

Setting the scene in Part Three in preparation for his discussion of the marine timekeepers known as H1-H5, Betts introduces Harrison's background, his early clockmaking and work on precision pendulum clocks. The image of one of Harrison's early houses brings a welcome human touch to the story. I also liked the information about the Harrison brothers experimenting (page 34), but would have liked a reference for the source of it. Betts' analysis of Harrison's thought processes enriched the description of the pendulum clocks – his usual approach was to identify an 'enemy' in the efficiency of the movement and then try to compensate for it as he did with the gridiron pendulum, having identified temperature change as the problem (page 39–41).

Betts then takes the reader on a journey through the marine timekeepers H1-H5 one by one, not only describing them, but also revealing the outcome of their tests and trials. I liked the contextual details such as H1 having been made following a visit by Harrison to the Astronomer Royal, Edmund Halley, and renowned clockmaker, George Graham. More of the human element of the story is brought to the fore in the description of H3 taking nineteen years to complete and even then Harrison realised that the design needed an overhaul (page 59) – this was a valuable acknowledgement of the mental stress that Harrison must have endured at that time. The accessibility of the narrative is noticeable when Betts describes H4 as having the appearance of a pocket watch of the era, but then explains what made it so different, for example the larger balance in the movement (page 77). Another powerful example of where contextual detail is employed artfully to provoke an emotional response comes with the description of one of the last Longitude Boards that Harrison attended. The group had hardened towards Harrison, so much time had passed since the last meeting, new methods and instruments were now being used, and Harrison's key contacts were dying out (page 82–83). Again, the reader really feels for Harrison and his perception of the shifting goalposts. Betts does balance this by pointing out that the Board were doing what they thought was right in the changed world where the lunar distance method had been shown to be a viable method and the sextant deemed a reliable instrument.

Betts finishes his presentation of the five marine timekeepers with Harrison's last-ditch attempt and appeal to King George III, who was supportive and agreed for it to be trialled in contrast with the negative response of the Board. Betts cleverly shows the passions involved in this case and, even with his factual descriptions of events, the reader cannot help

but feel as though they are on an emotional roller coaster following the story. Just when you cannot help but feel sorry for the elderly man that Harrison has become, who has dedicated a lifetime to solving the 'Longitude Problem', you then also feel the frustration of the Board when you hear of Harrison's son William's sulky behaviour at the meetings. I really liked Betts' discussion of whether Harrison effectively 'won' the Longitude Prize or not and what counts as a 'win'.

The conclusion consists of a nod to the legacy of Harrison's marine chronometers – Arnold & Earnshaw making the marine chronometer into a commercial product and their long-term home at Greenwich where the enthusiasm of Rupert Gould from the 1920s ensures that Harrison's story and contributions are always remembered.

The only areas that could be considered gaps in the overall narrative are that there could have been a little more context surrounding the lunar distance method (e.g. see de Grijns, 2020) and other work the Board were asked to consider. I would also have liked a little more about Harrison's work before he sought to 'win' the Longitude Prize. His early years are described, but I wonder if he was a busy clockmaker in the years before he moved to London. Even if we do not know, I would have liked to see this acknowledged.

I would certainly recommend this book to non-specialists and specialists new to the topic. As a Royal Museums Greenwich publication, it is also a really nice souvenir following a visit to see the Harrison timekeepers.

#### Reference

de Grijns, R., 2020. A (not so) brief history of lunar distances: lunar longitude determination at sea before the chronometer. *Journal of Astronomical History and Heritage*, 23, 495–522.

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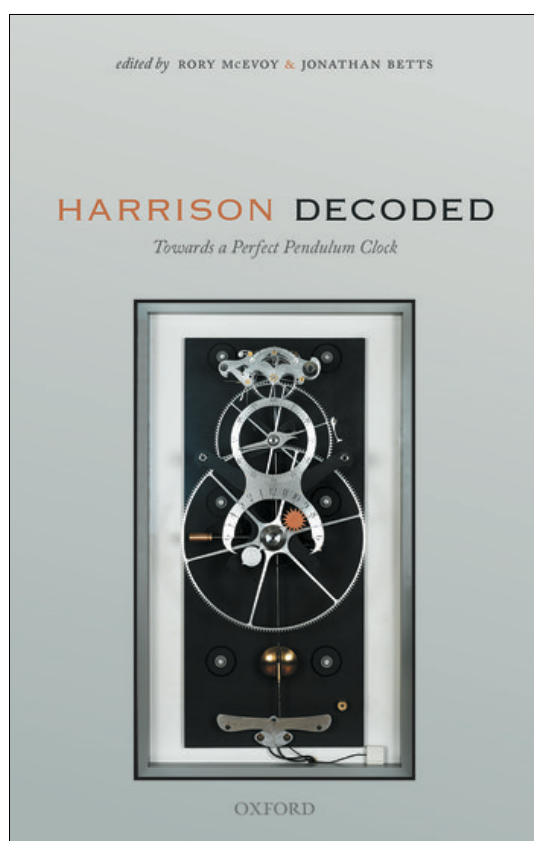
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***Harrison Decoded: Towards a Perfect Pendulum Clock*, edited by Rory McEvoy and Jonathan Betts. (Oxford, Oxford University Press, 2020). Pp. xii +183. ISBN 9780198816812 (hardback), 140 × 225 mm, US\$65.**

A collection of ten essays, this volume charts the making and testing of Burgess' Clock B, which is a reconstruction of a pendulum clock revealed in one of John Harrison's publications. In doing so, the authors share the conclusions they have subsequently formed about

Harrison's design. Assembled by Jonathan Betts and Rory McEvoy, both former Curators of Time at Royal Museums Greenwich, this volume contains (along with their own essays) contributions from fellow Harrison researchers: William Andrewes, Martin Burgess, the team at Charles Frodsham & Co., David Harrison, Mervyn Hobden, Andrew King, Donald Saff and Tom Van Baak.

While Betts has experience of more historical work and story-telling for non-specialists, this book is technical and aimed at specialists and technically-minded readers, rather than those new to the subject. In many places it assumes a good level of horological and



scientific knowledge, but is mostly written in such a way that those with a basic technical interest can follow the narrative

Published in 2020, it is presented as the latest output from the Harrison working group of researchers – intended to be seen as the story thus far. While there are other books on Harrison and the longitude story, this is the first book-length work to focus on Burgess' Clock B specifically.

The core argument is that, despite the 250-year separation, Burgess' Clock B demonstrates that Harrison formulated a remarkable, alternative method for making an accurate pendulum clock. This argument is put forward through the ten essays, which work beautifully together as a collection, taking the

reader on a journey through each stage of the research. I particularly liked that the essays reveal the different methodological approaches employed by the researchers.

The book begins with McEvoy's introduction to Harrison's pendulum clock known only from the publication in question, "A Description Concerning Such Mechanism as Will Afford a Nice or True, Mensuration of Time of 1775". The description of the challenges posed by this publication including those posed by the lack of standardisation in horological terminology in the period due to the master and apprentice oral tradition of learning (page 1) provided some valuable insight. I felt this set the scene for the rest of the journey – it gave the reader a reason to care, which is paramount for non-specialists. This historical scene-setting is followed by some technical scene-setting concerning the pendulum and the deadbeat escapement, again essential for non-specialists, and sets up the subsequent discussions of Burgess' Clock B.

King then discusses Harrison's pendulum clock with respect to his background, useful for readers unfamiliar with Harrison's biography. It was refreshing to read the early reference (page 20) to the economic status of the Harrisons – too often in the secondary literature Harrison's story is presented as a rags-to-riches narrative, but this can be overstated. King's identification of five key elements of Harrison's early clocks at the end of the essay (page 33), provides a clear pathway for the rest of the book.

Andrewes introduces the reader to the clockmaker Martin Burgess. During the first read, I liked the background information such as the decline of the trade (page 35) and the assessment of what Burgess was trying to achieve, which was an understanding of Harrison's technology and proving its merit to a sceptical world. However, when I reached the contribution written by Burgess himself, I felt that this entry was no longer necessary and could have been summarised by Burgess as part of his essay – it felt odd to be written by someone else.

Having been made familiar with Harrison, his pendulum clock, and Burgess, the reader is then introduced to Burgess' Clock B by Saff. While a little too anecdotal in format, this essay does provide some background as to the clock's biography, which is useful to readers unfamiliar with it.

Whereas the first four chapters feel like an introduction, the next essay feels like the beginning of the deep dive into the details of Clock B, which is the focus of the rest of the book. Written by Burgess himself, it pro-

vides his assessment of Harrison's methodology and the essentials of his Clock B (including the materials, pendulum, suspension unit, grasshopper escapement, and remonteire).

Written on behalf of the team at Charles Frodsham & Co., the subsequent contribution is highly technical, certainly requiring prior knowledge, and explains the work undertaken by the team to finish Clock B between 2009 and 2012. After which point it was collected by Burgess and taken to Royal Museums Greenwich for testing – this lovely detail maintained a sense of reader involvement in the journey.

Betts then describes the testing of Clock B at Greenwich between 2012 and 2015. His introduction to this essay let the reader know what to expect and contextualized Betts' contribution within the rest of the book (page 81). I appreciated the admission by Betts of initial doubts concerning Harrison's statements, which maintained a sense of tension in the narrative. The information about what was involved in the testing was intriguing and the graphs were fascinating, but the publisher should have made them larger. The essay concludes by dismissing the suggestion that Harrison's design was too costly and time-consuming to be viable as a commercial product, as testing showed this was not the case.

Van Baak provides an explanation of the analysis undertaken on the clock's performance. I appreciated having access to the testing results, but they do assume technical knowledge. The introduction also helps to convey the relevance to the larger argument – that Harrison's claim that such a clock could keep time to 1 second in 100 days was accurate. Van Baak's statement of impartiality was noticeable and welcome – his role was to process data and he was not involved with the clock. It was insightful to read of the identification of eight ways in which Harrison's claim could be tested (page 103) and the confirmation of the decision to pursue option two. However, more of a conclusion would have made the entry stronger. What is termed the Conclusion is in effect a reference to the GPS cross-referencing and an acknowledgement of thanks.

The next two essays, by Hobden and Harrison respectively, are both highly technical, requiring a large amount of prior knowledge, and I would have appreciated a conclusion for each referring back to the relevance of the findings to the main argument. Hobden considers the mechanical theory and Harrison shares an analysis of the compensation mechanism in Clock B.

The last contribution, by McEvoy, provides an update on Clock B as an appendix. It was useful to know what happened next, but this would have been better as an epilogue. There was no overall conclusion to the book, which was a shame, given the quality of the introduction and the strength of the scene-setting. This is a great book, but I feel it could have packed an even stronger punch with a really tight conclusion bringing everything together.

I would recommend this book, but I feel that as a Royal Observatory Greenwich publication it should come with the caveat that it requires some prior knowledge to get the most out of it. That said, I like that one book concentrates on one clock and the historical horological problem, and that it does so by bringing multiple perspectives together in one place.

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***Orreries, Clocks and London Society*, by Tony Buick. (Springer, Cham, 2020). Pp. xxvii + 348. ISBN 978-3-030-61776-9 (paperback), 155 × 235 mm, GBP24.99.**

Written by Tony Buick, a chemist by profession with a keen interest in astronomy, this book provides an introduction to the history of orreries. Suited to a popular rather than a purely academic audience, the volume is intended to be a follow-up to his earlier publication *Orrery: A Story of Mechanical Solar Systems, Clocks, and English Nobility* (Buick, 2013).

Requiring no prior knowledge, the present volume introduces the reader to the historical development of the orrery with some wider contextual information to ground the narrative. Its tone and language are appropriate for an educated reader, while still being accessible to non-specialists.

Rather than putting forward an argument as such, Buick presents a discursive journey from the astronomy of the ancients to present-day projection devices.

In terms of the overall structure, the narrative would benefit from a more explicit Introduction and Conclusion. The divisions of the chapters is fine, but they could perhaps be reordered and some of the content redistributed between them.

The opening chapter is intended to introduce the rest of the story by providing an overview of the prior history of the orrery. Buick poses the question as to what constitutes an