


keeping with this tradition, the Museum Boerhaave has filled its historic building with informative and accessible exhibits and has sponsored a series of catalogs that enable us to analyze and appreciate its objects from afar. The catalog at hand is intelligently organized and handsomely produced. For each object, there is a clear photograph and a succinct description, enriched with information about its date, dimensions, maker, and user(s), and references to publications concerning it and/or similar objects.

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The Development of the Rudder: A Technological Tale.

By Lawrence W. Mott. College Station: Texas A&M University Press, 1997. Pp. 218; illustrations, figures, tables, appendixes, notes, bibliography, index. $19.95.

The introduction of the centerline rudder, first on the ships of northern Europe and then on Mediterranean vessels, was a technological development of great importance. The usual interpretation has been that a superior technology, a single rudder hung at the center of the stern of a sailing vessel, developed in the Baltic and North Sea and spread to the Mediterranean rather quickly at the end of the thirteenth or the beginning of the fourteenth century. Its technological superiority has been considered self-evident; after all, the centerline rudder is virtually universal on boats and ships of all types, even today. That the technological transfer from north to south was sudden seemed almost equally self-evident. The fourteenth-century Florentine chronicler Giovanni Villani's entry for 1304 seems to imply that Gascon pirates introduced a new ship type, the cog, that used a centerline rudder and that it was immediately adopted by the leading seafaring cities of Italy. Even if one did not accept Villani's account literally, it seemed to fit well with other evidence of a sudden cross-fertilization between the northern and southern shipbuilding traditions beginning in the fourteenth century and leading quickly to the development of the full-rigged ship in the fifteenth. A clear case of interaction apparently exists between two traditional technologies, leading to the breaking of a conceptual logjam and opening the way for innovation on a grand scale.

Lawrence Mott's "technological tale" shows the value of questioning assumptions and applying careful analysis even to evidence long available. Traditional assumptions about the introduction of the centerline rudder prove not so much wrong as incomplete, without nuance, and simplistic. If rudders mounted on either side of the stern quarter of a vessel were manifestations of an inadequate technology, why did they persist for over two millennia in the Mediterranean? Mott demonstrates through careful analysis of primarily iconographic evidence that the quarter rudder was not a

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static technology, but that its design changed and evolved over time. With mathematical and experimental analysis, supported by testimony regarding the use of quarter rudders on modern Indonesian *pinisi*, he demonstrates that, far from being an inferior technology, quarter rudders can be highly efficient both mechanically and economically. Centerline rudders (Mott prefers the term "pintle and gudgeon rudder" as more precise and descriptive of the essential technology involved) can be less efficient, more expensive, and harder to repair at sea than quarter rudders. At this point the question of technological transformation becomes a much more interesting one. No longer can we be confident that this is a case of a self-evidently superior technology replacing an outdated and inferior one. The task becomes one of explaining how a technology that in its early form was decidedly less attractive on most counts than the older, more highly developed one gets a foothold that allows it to develop and eventually demonstrate its advantages.

The story of this development is at the core of Mott's book. He shows that the pintle and gudgeon rudder is truly effective only as a part of an ensemble of technologies that work together. The rudder only became truly efficient when changes in hull forms and rigging also took place. In essence, he explains how the cross-fertilization between northern and southern technologies operated. Not only was the adoption of the pintle and gudgeon rudder a question of breaking down conceptual barriers, it also required the true application of knowledge contained in the minds and hands of the masters of each tradition to specific problems. The single quarter rudder used in northern waters was not efficient for large vessels. Thus, as ships grew larger, northern shipwrights were faced with a problem that found its solution in a new ship type, the cog, which had a straight stern post with a pintle and gudgeon rudder hung on it. The rounded sterns of the southern tradition posed both mechanical and hydrodynamic problems for a stern rudder. Besides, the double quarter rudders used in the south were reasonably efficient and had been used on very large ships, from the great Roman grain ships to the large thirteenth-century ships such as the *Roccafortis* of Venice or the *Paradisus Magnus* of Genoa. The pintle and gudgeon rudders did not become fully efficient in Mediterranean vessels until they were mounted on a straight stern post faired into the rounded hull. Mediterranean sailors and builders, accustomed to multiple masts, quickly added a mizzen mast to aid in maneuvering, then a foremast and a spritsail. In this manner, the full-rigged ship developed. Still, double quarter rudders continued to be used on galleys and small coasting vessels for several centuries.

Lawrence Mott has provided a fascinating and rich investigation of a key development in late medieval maritime technology. More than that, he raises some very interesting questions on a more general level about the nature of technological developments and what propels them. As he puts it,

"Do radically new technologies arise from an innate human desire to experiment, or do they occur because technological crises force man to search for them?" (p. 156). Despite the question's use of a collective noun that some would find offensive, this is an important question and one that is explored very satisfactorily in this book.

JOHN E. DOTSON

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Ships' Bilge Pumps: A History of Their Development, 1500–1900.

By Thomas J. Oertling. College Station: Texas A&M University Press, 1996. Pp. xvii+105; figures, notes, bibliography, index. $17.95.

Some historic nautical subjects are so thoroughly prosaic in form and use that their importance is ignored, even by those who should know better. Bilge pumps must rank among the lowest of the lowly, yet their presence and working condition were vital to a ship's ability to stay afloat, not to mention its making a successful voyage. Taken for granted by everyone connected with shipping (except the ship chandlers and inspectors for insurance or safety of life at sea), marine pumping equipment of any kind has received scant attention in texts on ship design, construction, or handling.

For the period between 1500 and 1850, marine archaeology has made the most substantive contributions to our present knowledge of bilge pumps, through the discovery and description of their remains in wreck sites or in preserved vessels. Tangible (and more important, measurable) artifacts have fleshed out the brief verbal descriptions and crude illustrations that have been the chief sources of information for historians and museum specialists. Thomas J. Oertling's book is all too brief as a history of the bilge pump, but it is effective as a summary of archaeological findings on the subject.

A thoughtful first chapter deals with the problem that every ship's hull leaked, with disastrous consequences if its pumps were inoperative or inadequate to the task. The second chapter addresses the most difficult task in pump making: boring a log through its center to make the wooden tube for the pump shaft. The term "pump tube" as far as I know is an academic one. English and American sailors called this part the "pump log," and a log is exactly what it was in most ships. The pump logs in the 1627 Swedish warship *Vasa* still have their bark!

The four chapters that follow describe the basic types of bilge pumps, which include: the burr pump; the common, or "suction," pump; the chain pump; and the metal "patent" pumps of the late nineteenth century. The