

Accidental Anglo-Dutch Collaborations: Seventeenth-Century Science in London and The Hague

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On 23 January 1675 – as every historian of science knows – Sir Constantijn Huygens’s second son, Christiaan, who had for almost ten years been the leading scientist at the Académie Royale des Sciences in Paris, drew in his notebook a sketch of a coiled hair-spring with one end attached to the centre of the balance of a pocket-watch, and wrote underneath it, ‘eureka’. The exclamation signified his triumph at having devised a method of harnessing the isochronous properties of a spring, to allow it to be used to regulate the mechanism of a compact timekeeper, just as a swinging pendulum could regulate a clock.¹

A week later Huygens sent a letter to Henry Oldenburg, Secretary of the Royal Society in London, officially lodging with the Society an anagram cryptically containing the secret of his spring-driven balance. On 20 February, having heard that his French clock-maker Isaac Thuret had gone to the authorities claiming the clock he had made to Huygens’s technical specifications was his own, Huygens went public with his timekeeping breakthrough. He rapidly secured a French *privilège* or patent for the watch, and published an account of it (with diagrams) in the next issue of

¹ A coiled spring was a standard feature of a traditional clock, incorporated as a driver of the mechanism (wound up with a key to drive the clock-work as in any modern clock-work toy); Huygens’s original idea was to move it to act as a regulator of the balance.



the journal of the Royal Society's French counterpart, the Académie Royale des Sciences.

On 20 February Huygens wrote to Oldenburg disclosing the solution to the cipher: 'The arbor of the moving ring [the balance wheel] is fixed at the centre of an iron spiral'. He proceeded to enlarge on this with a verbal description:

The fact is, this invention consists of a spring coiled into a spiral, attached at the end of its middle [i.e. the interior end of the coil] to the arbor of a poised, circular balance which turns on its pivots; and at its other end to a piece that is fast to the watch-plate. Which spring, when the Ballance-wheel is once set a going, alternately shuts and opens its spires, and with the small help it hath from the watch-wheels, keeps up the motion of the Ballance-wheel, so as that, though it turn more or less, the times of its reciprocations are always equal to one another.²

London's leading expert in time-keeper development, the Curator of Experiments at the Royal Society, Robert Hooke, learned of Huygens's claim to be the first to invent a spring-regulated clock while dining with Robert Boyle (son of the Earl of Cork, and a distinguished scientist who had once employed Hooke as his laboratory assistant) on 25 February 1675 (London style). The following day Hooke lodged a formal complaint at a meeting of the Royal Society. He reminded the members that he had himself produced spring-regulated clocks at their meetings on several occasions in the 1660s, and declared that Huygens's version was 'not worth a farthing'. The affair rumbled on for several years. In the end, Huygens's priority claim was by-and-large accepted, even in England. Although (in spite of Oldenburg's best efforts) he was never granted an English patent for his balance-spring watch, he was issued with patents or licences in France and the northern Netherlands, and is today generally credited with this significant innovation in horology.

But was this really how it was? Instead of rushing to look for a 'winner' in the 'race' to find a precise longitude timekeeper, perhaps we should take our cue from the draft notes for a lecture by Hooke delivered around 1676, responding to Huygens's 'eureka moment', and preserved in the treasure-

² Oldenburg *Correspondence* 11, 186 (translation from the French taken from the version published by Oldenburg in the *Philosophical Transactions* of the Royal Society in November 1676).

trove of Sloane scientific papers in the British Library. In it he queries Huygens's claim to single-handed solution of the problem:

He should also have Remembred that Golden Rule to doe to others as he would have others doe to him <&> not to have vaine gloriously & most Disingenuously Indeavourd to Depri[ve] others of their Inventions that he might magnify himself and wth. the Jack Daw pride himself in the plumes of others.³

In the spirit of which, I propose to take another look at the evidence, to try to decide whether Hooke might have been right. Did that Anglo-Dutch exchange of ideas effectively amount to an international collaboration, and ought the two men in fact have been given the credit for a ground-breaking horological invention, the balance-spring regulator for a pocket-watch? The story begins in the Netherlands in the 1650s, almost twenty years before Huygens's eureka moment.

In the late 1650s, almost a decade after the execution of Charles I, and at the height of the English Commonwealth, the Scottish courtier Sir Robert Moray and his old friend Alexander Bruce (later second Earl of Kincardine) were both living in exile in the Low Countries.⁴ Bruce was attached to the itinerant court of Charles II, while Moray had settled in Maastricht, where he was part of a substantial English garrison assisting the Dutch Orangists to protect the southern Protestant Dutch border.⁵ The two were staunch royalists whose families had been closely involved in the fortunes of the Stuarts. Now, cut off from familiar social circles, and with no likelihood (or so it seemed) that they would ever be able to return to Britain, both were occupying their spare time in recreational scientific activities – Moray had a chemistry laboratory complete with a number of stills, and both men were interested in pharmaceuticals and medical remedies.⁶

³ BL Sloane MS 1039, f. 129.

⁴ Moray and Bruce were related by marriage I believe (there are too many Morays/Murrays and Bruces to be able to prove this). They were both probably prominent Speculative Freemasons – Moray certainly was, and the fact that the present Earl of Elgin and Kincardine was Grand Master of Scotland suggests the Kincardines are connected dynastically.

⁵ On the English community at Maastricht during the Commonwealth years see J. P. Vander Motten, 'Thomas Killigrew's "lost years", 1655-1660', *Neophilologus* 82 (1998), 311-334.

⁶ For the text of the correspondence between Sir Robert Moray and Alexander Bruce, earl of Kincardine, see now D. Stevenson, *Letters of Sir Robert Moray to the Earl of Kincardine, 1657-73* (Aldershot, Hampshire: Ashgate, 2007). On Moray's laboratory see e.g.: 'I have been working all day and must be at it again tomorrow morning, by God's favour. You never saw such a shop as my laboratory is' (*ibid.*, p. 82).

They were also interested in precision timekeepers. In April 1658, Moray wrote to Bruce (who was at this point in Bremen where his family had salt and coal business interests):

I haue a second=watch can measure pulses, but no art can make a watch measure 2 minutes equally, unless yong Zulicom [Christiaan Huygens] at the Hague have found it out, who they say makes clocks that fail not a minute in 6 moneths. But this you will beleave as litle as I do, for I can demonstrate that it must go wrong to keep foot with the sun.⁷

A week later, Moray was able to tell Bruce (who had moved on to Hamburg) that he had now seen and handled one of the new pendulum clocks:

I have yet to tell you that I have this day seen an exceeding pretty invention of a new way of watch, which indeed I take to be the very exactest that ever was thought upon.⁸

The brief examination of the clock which Moray had had, had whetted his horological appetite: 'I needed no more for that than the very first glance I had of it. The rest is but a matter of adjusting of numbers for wheels and pinions'.⁹ If Bruce were prepared to put up the money, he went on, the two of them together could easily construct an improved version of Huygens's clock:

⁷ Stevenson, *Letters of Sir Robert Moray*, p. 190. See J. H. Leopold, 'Christiaan Huygens, the Royal Society and Horology', *Antiquarian Horology* 21 (1993), 37-42; 37. It appears from this form of words a) that Moray had a good understanding of the improvement in accuracy achieved by the pendulum clock developed by Huygens from 1657, and b) he understood the need for correction to bring clock time in line with solar time.

⁸ 'The Rhyngrove shew it me. It is long since I heard of it, but did not expect what now I see. The inventor undertakes it shall not vary one minute in 6 moneths, and verily I think he is not much too bold. He is a young gentleman of 22, second son to Zulicon [Sir Constantijn Huygens], the Prince of Orange's secretary, a rare mathematician, excellent in all the parts of it. I need not describe it to you till we meet, and then I believe I may get you a sight of it.' Stevenson, *Letters of Sir Robert Moray*, p. 197.

⁹ The local Commander had shown it to him because it had a defect, and Moray could see what that was: 'I find the greatest matter I have at hand to do it with, is that clock I told you of in my last. It is one of the prettiest tricks you ever saw. It stayed no longer here then just to let me see it, as if God had sent it hither of purpose. It was a good part of the time in my hands. It hath a defect and the Rhyngrove sent it to me to consider of, for all that buy them oblige themselves not to put them into workemen's hands. I needed not look upon it long to know all was in it. I needed no more for that than the very first glance I had of it. The rest is but matter of adjusting of numbers for the wheels and pinions.' However, he thought it best to advise that the clock be returned to its maker, Solomon Coster.

If I thought you had a mind to bestow 40 dollars or some less on one of them I would think to have it ready for you against you come. Never any other design made wanrests¹⁰ go so equally. ... If I make any, I will make it beat another time then this doeth, for it beats at the rate of 80 strokes of the wanrest or thereby to a minute. and I will make it beat just 60 which will be the seconds, and will put an index to shew them. But there is no end of tricks of this kind. When you come to the shop you may perhaps find there will and weal.¹¹

Moray had, it seems, not at this point met Christiaan Huygens in person, but he was aware of his reputation.¹² It is likely that Bruce already knew the Huygens family too, as they were supporters of Charles II and his sister Mary Stuart (widow of William II of Orange), and frequenters of the social and cultural court circle of Elizabeth of Bohemia (Charles I's widowed sister, resident for thirty years in the Hague). By September that year he certainly had met Christiaan, and they had established a shared interest in maritime timekeepers. Bruce was one of the recipients of a presentation copy of Huygens's first publication on timekeepers, *Horologium* (1658) – the book in which Huygens announced his invention of the pendulum clock, and his proof of the isochronous properties of cycloids.¹³

In any case, it is Moray who is urging Bruce to take an active interest in the new pendulum clocks, which he himself clearly understands a good deal about already. And Bruce soon had ample occasion to follow his friend's advice.

¹⁰ Parts of the escapement mechanism in clocks.

¹¹ Stevenson, *Letters of Sir Robert Moray*, pp. 198-9.

¹² Since Christiaan's father, the diplomat and lifelong servant of the Princes of Orange Sir Constantijn Huygens, boasted about his son on every possible occasion – his 'Archimedes' as he dubbed him –, and Moray and he moved in the same circles, this is not surprising. The first surviving communication between Moray and Christiaan Huygens is a letter dated 22 March 1661 (o.s.), shortly before Huygens arrived in London for the first time from Paris. *Oeuvres Complètes* 3, 260-1. However, it is clear that the two already know one another well, since it concludes: 'Je n'ay rien a present à y adiouter si ce n'est que vous verre par le liure que le porteur vous presentera que J'ay eu raison de vous persecuter comme J'y ay fait, de ce que vous tardez tant de donner au iour les traitez dont Je vous ay si souuent parlé. ... Escriuez moy souuent.'

¹³ Huygens, *Oeuvres Complètes* 2, 209. Elizabeth of Bohemia, sister of Charles I, was another recipient, suggesting that Huygens and Bruce had met in her court circle at the Hague. In *Horologium* Huygens writes: 'I omit to speak of the so-called science of longitude, which, if ever it existed, and so had provided the greatly desired help to navigation, could have been obtained in no other way, as many agree with me, than by taking to sea the most exquisitely constructed timepieces free from all error. But this matter will occupy me or others later.'



The following year, in 1659, Alexander Bruce married Veronica van Aerssen van Sommelsdyck, daughter of Cornelis van Aerssen, Heer van Sommelsdyck, the wealthiest man – and one of the most politically prominent – in the United Provinces, and set up home in the Hague. The van Aerssens were a distinguished diplomatic family, who had served the house of Orange for three generations. They were neighbours of the Huygenses, in het Plein, the smartest quarter of the Hague, close to the Mauritshuis.¹⁴ On the eve of the Restoration of Charles II, Bruce – now the Earl of Kincardine – became an extremely rich and influential man in Holland, and a family friend of one of the most celebrated horologists in Europe. He retained his Scottish rank and position also – Dr Samuel Johnson’s friend and biographer James Boswell was a direct descendant.

From Moray’s correspondence we learn that Alexander Bruce and Christiaan Huygens began working on clocks together almost as soon as they met. In early 1660 Moray (now in Paris, probably helping negotiate the terms of the return to the English throne of Charles), wrote responding to a description of this work by Bruce:

If all Mr Zulicom’s addition to his invention be no more but the making of a clock of the size that the pendule beats the seconds, that is every stroak takes up a second, I do not consider that of [importance at] all. For I know the pendule must be about a yard long to do that, and it is believed here that all the church clock’s in the Hague are made after his way, so that they ever strike all at once, for so it hath been said here to our queen [Henrietta Maria]. I have not seen his book, nor think it can be bought here. therefore think of sending me one. If you recommend it to Sir Alexander Hume¹⁵ and bid him send it by some of the Earl of St Albans’s servants it will come safe. If I see him here I will talk to him of his perspective glasses, and mean to make my court with him upon your account.¹⁶

¹⁴ Lodewijk Huygens writes to his brother Christiaan in this period saying that the van Aerssens house is the most fashionable, and most frequented house in the Hague.

¹⁵ Hume was chamberlain to Maria (Mary), Princess of Orange. In 1665. Moray referred to ‘Sr Alexander Hume who was a kinde of Mayordomo, to the late princess Royalle and well known to Mr Huygens,’ Oldenburg, *Correspondence*, 2, 477.

¹⁶ Stevenson, *Letters of Sir Robert Moray*, p. 211.

So Moray and Huygens had still not met, though Moray was intent on their doing so, to discuss lenses and telescopes with him, and in order that he might ‘make [his] court’ on Bruce’s account.

In summer 1660, Sir Robert Moray returned to London, where he was given a senior Scottish appointment in the new government of Charles II, and became part of the close inner circle of courtiers, with lodgings within Whitehall Palace itself.¹⁷ By now Bruce has ordered a Huygens-designed clock for Moray, at his own expense, whose delivery Moray was eagerly awaiting.¹⁸

Alexander Bruce and his Dutch wife, meanwhile, settled into a well-to-do international life-style pattern which involved moving between the family home in the Hague, London, and Bruce’s family home (and coal-mines) at Culross (Fife) in Scotland.¹⁹ In 1668, for example, Veronica’s mother, in a letter to Constantijn Huygens congratulating him on the marriage of his son Constantijn junior, told him that she was currently staying with her daughter and son-in-law at Culross, which she found very beautiful (she planted tulips), though she was having trouble learning English.²⁰

The Royal Society was established in London on 28 November 1660 by a group of scientific enthusiasts that also included John Wilkins, Robert

¹⁷ Moray had played a prominent role in negotiations in Scotland, during events preceding the arrest and execution of Charles I. Charles II recompensed handsomely those who had stood by his father right up to his end. See now David Stevenson’s introduction to his edition of the Kincardine correspondence.

¹⁸ ‘I am well pleased with Mr Zulicem’s ordering of my clock. Let it be so, and I will thank him when I see him. I have not time now to talk of that curiosity you mention, but where people think it needless and that those watches are best that have the pendule fast to the axeltree that hath the two pallets [E.L. Edwardes, *The Story of the Pendulum Clock* (1977), 41, interprets this as a reference to a type of ‘crutch’ (a fork-like device through which a clock pendulum runs) that Huygens had introduced], but I am not yet of their mind, nor for that advantage he speaks of in the stoppers you mention. I shall onely say more of this that if the watch do not mark the inequality of the days, it goes not equally.’ Stevenson, *Letters of Sir Robert Moray*, p. 217.

¹⁹ On Culross, the Bruce family home, see *Royal Commission on Ancient and Historical Monuments and Constructions of Scotland: Fife, Kinross and Clackmannan* (Edinburgh: HMSO, 1933), pp. 69-87. See also Dutch-style water landscape of Culross (across the Forth of Firth) by John Slezer (1693).

²⁰ ‘[Dutch summary] I shall be going home shortly, because the winter is coming on. I regret that I did not come here three months earlier, then I would have made a little progress with the language. [French verbatim] And I would have had the contentment of spending [more] time with the Count of Kincardine and my daughter, and this agreeable peace and civility [civile noblesse]. [Dutch summary] It is very beautiful and fruitful here. The Lord of Kincardine’s house lies on a high hill and the park is delightfully close by. My daughter is extremely sad that I am leaving.’ Culross, 15 September 1668, Worp letter 6677.

Boyle and Christopher Wren.²¹ Sir Robert Moray and Alexander Bruce were founder members. The records show them to have been extremely active – usually together – in the Society’s early meetings.²² Precision timekeepers were on the agenda of these from the outset – particularly Huygens’s new pendulum clocks. The pendulum improved the accuracy of mechanical clocks dramatically – from a variance of 15 to 30 minutes a day, to less than a minute.²³ Its potential for naval and military use looked extremely promising.

Throughout the 1660s, the records of the Royal Society document a steady sequence of experiments involving pendulums and other isochronous oscillators in timekeeping.²⁴ Moray was not the only enthusiast, but his prominent position (he chaired the meetings) meant that his encouragement of improvements to Huygens’s published designs was important.



Christiaan Huygens paid his first visit to London in April 1661, as part of the official United Provinces delegation attending Charles II’s Coronation. It was his existing Anglo-Dutch social connections that were responsible for Huygens’s developing cordial social relations with those with similar scientific and technological interests to his own in London. Almost the first courtesy call Huygens paid was on Bruce’s Dutch wife Veronica, to deliver a package to her from a Dutch mutual friend he had spent time with in Paris.²⁵ The next day Bruce took Huygens to a meeting of the Royal Society at

²¹ Moray was delayed in Paris, negotiating the terms of Charles II’s return with the French, until summer 1660.

²² See references in G. E. Scala, ‘An index of proper names in Thomas Birch, “The History of the Royal Society (London, 1756-1757)”, *Notes and Records of the Royal Society of London* 28 (1974), 263-329. Moray remained an enthusiastic member; Bruce, however, was eventually too occupied with his own Scottish and Dutch affairs to participate actively. See M. Hunter, *Establishing the New Science: The Experience of the Early Royal Society* (Woodbridge: Boydell Press, 1989), p. 81.

²³ See D. S. Landes, ‘Hand and mind in time measurement: the contribution of art and science’, *Notes and Records of the Royal Society of London* 43 (1989), 57-69, p. 61.

²⁴ For a full and clear account of these see L. D. Patterson, ‘Pendulums of Wren and Hooke’, *Osiris* 10 (1952), 277-321.

²⁵ Huygens was given a commission in Paris 14 March 1661 to convey to Mme Bruce (Veronica van Aerssen van Somelsdijk) – *Oeuvres Complètes* 22, 561. Having arrived in London, on 4 April he duly visited Bruce and Mme Bruce, following which Bruce took him to Whitehall garden ‘veoir la / machine pour dresser le telescope de 35 pieds. Attendu M. Morre [Moray] dans sa chambre, qui ne vint point.’ [*Oeuvres Complètes* 22, 568-9]. 5 April, ‘apres souper M. Brus et Morre me vinrent querir pour observer au jardin de Weithall mais ne vismes rien a cause des nuées. M. Robert Morre nous donna des kaecks et du sec. M. Paul Neel de son Cidre fort excellent.’

Gresham College, at which Moray was presiding, following which, Dr Goddard took Huygens to his Gresham rooms and showed him three handsome pendulum clocks.²⁶

Thereafter Huygens spent much of his time in the company of Bruce and Moray (both of whom we should remember, spoke fluent French and good Dutch and had many Dutch social connections), and other Fellows of the Royal Society.²⁷ He did not even bother to attend the Coronation of Charles II, preferring to observe a lunar eclipse with members of the Society. Bruce showed Huygens pendulum clocks of his own design, in which Huygens took a particular interest.²⁸ John Evelyn tells us in his Diary that he and Huygens visited the clock-maker Ahasuerus Fromanteel on 3 May, ‘to see some pendules’.²⁹

By the time Huygens returned to the Hague in late May, a deep and lasting friendship had been established between himself and Moray, his relationship with Bruce had been consolidated, and he was also well-integrated with other leading members of the Royal Society. Thereafter he took a close personal interest in advancing the cause of pendulum-clocks in Britain, both scientifically and commercially. Thereafter, too, there was a regular to-and-fro Anglo-Dutch movement of letters and information exchanged between them, reinforced by social proximity and ease.

In October 1662, Bruce arrived in the Hague on one of his regular round trips to and from his home in Culross, having used the journey in both directions to test pendulum clocks modified to his own design for their suit-

²⁶ 6 April [*Oeuvres Complètes* 22, 569-70]: ‘[Johan Boreel] me mena veoir couper le peintre ou M. Brus me vint prendre et allames a l’assemblee à Greshams colleg. ou M. Morre presidoit, et me complimenta. on y recoit tous les lords, et non pas les simples gentilshommes sinon par election a la quelle il faut avoir les 2/3 des voix. qui parle oste le chapeau. l’on m’y apprit que les larmes de verre qui se cassent se sont en les trempant dans l’eau froide et les retirant subitement. Le doctor Godart nous mena veoir dans son appartement trois beaux horloges a pendules. de la fumes au jardin de Withall observer la Lune, Jupiter et / Saturne, mais cette lunette de 35 pieds ne me sembla pas bien distincte comme la miene de 22, dont je promis de faire venir les verres.’

²⁷ 11 April, Bruce, Moray and Huygens [plus Paul Neile, Brouncker, Boreel, Godard and ‘Vermuijen [Cornelis Vermuyden?] dined in ‘a cabaret’ and they would not let Huygens pay. 12 April Huygens ‘dit adieu a M. Brus’. 13 April went to Oxford. Saw Bruce and Moray again on 20 April. p. 576: ‘M. Moray nous regala souent dans sa chambre la aupres de kaeks, bottelail et vin. J’y appris a connoistre le Dr. Wilkins, autheur du livre que la lune peut estre un monde, et la terre une planete. Il est apres a faire une langue universelle.’ Huygens remarks twice in his diary on Moray’s generous hospitality and the ‘kaeks’ and ‘bottelail’ he provided as refreshments.

²⁸ *Oeuvres Complètes* 22, 606.

²⁹ E. S. de Beer (ed.), *The Diary of John Evelyn* 6 vols. (Oxford: Oxford University Press, reprinted 2000) 3, 285-6.

ability as longitude timekeepers.³⁰ According to Bruce, it was the success of these first trials which convinced Huygens that it was worth pursuing the possibility of adapting his new clocks to determine longitude at sea. He reminded Huygens later:

At my first arivall at the Hage, after the tryall I had made betwixt Scotland & that [the Hague] of my watch, when you did me the favour to see me at my chamber, we fell upon the subject of the going of the pendule watches at sea; & you told me positively then that it was your opinione that it was impossible, that you hade been making experiments of it, and all the effects of them was, to be settled in that opinion by them: you did lykewise urge reasons of the impossibility of it.³¹

It is not clear whether Bruce's marine clock had been built for him in Holland or England, by Dutch or English technicians, but it was certainly pendulum-regulated.³² He later told Huygens that this clock of his was the same one he had had in his possession in London eighteen months earlier when he and Huygens met there, and that it differed significantly from Huygens.³³

Encouraged by their mutual interest, and complementary expertise, Bruce and Huygens now began working collaboratively at the Hague, adapting pendulum clocks for sea-travel. Bruce favoured clocks with short pendulums for portability; it was he who added a 'double crutch' to keep the pendulum swinging in a single plane, and designed the methods of support

³⁰ Huygens, *Oeuvres Complètes* 4, 256, Huygens to Lodewijk Huygens, 31 October/9 November 1662: 'Je n'en suis pas encore si avant avec l'invention de Longitudes, comme il semble que vous croiez, et je voudrois que Mon Pere n'en parlast pas seulement tant que je ne l'aye assuré que la chose reussira. Monsieur Brus qui s'en est retournè en Escosse, aura fait une experience sur mer dont j'attens le succes avec impatience parce qu'elle est de grand importance, dans cette affaire.'

³¹ This version of events is confirmed in Hooke's 1674/5 Cutlerian lecture.

³² A description of this clock is to be found in Huygens's *Horologium Oscillatorium* (1673). See M. Mahoney, 'Christian Huygens: the measurement of time and of longitude at sea, in *Studies on Christiaan Huygens*, ed. H.J.M. Bos *et al.* (Lisse: Swets, 1980), pp. 234-270. In an unpublished Cutlerian lecture of 1674/5, rewritten (I believe) around 1678, Hooke describes the various clocks used in these trials.

³³ 'I came afterwards to see that watch by w[hich] you hade made your experiment; & I believe you will acknowledge that it was so farre different from mine in the whole way of it that it is not lyke they should ever have met. And the rather I thinke this, that I showed you at London 18 moneths before that tyme the same watch w[hich] received very small amendments thereafter; & if you hade thought that way able to bring it to passe, you might from that view have ordered one to be made for your tryell.' Huygens, *Oeuvres Complètes* 22, 606. Although by this time Bruce and Huygens had fallen out, there is no reason to doubt the accuracy of Bruce's memory of how their collaboration started. The letter is among the Kincardine Papers, and was intercepted by Robert Moray before it could be sent to Huygens.

and suspension which it was hoped would protect the clocks from the most violent of motions arising from storms and high seas (Huygens had simply tried suspending them from ropes).³⁴

It was the wealthy Bruce who paid for two state-of-the-art pendulum clocks, made by Huygens's current preferred Dutch clock-maker, Severijn Oosterwyck, which they agreed Bruce would test on his next journey to Britain, this time to London. By December the clocks were almost ready, and the two men were spending a lot of time together. On 4/14 December 1662, Christiaan told his brother Lodewijk that he had been slow responding to a letter, 'because of several visits I have received, and principally by that of Mr Brus [Bruce], who did not leave me alone for a single moment all afternoon. And he has been doing that quite often, ever since we set about perfecting our invention for [measuring] Longitudes.'³⁵

In other words, the earliest trials of pendulum-regulated longitude timekeepers – much discussed by historians of science – began as a robustly Anglo-Dutch venture. And once Bruce arrived in London, the correspondence with Huygens that followed demonstrates an extraordinary level of continuing Anglo-Dutch collaboration, with the English contributors now making the running.



For two weeks Huygens waited anxiously for news from London. He consulted the van Aerssens, but even they had not yet heard from their son-in-law. Eventually Huygens received a letter from Bruce, written on 2 January 1663 (English style). He apologised for having 'forgotten' to write, blaming this on the fact that he had nothing very positive to tell Huygens about the performance of 'his' (that is, Bruce's) clocks. The sea trials of the two pendulum timekeepers during his journey to London had not been a success. As they left the harbour, the 'packet-boat' which Bruce had secured for the crossing was hit by a contrary wind, 'and the boat was so small that even though it really was not a storm, the ship was shaken more strongly than one can shake a cradle, so that the suspending shaft [vis] that

³⁴ See Leopold, 'Christiaan Huygens, the Royal Society and Horology', p. 39.

³⁵ Huygens, *Oeuvres Complètes* 4, 278. Several days later, Huygens was expressing exasperation to Lodewijk that the enthusiastic Bruce had not yet left and was monopolising of his time. Christian to Lodewijk, 18/28 December 1662, *Oeuvres Complètes* 4, 284-5.

went into the ball and socket [boule] broke under the vibrations of the ship, and the older [clock] fell, while the newer [clock] stopped'.³⁶

A flurry of letters from Bruce and Sir Robert Moray to Huygens followed, detailing what had happened during the trials, and describing work the two Scots were now doing together in London, to improve the clocks' performance against the next trials. On 9/19 January Moray wrote to Huygens from London to tell him that he and Bruce were in discussions about 'your clocks', and 'the design which would make them succeed at sea'. More modifications, then, were being undertaken, this time with the help of the English clock-maker Ahasuerus Fromanteel (whose son John had recently returned from several years training in the Hague, learning to manufacture the new pendulum clocks with Huygens's original clock-maker Salomon Coster).³⁷ The clock which had fallen during the journey was too badly damaged to be repaired, and was replaced by one entirely manufactured in London by Fromanteel.

On 16 January 1663 (London style) Bruce wrote to tell Huygens that the damaged clocks were about to arrive (they had been held up at customs): 'I expect them tomorrow and then I shall show them to Sir Robert Moray & lett yow know their [his] opinions of them'.³⁸ Huygens remained optimistic. 'The lack of success you have had does not bother me,' he responded, 'nor does it diminish my good opinion of our undertaking'.³⁹ He told Bruce that he had begun modifying his clock-design in consultation with his Dutch clock-maker Severijn Oosterwijk, and would let him know how the improved mechanisms behaved.⁴⁰

At the beginning of March 1663, Moray wrote to Huygens letting him know that he and Bruce were going to conduct further trials 'at sea, going as far as the Dunes, to try out Mr Bruce's clocks, which he is trying to adjust to the best of his ability'.⁴¹ (Note that for Moray, now, 'your clocks'

³⁶ *Oeuvres Complètes* 4, 290-1, Bruce to Huygens, 2/12 January 1663.

³⁷ Leopold, 'Clockmaking', p. 159. In a later article, 'Christiaan Huygens, the Royal Society and Horology', Leopold attributes this clock to another Dutch clock-maker working in London, John Hilderson. He bases this on a reference by Moray (in a letter to Huygens) to having taken clocks to be adjusted at Hilderson's. Both clock-makers may well have been involved.

³⁸ *Oeuvres Complètes* 4, 301-2 Bruce to Huygens, 16/26 January 1663.

³⁹ Huygens to Bruce, 9/19 January 1663 *Oeuvres Complètes* 22, 593 (this is a letter from the Kincardine papers, so out of order in the *Oeuvres Complètes*).

⁴⁰ See J. H. Leopold, 'Clockmaking in Britain and the Netherlands', *Notes and Records of the Royal Society of London* 43 (1989), 155-65; 159.

⁴¹ *Oeuvres Complètes* 4, 318, Moray to Huygens, 19 February/1 March 1663.

(Huygens's) have now become 'Mr Bruce's clocks', though essentially the same two timekeepers are involved.) The usually conciliatory and tentative Moray continues, somewhat testily:

You are right in saying that the movement of large boats is gentler than that of small ones, but in heavy swells, particularly when the wind is head on, or when the ship is at anchor, the shocks are stronger and more violent. But what I fear most is not the agitation the ship gives to the whole body of the clock (though I am worried that that may have its effect also) but rather that the sudden movements of the ship downwards, and in the contrary direction, which in the one case will make the pendulum slow down, in the other will accelerate it. sometimes making it heavier, sometimes lighter, and either way unequally, which it seems to me is bound to cause deregulation in the movement of the clock's mechanism. But it still seems worth testing this experimentally.⁴²

The sharp critical tone of this commentary on the whole Bruce-Huygens project suggests that Moray (usually genial and urbane) is drawing on broader Royal Society discussions which had taken place concerning the performance of the clocks. Indeed, I'm afraid this sounds awfully like an expert assessment by Robert Hooke (who is just about to enter this part of our story).⁴³

Sure enough, we learn that Lord Brouncker (President of the Royal Society) and Robert Hooke (Curator of Experiments) had both taken part in those trials 'at sea, going as far as the Dunes' on 'one of his Majesties *Pleasure-Boats*'.⁴⁴ And according to Hooke, they 'experimentally found

⁴² Huygens, *Oeuvres Complètes* 4, 318.

⁴³ This suspicion is confirmed by the fact that Hooke's criticism of the Huygens longitude clocks, as recorded in the minutes of the Royal Society in 1665, repeat these criticisms in very similar words.

⁴⁴ In *A Description of Helioscopes and some other Instruments* (London: T. R. for J. Martyn, 1676) (conveniently to be found cited at length in Huygens, *Oeuvres Complètes* 7, 517-26) Hooke gives the date of this trial as 1662. In BL Sloane MS 1039, fol. 129v, in his Cutlerian lecture on the subject delivered in 1678 [?], he recalls the date as March 1664. I am confident that the actual date is March 1663. Pepys records another occasion on which a similar group took a boat to conduct scientific trials: Pepys records in his diary one such trip, in which he too happened to participate, in 1665: '1 [May]. [A]t noon, going to the Change [Royal Exchange], met my Lord Bruncker [Brouncker], Sir Robert Murry [Morauy], <Deane Wilkins> [John Wilkins], and Mr. Hooke, going by coach to Collonell Blunt's to dinner. So they stopped and took me with them. Landed at the Tower-wharf and thence by water to Greenwich, and there coaches met us and to his house, a very stately seat for situation and brave plantations; and among others, a Vineyard, the first that ever I did see.'

[the method of suspension] useless to that effect', though Hooke claimed he could see ways to correct the deficiencies of Bruce's ball-and-socket suspension arrangement.⁴⁵ Both Hooke and Brouncker had experience working with precision timekeepers, and both had an interest in perfecting their use to determine longitude at sea.⁴⁶ Both are now collaborating with Bruce (who, we recall, had impeccable connections on both sides of the Narrow Sea, in London and the Hague) in the hope of achieving a clock-based solution to the longitude problem.⁴⁷

So by early 1663, Robert Hooke has joined the team of Dutch, Scottish and English clock-experts collaborating in the development of precision longitude timekeepers. As he later insisted, he had been conducting experiments with clock-design for several years; now that experience is funnelled into the Bruce-Huygens project.

As far as Huygens was concerned, Hooke was a background figure in the activities of the Royal Society, an experimentalist and instrument-maker, who was inclined to make exaggerated claims for his technical instruments. Both Moray and Brouncker were well-informed amateurs, with a private and a professional interest in precision timekeepers (both owned state-of-the-art clocks and watches themselves, and knew how to look after them).⁴⁸ For the purposes of the longitude-timekeeper developments and trials, Hooke was their expert technician, acting as advisor and consultant on the English end of design and testing, who fed his results into Moray and

⁴⁵ Conveniently to be found cited at length in *Oeuvres Complètes* 7, 519.

⁴⁶ On 22 December 1665 Pepys recorded in his diary: 'I to my Lord Brouncker's and there spent the evening by my desire in seeing his lordship open to pieces and make up again his watch, thereby being taught what I never knew before; and it is a thing very well worth my having seen, and am mightily pleased and satisfied with it.' cit. Leopold, 'Christiaan Huygens, the Royal Society and Horology', p. 39.

⁴⁷ In 1663 Christiaan Huygens was again in London with his father, and frequented the Royal Society, which made him a foreign Fellow. The recently discovered 'Hooke folio' reveals that in early 1678, when Hooke was obsessively combing the early Journal Books of the Royal Society for all signs of Oldenburg's having 'done him down', and Huygens was beginning to claim that he had made key microscopical observations ahead of anybody else, one of the items Hooke chose to transcribe records a quite routine sort of occasion in 1663 when he and Henry Power (one of Hooke's fellow-microscopists at the Royal Society) carried out three experiments with the improved mechanism at the weekly Society meeting. 'Huygens [there]', Hooke has reminded himself aggressively between square brackets. And indeed, both Sir Constantijn and Christiaan attended this meeting.

⁴⁸ See e.g. Pepys, *Diary* 6, p. 377: 'I to my Lord Brouncker and there spend the evening, by my desire in seeing his Lordship open to pieces and make up again his Watch, thereby being taught what I never knew before; and it is a thing very well worth my having seen, and I am mightily pleased and satisfied with it', and Moray's exchanges with Huygens about the new-design clock he is trying to get William Davidson to collect from the Hague for him in early 1665.

Brouncker's dealings on this topic with the Royal Society (including Bruce and Huygens). Everything Hooke told Moray was directly communicated to Huygens; all Huygens's comments were relayed back to the Royal Society. The fact that England and Holland were at war for much of this period was apparently irrelevant.⁴⁹



Both knowingly and inadvertently, then, years before Christiaan Huygens's public announcement of his balance-spring solution to regulating a pocket-watch, English and Dutch scientists were in long-distance collaboration. Not everyone involved was as comfortable about this two-way traffic in intellectual property as were the elite, cosmopolitan amateurs, Bruce and Huygens, Brouncker and Moray. Robert Hooke had already taken issue with Christiaan Huygens's *On Pendulum Clocks* publicly, in one of his Thursday Cutlerian lectures. It was probably delivered in 1672-3, and survives in an autograph copy in Hooke's hand in the BL. Hooke makes a particular point of challenging the originality of Huygens's pendulum time-keeper on the grounds that others (including Hooke himself) had played a significant part in its development.⁵⁰

There is no mistaking Hooke's tone in this lecture – not for the first time he was deeply affronted that experimental results on a topic he considered one

⁴⁹ Patterson does, however, quotes a comment on the Bruce-Huygens trials by Abraham Hill which 'indicates that the problem of the free discovery of invention versus national security already had reared its head; "the only difficulty is, whether such arcana may be divulged, and so become of as much advantage to foreigners as to ourselves."' (L. D. Patterson, 'Pendulums of Wren and Hooke', *Osiris* 10 (1952), 277-321; 283.)

⁵⁰ The opening paragraph makes it clear that this was a Cutlerian lecture, written shortly after the arrival in London of the 12 presentation copies of Huygens's new work. There is a pattern, however, in other surviving lectures among the Royal Society papers, of Hooke's writing the lecture, and possibly delivering it, as a Cutlerian lecture, and then 'reading' it again to the Royal Society some four to six months later. The surviving manuscript of the lecture dealt with here begins: 'Gentlemen [this para struck through] I am very glad you haue giuen me an opportunity of Presenting the De-signe of Sr John Cutler and of Reading his Lecture <again> in this Place where it was first begun. I think I need not tell you that it was appointed in order to the prosecution of the History of Nature and of art a subject soe copious that tis not to be expected from the single indeauour of <any> one person how able soeuer that there should be any very notable progresse made therein, much lesse from my weak abilities. But tis from <the> vnited indeauours of the Royall Society <wth> whose <noble> designe <this> is coincident that great product is to be expected, Into whose <Grand> treasury however I shall not (god willing) be wanting to cast in my mite.' It looks to me as if Hooke first wrote the lecture when he got the *Horologium oscillatorium*, 1673-4, then rewrote it (and redelivered it?) when Huygens sent his eureka! announcement about the balance-spring watch in January/February 1675.

of his own specialist areas of interest should arrive on his desk in published form, without any acknowledgement from the author of Hooke's own contributions to the field, nor indeed, any reference to discussions he and Christiaan Huygens might have had on these or related topics.⁵¹

The two-way investigative traffic between London and the Hague, plus Hooke's less than generous protest against Huygens's priority claims, together provide a context for the collection of scattered papers belonging to Hooke which are now in the Wren Library at Trinity College Cambridge. These are undated, but the first section seems to correspond to a period of ongoing discussions between Hooke, Brouncker and Moray (with some interventions by Wilkins and Boyle), preparatory to Hooke's lodging a patent claim for a longitude clock of his own design on behalf of the Royal Society, during the period 1663-5.⁵² After Hooke's death, his friend and executor Richard Waller claims to have seen the draft patent document in Moray's hand among Hooke's papers.⁵³ We are now in a position to note the importance of the fact that Moray was also the person who had drafted a competing patent on behalf of Bruce and Huygens for *their* longitude timekeepers, which was being negotiated at exactly the same time.

On 13 January 1664, 10 months after Hooke had assisted at the trials of the Bruce-Huygens clocks and pronounced them unsatisfactory, Brouncker reported to the Royal Society that Hooke had 'discovered' to himself, Sir Robert Moray and Bishop John Wilkins (Hooke's mentor, and founder of the Society) in confidence 'an invention which might prove very beneficial to England, and to the world'.⁵⁴ The Society agreed to pay up to £10 for

⁵¹ 'I haue Lately Receiued from the Inquisitiue Hugenius van Zulichem a book <written by himself> containing a description of seuerall mechanicall & mathematicall Inuentions Intituled *Christiani hugenij Zulichemij test, f. Horologice[m] Oscillatoriu[m] siue de motu pendulorum ad Horologia aplaate demonstrationes geometricae*. There are <in it indeed> many things very ingenious and very usefull but there are not wanting also seuerall things that are of a <quite> contrary nature <as I shall show you by some few obseruations which I haue made in the Cursory reading of it hauing not yet had time to examine euey particular hereof more strictly.' Sloane MS 1039 fol. 129 r (Hooke's hand).

⁵² Having finally examined the Trinity College Cambridge Hooke papers myself I am now confident that sheets A-L of the longitude papers are early (early 1660s), but that everything thereafter is from the 1670s, possibly as late as 1678-9. I am grateful to the Wren Library, Trinity College Cambridge, for giving me access to these papers.

⁵³ Richard Waller, *Posthumous Works of Robert Hooke* (1705), p. v. On the Moray negotiations with Bruce and Huygens see the Kincardine papers (RS transcript), pp. 406-7.

⁵⁴ I base this account on the important article by Michael Wright. M. Wright, 'Robert Hooke's longitude timekeeper', in M. Hunter and S. Schaffer (eds), *Robert Hooke: New Studies* (Woodbridge: The Boydell Press, 1989), pp. 63-118. Wright's compilation of key recorded moments in Hooke's spring-regulated timekeeper development is at pp. 76-8.

trials. Moray later described it as ‘an invention of his for measuring time at sea better than pendulum clocks can, and indeed as well as they do on land’, and told Huygens, that Hooke had been working on it for some time. He had ‘given a proof [preuve] of it to the President, on a watch which I lent him’. However, Moray added that ‘having compared it to his own pendulum clock [the President] found that [Hooke’s] did not keep good time’⁵⁵ On 15 September Hooke wrote to his patron Robert Boyle that he hoped ‘shortly to make some observations ... with an exact timekeeper, which, I have some reason to believe, shall not be much excelled by any whatever. But these are not yet completed.’

On 18 January 1665, it was announced at the Royal Society meeting that Hooke was ready to apply for a patent for his longitude timekeeper.⁵⁶ At the meeting in question doubts had been expressed as to how satisfactorily the Bruce-Huygens clocks had performed during lengthy trials to Guinea and back (I will return to these trials shortly). The Society had backed the Guinea trials heavily, and staked a lot on their success; now Hooke offered them an alternative timekeeper.

Hooke’s first biographer, Richard Waller, has preserved a fragment of a memoir by Hooke himself, describing what happened next:

I shew’d a Pocket-watch, accommodated by a Spring, apply’d to the Arbor of the Ballance to regulate the motion thereof; concealing the way I had for finding the Longitude; this was so well approv’d of, that Sir *Robert Moray* drew me up the form of a Patent, the principal part whereof, viz. the description of the Watch, so regulated, is his own hand Writing, which I have yet by me.⁵⁷

⁵⁵ Huygens *Oeuvres Complètes* 5, 503-4 [letter 1481]. This is one of the two letters Hooke considered to constitute a betrayal of his confidence to Huygens on Moray’s part. The other letter is that of 22 July 1665, Huygens *Oeuvres Complètes* 5, 426-8 [letter 1436]. Hooke copied out the relevant passages of both letters in 1678 as part of his scouring of the Oldenburg papers for evidence of senior members of the Society’s having been responsible for giving away his technical secrets, thereby depriving him of credit.

⁵⁶ ‘Mr. Hooke having made a proposition of giving the discovery of the longitude, as he conceived it, to the society, it was ordered, that he should choose such persons to commit this business to, as he thought good, and make the experiment; that by such persons chosen, the council might be satisfied of the truth and practicableness of his invention, and proceed accordingly to take out a patent for him.’

⁵⁷ Richard Waller, *Posthumous Works of Robert Hooke* (1705), p. v.

Waller goes on to confirm Hooke's statement on the strength of original documents then in his possession, shortly after Hooke's death:

In confirmation of what is abovesaid, I met with a Draught of an Agreement between the Lord *Brouncher*, Mr. *Boyle*, and Sir *Robert Moray*, with *Robert Hooke* Master of Arts to this purpose, that *Robert Hooke* should discover to them the whole of his Invention to measure the parts of Time at Sea as exactly and truly as they are at Land by the Pendulum Clocks invented by Monsieur Huygens; ... as also of a Warrant to be granted by the King to *Robert Hooke*, M.A. &c. for a Patent for the sole use of the said Invention for fourteen Years, and sign'd by his Majesty's Command, *William Morrice*.⁵⁸

This last document surfaced briefly at auction some years ago, only to disappear again to a private buyer.⁵⁹ It clearly confirms all the key points from Waller's account: it describes (in Hooke's hand, inserted into a document largely in Morrice's) a spring-regulated longitude timekeeper, 'different from all other watches or clockes by hauing instead of a Ballance a Spring of mettall. wood quill /bone/ glass or other fit matter so aplyed to the Arbor of the Ballance that it makes it moue alwise equally'; it is signed by William Morrice in his capacity as Secretary of State (a position he held until September 1668); and it also invokes the names of Sir Geoffrey Palmer 'Attorney Generall' and Sir Heneage Finch 'Solicitor Generall' (both men left these posts before 1670). It allows us to say with reasonable confidence therefore, though sadly without the evidence before us, that Hooke had indeed come close to applying for such a patent, in direct response to the Bruce-Huygens pendulum-clock based attempts at a longitude timekeeper, during the first half of 1665.

There is no doubt that Hooke's idea of using springs as isochronous regulators in place of pendula was transmitted to Huygens by both Moray and Oldenburg.

On 30 September 1665 (the very day on which Moray told Huygens in a letter that Hooke had demonstrated a spring-regulated clock or watch to

⁵⁸ *ibid.*

⁵⁹ I am extremely grateful to Felix Pryor for assisting me in tracking down this document, and giving me sight of a legible xerox copy. A second document sold with it, describing the levy to be paid by mariners using Hooke timekeepers, matches Waller's description of another of the patent-related drafts he had sight of.

himself and Lord Brouncker two years earlier), for example, Moray wrote to Oldenburg (in a letter Waller saw, now lost):

You will be the first that knows when his [Huygens's] Watches will be ready, and I will therefore expect from you an account of them, and if he imparts to you what he does, let me know it; to that purpose you may ask him if he doth not *apply a Spring to the Arbor of the Ballance*, and that will give occasion to say somewhat to you; if it be that, you may tell him what *Hooke has done in that matter, and what he intends more*.⁶⁰

Hooke's not-so-confidential negotiations with Brouncker, Moray and Wilkins to obtain a patent on behalf of the Royal Society for Hooke's longitude timekeeper broke down in mid-1665. The Senior officers of the Society were of the opinion that because Hooke insisted on stating that a spring-regulator could be applied to a timekeeper in many different ways, no patent would be granted, since to do so would be to inhibit developments other than Hooke's based on the same principle.



Now, at precisely the same time that they were dealing 'in secret' with Hooke's proposed revolutionary designs for longitude timekeepers, Brouncker and Moray had taken it upon themselves to move the Bruce-Huygens clock trials onto a more systematic footing (and in fact Moray was also secretly discussing a patent claim for *their* clocks), with the Royal Society's official backing. They arranged for Robert Holmes, captain of the 'Jersey' to carry the two pendulum clocks to and from Lisbon (1663), and then on a longer voyage to Guinea and back (1663-4).⁶¹

For the history of development of longitude timekeepers these trials were a turning point. By contrast with Bruce's trials, those conducted during Holmes's voyages – particularly on the voyage to Guinea – were spectacularly successful. The clocks ran well throughout the journey, Holmes set

⁶⁰ 'Now tho' this does not mention the Springs being spiral or fastened to the Arbor of the Ballance, yet it appears by what is related above and a Passage I have seen in a Letter from Sir Robert Moray to Mr. Oldenburgh, dated Oxon Sept. 30 1665. clears it' (Waller, *Posthumous Works*, p. vi). Corroborating evidence that Waller is as usual telling the truth here can be taken from the fact that Moray's letter to Huygens of the same date was indeed written from Oxford.

⁶¹ Holmes was already carrying out tests of deep-sea sounding devices for the Royal Society.



them regularly and kept them running, and crucially, the clocks allowed Holmes to make a calculation of his position at a key moment in the Guinea voyage which revealed the inadequacy of traditional longitude-finding methods.

On the return journey, Holmes had been obliged to sail several hundred nautical miles westwards in order to pick up a favourable wind. Having done so, the *Jersey* and the three ships accompanying her sailed several hundred more miles north-eastwards. At which point, the four captains found that water was running worryingly low on board. Holmes's three fellow-captains produced three conflicting calculations of their current position based on traditional reckoning, but all agreed that they were dangerously far from any potential source of water. Not so, declared Holmes. According to his calculations – based on the pendulum clocks – they were a mere 90 miles west of the island of Fuego [Fogo], one of the Cape Verde islands. He persuaded the party to set their course due east – whereupon, the very next day, around noon, they indeed made landfall on Fuego, exactly as predicted.⁶²

Lost off the coast of Africa, and running short of water, Huygens's clocks saved the day, by enabling Holmes to locate the Cape Verde islands. This was exactly the kind of publicity the pendulum timekeepers needed in order to capture the public imagination. Moray's report of this dramatic success, in a letter to Huygens dated 23 January 1665, is clear as to its impact: 'At last Captain Holmes has returned, and the account he has given us of the experiment with the pendulum clocks leaves us in absolutely no doubt as to their success'.⁶³

The following day Huygens replied. He was delighted to hear of Holmes's success with the clocks; every line of the account gave him the greatest

⁶² Holmes's account of this incident is recorded in the Journal Books of the Royal Society for 11 January 1665. See Birch 2, 4-5.

⁶³ Huygens, *Oeuvres Complètes* 5, 204 [letter 1315]. On 5 February Huygens wrote to a close friend to tell him of his successful application to the States General for a Dutch patent for his longitude clock, based on Holmes's testimony: 'On his return, Captain Holmes has lodged his report concerning the usefulness of pendulum clocks, which goes far beyond my expectations. I could never have imagined that clocks of this first, preliminary mode of construction could have succeeded so well, and I had reserved my principal hopes for the new ones. But since these have already been so successful, and that the other are even more precise, I feel entitled to believe that the discovery of true longitude will shortly reach its final perfection.' 'The pendulum clocks are a success, The Estates General want to see the clock at their Assembly.' (summary). Huygens, *Oeuvres Complètes* 5, 222-3 [letter 1324].

pleasure, and he thanked Moray for being the bearer of such good tidings.⁶⁴ Holmes's report was published verbatim in the Royal Society's *Philosophical Transactions* and in French in the *Journal des sçavans*, eventually featuring as the unique account of a sea-trial of pendulum clocks to be included in Huygens's landmark book on pendulum clocks, the *Horologium oscillatorium*, published in 1673.⁶⁵ Right down to the present day, it is the spectacular success of these trials which is invoked as the crucial evidence, on the basis of which Huygens's pendulum-clock timekeepers take their place as a significant step along the timeline from the theoretical aspiration to determine longitude at sea using a precision clock, to the realisation of that dream with John Harrison's longitude timekeeper.

The success of the Holmes trials probably did lead directly to Moray and Brouncker abandoning attempts to agree a patent document with Hooke (by this time too, ironically, Moray had given up hope of getting Bruce and Huygens to agree a fair distribution of financial reward, and abandoned their patent bid also).⁶⁶

So it might appear that there is some justice in the fact that Huygens has continued to receive most of the credit for early longitude clock trials, and developments culminating in the balance-spring regulated pocket-watch, ever since. But new evidence suggests that Hooke deserves more credit, and Huygens, perhaps, a little less.



The problem with this part of the story is that Sir Robert Holmes (as he later became) was not known as a person who could be relied upon. He is, in fact, infamous as the hot-tempered, violent and uncontrollable commander of the English fleet, whose impetuous naval exploits were responsible for starting both the second and third Anglo-Dutch wars. He had served under Prince Rupert and James, Duke of York, and eventually rose to the rank of Admiral. In 1664, on the very voyage on which he was ostensibly testing the Bruce-Huygens clocks, he sacked the Dutch trading-stations along the

⁶⁴ Huygens, *Oeuvres Complètes* 5, 224 [letter 1325].

⁶⁵ *Philosophical Transactions* 1, 6 March 1665.

⁶⁶ The grave outbreak of plague in July 1665, which necessitated the removal of the Court first to Hampton Court and then to Oxford, and the dispersal of the Royal Society members to the safety of the country, marked the end of this phase in Hooke's longitude timekeeper aspirations.

coast of Guinea one by one, seizing goods and property and laying waste the Dutch settlements. On his return he was twice imprisoned in the Tower of London (on 9 January and 14 February 1665), for having gone beyond orders or for failing to bring back adequate amounts of booty (it is not quite clear which). His actions led directly to the Dutch declaring war on 22 February 1665 (by announcing that they would retaliate against any British shipping in the Guinea region), at which point Holmes was released and pardoned, in order to command his Majesty's forces. In August 1666 Holmes attacked and destroyed by fire 150 East-Indiamen in the Vlie estuary and sacked the town of Westerschelling on adjacent Terschelling island.

Samuel Pepys was afraid of him ('an idle, proud, conceited, though stout fellow'), and on several occasions expressed reluctance at having to deal with him on matters of naval discipline. After the second Dutch war he was rewarded for his exploits with the Governorship of the Isle of Wight; he eventually became extremely rich and somewhat more respectable.⁶⁷

Huygens himself was the first to raise concern about Holmes's report (as a Dutchman he might be expected to have a particularly low opinion of Holmes's integrity). On 6 February 1665, in his first response to Moray, Huygens, after expressing his delight at the dramatic outcome of the trials, added a small caveat:

I have to confess that I had not expected such a spectacular result from these clocks. To give me ultimate satisfaction, I beg you to tell me what you and your colleagues at the Royal Society think of this Relation [of Holmes's], and if the said Captain seems a sincere man whom one can absolutely trust. For it must be said that I am amazed that the clocks were sufficiently accurate to allow him by their means to find such a tiny island [as Fuego].⁶⁸

On 6 March, Huygens was still pressing Moray for 'something of the detail of what you have learned from Mr Holmes, principally in order to know

⁶⁷ It is via the Isle of Wight route that Holmes's path crossed that of Robert Hooke (born on that island). It has been plausibly argued that Grace, Robert's niece, was the mother of Holmes's illegitimate daughter Mary. See L. Jardine, *The Curious Life of Robert Hooke: The Man Who Measured London* (London: HarperCollins, 2003).

⁶⁸ Huygens, *Oeuvres Complètes* 5, 224 [letter 1325]. Huygens's attitude to his first longitude clocks was entirely consistent: he doubted their suitability from the start (*Oeuvres Complètes* 4, 285).

how the clocks behaved in a storm, and if in that climate rust did not eventually cause them to stop'.⁶⁹

The matter of Holmes's trustworthiness was raised at the March 8 meeting of the Royal Society (at which Huygens's concerns were raised, and the letter of 6 March read):

There being also mention made again of Major Holmes's relation of the late performances of the pendulum watches in his voyage to Guinea, it was affirmed by several of the members, that there was an error in that relation, as to the island named therein; and that it was not the island of Fuego, which the Major's ships had touched in order to water there, but another thirty leagues distant from it.⁷⁰

Samuel Pepys (recently elected a Fellow) was 'desired to visit the Major, and to inquire farther concerning this particular for the satisfaction of the society'. In practice this meant visiting Holmes in the Tower, where he was still imprisoned for his conduct towards the Dutch settlements at Guinea, during his voyage.⁷¹ On 14 March Pepys attended 'a farewell dinner which [Sir John Robinson, Lieutenant of the Tower] gives Major Holmes at his going out of the Tower', 'Here a great deal of good victuals and company'.⁷²

On 15 March both Pepys and Moray reported on their dealings with Holmes. Pepys had spoken to the master of 'the Jersey ship' – that is, Holmes's own vessel:

The said master affirmed, that the vulgar reckoning proved as near as that of the watches, which [the clocks], added he, had varied from one another unequally, sometimes backward, sometimes forward, to 4, 6, 7, 3, 5 minutes; as also that they had been corrected by the usual account. And as to the island, at which they had watered, the said master declared, that it was not Fuego, but another 30 miles distant from the same westward.⁷³

⁶⁹ Huygens, *Oeuvres Complètes* 5, 256 [letter 1345].

⁷⁰ Birch 2, 21.

⁷¹ For a clear sense of the concern caused by Holmes's conduct on that voyage, and Pepys's lack of trust of him, see Pepys, *Diary* 6, p. 43.

⁷² Pepys, *Diary* 6, p. 56.

⁷³ Birch 2, 23.

According to the Master of Holmes's ship, then, there was not much to choose between the old way of calculating longitude, and that using the new clocks. Moray, who had spoken to Holmes himself, corrected 'some mistakes in the number of the leagues formerly mentioned'. He confirmed that the ships had not watered on Fuego, 'yet they had made that island at the time, which the Major had foretold, and were gone from thence to another, more convenient, for watering'.⁷⁴

This was the meeting at which, immediately following Moray's rather obviously fudged report, Hooke told the Royal Society 'that he intended to put his [own] secret concerning the longitude into the hand of the president, to be disposed of as his lordship should think fit'. In his opinion, 'no certainty could be had from [pendulum] watches for the longitude'.

At the very next meeting, on 22 March, 'Mr Pepys was desired to procure the journals of those masters of ships, who had been with Major Holmes in Guinea, and differed from him in the relation concerning the pendulum watches'.⁷⁵ Nothing further was heard, however, of discrepancies between the ship's journals and his 'relation concerning the pendulum clocks'. Had that convivial dinner a week earlier perhaps predisposed Pepys to draw a veil over the matter? Holmes's account has been firmly lodged on the record ever since.

However, a presentation copy of Holmes's Guinea voyage journals, which Pepys had indeed procured, as instructed by the Royal Society, still survives in the Pepys Library at Magdalene College, Cambridge. I believe that I am one of the first scholars to have consulted it in the context of the Holmes trials, on that voyage, of Huygens's longitude clocks.⁷⁶

Holmes's journal is extremely full and specific. It is also rather well written – Holmes has a nice line in racy narratives, particularly where bombarding

⁷⁴ Moray also added two further experiments Holmes claimed to have carried out with the clocks (Birch 2, 23).

⁷⁵ Birch 2, 26.

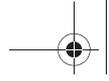
⁷⁶ I owe this discovery to some chance remarks in C. H. Wilson, 'Who captured New Amsterdam?', *The English Historical Review*, 72 (1957), 469-74: 'Fortunately our answer [to the question of whether Holmes was involved in the capture of New Amsterdam in 1664] need not rest on surmise, for we have Holmes's own account of his movements during the months when he is supposed by some historians to have been on his way to America, and capturing New Amsterdam [*Captain Robert Holmes his Journalls of Two Voyages into Guynea in his Mts Ships The Henrietta and the Jersey*, Pepys Library Sea MSS. No. 2698].' (pp. 472-3).

and plundering Dutch merchant ships is concerned.⁷⁷ Day by day he chronicles the progress of his band of ships – the Jersey, the Brill, the Golden Lyon and the Expedition. Only once in the course of the entire voyage does he mention the pendulum clocks (in connection with the incident we have already heard about), and it is hard to see how they could have been kept going steadily throughout, given naval battles with Dutch East Indiamen in which (for instance) Holmes's topmast and mainsail were shot away.

In July Holmes was on San Thome, reprovisioning and rewatering. He set out for home on 11 August. For more than a month strong currents, contrary winds and becalmings bedevilled him. By the third week of September they were well and truly lost on the open seas. There is indeed a full sequence of entries relating to Holmes and his fellow captains getting lost and running short of water, which does, uniquely in the entire journal, mention 'pendula' (this is a fair copy of the journal, prepared for James, Duke of York). It was with great reluctance that Holmes's companions agreed to turn westwards. It was three days before they sighted land, during which time variable winds took them in several different directions. As Pepys had learned, they did not land on Fuego, but some time later on another of the Cape Verde Islands, Brava. Holmes had, at the very least, greatly exaggerated.

But once Holmes had lodged his misleading report, with its bravura claims for the pendulum clocks, Huygens's claim to priority in relation to longitude timekeepers was assured. The account was prominently reprinted in 1673 in the *Horologium Oscillatorium*, and then followed within the year by the announcement from Paris of the balance-spring watch. Huygens's impressive sequence of horological innovations – pendulum clock (1658), longitude pendulum timekeepers (1665) and balance-spring regulator (1674) – entitled him to precedence over others working close to him, and assured his lasting reputation as the preeminent figure in the field.

⁷⁷ For Holmes's buccaneering style, see for example the following, in a letter he transcribes into his journal: 'Since my Letters from Cape Coast wee have taken in Aga & Anamaboa the former by storm, and after promseing Quarter to the Flemins & taken possession our men being somewhat greedy of Plunder, the Flemins treacherously blew up the Powder & withall 80 or 90 whites and Blacks which the Blacks rewarded by cutting of all their heads; At my Return from the Coast all things were in a good Posture, & well settled. ... I know not how my Actions vpon the Coast of Guyny are resented at Court, nor how my Condiscon stands' *Captain Robert Holmes his Journalls of Two Voyages into Guynea in his M[ajestie]s Ships the Henrietta and the Jersey*, Pepys Library Sea MSS. No. 2698, p. 168.



By this time, however, both Moray and Oldenburg were of the opinion that Huygens was overstating his personal claims for priority. On 27 June 1673, Oldenburg himself urged Huygens to be more generous in his acknowledgements, and urged a more collaborative approach in the interest of scientific progress. Indeed, let us (for once) leave Oldenburg the final word. For his response to Huygens was tantamount to a public plea for more structured, acknowledged Anglo-Dutch scientific research:

If candour reigned everywhere, what friendships might we be able to establish amongst the learned, and what advantages might the public derive?⁷⁸

What friendships indeed. How much more robustly Anglo-Dutch scientific endeavours might have developed thereafter. And how much more generous and international the history of precision timekeeping in this period would appear today, had Christiaan Huygens acknowledged the network of information and practitioners whose work had contributed to his own brilliant contributions.

⁷⁸ Huygens, *Oeuvres Complètes* 7, 323-4. Bruce's response to receiving his own complimentary copy of Huygens's *Horologium oscillatorium* was similarly critical. See Leopold, 'Clockmaking in Britain and the Netherlands', p. 41.