Three aspects of maritime concern can be identified: cosmographic theories about the globe and the oceans involved astronomy, cartography, and mathematics. The measurement of space and time depended on the development of instruments, and the story of ships and sail is that of technology. The social dimensions of a maritime society, and the trend toward "scientific" description, representation, explanation, and treatment of new environments and societies, are discussed in the context of the Casa de la Contratación and the Consejo de Indias, unique centers of learning built on secular concerns.

There are no footnotes, but a basic bibliography, an index, and a chronology make this well-written survey a useful reference as well.

URSULA LAMB

■ Early Modern Period

Marinus Dirk Stafleu. *Theories at Work: On the Structure and Functioning of Theories in Science, in Particular during the Copernican Revolution.* (Christian Studies Today.) 310 pp., bibl., index. Lanham, Md./New York: University Press of America, 1987; Toronto: Institute for Christian Studies, 1987. $28.75 (cloth); $16.50 (paper).

Theories at Work arose from classroom teaching and probably is intended for use in upper-level courses in the history and philosophy of science. It attempts to develop a theory of theories and to test that theory against the "history of ideas," both philosophical and scientific, during the Copernican revolution. Two reasons are offered for this choice of historical test. First, it is claimed that the Copernican revolution brought about a fundamental change in the way the basic axioms of a theory were conceived: whereas the ancient ideal required that axioms be self-evident or intuitively obvious, Copernicus's willingness to flout common sense ushered in the modern penchant for treating theoretical axioms as contingent and as initially unknown. Second, the Copernican revolution has been a central test case for the "new" philosophy of science of Karl Popper and Thomas S. Kuhn.

The second reason plays the larger role in structuring the book, which effectively contains two parts: an examination of the role of theories in early modern astronomy and physics (Chs. 2–6), and a discussion of the norms and values that should guide the development of theories (Chs. 7–12). In the first part the author argues that theorists should aim for causal explanation, rather than mere prediction; that during the Copernican revolution there was a change in the principles of scientific explanation, and in particular that motion changed from being something that required explanation to being a principle of explanation; and that the aim of modern science is to discover laws, not merely to solve problems. In the chapters on value he argues that the norms of theory making should include the attempt to be clear, the attempt to avoid giving offense, the duty to publish, and the search for simple and harmonious laws. In the final chapter the author contends that realism in science always is a matter of belief, for which no proof is possible. He commends a "reformationist view" of the laws of nature, attributed to John Calvin, according to which laws are the free and arbitrary creation of a god who remains faithful to the laws so decreed, thereby ensuring a stable natural order that is subject to scientific investigation. The author describes this view not as a metaphysical tenet but as an article of faith.

The book's theism will seem a benefit to some and a drawback to others. Let us place it to one side and examine the book on its historical and philosophical merits. The description of the "article of faith" just mentioned as essentially "reformational" may be questioned, for Descartes adopted a voluntarist position virtually identical with the one attributed to Calvin. More generally, although the book cites primary sources frequently, the interpretation of these sources draws heavily upon such authors as E. A. Burtt, E. J. Dijksterhuis, the early A. R. Hall, and Alexandre Koyré. The historiography is thus quite dated and echoes the familiar but dubious position that Archimedes, Copernicus, Galileo, and Descartes were all "Platonists." In accordance with Pierre Duhem, all technical astronomy prior to Copernicus is incorrectly described as "instrumentalist" (Sec. 2.1). Some of the historical discussions are interesting, including the analysis of Christiaan Huygens as a "normal scientist" (Sec. 4.2), the claim that "crises" follow the introduction of new theories, rather than preceding them (Sec. 4.5), and the discussion of the

relations among the theories of Newton, Galileo, Kepler, and Descartes (Sec. 5.1). In general the work is strongest when dealing with the relation of Newton to his predecessors and successors. However, numerous factual and interpretive errors undercut its usefulness as a textbook, as when it is claimed that according to Descartes planetary rotation is the cause of vortical motion, or that Descartes's treatment of rest and rectilinear motion as "states" was fully equivalent to Newton's law of inertia (Sec. 3.4; according to Descartes, a change in the direction of straight-line motion does not require force). Moreover, the chief historical argument of the book, pertaining to the rejection of the Aristotelian ideal of self-evident axioms, is weakened by a failure to discuss the Aristotelian distinction between the order of knowledge and the order of nature (in the former order, axioms are not originally evident).

Philosophically, the attempt to observe "theories at work" is commendable and indicates the author's alliance with Popper, Kuhn, Imre Lakatos, and Larry Laudan, who are frequently cited, sometimes with approval, sometimes in disagreement. The more particular philosophical claims of the author, such as that human experience can be analyzed into four irreducible modes (number, space, motion, and physical interaction), are of interest but are not developed sufficiently to permit evaluation.

GARY HATFIELD

Juan A. Frago Gracia; José García-Diego. *Un autor aragonés para "Los veintiún libros de los ingenios y de las máquinas."* (Colección Estudios y Monografías, 7.) 148 pp., illus. Zaragoza: Diputación General de Aragon, 1988.

The *Veintiún libros* is among the most substantial technological manuscripts of the sixteenth century. Running to over nine hundred pages, now bound in five volumes, the twenty-one books describe every technology that makes use of water, with information on such matters as the chemical processes used in refining, the material used in the construction of bridges, harbors, conduits, and much else. In all, the work is almost as comprehensive as Georgius Agricola's *De re metallica* or Vannoccio Biringuccio's *Pirotechnia,* which may have been its model.

Until 1976 the manuscript was assumed to be by a celebrated maker of clocks, planetaria, and automatic puppets, Juanelo Turriano of Cremona: he was also known as a hydraulic engineer and had designed a novel if cumbersome waterworks for Toledo and its palace, the Alcazar. In that year, however, J. A. García-Diego showed how implausible this attribution was. Simply, there is hardly any congruence between Turriano's career as known to us and the areas of expertise of the author of the *Veintiún libros*—no mention of any of the inventions of Turriano or of the places where he worked (the places that are mentioned are in Aragon, where Turriano apparently never went).

At first García-Diego thought something at least of the manuscript was contributed by Giovanni Francesco Sitoni, an Italian engineer who did work in Aragon. García-Diego has since found a manuscript on irrigation by Sitoni, which he hopes to publish. But it is now clear that Sitoni cannot be the author of the *Veintiún libros*. García-Diego had already concluded that the author must be a native speaker of Spanish. He has now collaborated with the philologist Juan Frago Gracia to produce what must be a definitive study of the language of the *Veintiún libros*.

Frago Gracia's thorough investigation reveals a wealth of words used only in certain parts of Aragon, with local spellings and syntax. Clearly the author's mother tongue was Aragonese Spanish. Indeed, although a number of the place names mentioned are in the southern highlands of Aragon, the vocabulary strongly suggests an origin further north, in the Alto Aragon between the Ebro basin and the Pyrenees (roughly, the modern province of Huesca). More tentatively, Frago Gracia proposes the central part of the province. Other inquiries by García-Diego, to experts in design, tell us that the costume and architectural details of the four hundred–plus drawings that illustrate the *Veintiún libros* are probably of the last decade of the sixteenth century. The language seems to bear this date out, broadly speaking. So we now have a time and a place—approximately. Have we an author?

N. García Tapia has argued for the one man he believes fits the bill, Pedro Juan de Lastanosa (most recently and most fully in "Pedro Juan de Lastanosa y Pseudo-Juanelo Turriano," *Llull,* 1987, *10*:51–74). He has claimed that Lastanosa is the only engi-