

Berthoud, Harrison, and Lalande: A Near Myth

by Richard Watkins

Berthoud a Plagiariser?

Pierre Le Roy and Ferdinand Berthoud had been developing marine chronometers in France, but without much practical success. Then in 1763 Berthoud went to London and on his return to Paris he made two watches. As Anthony Randall¹ puts it:

“Berthoud also made a large watch whose mechanism was probably based on what he imagined H4 [John Harrison’s fourth attempt to craft a mechanism to find longitude] to contain. He would have been able to gain some idea of the size and shape of H4, either through Lalande who had seen it on the 22nd of April, or through some other contact. This knowledge would have been invaluable to him. Not content with that, he also made a pocket watch that looks suspiciously as if it was based on ideas inspired by the Jefferys watch.”

Jefferys made a watch for John Harrison, which I will call J1, that formed the basis for the design of H4.² This watch was probably made in 1753 but not finished until 1755, and because of the seven-year war with France, it is unlikely Berthoud could have known about it until 1763; he certainly didn’t know anything about H4.

Randall’s statement appears in a section of his paper titled, “The French are invited to send ‘spies’ to see H4,” which can be interpreted as suggesting the French stole ideas from England.

This paper examines the allegation that Ferdinand Berthoud copied John Harrison’s watches and its implications.

Longitude

The accurate determination of longitude at sea was the necessary precursor to gaining control of the oceans and hence world domination. The English government did not offer a £20,000 reward in 1714 for an interesting bit of abstract research, but rather for the ability to gain naval and trade ascendancy. That reward (and those offered by other countries) made finding longitude the talk of the town, and for 70 years many scientists and crackpots turned their attention to the problem.

1. Anthony Randall, “The Timekeeper That Won the Longitude Prize,” in *The Quest for Longitude*, ed. William Andrewes (Cambridge, MA: Harvard University, 1996), p. 245.

2. Following the penchant to abbreviate everything. Note that the H’s, J’s, K’s and M’s (for Mudge) form both an alphabetical and chronological sequence. Earnshaw should have been called Zachariah!

Two distinctly different, feasible solutions were proposed.³ One, the method of lunar distances (and the related method by observing eclipses of Jupiter’s moons) is a theoretical model based on astronomy and mathematics. Its development required a large amount of scientific research involving astronomical observations and the solution of complex equations for the motion of bodies in space. By 1755, the mathematicians Euler and Tobias Mayer had produced the necessary theoretical tables to accompany star catalogs, and in 1761 Nevil Maskelyne successfully tested the method.

The other method, the marine chronometer, is a pragmatic application of mechanics and clockwork. It required no science and no research, but simply needed a mechanic to build a sufficiently accurate clock. John Harrison was the first person to successfully do so, and between about 1730 and 1760, he built three marine clocks and a marine watch, commonly referred to as H1 to H4.

The distinction between these two methods is very important. The method of lunar distances was one of the primary reasons for founding the Greenwich Observatory. It was intellectually satisfying and stimulated a huge scientific effort. This work was carried out by people with education who held prominent positions in London society, like the Astronomer Royal. I have no doubt that this intellectual superiority of the lunar distances method significantly affected the decisions of the overseeing body, the Board of Longitude, which included important scientists and leaders of the day. It is also reasonable to presume socio-political pressures influenced their decisions.

In contrast, the marine chronometer is intellectually trite and was created by a country carpenter with help from people, albeit highly regarded, who were graduate mechanical apprentices. As this may upset my readers I had better explain. Although timepieces are mechanically complex and the marine chronometer is a marvel of practical ingenuity, there is little theory in horology other than general principles derived from

3. The best overviews of the theoretical and practical problems are given in *The Quest for Longitude*, ed. William Andrewes and R. J. Gould, *The Marine Chronometer, Its History and Development* (London: Potter, 1923, 1960, 1971, 1973, 1978, and 1989). *The Quest for Longitude* also contains an excellent paper summarizing the crackpot proposals. Reprinted, Owen Gingerich, “Cranks and Opportunists: Nutty Solutions to the Longitude Problem,” *NAWCC BULLETIN*, No. 329 (December 2000): p. 769.

astronomy and mechanical engineering. Time measurement was certainly central to much research and horology, directly or indirectly, spawned theories on gearing, elasticity of springs, expansion of metals, and so on. But the clock is simply a practical implementation of ideas and the clockmaker a mechanic. The clock bears the same relationship to theoretical astronomy as the sextant, and to theoretical mechanics as the automobile. This may be clearer if I note that few (if any) of the eminent theoreticians were horologists (people who described their occupation as time measurement). For example, Huygens, Hooke, Camus, and much later Guillaume, were scientists in other disciplines with an interest in horology.

Describing Harrison as a carpenter is deliberate. No matter how intelligent or creative he was, he was still a country workman who repaired carts and became a consummate craftsman. He was not a scientist and probably not desirable company in polite London society (except as an exhibit).

Questions ...

The year 1763 was at the beginning of a momentous period in English horology. The watch H4 had just been built and it had its first sea trial in 1761-62—the same time Nevil Maskelyne demonstrated the viability of lunar distances. John Arnold had been in business for just a year and in 12 month's time (June 1764), he would present King George III with a repeater watch mounted in a ring. In the ensuing years, Harrison's ideas were proved valid through watches made by Larcum Kendall. Arnold started to research chronometer design, and about 16 years later, Thomas Earnshaw created the marine chronometer as we know it today. At the same time, Thomas Mudge invented the lever escapement, one of the most significant developments in the history of the watch; but he too was smitten by the "longitude bug" and ignored his invention, preferring to build chronometers.

The year 1763 was also the end of a momentous period in English relationships with France. For seven years, from 1756 to 1763, England and France had been at war, a war England won. Throughout this period, French astronomers and horologists were prevented from meeting English friends and studying English developments. Also during this time that most remarkable invention, the watch H4, came into being. And so at the very first opportunity in 1763, together with a tide of other French people, an official delegation from the French Academy of Science was sent to London to find out about Harrison's timekeepers.

Three eminent Frenchmen stepped into a furnace of activity, fired by the promise of huge financial gains. The 36-year-old Ferdinand Berthoud was an esteemed watchmaker developing marine chronometers and became one of the greatest writers on horology. Charles

Camus, then an old man of 69, was the mathematician and mechanist who had developed the theory of gearing, so necessary for accurate timekeeping (and all other machinery), who undoubtedly had some knowledge of horology. And the youngest at 31 was Jerome Lalande, the astronomer who had also written on the theory of gearing and its application to horology. Fortunately, Lalande kept a diary of his trip.⁴

It is in this context that Lalande's journal is important. Throughout the journal are references to matters relating to navigation and the discovery of longitude. Indeed, Helene Monod-Cassidy says in her preface to the transcript that the goal of Lalande's trip was, "to examine and if possible to bring back to France a model of the marine chronometer comprising a pendulum with compensation invented by John Harrison a few years before."

We have already seen that Randall believes the visit was very significant. In the same book, William Andrewes guardedly suggests Lalande was much more involved with H4 than Randall indicates⁵:

"I have transcribed both quotes, with all their imperfect punctuation, exactly as written on page 81 of Lalande's original manuscript. The number '84' at the top of the following page of the manuscript is probably a mistake in pagination, although it suggests pages 82 and 83 contained more information about their visit [to Harrison]. While there is no record of Berthoud seeing H4 on that occasion, it would seem from the outward appearance of his Montre Marine No. 3—made upon his return to Paris—either that he saw the watch in its case, or that Lalande, who had seen it three weeks earlier on April 22, gave his colleague a careful description."

Monod-Cassidy, Randall, and Andrewes all indicate that Lalande may have played a pivotal role in providing Berthoud with information on chronometer design,

4. The manuscript of *Voyage en Angleterre* is in the Mazarine Library, Paris, under the number 4345. Copies are available from *Societe d'Ingenierie et de Microfilmage* in Paris (microfilm or printed).

An edited and annotated transcript has been published:

Helene Monod-Cassidy, *Jerome Lalande, journal d'un voyage en Angleterre 1763*, Studies on Voltaire and the Eighteenth Century No. 184 (Oxford, The Voltaire Foundation, 1980).

I have produced a complete translation of the diary:

Jerome Lalande and Richard Watkins, *Jerome Lalande, diary of a trip to England 1763*, electronic text available from the author: www.watkinsr.id.au.

This includes Monod-Cassidy's notes and my own analysis of Lalande and his diary.

5. William Andrewes, "Even Newton Could Be Wrong," in *The Quest for Longitude*, ed. William Andrewes (Cambridge, MA: Harvard University, 1996), p. 208. I don't give the quotes because they are not important here.

80 beaucoup et ne finit rien, il porta ses instruments chez le puobroket, et on en avoit vendus pour la dix^e de leur valeur. il est obligé de se presser beaucoup et abort il ne fait rien qui vaille, mais d'ailleurs personne n'a autant d'esprit que lui. m. Jiffon m'a fait voir encore son instr. ragoant sur le mercure, avec lequel il prend hauteur à la minute suivant le certificat de son maître d'un navire de guerre, il y a un miroir sur le Centre et on met l'eau à la verticale, il y a un contre-poids qu'on règle avec un vis; les oscillations redurent par 4" et l'on n'a pas besoin de voir l'horizon.

il nous a fait voir la premiere chaise marine qui estoit portée sur une suspension à 4 pivots et deux boîtes dont les pivots roulaient sur 6 rouleaux de bel metal de même que les pivots eux mêmes la 2^e estoit un genou ordinaire à 3 pivots et un seul pendoit

un pendule de 6 pieds et en bay un pied dans l'eau). la 3^e est composée de 2 cercles qui ont chacun 2 pivots, mais dont les directions se croisent, elle a 4 pieds de haut, 4 de diamètre il y a des poids de plomb pour en mesurer et en arrêter le mouvement plus vite; il y a une table pour l'usage à la hauteur de l'œil qui s'incline, et qui est en équilibre).

3^{me} nous avons été voir m. Harrison et ses 3 pendules, la pendule de longit. la pendule à seconds qu'il fit en 1712 lui sert encore réglé, la 3^e d'Espagne lui en vouloit donner 2000 piéces.

m. Berthoud a trouvé les pièces très belles très ingénieuses, très bien exécutées, et quoique la régularité de la montre lui paroitte bien difficile à croire il est encore plus impatient de laisser sapper's qu'il avoit les 3 pendules.

84 Mardi 10 May. j'ai été de grand matin chez le docteur Bevis, nous avons été nous promener à istington, sur le bord de nos rives, au grand et au petit reservoir, à l'endroit où il est porté sur un charpenté recouvert de plomb. à l'endroit où il y a une écluse pour clarifier l'eau. à l'advers de elle, dans les jardins de White Conduit, pour ainsi nommez parce qu'il y a un reservoir blanc qui conduit l'eau à charter house. nous avons approché de haygate, mesuré la profondeur, la largeur 6 1/2 en haut, et la surface à la surface 2 pié et 1/10.

j'ai été au college de quresham, affilé à la leçon de m. mace en civil law à 4h. elle n'a duré que une demi heure il alla son cayer dans sa chaire il y avoit 6 personnes; une chaisiniere pris de la porte de l'école m'a donné la liste des professeurs et de leurs jours.

le soir promener au ho. de douerches. chez m. Bevis. j'ai été chez le public. 1734.

Figure 1. Manuscript pages 80 and "81." The bottom third of page 80 and the top half of "81" describe three marine chairs. The visit to Harrison is the second half of "81."

Figure 2. Manuscript page 84 on the back of "81" (shown in Figure 1).

hence supplying France with the technology needed to compete with England on the high seas.

In order to decide if these suggestions are right or wrong, we need to answer some fundamental questions (which I have listed in order of the certainty with which they can be answered, rather than the order in which they ought to be answered):

- Could Lalande have removed pages from his diary, which might have contained descriptions of H4 and J1?
- Did Lalande see H4 and J1?
- Did he have sufficient knowledge of horology to communicate useful information to others?

So I got Monod-Cassidy's book and, as her transcript contains a few errors and omits some of the text, I then got a microfilm of the original diary and examined that. Slowly, after I had translated and read the whole diary, a picture of Lalande and his involvement in the events of the time emerged.

What follows are my answers to the above questions and the suggestions of Randall and Andrewes. Rather than simply recite the essential conclusions, I will take you on a journey of discovery and, as I did, you will learn about Lalande and his journal before the pieces of the jigsaw puzzle are put together. I do this because there are some useful lessons to be learnt from the process as well as the results.

The Missing Page Numbers

Take a first edition of Berthoud's *Essai sur l'horlogerie* (which was published in 1763) and tear out

page 67 without removing page 68. It can't be done, can it? Now try to rip out page 83 without removing page 84. You can't do that either, can you? This is fortunate, as the book is extremely valuable! (This exercise can be done with almost any book. With very few exceptions, books are printed with the even-numbered pages on the left and the odd-numbered pages on the right. Indeed, you can rip pages out of the NAWCC BULLETIN if you wish.)

If you did actually tear a leaf from Berthoud, you will have discovered that another leaf fell out from somewhere else. This is because the pages in proper books are printed on sheets of paper sewn down the middle, and each sheet has four pages printed on it (if the book had glued pages probably all of them would have fallen out). Lalande's diary is like a thin notebook where all the sheets are stapled together in the middle, but his is sewn. I remember pulling pages out of notebooks at school. If I removed one page another one dropped out and I hoped I hadn't written on it! It was much easier to pull out the whole of the middle sheet of paper, except sometimes the staples opened up.

Monod-Cassidy noted that there are four page numbers missing from Lalande's diary:

"pp. 66-67 missing in the manuscript; probably an error in pagination

"pp. 82-83 missing; probably an error in pagination"

Andrewes refers to the second of these discrepancies. These missing numbers must be errors in pagina-

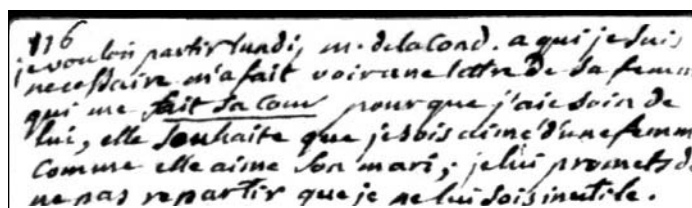
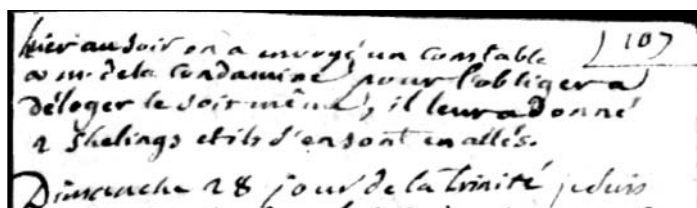


Figure 3. In (a, left) words which would fit on the first line are written on the second line to make room for the number. In (b, right) the start of the first line is written at an angle to avoid the number.

tion. This is because, as we have already seen, page 67 cannot be removed without also removing page 68 and page 83 cannot be removed without also removing page 84; but 68 and 84 are still in the diary.

Another way to arrive at the same conclusion is to note that Lalande did not number every page. Page 80 is numbered and the next page isn't (Figure 1), but the other side of it is numbered 84 (Figure 2). Figure 1 also shows that a sentence on page 80 continues onto the next page, so Monod-Cassidy and Andrewes did the obvious thing by assigning it the number 81. But then we have pages 81 and 84 on the same piece of paper and, if pages 82 and 83 had existed, they must have been inside that piece of paper! Impossible, and there must be an error in pagination with no physical pages missing. The same argument applies to 66-67.

Unfortunately this argument is wrong. Both Monod-Cassidy and Andrewes have assumed the number 81 when another choice is possible. We can also assign 83 to the unnumbered page; then pages 81-82 are missing and you can tear them out of a book. It is more difficult to decide in the other case, but we can arbitrarily choose 65-66 or 67-68 as well as 66-67, and either pair can be removed. So there is not necessarily an error in pagination.

As there are no other discrepancies, we can be sure that the pages in the manuscript are numbered 1 to 64, 67-68, 69 to 80, and 83 to 172.⁶

Lalande's diary contains 42 sheets making 84 leaves or 168 pages. If pages were removed, then the diary must initially have had 44 sheets and 176 pages. Take an exercise book with 44 sheets of paper in it and number the pages from 1 to 176. Pull out the sheets containing pages 65-66 and 81-82. You will find the numbers on the other pages that fall out are 111-112 and 95-96. The middle sheet in Lalande's diary has pages 87 to 90 on it; these will be the numbers on the middle sheet of your exercise book.

From this first experiment you will have discovered that Lalande did not number all the pages of his diary before he pulled out pages, because the last number in

6. Actually we can't be sure unless we show that pages could not have been mis-numbered, which I will consider later. There is evidence that shows that the leaf 67-68 was not removed (see the postscript to my translation of the diary) and the choice is not arbitrary.

his diary is 172 and the last number in your exercise book is 176. Also, there are no errors in numbering in the second half of the diary, 89 to 172. If pages had been numbered in the second half before the sheets were removed, there would be gaps in the numbering where the other halves of the sheets fell out.

Take another exercise book and do the same page-pulling exercise, but this time don't number any pages at all until you have finished (a little difficult because you will have to count to 65 and from there to 81 without writing on the pages). Again you will be wrong because there will be no gaps in the numbering and the last number you write will be 168. Now start again and number the pages as you go, but pull out 65-66 after you write the number 69 on its page and then continue numbering. And do the same thing with pages 80-81 after numbering page 84. In this case you can get the right page numbering.

That is, Lalande must have numbered some pages at the time he wrote on them or soon afterwards. Although it is difficult to be sure, I think some pages show this (see Figure 3).

When Lalande wrote his diary he used the first 118 pages for chronological entries from March 4 to June 9. So we can be certain that the other halves of the missing sheets were blank provided he removed them before the date he was due to write on them.

The upshot of this is that, although Monod-Cassidy and Andrewes got the numbers wrong, pages could have been removed before Lalande got to the date when he would have numbered or written on their other halves; about 30th May and 19th May respectively.⁷

The Devil is in the Detail!

Although my reasoning is correct and might seem conclusive, it is not necessarily right! I have already hinted at this by noting that pages 65-66 were removed and not 67-68. If, as in the last exercise, you number

7. Most likely, like me, you will go hysterical as you try to keep track of the page numbers. The simplest way to understand them is to take a 44-leaf booklet and number every page from 1 to 176. Then write Lalande's page numbering on the pages and mark the pages that were torn out without actually removing them. You will find, for example, that Lalande's page 118 is on the 122nd page of the original booklet.

pages 64 and 69 and then pulled out a page, you could remove either 65-66 or 67-68 and arrive at the correct result. Indeed, if you number only pages 30 and 69, you could pull out any leaf between 31-32 and 67-68. And if you later number the intervening pages, the discrepancy will appear just before page 69, giving the impression that 67-68 were removed.

Why am I making you think hard and look carefully at such fine detail? Well, the assumption is that Lalande wrote something interesting on the missing pages relevant to the adjacent diary entries. But if the pages removed change, then the relevant entries change and maybe he wrote something quite uninteresting, like a letter to his mother!

Look at the three arguments I have given. I began by showing that, if we accept the statements of Monod-Cassidy and Andrewes, pages couldn't be removed and there must be an error in pagination. Then, if we examine the numbering, we see that pages 65-66 and 81-82 may have been removed. Finally, if we are very careful we discover that almost any pages could be removed!

We can take a fourth step, but rather than giving the details I will just summarize the things we will learn.⁸

The final two pages are a table of contents. From it we can deduce that Lalande numbered pages only if they were listed in this table, and the table was mainly created in London during his trip. Further, it can be shown that most of the pages were numbered in numerical order from 1 to 172. Knowing this, you can get some more notebooks and easily prove that, whether caused by mis-numbering or removal, the discrepancy at 65-66 was created before the discrepancy at 81-82. Not only that, Lalande must have numbered page 69 before he removed 65-66, and numbered 84 after removing 65-66, but before removing 81-82. You will then see that mis-numbering page 84 could only happen if Lalande was stupid or careless enough to make a mistake counting to 13.⁹ From these points we can be very confident that Lalande simply could not have mis-numbered pages and he removed two

8. A detailed examination of these points is in the postscript to my translation of the diary.

9. The worst case is that after numbering page 69, Lalande counted to page 82 and mis-numbered it 84. It presumes Lalande later went back and numbered intervening pages. Similarly, in the other case I think the most he needed to count was 20 to get to page 67 and mis-number it 69 (there are features of the diary which suggest that 47 is the earliest page that could have been removed).

sheets of paper from his diary. But we can be sure that if 81-82 were removed, then it could not have been before 84 had been numbered and so it was done on or (more probably) after May 10. This is very important because it shows that Lalande did not remove the page while visiting Harrison. As Berthoud was present, Lalande had no need to make his own notes on what he saw.

Harrison

So far all I have shown is that Lalande could have given information to Berthoud, not that he did do so. Did he see H4 and J1? There are ten relevant entries in the diary:

April 15th: "On the 13th there was a meeting of the eleven commissioners named for the discovery of Mr Harrison's secrets. They declared that they needed Mr Harrison to make three watches before receiving the £5,000 and that they be tested on a voyage to Jamaica." So we can be pretty sure that from April 13th onwards Harrison would have been, to put it politely, very unhappy. From then on I doubt if he intended to show H4 to anyone, let alone a bunch of Frenchmen.¹⁰

April 22nd: "Mr Short took me to Harrison to see his three longitude clocks and his watch." This was Lalande's *first* meeting with Harrison.

May 3rd: "We wrote to Lord Charles Cavendish and Lord Morton informing them that we had arrived from France on behalf of the Academy of Science to receive information on the discoveries of Harrison."

May 6th: "I, with Mr Camus and Mr Berthoud, wrote to Lord Morton, Lord Charles Cavendish and Mr Scott" (presumably to remind them they were there).

May 7th: "Lord Morton came to see us. He complained about the obstinacy of Harrison and persists in wanting Harrison to make a second watch that can be tested. However he gave us hope that we would see the piece before our departure."

May 9th: "We went to see Mr Harrison and his three longitude clocks....Mr Berthoud ... was even more impatient to see [H4] after seeing the three clocks." This was the *second* and *last* time Lalande met Harrison.

10. Harrison had already refused to show the workings of H4 to the Board of Longitude. In 1765 he said, "I hope I am the first and, for my country's sake, shall be the last that suffers by pinning my faith on an English Act of Parliament." He wasn't the last, as Thomas Earnshaw found out.



Figure 4. Joseph-Jérôme le Français de Lalande, F.R.S. Reproduced from Sir Archibald Geikie, *Annals of the Royal Society Club* (London, 1917).

May 11th: "I saw Mr Scott in the morning, who made me hope...." This is not directly about seeing H4. However, it clearly refers to the conditions that Harrison needed to satisfy before the Frenchmen would be allowed to view it.

May 14th: "I had a long discussion with Lord Morton and I left convinced that we will not see the watch."

May 31st: "Mr Camus wrote a letter to the commissioners, telling them that he cannot remain here longer."

June 2nd: "Mr Camus presented his report to the commissioners on the matter of Harrison to get an answer." Although it is not spelled out, I have no doubt this relates to the letters written on the 3rd, 6th, and 31st of May.

Both Andrewes and Randall (following others before them) use the entry for April 22nd to show that Lalande saw H4, ignoring the later contradictory entries. But if we examine the diary we will discover a few places where Lalande wrote "I went to see..." when he definitely did not see; and unless Lalande explicitly described something, there is no guarantee his visit was successful. Further, Lalande never even mentions J1. So the only conclusion to be drawn from these events is that Lalande never saw H4 or J1.

Lalande

Just in case my deductions are wrong, we had better see if Lalande knew enough about horology to help Berthoud. But in order to do so we need to know something about him—who he was, what he did, and his involvement with science. A typical biography reads:

"As a student of law in Paris, Lalande (1732-1807) became interested in astronomy while he was lodging at the Hôtel de Cluny, where the noted astronomer Joseph-Nicolas Delisle had his observatory. In 1751 Lalande went to Berlin to make lunar observations in concert with the work of Nicolas-Louis de Lacaille at the Cape of Good Hope. The success of this task and the subsequent calculation of the Moon's distance secured for Lalande, before he reached the age of 21, admission to the Academy of Berlin and the post of adjunct astronomer to the Academy of Paris. Lalande then devoted himself to the improvement of planetary theory, publishing in 1759 a corrected edition of the tables of Halley's Comet. He helped organise international collaboration in observing the transits of Venus in 1761 and 1769; the data obtained made possible the accurate calculation of the distance between the Sun and the Earth. His tables of the planetary positions were considered the best available until the end of the 18th century. In 1762 Lalande was appointed to the chair of astronomy in the Collège de France, Paris, a position that he held for 46 years. In 1802 he instituted the Lalande Prize for the chief astronomical contribution

of each year. He became well known as a populariser of astronomy."

But such "sanitized" facts ignore horology and are misleading and too narrow in focus. So a "devil's advocate" view of Lalande will be useful.

The bald facts provided by the diary and Monod-Cassidy¹¹ are that Lalande was about 31 years old when he went to England in 1763. He was educated, with some training in law, mathematics, and astronomy, and he had a good command of English and German.

He was stunted, four feet six inches or about the size of an eight-year-old boy, weighed 106 pounds, and had poor eyesight. Furthermore, he lists two stay-makers in his "address book." I think it is extremely unlikely that he went to them on behalf of his mother or female friends and I presume they were for his own benefit; so he probably had back problems.¹²

Lalande said, "I scorn worldly pleasures, I put up with plays, festivals, dinners. I do not go to spectacles...." In stark contrast, when he visited England he was delighted by plays and spectacles! To mention just a few entries in his diary: on April 21st he went to a

11. Helene Monod-Cassidy, *Un astronome-philosophe, Jerome de Lalande* (Studies on Voltaire and the eighteenth century, LVI, 1967, pp. 907-930). The preface to her transcript of Lalande's journal is a much shortened version of this paper.

12. The only description of Lalande that I have found (from 1788 when he returned to England) says: "M. de Lalande advanced to meet me—I will not be quite positive it was on tiptoe, but certainly with a jerk and strut that could not be quite flat-footed. He kissed his hand with the air of a petit-maitre...His figure corresponds no better with his discourse than his scientific profession, for he is an ugly, wrinkled old man, with a fine showy waistcoat, rich lace ruffles and the grimaces of a dentist. I believe he chose to display that a French man of science could be also a man of gallantry," quoted from Sir Archibald Geikie, *Annals of the Royal Society Club* (London, 1917).

Someone suggested to me that it was "fashionable" for men to wear stays. I am inclined to think there was, in most cases, an underlying practical reason in an age when there was no surgery to correct problems like hernia or deformity. I cannot refrain from quoting R. Campbell's *The London tradesman* (London, 1747) at this point:

"The delicate easy shape we so much admire in Miranda is entirely the workmanship of the stay-maker; to him she reveals all her natural deformity, which she industriously conceals from her fond Lord, who was caught by her slender waist. Her shape she owes to steel and whalebone...and her natural self, when deposited in the bridal bed, is a mere lump of animated deformity, fitter far for the undertaker than to be initiated in the mysteries of connubial joy."

When I showed Lalande's portrait to a person with medical knowledge, I received an immediate and unprompted response of "hydrocephalus," water on the brain, a congenital disorder.

ball where “one can play cards and drink tea, ... it cost me 8/6 from 5 pm to 1 am”,¹³ a play on April 24th (to howl at the actors and shout encore); an orchestra and some “rather pretty singers” on the 25th; and a ball on the fourth of June. For someone who scorned plays and spectacles, this must have been a punishing atonement of sins! But Lalande’s visits to Vauxhall (the eighteenth century’s equivalent of Disneyland) are the most notable examples of a dispassionate scientist stoically putting up with worldly pleasures. On May 19th, “I spent eleven and a half hours there,” eating and drinking and taking in the entertainment. Not satisfied, two days later, “I went to Vauxhall where time passed deliciously.”

Later in his life he organized glittering soirées at a Masonic lodge and “he affected to have in his pocket a box full of spiders, to delicately take them in his fingers, to suck them and to swallow them, while asserting that there was no meat finer or more delicious.”

But what sort of philosopher was Lalande? He “continuously shifted interests and this prevented him from closely examining anything.” Although noted as an astronomer, this science does not seem to have occupied him much; of the approximately 20 books that he wrote, only five relate to astronomy and these include an annual ephemeris, a popularization, and *Astronomy for ladies*. He also wrote a paper about the possibility of a comet colliding with the earth, which created panic in Paris. Monod-Cassidy says “a rumour was spread” about the paper and I would not be surprised if Lalande, who liked to be talked about, originated the rumor. Further, I have seen no evidence that he was a competent mathematician and he may have used Lepaute’s wife to do calculations for him.¹⁴

13. Undoubtedly cards for gambling rather than a purely social activity. The cost was about \$260 in today’s U.S. dollars.

It is useful to have some idea of costs expressed in present-day values, so let me make a very crude comparison. From several explicit statements in the diary, we know that the annual wage of an ordinary person was about £50; for example, the servant employed by Camus received 18/- per week. Consequently, a very crude, but for my purposes adequate, comparison is to set inflation since that time at about 300:1.

For example, Lalande’s trip cost 1,177 livres, the equivalent of about one year’s wages for a worker or perhaps \$30,000 today. The quadrant purchased by Lalande cost a year’s wages and the longitude prize was worth about \$12,000,000, which goes a long way to explaining the attitude of Harrison and others towards the Board of Longitude, and Harrison’s reluctance to show H4 to anyone.

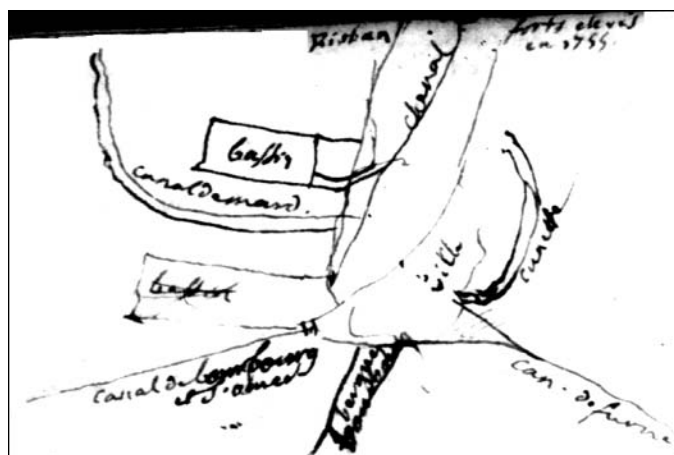


Figure 5. Plan of Dunkirk. The top third of page 12 of the manuscript.

Perhaps Monod-Cassidy’s comment that he “discussed methods...” is the critical point. He may well have been “filled with enthusiasm and exceeded the logical limits of the problem” (whatever that means), but this enthusiasm appears to have been directed towards philosophical description rather than practical research. For example, in his diary Lalande provides quite detailed information about three marine chairs (most of page 80 and the top half of 81 shown in Figure 1). The marine chair was created to determine longitude by observing the eclipses of Jupiter’s moons, a method that required powerful telescopes. However, to a sailor standing on a ship’s rocking deck it was nonsense, because it could not stabilize a telescope sufficiently to get the necessary sightings. As Maskelyne discovered, this intellectually satisfying and theoretically correct method was a delight to the scientist who viewed the Earth as a perfect sphere partly covered with smooth, steady, and equally spherical fluid; but it was a navigator’s nightmare. As far as I can tell, Lalande never went outside Europe and his longest sea voyage was the 20 or so miles across the English Channel.

This picture of the man and his work enables us to understand Lalande’s relationship with science and technology. Lalande’s physical disability and intellectu-

14. Alan Cook, *Ladies in the scientific revolution*, Notes and records of the Royal Society, 1997, vol. 51 (1), pp. 1-12.

It is interesting to compare the notes in Lalande’s diary with Thomas Hatton, *An introduction to the mechanical part of clock and watch work 1773* (Reprint, London, Ont.: Movements in Time, 1978), the only contemporary “arithmetical” book I am familiar with. Lalande merely displays the skills Hatton teaches to uneducated apprentices.

al curiosity led him into an academic education, and he became an astronomical observer. But his eyesight deteriorated; so, being intelligent and multi-lingual with much more in common with Derham than Hooke, he turned his skills to technical journalism.¹⁵ He wrote on astronomy, the manufacture of paper, the treatment of leather, and ocean tides. He added supplements to the *Dictionary of atheists* and edited mathematical tables created by others. And he wrote an eight-volume travel guide to Italy and a booklet on the interior of Africa (which I believe he never visited).

Lalande was intelligent and educated, an able philosopher, and a thoughtful writer. But what we know about him also points inexorably towards the conclusion that he was a disabled, quarrelsome dilettante who affected an artificial, austere intellectualism.

Now we can look at what Lalande might have known about horology. There are several points to be gleaned from the diary and other documents.

First, in 1755 J. A. Lepaute published his *Traite d'horlogerie* containing two chapters written by le François de Lalande, *Traite des engrenages* and *Remarques sur la maniere de trouver facilement des nombres pour les roües*. This at least indicates some knowledge of gearing, but the chapters do not show any real involvement with horology; they are abstract mechanics and, in many ways, simply a reiteration of the work of his fellow traveler Camus, Philippe de La Hire, and others.¹⁶

Second, Berthoud and Camus were sent to London as an official delegation from the French Academy of

Science to examine Harrison's timepieces. If Lalande was a member of this delegation he must have been interested in H4, and many of his meetings with people should be viewed as deliberate contacts to further this aim; at least one entry (May 3rd, quoted above) seems to support this view. But there are several facts that contradict this suggestion. He never says he was a member of the delegation. He paid his own way and had to borrow some of the money, whereas Berthoud and Camus had their trip financed.¹⁷ Further, he traveled by himself and he indirectly heard of the arrival in London of Camus and Berthoud. Most importantly, the certificate Berthoud submitted to the Royal Society for election as a fellow does not mention him:

"...the Academy of Science..., by the choice of [Berthoud] by the same society to accompany Mr Camus, one of its members, deputised to assist in the explanation and examination of the elder Harrison's marine chronometer."¹⁸

There is little doubt that Lalande knew Camus and Berthoud from Paris. Consequently, he would have been very useful to this two-man delegation because he spoke English, he knew his way around London, and he had already met most of the key people. It is far more likely that Lalande "tagged along" with two acquaintances on an exciting quest, acting as guide, interpreter, and letter-writer.¹⁹

Third, it is noteworthy that Lalande had a letter of introduction to James Short and visited him as soon as he arrived in London. Short was a fellow of the Royal Society and an astronomer who made optical instruments; hence he and the astronomer Lalande had com-

15. William Derham (1657-1735), an English "divine" and Fellow of the Royal Society who devoted his talents to natural philosophy. He was "essentially a good observer" who submitted many papers to the Royal Society on his experiments in diverse areas, but he did nothing of lasting importance. He wrote several natural philosophy books, (justifying them to his church by arguing for an underlying "hand of God" without detracting from their essentially scientific nature) and one on the discoveries of Robert Hooke and his contemporaries. These are compilations, summaries of the work of others, and contain little original to the author; they are good surveys, but show Derham to be primarily a commentator. He is perhaps most noted for *The Artificial Clockmaker*, a book of dubious merit. See Charles Aked, "William Derham and *The Artificial Clockmaker*," *Antiquarian Horology*, March, June, and September 1970) and my review of *The Artificial Clockmaker* (in Richard Watkins, *Mechanical Watches, an Annotated Bibliography of Publications since 1800*, 2004) for two different opinions.

16. The first of the chapters in Lepaute appears in translation as "A treatise on pitchings" in H. L. Nelthropp, *A treatise on watch-work, past and present*, (London: E. & F. N. Spon, 1873). My earlier comments on Lalande's mathematical ability make me wonder if Nicole-Reine Lepaute was actually the author (see note 14).

Camus was undoubtedly a mathematician and mechanic of outstanding ability, and he published a major work on gearing well before Lepaute's book. Perhaps the most accessible version is C. E. L. Camus and J. I. A. Hawkins, *A treatise on the teeth of wheels* (London: J. S. Hodson, three editions in 1806, 1837, and 1868), which is a translation of two chapters from his *Cours de mathematique*.

17. Not only that, the official party had about ten times the money that Lalande spent. Between them, Berthoud and Camus had 12,000 livres or about \$300,000 in today's money, the equivalent to roughly ten year's wages for a worker. I hope all of this was not meant for living expenses and some was to purchase information.

18. Royal Society Certificate EC/1764/12 dated May 19, 1763.

19. Berthoud couldn't speak English; see *L'art de l'horlogerie en France* (Antiquorum auction catalog, 1993), p. 132, and Anthony Turner (note 28).

mon interests. Short was also one of Harrison's main supporters. But it was not until the *seventh* time Lalande and Short met that he took Lalande to meet Harrison. This makes sense when we realize that Lalande's visit to England was, in part, in order to become a Fellow of the Royal Society. The certificate for his election lists eight proposers, six and possibly all of whom he met within a few days of his arrival.²⁰ So it is not necessary to suppose the meeting with Harrison was anything more than Short introducing two of his friends to each other.

Finally and most importantly, references to clocks and watches are almost totally absent from the diary. Other than noting that Berthoud thought the clocks were marvelous, there are no details at all of Harrison's timepieces; and the only other horological remarks are a passing comment about a clock and that Mr. Nivernais bought a watch. Horologists are not mentioned. He met Harrison and Ellicott (almost certainly just socially), but where are Cumming, Dutton, Emery, Kendall, Mudge, and the rest who placed England at the forefront of horology? In contrast, Lalande provides explicit details of marine chairs, experiments in electricity, the design of ships, and the layout of Vauxhall gardens, amongst other things. And the people he did meet were scientists, politicians, and Frenchmen.

Consequently, all the evidence indicates that, although he may have dabbled in it some ten years earlier, Lalande knew little about horology and wasn't interested in Harrison's work.

... and Answers

In examining the three questions I posed at the beginning of this paper, I have shown that Lalande removed pages from his diary, but he had little interest in or knowledge of horology, and he almost certainly didn't see H4 or J1. Under these circumstances, how can we explain the missing pages?

Do one more experiment for me. Take a blank notebook and go on a holiday to London. While you are there keep a diary as Lalande did and, when you feel like it, write something independent of but perhaps related to a diary entry on the next blank page. Then,

20. Royal Society Certificate EC/1763/13, 1763. The proposers were Lord Morton (March 24), J. Parsons (March 24), James Burrow (not mentioned but probably March 17), James Short (March 16), Gowin Knight (April 14 but probably much earlier), Thomas Birch (March 17), Charles Morton (March 17), and M. Maty (March 16); the dates in parentheses are when Lalande notes in his diary the earliest time that he met the person. The certificate was posted on April 14. Lalande met most (all?) at the weekly dinners of the Royal Society Club in the Mitre Tavern, where he was taken at least five times; see Sir Archibald Geikie, *Annals of the Royal Society Club* (London, 1917).

before you write on the other half of the sheet or leave London, pull out the page for some purpose. What was the purpose?

This is the crux of the missing pages. Lalande must have had a purpose in removing them and the only credible reason I can think of was to give them to someone else; if he had written something for himself there would be no reason to remove the pages. Further, he had to be in a place where an alternative source of paper was not readily available; it is silly to pretend that London was devoid of notepaper.

I have shown that we cannot definitely state which pages were removed, so we need to find entries in pages 47-66 and 69-80, where Lalande was out-and-about and might have noted something to give to another person.²¹ In the first case the only likely entries are April 22nd (pages 53-54, to describe the clocks he saw when he visited Harrison) and April 26th (pages 57-58, to write a letter to Fouchi). As he was a poor draughtsman (see Figure 5), I think the latter is more probable. In the second case there is only one possibility: May 3rd (pages 73-74), to make notes on street lighting for Parcieux; as I have noted above, it could not be May 9th (pages 81-82).

Until now I have deliberately avoided mentioning a crucial point and the question it poses: The justification for Lalande's involvement is that Randall and Andrewes said Berthoud made watches looking suspiciously as if based on ideas inspired by Harrison's H4 and J1. So, in what ways are Berthoud's watches suspiciously like Harrison's?

From the photographs in Randall's article and in other books, I must admit they look a bit similar. But nearly every watch of that time looks similar to nearly every other watch of that time; and the aspects that make them suspiciously alike must be something far more significant than roundness and wheels with pinions. For example, Jonathan Betts²² argues that early Arnold chronometers were derived from H4. But he provides specific dimensional and constructional information to show that the similarities could not be the result of mere chance. Similarly, no one would suggest that the cheap verge watches signed Breguet were made by copying Breguet's designs. So what details of Berthoud's and Harrison's watches does Randall provide?

J1 has maintaining power, internally cut teeth on the third wheel, a dramatically modified verge escapement, a straight bimetallic curb, and the diameter of

21. See note 9. Also, Lalande may have removed any number of sheets from the middle of his diary! But as no one else has mentioned this possibility, I am going to ignore it.

22. Jonathan Betts, "Arnold and Earnshaw: The Practicable Solution," in *The Quest for Longitude*, ed. William Andrewes (Cambridge, MA: Harvard University, 1996), p. 315.

the back plate is 4.1cm. In contrast, Berthoud's *Première montre astronomique* is an ordinary verge with gridiron compensation housed in a 4.9cm case. From which I conclude they were both about the size of an ordinary pocket watch, but otherwise quite different.

In the case of H4 and Montre marine no. 3, the only aspect stipulated by Randall is size. However, the fact that H4 was large was not unknown and I can easily imagine James Short saying, "Oh, it's big!" spreading his fingers and demonstrating, "about this big." Although the size of H4 is important, by itself it is not an "invaluable" or precise piece of information, especially as one watch is more than an inch larger than the other. The internal design of the movement and especially the escapement is vastly more important than the size of the movement; and later, Earnshaw demonstrated this when he made pocket chronometers with a performance similar to full-size marine chronometers. Thus, despite Lalande's explicit contradiction, we may admit that Lalande could have seen the outside of H4, but what he may have learned and then related to Berthoud would not have required notes and would not have helped Berthoud understand the significant features of that watch. Indeed, Randall also says "that Berthoud had only a superficial grasp of Harrison's concepts," but it would be more correct to say that Berthoud had no grasp at all because he knew nothing at all about the design of J1 and H4.

So, in fact, Berthoud did not copy Harrison's watches J1 and H4.

At last we are in a position to give sensible, if tentative explanations of the missing pages. On April 26th, Lalande went shopping and bought some eyeglasses for himself and two books for Mr. Fouchi. He probably used a page from his diary to write a letter to Fouchi so that he could post it immediately. On May 3rd Lalande probably made notes on street lighting. These suggestions are not necessarily correct, but they do fit what we know of the diary and how it was written, and I am not aware of any other explanation that fits the facts.

A Near Myth

In 1954, Morpurgo wrote a small pamphlet on the origin of the watch.²³ In it he critically examined the evidence for Peter Henlein being the inventor of the watch and proved quite conclusively that the honor bestowed on Henlein is simply a myth.²⁴ Although

23. E. Morpurgo, *The origin of the watch* (Roma: Edizioni La Clessidra, 1954).

24. Henlein is not horology's only myth. As we know, the Nuremberg egg is a mythical style of watch created by a misinterpretation of Rabelais when *Gargantua and Pantegruel* was translated into German (and there is a subsidiary myth because the error was by the typesetter and not the translator as most would have us believe). There are probably many more and I would include amongst them the Arnold/Earnshaw controversy.

Henlein was his subject, Morpurgo was more concerned with author responsibility and central to his argument is that professional historians are "those people who, by the use of documents and their own intelligence and knowledge, pursue a matter to its core." In addition, he states that we should beware of writers "who blindly repeat the opinions of others." However, this is an idealistic and impractical point of view. All historians necessarily rely upon the research of earlier authors, not only to avoid "reinventing the wheel" but also to reduce their tasks to something manageable. Except for the remark about "spies," which I feel was unwise, both Andrewes and Randall quite reasonably rely upon the opinions of others, just as I have used Jonathan Betts' study of John Arnold's watches without verifying his statements.

The origins of the "myths" that Lalande was a member of the commission and that he had seen H4 are hard to pinpoint. In 1923 Gould wrote in his *The Marine Chronometer* that "Camus, Berthoud and Lalande came over for this purpose," which is the earliest statement about the commission I have found, except for the diary and other contemporary documents. In 1926 Frederick Green supported this view by writing that "the immediate object of [Lalande's] crossing was to take back to France a pendulum invented by the famous Harrison," a nonsensical statement repeated by Monod-Cassidy in 1980.²⁵ In contrast, in 1955 Guyot got it right, omitting Lalande.²⁶ Unfortunately, Gould and Green do not give sources for their views.

The next article was in 1977 when Seymour Chapin examined Lalande in the context of Harrison and H4.²⁷ However, Chapin's paper contains a number of errors and relies on the April 22 meeting to show that Lalande had seen H4. Unfortunately, Randall used Chapin as a source, including repeating Chapin's statement that "Short expressed his astonishment that Harrison had left London without confiding even with him" when the diary explicitly refers to "Harrison's son." But Chapin, and hence Randall, do state that Lalande was not part of the commission. After this paper we next have the 1980 publication of most of the diary by Monod-Cassidy.

25. Frederick Green, *The journal of Lalande's visit to England in 1763*, History teachers' Miscellany, 1926, vol. IV, pp. 113-118 and 140-144. Green translated only a part of the diary and "purposely omitted several passages of a technical sort which today are devoid of interest"! In fact, one purpose of Lalande's visit was to purchase an instrument, but it was a quadrant to be made by Bird and not a chronometer.

26. Edmond Guyot, *Histoire de la détermination des longitudes*, (La Chaux-de-Fonds: Chambre Suisse de l'Horlogerie, 1955).

27. Seymour Chapin, *Lalande and the Longitude: a little known London voyage of 1763*, Notes and Records of the Royal Society of London, 1977-8, pp. 165-180.

Then, in 1984, Anthony Turner repeats the statement that Lalande saw H4 on April 22, and also says he met watchmakers when in fact he did not.²⁸ Finally, in 2000 David Landes loosely cites Turner when describing Lalande's role and seeing H4.²⁹ However, Turner is quite clear that Lalande was in England as a private person and Landes unaccountably changes this to "France sent two other commissioners to join him."

The "errors" in pagination are less of a problem. They are first mentioned by Chapin (who fails to note the "error in pagination" at pages 66-67) and then "correctly" specified by Monod-Cassidy. The significance of them is ignored by everyone except Andrewes.³⁰

This brief summary makes it clear that although we should respect Morpurgo's advice, we need to treat it with care. All of these writers are professional, competent historians and researchers, and yet some dubious opinions of the role of Lalande have been repeated over many years, so that now they tend to be treated as fact. All have (quite reasonably) relied on the groundwork of those before them, and so the substance of myths can be the result of misfortune or oversight rather than shoddy work. But this is not surprising. I don't think anyone imagined that a couple of page numbers and the interpretation of words such as *j'ai été voir* could be important. Anyway, in 1766 Berthoud returned to London and managed to get some details of H4 from Thomas Mudge, and the complete specifications were printed in 1767; consequently, any role Lalande might have played ceased to matter. But, if you will excuse a pun: a near myth is as good as a mile, both are off target.

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About the Author

Richard Watkins lives in the horological desert of Tasmania (the little bit under Australia). When not hand-feeding parrots and a shrike thrush, he collects pocket watches. Richard has produced nine translations of horological books and a bibliography, *Mechanical Watches, an Annotated Bibliography of Publications since 1800*, all but two of which can be freely downloaded from www.watkinsr.id.au. His aim in life is to work out what to do next, but so far, he has no idea.

28. Anthony Turner, "Les problèmes de la navigation en France et en Angleterre: un contexte historique pour les recherches chronométriques de Ferdinand Berthoud," in *Ferdinand Berthoud 1727-1807 horloger mécanicien du roi et de la marine*, ed. Catherine Cardinal (La Chaux-de Fonds, 1984), pp. 143-163. As I have noted, Lalande did meet Ellicott, but almost certainly only socially, because he was a Fellow of the Royal Society.

29. David Landes, *Revolution in Time*, (Rev. ed., Cambridge, MA: Belknap Press of Harvard Univ., 2000), p. 170. This does not appear in the first edition.

30. Andrewes, as I have noted, wrote "exactly as written on page 81 of Lalande's original manuscript," but the page is not numbered and, as I have shown, has to be page 83. But Andrewes is in excellent company because Lalande himself incorrectly references this page in his table of contents! Both naturally assume the page following the numbered page 60 must be 61. Lalande's error is interesting because it shows that a page was removed before he made the table of contents entry.