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978-0-521-08716-2 - Heavenly Clockwork: The Great Astronomical Clocks of Medieval China, Second Edition

Joseph Needham, Wang Ling, and Derek J. de Solla Price

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ANTIQUARIAN HOROLOGICAL SOCIETY MONOGRAPH NO. 1

HEAVENLY
CLOCKWORK

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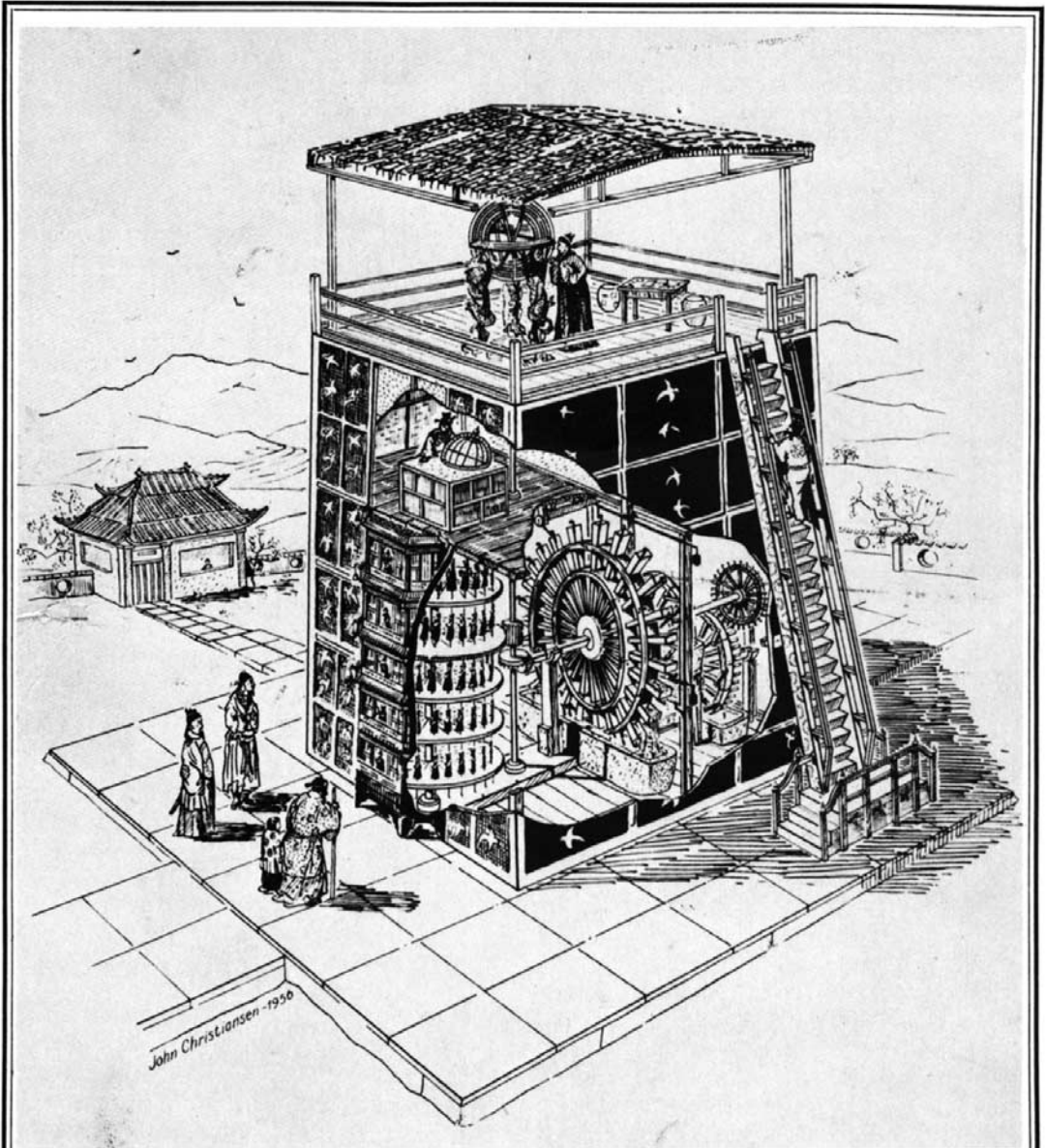
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Fig. 1. A pictorial reconstruction of the astronomical clock-tower built by Su Sung and his collaborators at K'ai-fêng in Honan province, then the capital of the empire, in A.D. 1090. The clock-work, driven by a water-wheel, and fully enclosed within the tower, rotated an armillary sphere on the top platform and a celestial globe in the upper storey; puppet figures giving notice meanwhile of the passing hours and quarters by signals of sight and sound. (Original drawing by John Christiansen.)

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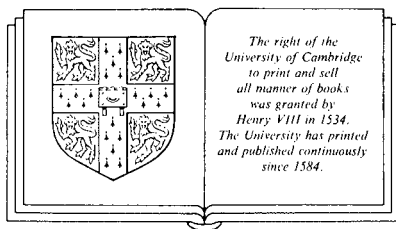
HEAVENLY CLOCKWORK

THE GREAT ASTRONOMICAL CLOCKS OF
MEDIEVAL CHINA

JOSEPH NEEDHAM,
WANG LING,
AND
DEREK J. DE SOLLA PRICE

SECOND EDITION

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CHRONOLOGICAL TABLE

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| CHOU (feudal age) early | 1030–722 | |
| Spirings and Autumns period | 722–480 | |
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| Five Dynasties period | 907–60 | |
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| SUNG dynasty (Northern) | 960–1126 | |
| | 975–9 | Work of Chang Ssu-Hsün |
| | 1000 | Han Hsien-Fu |
| | 1050 | Shu I-Chien |
| | 1074 | Shen Kua |
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| | 1124 | Wang Fu |
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| | 1170 | Efforts of Chu Hsi |
| | 1172 | First printing of Su Sung's book |
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| YUAN (Mongol) dynasty | 1260–1368 | |
| | 1275 | Kuo Shou-Ching |
| | 1354 | Toghan Timur |
| MING dynasty | 1368–1644 | |
| | 1370 <i>c.</i> | Chan Hsi-Yuan |
| | 1583 | Coming of the Jesuits |
| CH'ING (Manchu) dynasty | 1644–1911 | |
| KUOMINTANG Republic | 1911–48 | |
| PEOPLE'S Republic | 1949– | |

NOTES AND CONVENTIONS

1. We distinguish between Glosses and Commentaries in the main text and occasionally elsewhere. The Glosses appear in the original text as small characters in double rows within the main rows of standard-size characters; they are usually single sentences, and we have incorporated them in the translated text inside single angle-brackets < >.

Commentaries, on the other hand, are paragraphs which follow the sections of the main text, in characters of standard size but differentiated from it by the fact that they begin a few lines lower on the page. We have incorporated these as separate paragraphs, enclosed in double angle-brackets << >>.

Both types of addition occur only in sections A–D and F–N, and we believe them to be coeval with, and perhaps by the same hand as, the sections E and P–S (cf. Fig. 2).

Minor glosses, if purely repetition, have been omitted.

2. It must be remembered that the text is not intended as one continuous narrative. About half of it consists of captions describing at length the successive illustrations.

3. Round brackets () are used to indicate editorial additions whether by way of explanation, amplification, or adaptation to the grammar of the English language. Square brackets [] have been reserved for the reference numbers which direct the reader to the lists of Chinese characters (pp. 229 ff.).

4. An effort has been made to render consistently the technical engineering terms involved in these texts. This has sometimes necessitated overlooking certain minor variations in the Chinese technical terms. Phrases which we believe to be synonyms will therefore be seen in the first list of Chinese characters (pp. 229 ff.).

5. Attention may be directed to the fact that in medieval Chinese engineering descriptions back and front, left and right, are often referred to as ‘north’ and ‘south’, ‘east’ and ‘west’, respectively. The upper parts of a machine are called ‘heavenly’ and the lower parts ‘earthly’. The text is sometimes inconsistent with the orientation of the illustrations. This is probably due to the fact that Chinese wood blocks were made by pasting on the drawing (or page of writing) to the piece of pear or other wood which the carver would then carve. As the paper was almost transparent, lateral inversion of a drawing could arise. It is also very likely that the draftsmen were not consistent in the aspect from which they regarded the apparatus.

6. The Chinese foot (*ch'ih*) varied in length, during the period under discussion, from 9 in. to a little over 12 in. of our measure, being almost identical with our foot during the Sung dynasty in which Su Sung worked. The Chinese foot was always subdivided into 10 ‘inches’, but to facilitate translation we have silently ignored the duodecimal implications of the word ‘inch’, and the relatively unimportant variations in its absolute length.

Similar conventions relating to the numbers of hours and quarters in the day and night will be found discussed in the Appendix.

7. Braces { } are used in the Foreword and Supplement to the second edition to indicate references to pages or Figures in the original text, general bibliography, and tables of Chinese characters.

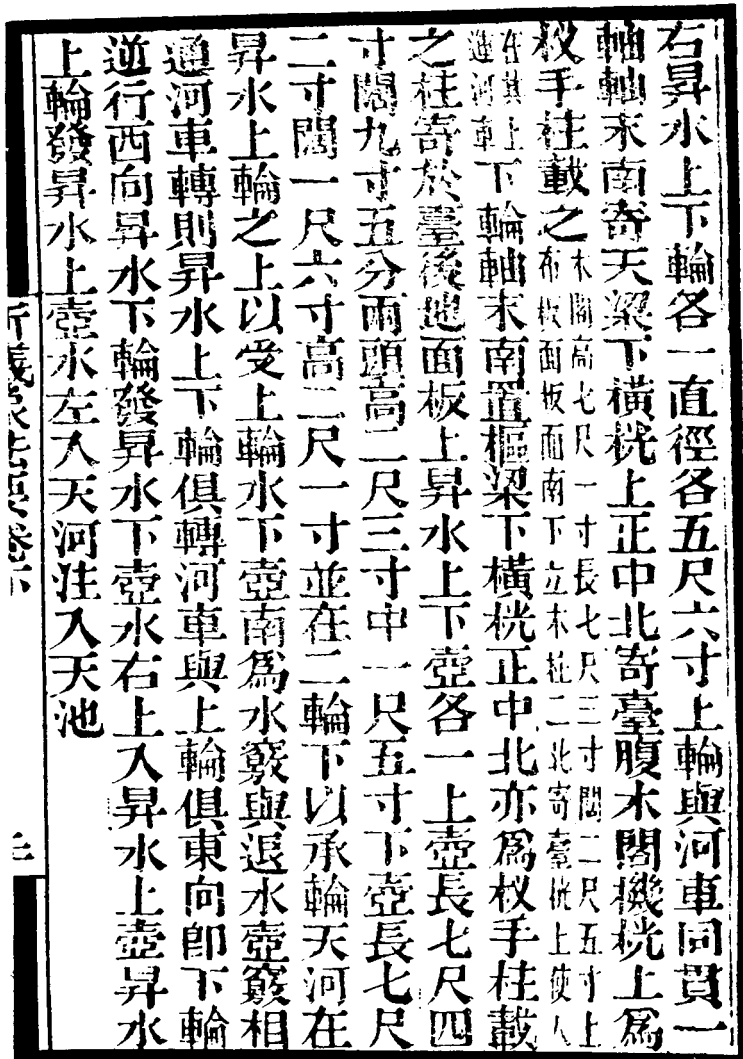


Fig. 2. A page of text (ch. 3, p. 20a) of the *Hsin I Hsiang Fa Yao* (section L, p. 42 below), showing a gloss in small characters. This section describes the noria wheels which replenished the water-supply tanks for the clock's driving-wheel.

FOREWORD TO THE SECOND EDITION

JOSEPH NEEDHAM

SINCE the original publication of *Heavenly Clockwork* in 1960, textual studies and practical work have substantially increased our knowledge, and correspondingly modified some of the views which we then held about the text of Su Sung's *Hsin I Hsiang Fa Yao*, about the astronomical clock-tower which he sponsored, and about some of the other time-keeping devices mentioned by us.

Distance has for many years separated us from Wang Ling, now retired from the Institute of Advanced Studies at Canberra, Australia; and a recently lamented death has sadly finalised our already long separation by distance from Derek J. de Solla Price, lately Professor of the History of Science at Yale University, New Haven, Connecticut, U.S.A. Without their help, it was impossible to undertake the rewriting of this work for a projected new edition. Instead, pp. 1–205 have been reprinted without amendment, and I have pleasure in commending to readers the Supplement, on pp. 206–15, which has been prepared by John H. Combridge, whose collaboration in our studies began as a spare-time hobby in 1961.

The attention of readers is especially drawn to the following matters, referred to both on the reprinted pages and in the Supplement:

NOTES AND CONVENTIONS {pp. xii–xiii}

The 'Glosses' and 'Commentaries' have been shown to be the results of Shih Yuan-Chih's editorial conflation, in A.D. 1172, of two or more interdependent texts describing and illustrating features of astronomical clock-towers built in 967–9, 1078–85, and 1086–9, with Su Sung's memorial of 1092 included as an introduction. The latter led to the attribution of the whole work to Su Sung.

INTRODUCTION {p. 3}

The synopsis of the operation and timing of the clockwork mechanism should be read in conjunction with Section I of the Supplement, on pp. 206–9.

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CHAPTER II {p. 14}

An 1844 quarto reprint of the 1172 edition of the *Hsin I Hsiang Fa Yao* is held by the Cambridge University Library [class-mark FC. 55.84/19 (Wade B 1258)], and contains woodblock illustrations substantially clearer in some parts than those of the 1922 octavo reprint used for Figs. 2, 3, 5, 7–22, 28–9 and 70. Further octavo reprints were published in 1935–7 and 1969 (see Shih Yuan-Chih (ed.) (1), in the Supplementary Bibliography, p. 218).

CHAPTER III {p. 20}

It has been shown (see Supplement, p. 208) that in both their practical work and its subsequent recording, Su Sung and his collaborators made extensive use of the then-surviving illustrated descriptions of the 976–9 and 1078–85 astronomical clock-towers.

CHAPTERS IV AND V

These chapters should be read, throughout, in the light of the information set out in Section 1 of the Supplement, on pp. 206–9.

CHAPTERS VI AND VII

Revised ideas about steelyard clepsydras {pp. 86ff}, monumental Striking Clepsydras {pp. 135–40}, Ming sand-clocks {pp. 154–61}, Wang Chêng's verge-and-foliot clock {pp. 146–7}, and the Korean armillary clock {p. 162 and Fig. 59}, are referred to in Section 2 of the Supplement, on pp. 209–14.

CHAPTER X

Revised ideas about compartmented cylindrical clepsydras {pp. 191–5}, and early European mechanical clocks {pp. 195–6}, are referred to in Section 3 of the Supplement, on pp. 214–15.

East Asian History of Science Library, Cambridge

1986