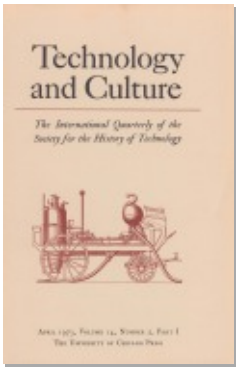
Science and Civilisation in China . Vol. 4: *Physics and Physical Technology: Part III. Civil Engineering and Nautics* by Joseph Needham (review)



E-tu Zen Sun

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always had to meet, subject, unlike the scholarly scientist, to the two very stringent conditions of time and cost. He seems bent upon disabusing the student of the notion that engineering is merely applied science. "Science and mathematics are important fundamentals in engineering education, but they must be seen in their proper perspective as only a small part of engineering" (p. 5). Throughout, Gregory portrays the mind of the master engineer as eclectic, possessed of insight, intuition, a sense of the practical. First it lays hold of an objective problem; always a problem with economic and ultimately social dimensions, but the solving of which affords scant time for philosophizing. Then it grasps for useful knowledge wherever it can be found, discarding hallowed theories that will not serve, boldly cantilevering out beyond others that suffice to carry only part way to a solution, all the while experimenting and testing ad hoc. Even in the chapter explaining how the computer serves engineering, Gregory brutally tells the student that "important design decisions must always remain subjective" (p. 132). One puts down the book with the impression that the quintessence of engineering talent remains, as Samuel Smiles described it over a hundred years ago, "mother-wit," though nowadays it had better make use of a much wider range of general knowledge.

CECIL O. SMITH, JR.*

Science and Civilisation in China. Vol. 4: *Physics and Physical Technology: Part III. Civil Engineering and Nautics.* By Joseph Needham, with the collaboration of Wang Ling and Lu Gwei-djen. Cambridge: Cambridge University Press, 1971. Pp. lvii+699; illustrations, maps, bibliographies, index. £18 (Great Britain); $55.00 (United States).

This volume, consisting of sections 28 and 29 of Dr. Needham's survey of science and technology within the context of premodern Chinese society, completes volume 4 of this major work. Section 28, "Civil Engineering" (pp. 1–378), deals with five different areas under that general heading: road building; walls; building technology, including such topics as principles of architecture and town planning; the construction of bridges of various types; and hydraulic engineering.

The last is a major subject in itself, and the discussion encompasses the control, construction, and maintenance of waterways, examples of the greater works which describe the historical setting and the technical aspects of six examples, including a thorough

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examination of the Kuan-hsien irrigation system—the Tu-chiang yen, completed in the 3d century B.C. and still in use—in Szechuan (pp. 288-96) and the Grand Canal (pp. 306-20); and a discussion of the traditional Chinese techniques of hydraulic engineering (pp. 329-65) which concludes this section. There is much material here that is useful to the economic historian. One should, however, read some of the far-reaching generalizations with selectiveness; for instance, the reference to annual inundation and its relation to the development of water conservancy in ancient China (p. 375), in view of the fact that in recent years the origins of Chinese agriculture have been subjected to reevaluation by such historians as Ping-ti Ho, Lao Kan, and others.

Section 29, "Nautical Technology," treats the subject in detail (pp. 379-699). The very mobility of the sailing craft itself adds a further degree of splendor to Needham's discourse on one of his special concerns, that in the cross-currents of technological influences across the wide spans of territory and time; his comparative studies of the construction of ships and sails and their evolution in the global scene are historical assessments as well as comprehensive technical discussions on marine architecture. His conclusions are summarized in table 71, "Chart of the Development of Boat Construction" (p. 384), and table 72, "Chart Showing the Distribution and Possible Genetic Derivation of Types of Sail" (p. 606), where the interaction of ancient Egyptian, Western European, southwestern and eastern Asian influences on ships and sails is schematized.

Within the confines of China herself, the "natural history" of Chinese ships, the techniques of their control (such as navigation and steering) and propulsion (sails and oars and how they were made to work), and the Chinese preferences in action afloat, whether in peaceful pursuits or warfare (parts d, f, g, h, i) are explicated with the usual care, with the revelation of several facts not commonly known. For example, in naval engagements the Chinese long preferred projectile tactics as against boarding and close combat (pp. 682-95), which in time led to the protective device of armor plating above-water portions of one's warships, including the deck, from about the Sung (10th-13th centuries), and this in turn led to the Korean "turtle ships" that proved so effective against the Japanese in the late 16th century.

Equipped with highly advanced ships and instruments, where did the Chinese sail to? The well-known and spectacular voyages of Cheng Ho aside (early 15th century, pp. 487-94), Chinese ships might have explored much farther afield in medieval times than the average person normally would assume. Although some of the evidences for the early Chinese voyages and discoveries are scanty, they are nonetheless tantalizing. Was the correct depiction of the southern end of Africa in a Chinese atlas of the 14th-15th centuries proof

that they were the first sailors to round the Cape of Good Hope (pp. 498-502)? Or did the old Chinese statuette unearthed near Port Darwin in the last century indicate that Chinese sea-going junks were visiting Australia—via the Indonesian archipelago—before the Europeans (p. 537)?

Veteran readers of Needham's writings will recognize the above samples as typical of the questions—and very often answers—that his meticulous investigation presents us with; questions of vast historical and cultural significance, and answers that revise people's preconceptions of East Asian civilization. The present volume does not deviate from the general pattern. Here the underlying theme still is to assess, through careful research and reconstruction, the Chinese contribution to the world fund of knowledge in specific areas of science and technology and to project these contributions against a world context. Thus, while the genesis of certain features in ship design (e.g., the bipod masts, p. 435) is still subject to speculation, other features are clearly pointed out as undoubtedly Chinese contributions to general nautical technology. To cite but two examples; the shaping of the ship's hull with a narrow bow and wider stern for the most efficient sailing (p. 419); and the introduction of bulkheads at an early date, thus creating water-tight compartments in ships, a technique that was introduced twice into Europe, in the late 17th century and again one century later (p. 422). Or, in the very important section on bridge building, the evolution of the suspension bridge in China from bamboo-cable to iron-chain bridge was accomplished between the first and sixth century of the Christian era (p. 193), which was an indication of the advances made in siderurgy at the time as well as in bridge construction.

Though seemingly divergent, the subjects treated in this volume yet share a common characteristic—their close and direct impingement on the daily life of the people. More than any other, the present volume reminds us of the functional origins of the products and devices we see. In discussing traditional building techniques, for example, the weight-distributing role of the corbel bracket (*tou-kung*) in relation to the rafters is explained; this leads to a view of their relation to the eaves and hence to the device of the curved roof (pp. 93-97). Thus, the importance here is to appreciate the correlation between structure, style, and material: the raison d'être of the "upturned roof edge" was the fulfilling of an essential function where most of the walls were made of adobe bricks and not meant to carry weight. In this connection, one might mention that, in order to illustrate domestic architecture, figure 745 (a drawing showing a traditional house in Peking) could be supplemented to good advantage with several photographs from the admirable book *The Traditional Architecture of Peking* [*Pei-ching ku chien-chu*] (Peking, 1959).

The sense of a living, constantly evolving civilization benefiting

from its diverse legacies is enhanced in two ways. First, in the course of his analyses Needham makes frequent references to pertinent points in the previous volumes of this work, so that one gains the perspective of viewing a network of mutually related parts that made up the entire fabric of a functioning society. Second, there are many indications that problems and techniques of the past are often present still, problems such as the difficult terrain of San-men Gorge on the Yellow River (pp. 274–75), where the new multipurpose dam stands today, or the pen sketches of farm dwellings made in 1955 showing localized age-old profiles (figs. 794, 795), and the continued use of terre pisé in building construction (fig. 720, photo taken in 1964). One comes to realize that this civilization is grown from deep and strong roots, that its premodern ways of doing things are not relics for the antiquarian's eyes only but are techniques of daily living that are, today, undergoing rapid change, and that we should all profit from a deeper understanding of it.

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The Sugar Hacienda of the Marqueses del Valle. By Ward J. Barrett. Minneapolis: University of Minnesota Press, 1970. Pp. 147. $10.00.

Professor Barrett's study of the Cortés estate in colonial Mexico, which has already become a classic in Latin American historical geography, constitutes, among its other salient recommendations, a chapter in the history of technological diffusion and the transfer of European technology. The technology is that of sugar production, and the path of diffusion includes such outposts of the Iberian world as Madeira and Gran Canaria, Brazil, Santo Domingo, and Mexico.

The sugar industry of the Spanish empire is presented as the beneficiary of an efficient network of technological communication, demonstrated in uniformity of growing procedure and processing technique throughout the colonial plantations. Barrett supplies detailed descriptions of both the agricultural practice and sugar-making techniques and hardware as employed in Mexico.

Most striking is the fact that sugar production per unit of labor rose fourfold over a period of several hundred years, a true revolution in Barrett's view. Yet this increment was owing to no one technological change (there were none until the introduction of steam power) but rather to an accretion of minor adjustments, most-

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