JÜRGEN RENN and PETER DAMEROW : *The Equilibrium Controversy. Guidobaldo del Monte's Critical Notes on the Mechanics of Jordanus and Benedetti and their Historical and Conceptual background.* Berlin : Edition Open Access, 2012. Pp. x + 376.

The law of the lever (of which the balance is a special case) dominated the research that Galileo undertook in mechanics at the end of the sixteenth century. By means of the principle of virtual velocities, he extended the law of the lever to the simple machines and even to problems of hydrostatics. In all instances, the governing principle is the equality of the product mv at one end of the lever to that at the other. The *momento* (moment) of the lever thus easily transforms itself into the *momento* (momentum) of the moving body. A possibility of serious ambiguity is built into the lever, and Galileo, together with the whole century following him, slips into it unaware. Since both ends of the lever move in identical time without acceleration, it is immaterial whether one uses the virtual velocities of the two weights or their virtual displacements. Velocities must be in the same proportion as displacements, and when Galileo states the general principle of the lever, he does so in terms of velocity although he often uses the word displacement. Now it is all too easy to forget that the equivalence holds only for the lever and analogous instances in which a mechanical connection ensures that each body moves for the same time, and in which, because of equilibrium, the motion involved is virtual motion, not accelerated motion. The case of free fall is not, of course, identical to the conditions of equilibrium because the times involved are not identical and because two separate, accelerated motions take place. If there is an equality of the product of weight x distance (that is, in our terms, work), there cannot be an equality of momentum (mv) but rather of kinetic energies ($1/2\ mv^2$). From the ambiguity of the lever springs the controversy between quantity of motion and *vis viva* in which the second half of the seventeenth century was to engage. This second phase has been studied by a number of distinguished historians of science, for instance, Richard S. Westfall in *Force in Newton's Physics*. What was lacking until the publication of *The Equilibrium Controversy* was a clear understanding of the historical and conceptual background to Galileo' s endeavors. This lacuna has now been admirably filled by Jürgen Renn and the late Peter Damerow.

This book is the second to appear in an exceptionally valuable new series, the Max Planck Research Library for the History and Development of Knowledge, which makes available original scientific and scholarly works both as printed books and as online open access publications. The first book, also authored by Renn and Damerow, was Guidobaldo del Monte's *Mechanicorum liber*, a work that deeply influenced Galileo and his generation.

The extensive research that led to *The Equilibrium Controversy* began in 2006 when the Max Planck Institute for the History of Science acquired a copy of Giovanni Benedetti's *Diversarum speculationum mathematicarum et physicarum liber* that appeared in 1585. This book comprises several treatises including one on mechanics which contains a critique of section of the Aristotelian *On Mechanics* that was much discussed at the time. While Benedetti's book is in itself an important source for understanding the struggles of early modern engineer-scientists with the ancient attitudes of mechanical knowledge, this specific copy is of special value since it contains handwritten marginal notes by Guidobaldo del Monte. These interesting notes are studied in great detail and the pages of the book on which they appear are reproduced in a facsimile edition (pages 356-376).

Benedetti was influenced by earlier writers and more specifically by his master Tartaglia who had himself borrowed and modified material taken from the thirteenth-century author Jordanus of Nemore whom he edited. The importance of Jordanus is illustrated by the fact that Guidobaldo del Monte not only read but annotated his copy of Jordanus. These additional notes are also analyzed in *The Equilibrium Controversy* where they are clearly and concisely summarized. But Renn and Damerow do not merely make the relevant material available they also offer, in a monograph-length chapter (pages 39-167), a masterly survey of the development of mechanical knowledge from its origins in Antiquity to the dawn of classical mechanics in the late Renaissance. The authors stress that the development of technology owes much to *challenging objects* such as labor-saving machinery, ballistics, the stability of buildings and the performance of ships on the high seas. As a consequence a multiplicity of different pathways emerged, and we are cautioned against the danger of treating the results of these different approaches as if they were pieces of a puzzle that can be combined into a coherent whole. Strictly speaking, the solutions proposed in preclassical mechanics are incompatible with those of modern science, and they make use of alien concepts such as natural and violent tendencies. A crucial problem was the exact relation between the key-concepts of *center of gravity* and *positional heaviness*. Guidobaldo del Monte was proud to have reconciled the Archimedean theory of equilibrium, based on the concept of center of gravity, with the Aristotelian understanding of weight as tending to the center of the world. This reconciliation was embodied in what he saw as his greatest discovery : the insight that both an ideal balance and also what he called a cosmological balance remain in indifferent equilibrium. Benedetti had claimed that while such an indifferent equilibrium holds under terrestrial circumstances, it is impossible for a cosmological balance thereby challenging Guidobaldo's great synthesis. While Benedetti's conclusion is in accordance with later classical physics, the controversy could hardly be settled with the arguments available at the time. In this sense, it was the equilibrium *controversy* more than its *resolution* that spurred the further developments of physics.

Renn and Damerow have made an outstanding contribution to our knowledge of the history of mechanics, and their book can be warmly recommended not only to specialists but to anyone interested in the history of physics and its conceptuall underpinning.

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