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La via delle acque (1550–1700): Appropriazione delle arti e trasformazione delle matematiche

By Cesare S. Maffioli. Firenze (Olschki). 2010. ISBN 978-88-222-6008-6. xxii + 394 pp. 43 €

Historians of science who are acquainted with Maffioli's previous book *Out of Galileo: The Science of Waters 1628–1718* [Maffioli, 1994] will welcome this new work, which promises to become a valuable secondary source. The title, *La via delle acque*, is an old-fashioned Italian locution which cannot be translated into neat English. Roughly, it means two different things: on the one hand, it denotes the path of flowing water; on the other, it refers to going by waterway rather than by road or rail.

Although there is some overlap with *Out of Galileo*, the intention of the new book is different. While *Out of Galileo* is a history of hydraulics in the 17th century, the *Via delle acque*, to quote from the Introduction, is an analysis of "the intellectual appropriation of the mechanical arts and the parallel social and disciplinary transformation of mathematics during the sixteenth and the seventeenth centuries" (p. VII, my translation). In other words, Maffioli is interested in the debates surrounding the earlier attempts at the mathematization of hydraulics. Rather than aiming at a consecutive account, he focuses on some key episodes. In effect, the book is a collection of case-histories expounded in chronological order. Most of its content is drawn from the author's earlier papers, scattered through several journals and extending over a period of about 20 years.

After the Introduction, the bulk of the book consists of six long chapters, which are in turn divided into sub-chapters. The first chapter is an overview of some aspects of mechanics during the Renaissance, such as Galileo and the practice of engineering or Niccolò Tartaglia's ballistics. Chapter 2 discusses the work on hydraulics of Girolamo Cardano, who is mainly known for his discoveries in algebra. Chapter 3 deals with the relationship between theoretical and applied science in the second half of the 16th century. Chapter 4 is devoted to the Benedectine friar Benedetto Castelli, one of the truly great pupils of Galileo. Chapter 5 is about the reactions to Castelli's theory. The last chapter is mainly about Domenico Guglielmini, the systematizer of 17th-century hydraulics, for whom the new chair of *hydrometry* was created at the University of Bologna in 1694. The work is topped-off by an Epilogue in which Maffioli ties together the different threads and by a thirty-page bibliography of manuscripts, printed sources and scholarly literature.

This list of topics does not adequately indicate the scope of the treatment. For example, there is an unexpected detour on "rational medicine" in the second half of the 17th century; the account of the technological origin of the principle of continuity is in itself nearly worth the price of the volume.

From the above description it is evident that Italy is the only actor on the stage. The reason for this predilection is explained at length in *Out of Galileo*, where Maffioli argues that during the 17th century hydraulics was primarily an Italian science. In fact, a look at the multi-volume collection *Raccolta d'autori che trattano del moto dell'acque* [Albizi et al., 1723], reprinted several times in different editions, shows the high level of the Italian research on hydraulics during the 16th, 17th and 18th centuries.

Turning now to the content of the book, we may begin by asking what is the role of hydraulics in the larger context of the scientific revolution. In short, hydraulics holds a paradoxical position in science. The central importance of water distribution for the economy of a country has always been recognized, and every civilization has liberally deployed resources, time and energies for the construction of canals and aqueducts. Yet these efforts apparently did little for the advancement of *pure* science. For centuries hydraulics mainly consisted in a variety of rule-of-thumb methods perpetuated by tradition and custom; the most authoritative text on hydraulics from antiquity, Sextus Julius Frontinus' *De aquaeductu urbis Romae*, written at the end of the first century (see Frontinus, 2004 for a critical edition), is more of a cookbook than a scientific treatise. Only with the publication of Castelli's *Della misura dell'acque correnti* [Castelli, 1628] the process of putting hydraulics on rational foundations really began. In the decades before and after this momentous step, hydraulics became a natural ground of confrontation among natural philosophers, mathematicians, engineers and artists. To a historian looking at the scientific revolution from this perspective, well-known questions in the history and philosophy of science take on a new flavor.

I will not try to detail the diversity of themes explored by Maffioli; every story in the *Via delle acque* has its own moral. But from the completed puzzle there emerges clearly a historical picture more complex and nuanced than the one set out in textbooks. In expounding his views, Maffioli politely criticizes several major historical theses: Italian science during the late 17th century did not totally coincide with the work of Galileo's pupils, nobody plagiarized Leonardo's writings on hydraulics, the Catholic Church did not always hinder the development of science, the label "engineer-scientist" does not adequately describe Galileo, Kuhnian revolutions do not apply to the impressive growth of science discussed in the book. More of this gentle but powerful criticism is sprinkled throughout the text.

Readers of this journal will mostly be interested in mathematical things. Maffioli's writing has almost no formulas, but his research has implications for our understanding of the internal development of mathematics and physics. Here is an example: during the second half of the 17th century hydraulicians were concerned with the determination of the profile of velocities of a river. This involves a continuous distribution of stationary velocities, a concept more advanced than anything found in the kinematics of projectiles discussed by Galileo. Scientists such as Christiaan Huygens and Gottfried Wilhelm Leibniz were interested in these matters. A natural question that arises is then: what is the connection between these semi-empirical results and the abstract mechanics of those years? All of these different ideas converged into Daniel Bernoulli's *Hydrodynamica* [Bernoulli, 1738], but we do not know the details of the story. And was there any influence on pure mathematics? Such questions are starting-points for future research.

The *Via delle acque* is not an easy read for the uninitiated. While the speculations on fluids of Leonardo, Cardano and Galileo are extensively discussed, there is no general presentation of their work. In addition, some important scientific questions are only superficially explored; thus, for example, Maffioli says little about Evangelista Torricelli's law of efflux, Simon Stevin's and Blaise Pascal's theories of hydrostatics or Archimedean mathematical physics during the Renaissance. The reader must therefore already be well-informed on a number of topics, perhaps from Maffioli's earlier work. The syntax is sometimes convoluted.

But for those willing *to overcome* these obstacles, there is a high payoff, for the book contains much that is new and valuable. Maffioli's conclusions are well-argued, compelling and stimulating. Anyone interested in the scientific revolution, in the birth of mathematical physics or in the interaction between mathematics and the arts will be richly rewarded in the study of this erudite work. It deserves to be made accessible to a wider public by translation into English.

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