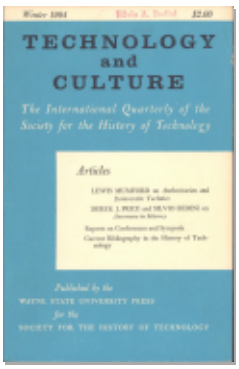
Science and Civilization in China . Vol. IV, *Physics and Physical Technology* ; Part I: *Physics* by Joseph Needham (review)



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Science and Civilization in China. Vol. IV, *Physics and Physical Technology;* Part I: *Physics.* By Joseph Needham, with the collaboration of Wang Ling, and special cooperation of Kenneth G. Robinson. Cambridge and New York: Cambridge University Press, 1962. Pp. xxxiv, 434. Illustrations. Tables. Bibliographies. 84s. or $15.00.

With the publication of the first part of Volume IV, Dr. Needham's treatise on Chinese science and civilization, which has already won wide recognition as the most valuable survey of this vast subject, has now reached the half-way point in a projected seven-volume series. The present volume deals with the more basic aspects of the science of physics and their expressions in ancient and medieval China, approximately from late Chou to the Sung and Ming periods (ca. fourth century B. C. to early seventeenth century A. D.).

After a brief introduction, in which the author indicates some special characteristics of the Chinese thought system, the book gets under way with a chapter dealing with theories of waves and particles. The dominant conception in Chinese thought was wave theory, as opposed to atomistic or particulate conceptions. Needham cites instances to demonstrate that the Chinese view of the physical universe as a continuous whole and the preoccupation with the "intrinsic rhythms in natural objects" may have inhibited the growth of scientific knowledge (p. 7). The exceptions were the Mohists (fl. fourth century B. C., or contemporaneous with Aristotle), who speculated on "point" and "instant." In the next chapter, "Mass, mensuration, statics, and hydrostatics," the important role of the Mohists as scientists is again pointed out and their writings analyzed in terms of modern knowledge. Of special interest is a section on China and the metric system, in which we are shown the methods by which a large-scale attempt was made in the eighth century to establish terrestrial length measures in terms of astronomical units (pp. 42 ff.). Chapters on "The study of motion (dynamics)" and "Heat and combustion" survey two fields in which the Chinese did not make strong contributions relative to modern science.

In the area of optics, the highly advanced inventions of the Chinese—the long array of mirrors, burning-mirrors, camera obscura, lenses, and the like—were intermingled with much perceptive theoretical work, from the early Mohist literature, containing discussions of the pin-hole phenomenon, down to Shen Kua of the eleventh century, who wrote on the cone of light and the inversion of images (pp. 81-99). Included in this chapter is a discussion of early Chinese glass technology. The following chapter on "Sound (acoustics)" is mainly devoted to an analysis of Chinese music and musical instruments and the acoustical knowledge they manifested.

The last 101 pages of the volume are given over to a chapter on "Magnetism and electricity," matters of the utmost importance to modern science and technology. Knowledge of the lodestone was recorded in China from the third century B. C. on, and from the early observations of the attractive powers of the magnet the author traces the development of experiments and thought through later stages where magnetic directivity, polarity, and declination were studied and discussed. Needham also brings to view the relation between such knowledge and what he terms the "pseudo-science" of geomancy. But the most fascinating portion of all is his presentation of the historical evolution of the magnetic compass, which in China passed through the phases of the diviner's board, the lodestone spoon, and the floating and, lastly, the dry needle. Here, as in the previous chapters, archaeological studies carried out in China in recent years have proved valuable for arriving at the conclusions.

Throughout the entire book can be discerned some of Needham's overriding concerns that have given unity to these volumes. In terms of the present volume these may be summed up as follows: (1) the particular characteristics of Chinese physics both as to theory and to the milieu that produced it; (2) the practical inventions that demonstrated the existence of this knowledge; (3) wherever feasible and to good purpose, comparison is made with similar developments in the Western civilization (it will be recalled that in Volume I there was a considerable discussion of cultural transmission). What the author has done is, in effect, the reconstruction of a cultural past. The material is gleaned from a wide range of Chinese sources and secondary studies that in one way or another illustrate how the empirical knowledge of physics and its theoretical formulations fitted into the past intellectual life of the Chinese, with threads that lead to the present day. The scenes are brought to vivid life with such accounts as the astronomers being sent, in the eighth century, to take measurements of terrestrial latitudes across the length and breadth of the T'ang empire (pp. 42 ff.), or of the Sung officials testing the strength of brine for salt-making by utilizing the principle of specific gravity (pp. 39-42), or the story of the iron oxen that served as anchors for a floating bridge across the Yellow River, built in the eighth century A. D., and their recovery from the river bottom in the eleventh century, to illustrate the utilization of the principles of buoyancy (pp. 40-41).

Although scores of Chinese and Western specialists have done detailed research on the various subjects related to physics in China, Needham has made a comprehensive synthesis of their findings; in so doing he has made two further contributions. First, when individual pieces fall into place within a general framework, the lacunae become more obvious, bringing to view certain questions that need further study. For example, why did the Chinese lack a philosophy of dy-

namics, although their mechanical practice was ahead of Europe until Galileo and the other aspects of their thought would seem to be liable to encourage explicit dynamics (pp. 59-63)? Was it solely due to the predominance of the wave theory, making it difficult for the Chinese to visualize motion by individual bodies? A similar question may be asked in relation to thermal science (pp. 63-71): the Chinese were using sulfur matches as early as the 6th century A.D.; yet in the philosophy of heat, the traditional ideas, similar to those of pre-Renaissance Europe, prevailed until the seventeenth century when the Jesuits brought more modern ideas to China. These and many other questions cannot be answered all at once, but they deserve the attention Dr. Needham has given them, and certainly the collection of information assembled in the present volume helps to clear the way.

Secondly, in the course of synthesizing previous work, new insight is gained with the availability of newer source material, which enables the author to formulate new interpretations that often are of major importance. As examples one might cite his refutation of Bertold Laufer's contention that glass was not made in China before the T'ang dynasty (pp. 99-114) and his emendation of A. Forke's reading of *ching* in the tenth-century book *Hua shu* as "mirror" into the more correct rendition of "lenses" (pp. 116 ff.).

In the face of so much magnificent erudition, such riches of superb expository prose, one is reluctant to mention a few doubtful points in the book which, compared to what has been achieved, are puny indeed. It only behooves the reviewer to remind the reader that pitfalls attend even the most careful of scholars. Where lexicographic analysis forms such an important part of the study, the scholar must be constantly on guard. (Example, p. 113: the character *ping* belongs to the "fire" element, therefore more directly germane to the manufacture of glass than the roundabout interpretation via the word's supposed affiliation with "west" and "metal.") Then again, the author's enthusiasm for his subject sometimes leads him to somewhat forced inferences—a wistful look at certain points in the cultural history under analysis that do not quite come up to his expectations, perhaps. One thinks of the paragraphs dealing with sound as vibration, in which Needham quotes Tung Chung-shu (second century B.C.) and Liu Chih (third century A.D.) as both having made statements describing the movement of concentric wave-rings, adding that these two men therefore bracket Vitruvius in time. The fact is that neither of these writers had made specific reference to *sound waves*—while Vitruvius had. One has to accept the truism that one cannot be the first in everything.

But enough of this hair-splitting. Dr. Needham and his associates must be congratulated for giving the scholarly community another

brilliant volume on science and civilization in China; one awaits the subsequent ones with anticipation.

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Chinese Architecture and Town Planning, 1500 B.C.-A.D. 1911. By Andrew Boyd. Chicago: University of Chicago Press, 1962. Pp. vi, 166. Illustrations, bibliography. $7.50.

The Turning Point of Building: Structure and Design. By Konrad Wachsmann. Translated by Thomas E. Burton. New York: Reinhold, 1961. Pp. 239. Illustrations. $15.

Structure and Form in Modern Architecture. By Curt Siegel. Translated by Thomas E. Burton. New York: Reinhold, 1962. Pp. 308. Illustrations. $15.

Works in English on the scientific and technical culture of China could scarcely be said to exist until Joseph Needham began to publish his encyclopedic study in 1954. Several books dealing with Chinese architecture have appeared in recent years, but Andrew Boyd, so far as I know, is the first architect to treat the subject and is thus one of the few to pay some attention to the technical basis of the art. His volume can only be regarded as a concise introduction. He begins with a brief survey of the social and cultural institutions of the country from the early Bronze Age to the overthrow of the imperial government in 1911. He is left with 135 pages of text to cover the evolution of structural principles, town planning, the forms of residential, religious, and public building, gardens and artificial landscapes, and engineering works. To deal with 34 centuries of the Western building tradition in this space would be absurd, but Boyd is aided in his condensation by the extraordinary stability of Chinese architectural and structural forms. The generous number of plates and the clear drawings provide a valuable supplement to the text.

The great majority of Chinese buildings and bridges are of timber construction, with masonry confined mainly to pagodas, defensive structures, and a few large bridges. Boyd limits his discussion of masonry techniques to the method of constructing bridge arches in long segmental blocks curved to the arch curvature. This technique

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