Reckoning with Matter: Calculating Machines, Innovation, and Thinking about Thinking from Pascal to Babbage, Matthew L. Jones (2016), University of Chicago Press, Chicago, 336pp., cloth \$35.00, ISBN: 978 0 226 41146 0

Reckoning with Matter is an essential book in an era obsessed with computing and rapidly losing sight of its mechanical heritage. Matthew Jones reveals the essential materiality and mechanicity of early computing machines, built by masterful craftsmen who put mathematical logic into mechanical terms as parts and linkages. Much of recent computing history has focused on computing logics and software rather than hardware. Yet materials did not, and do not, do what is logically expected of them: as Jones notes, computer chip designers cannot even now predict many characteristics of a working chip, sometimes even its heat and speed.

Jones puts hardware history directly in the centre of this detailed analysis of early calculating machines, an analysis that encompasses developing ideas of intellectual property, the rise of a narrow concept of innovation as a measure of inventive creativity, and continued philosophical – and religious – reflection on what it meant to think mechanically. At *Reckoning*'s analytical centre is a specific type of hardware – carrying mechanisms, devices that, during addition, carried digits into the next-left column. Carrying mechanisms were an extraordinary technical challenge. They had to store up values, in a series of linked dials or wheels or drums, until they reached the threshold for a carry (e.g. ten, or one hundred, or one thousand). Keeping the wheels in sync, and making sure they turned only as much as needed, required two sub-systems: a power system, often a crank, strong enough to turn all wheels at once; and a brake system to stop individual wheels from turning too much and muddying up the results.

Intriguing characters populate the book. Some are well-known: mathematician and *penseur* Blaise Pascal, industrial reformer Charles Babbage, scientific polymath Gottfried Wilhelm Leibniz. Others are largely unknown: Joseph Clement, the mechanic who worked alongside Babbage; Parisian clockmaker Ollivier, hired by Leibniz to construct his calculating machine; Samuel Varley, London lecturer, watchmaker, and jeweller, who moved to the estate of Charles Mahon Stanhope (3rd Earl Stanhope) to focus exclusively on Stanhope's own device. Jones draws from dense materials surrounding the history of each machine: devices themselves, and copies of them resident in museums; model machines; correspondence between mechanics and their employer/collaborators; mechanics' notes and drawings.

A narrative core emerges from the analysis of mechanical and personal detail: Babbage's progress from naïve hubris to, in his partially built difference engines, 'studied production of great skill, uniting the design of practical contrivances with profound theoretical inspiration' (p.9). Babbage's story emerges in a series of interludes that Jones has titled 'carries'. First carry, second carry, and so on, appear between each of the named chapters. Computing work in the seventeenth and eighteenth centuries is thus made immediately relevant both to Babbage's struggles and to our contemporary understandings of innovation and intellectual property, which, Jones argues, took on their contemporary meanings in Babbage's time. These contemporary meanings have come to emphasize logic and design, and often fail to recognize the demands of material construction and the social worlds around it.

Jones has revealed the dense technical society within which early computing devices were created. Pascal, lacking entre to technical society and insisting that artisans were not truly creative, was thus naïve about the demands of material construction; he could not build a useful machine, nor could he envision one. The most successful collaborations were close, with mechanics working and

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often living alongside their employers and collaborators. The 'first necessity' in building his difference engine, Babbage wrote, was 'preserv[ing] the life of Mr Clement' (p.124). These machines all ultimately failed to do what they were designed for, largely because inventors failed to coordinate and cooperate with those skilled in material production. In this beautifully written and inventive study, Jones reveals how computing was never a matter of design and logic only; computing has always been a matter of matter.

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