry which seems to have been at least one factor contributing to the emergence of the device in Europe. We may be certain, therefore, that the Asian fire piston, if it was in fact indigenous in Asia, would have been invented as the result of a chance observation. How this observation might have been made has been the subject of much speculation, but almost inevitably it remains an unsolved question. Balfour, for example, argued convincingly against toy popguns, water syringes, and the pestle and mortar commonly used in Asia for crushing betel nuts as possible antecedents of the fire piston, but, as an alternative, he was able to do no more than suggest tentatively that the chance ignition of some combustible material might have occurred while a muzzle-loading cannon was being cleaned with a closely fitting cleaning rod.[47] As Balfour recognized only too well, the lack of adequate documentation insures, and always will insure, that none of these possibilities can be rejected outright, however improbable they may appear. Nevertheless, in any assessment of the likelihood of an independent process of invention in Asia it is worth emphasizing that in none of the devices mentioned above was a well-fitting piston moving smoothly in a cylinder an essential element of the design, as it was in the fire piston.

Of the products of Asian technology to which this last objection does not apply the most likely candidate as a possible antecedent of the fire piston is the piston bellows,[48] an ancient device in which a good fit between the walls of a cylinder of uniform cross-section and a piston moving in it was almost as important as in the fire piston itself.[49] The case with regard to this instrument is made particularly strong by the fact that it had long been in common use in those parts of southeast Asia where the fire piston was found by nineteenth-century travelers from the West. The bellows consisted of a cylinder, held vertically and usually made of a hollowed-out tree trunk, in which a piston was moved by hand. The size appears to have been very variable, but a typical cylinder would be rather less than 5 feet in length and

[47] Balfour, *Anthropological Essays*, pp. 44–46.

[48] These two instruments are particularly closely associated in, for example, Needham, *Science and Civilisation in China*, IV, Part 2, 140–41.

[49] For an account of the piston bellows see T. Ewbank, *A Description and Historical Account of Hydraulic and Other Machines for Raising Water, Ancient and Modern* (New York, 1842), pp. 244–58.

between 4 inches and 6 inches in internal diameter. At its lower end, which was usually held in contact with the ground, it was closed and a small hole in the wall of the cylinder, near the bottom, allowed the air compressed by the descending piston to pass to the furnace by way of a short pipe. A leather washer or other packing, which was commonly fitted to the piston, insured that the fit was a reasonably good one, yet the extent to which pressure could be built up inside the cylinder would obviously depend on the ease with which air could escape through the exit hole. If the device was to be efficient, this hole and the attached pipe would certainly not be narrow; it seems unlikely, therefore, that any temperature increment large enough to be noticed, to say nothing of one sufficient to ignite tinder, would have been obtained in the course of normal usage. And even if effective compression had occurred, possibly as a result of some temporary blockage in the exit pipe, the force necessary to reduce the air to one-fifth its original volume (the degree of compression found necessary in operating a purpose-built fire piston, even with perfectly dry tinder[50]) would certainly have been far greater than any single man could apply, being many times greater in a piston bellows of typical dimensions than in any known fire piston.[51] Moreover, any slight heating which might have occurred would surely have been associated only with the proximity of the furnace and so ignored.

But even if the piston bellows did not lead to an independent discovery of the fire piston in Asia, the instrument may not be wholly irrelevant to this account. It is at least conceivable that the Europeans who brought fire pistons, or more probably a knowledge of them, to the East saw in the established methods for the construction of piston bellows a ready-made technology suitable for the manufacture of a form of fire piston using materials easily obtainable in the region. The fact that piston bellows were in common use in those areas where fire pistons were found in the nineteenth century would be wholly consistent with this view; it would also go some way toward answering two points raised by Balfour as objections to the possibility that the Asian fire piston was introduced originally from Europe. These points are, first, that no instrument of European origin has ever been found in Asia, and second, that if the fire piston was introduced by Europeans in the early years of the nineteenth century, then knowledge of it must have spread with astonishing rapidity for it to be in use in areas as far apart as Burma, Java, and the Philippines by the 1860's. The weight of both of

[50] J. L. Gay-Lussac, "Sur le froid produit par la dilatation des gaz," *Annales de Chimie et de Physique,* IX (1818), 308.

[51] The force being proportional to the cross-section area of the cylinder.

these objections would be greatly diminished if we could assume that the techniques required for the production of the fire piston were derived directly from the long-established and widely known procedures used in the manufacture of the piston bellows. If this was the case, would importation from Europe ever have been necessary, and would it be surprising that the ability to manufacture fire pistons spread so quickly through Asia?

VI. *Conclusion*

The case for seeing Europe rather than Asia as the unique home of the fire piston is, I must admit, scarcely advanced by this paper. My attempt to answer some of the weightier objections to such a view, my examination of the history of the fire piston in Europe, and the suggestion of a possible role for the piston bellows do not constitute conclusive evidence, and they are not offered as such. When we recall that even in France the principle of the fire piston belongs wholly to the class of discoveries made, as Bacon put it, "when men were not seeking them but were busy about other things,"[52] it would be rash indeed to state that the device could not have emerged in Asia as the result of a pattern of development quite different from that followed in Europe. Certainly, the patterns of development which have been suggested so far all have a strong element of implausibility, but very few of them can be ruled out entirely, and, in any case, there are undoubtedly others which could be suggested in their place.

Concerning the origins of the fire piston in Europe, however, there is far less room for doubt. The evidence establishes conclusively, I think, that credit for the invention of the European instrument must now be given to Joseph Mollet and his ingenious friends and colleagues in Lyons.

APPENDIX

Domestic fire pistons of European origin have been located in the following museums:

Science Museum, London

1. Fire piston in brass (length 5½ inches), modeled on one described in an unsigned article on "Fire," *The Penny Magazine*, III (1834), 286, and stated there to have been manufactured in France. In this instrument, which was probably made in London, the air is forced through a number of small holes in the end of

[52] *The Works of Francis Bacon*, ed. J. Spedding, R. L. Ellis, and D. D. Heath (London, 1860), IV, 98. The phrase is in the first book of the *Novum Organum*, aphorism 108.

the cylinder before encountering the tinder. See Plate I, item 1. (Bryant & May collection, No. 1228.)

2. Fire piston of conventional design with cylinder in brass and piston in steel with brass head (length 4⅛ inches). British. See Plate I, item 2. (Bryant & May collection, No. 1231.)
3. Conventional fire piston with cylinder in brass and piston in steel with brass head (length 3 inches). British. See Plate I, item 3. (Bryant & May collection, No. 1230.)
4. Conventional fire piston in brass (length 5½ inches). British. (Bryant & May collection, No. 1229.)
5. Fire piston contained in a walking stick of dark mahogany or rosewood (length 2 feet, 5½ inches, but reduced from about 2 feet, 10 inches through use as a poker!). British. In Plate II the instrument is shown dismantled. It consists of (left to right): a knob which unscrews to disclose a compartment for storing tinder, a brass screw for holding the stored tinder in position, the handle of the stick from which there projects a short hollow brass cylinder (length 3 inches), and finally the main body of the walking stick bearing a short projection which just fits inside the brass cylinder. This projection has a perforated screw-on cap under which the tinder is placed. Ignition is effected by placing the cylinder over the projection and then forcing it down rapidly (the point of the stick being struck sharply on the ground). (Bryant & May collection, No. 1232.)

The Science Museum instruments are all described in detail in M. Christy, *The Bryant and May Museum of Fire-Making Appliances. Catalogue of the Exhibits* (London, 1926), p. 91, and in the supplement (London, 1928), p. 266. A photograph of item 4 (above) appears on p. 233 of this catalogue.

Pitt Rivers Museum, Oxford

6. Conventional fire piston in brass (length 5½ inches). Probably British.
7. Fire piston in white metal of a type which was introduced in France *ca.* 1900 (length 3 inches). See note 42.

Museum of the History of Science, Oxford

8. Conventional fire piston with cylinder in brass and piston in steel with brass head (length 6½ inches). Probably British.

(The lengths given are those of the cylinders only.)